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PREFACE

Welcome to the Workshop Proceedings of the 23rd International Conference on Computers in Education (ICCE 2015), held from November 30th to December 4th in Hangzhou, China.

Established in 1989, ICCE is now an annual international conference organized by the Asia-Pacific Society for Computers in Education (APSCE), and it has become a major event for scholars and researchers in the Asia-Pacific region to share ideas and to discuss their works in the use of technologies in education.

This year we accepted 15 workshops and we aim to explore focused issues in various themes related to the use of technologies in education. Each proposal was peer-reviewed by international reviewers with relevant expertise to ensure high-quality work. All the workshops, organized by the International Program Committees, are in the mini-conference format and this proceeding includes all the papers submitted to our workshop. We believe that the workshop provides a valuable opportunity for researchers to share their works and to seek further collaboration. Papers of our workshop will certainly stimulate more interesting research works in these relative areas in Asia-Pacific countries and beyond. We hope that readers will find the newly ideas relevant to their research works in this proceeding.

Finally, we would like to thank the Executive Committee of the Asia-Pacific Society of Computers in Education and the ICCE 2015 International Program Committee Coordination Chair and Co-Chair for entrusting us with this important task of chairing the workshop program and giving us an opportunity to work with many outstanding researchers. We would also like to thank the Local Organizing Committee for helping with the logistic of the workshop program.

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To Explore the Effect of Age on Cognitive Load When Using Social Websites to Conduct Flipped Classrooms on Musical Instrument Performance Teaching - Taking Amateur Erhu Learners as an Example

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Abstract: Since the development of information technology, the teaching mode keeps innovating and flipped classrooms become popular. However, flipped classrooms need to preview the course videos on websites. It might affect the learners' cognitive load of different age levels during their learning process. Because the age range of amateur erhu learners is very wide, this research focus on amateur erhu learners. We use the teaching mode of flipped classrooms on websites and explore whether the age will affect the cognitive load. The result shows that the middle age learners got heavier cognitive load than the young and the old age learners.

Keywords: Age, flipped classroom, cognitive load, musical instrument performance teaching, social websites

1. Introduction

Erhu is a popular traditional string instrument in Taiwan. Learning erhu is difficult because the pitches of erhus must be controlled by the players themself. In the traditional amateur erhu teaching, teachers usually demonstrate erhu music in classrooms. Students learn the bowing and fingering in classrooms and then practice at home. But, Liou and Cai (2015) pointed out that traditional classrooms usually have poor performance because most students have no enough time for knowledge internalization. To improve this disadvantage, the concept of flipped classrooms comes out. Flipped classrooms were proposed by two chemistry teachers, Jon Bergmann and Aaron Sams in "Forest High School" located at Rocky Mountains (Bergmann & Sams, 2012). Flipped classrooms can just deepen the knowledge internalization through the preview before class and the interaction with teachers and classmates in classrooms. This improves the problem of knowledge internalization of traditional teaching.

However, flipped classrooms need to preview at home before class. It may be a burden for busy amateur erhu learners. Sometimes, it is difficult to understand how to play the musical instruments from demonstration videos. In addition, learners are asked to show their previewing results in classrooms. If the preview is not sufficient, it may cause a lot of pressures. Therefore, whether all ages of amateur erhu learners are well suitable to use flipped classrooms mode is worthy to explore. However, to conduct flipped classrooms need to upload the demonstration videos to the teaching websites to provide learners to preview. If learners need to re-apply usernames and passwords, it's not convenient for amateur erhu learners (Roblyer, McDaniel, Webb, Herman, & Witty, 2010). Therefore, to use a famous video website (e.g., YouTube) to provide learners to preview and a famous social website (e.g., Facebook) to provide a mutual exchange for students and interaction with the teachers can reduce the time to re-familiar with the teaching sites for learners.

Thus, taking amateur erhu learners as an example, this paper uses the flipped classroom mode to teach by social websites and investigate whether age will affect the learners' cognitive load. The results showed that, for the 34 valid samples, the cognitive load of the middle age learners is higher than that of the young learners and the old age learners.

2. Literature Review

2.1 The related researches and findings of flipped classrooms

Traditional classrooms are that teachers lecture the knowledge, raise questions and solve problems in classrooms. Then students conduct review at home after class. But knowledge is often not internalized in the process of traditional classrooms. This causes that the learning effective is poor or the progress is slow. Bergmann and Sams (2012) proposed the concept of "flipped classroom". The meaning of flipped classrooms is that the students watch the preview videos before class. Then students conduct raise questions and discussions by groups. Finally, teachers explain the key points and consolidate the learners' knowledge. This teaching style focuses on promoting the learners' abilities of autonomous learning, independent thinking and problem-solving. The comparisons of traditional classrooms and flipped classrooms are shown in Figure 1.

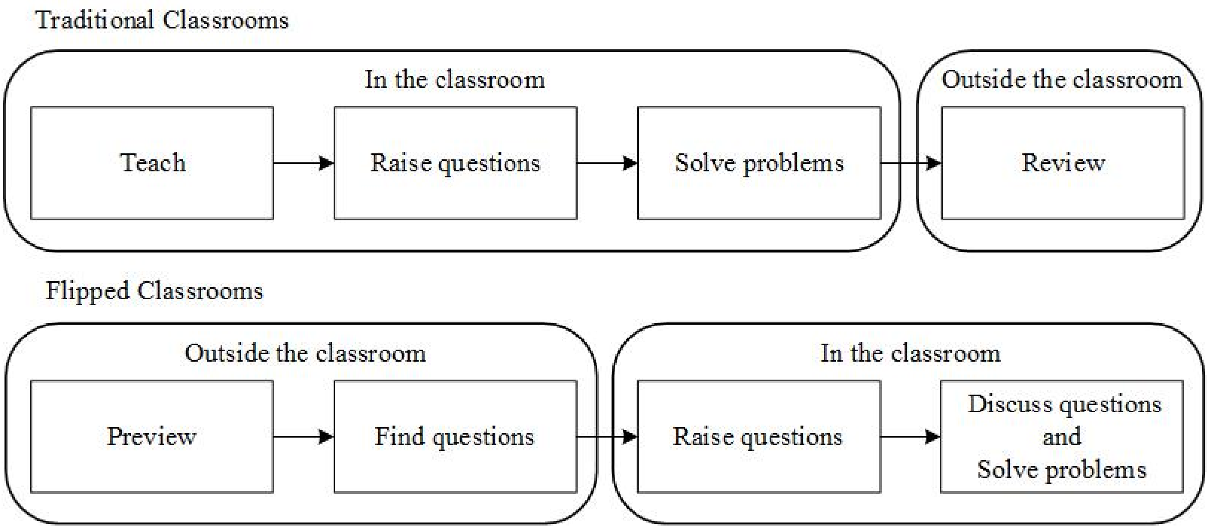

Figure 1. The comparisons of traditional classrooms and flipped classrooms.

Flipped classrooms subvert the structure of traditional classrooms. Flipped classrooms import information technologies into teaching perfectly. As long as flipped classrooms are understood and applied, it is believed that the teaching effectiveness will be better (Wang, Shi, & Ma, 2015).

2.2 The Applications of Social Websites in Teaching

Roblyer et al. (2010) pointed out that the current students prefer to use social websites (e.g., Facebook) to conduct online learning exchanges and discussions. In addition to sharing the stories, photos, videos and interests, Facebook can establish communities to let their friends join. After these features are applied to teaching, the results showed that the students not only have excellent performance in the communication of learning and interaction, but also their professional knowledge is increased effectively (Pérez, Araiza, & Doerfer, 2013).

2.3 Cognitive Load Theory

Sweller (1988) proposed the concept of cognitive load theory. The cognitive load theory contains two parts: mental load and mental effort (Paas, 1992). The meaning of mental load is whether the students feel difficulty or frustration when learning the content of activities (Paas & van Merriënboer, 1994). The meaning of mental effort is whether the students feel difficulty to understand the presentation of the materials and the process of learning (Pass, Tuovinen, Tabbers, & van Gerven, 2003).

Using the above theory, we can understand the burden of students in the process of learning and improve the teaching method to reduce the burden on students. As a result, cognitive load has become one of research areas of E-learning to understand whether students can learn from different ways and whether they will produce the burden of learning in different ways (Chang & Wu, 2011; Chen & Chen, 2012; Hwang, Yang, & Wang, 2013; Hwang, Kuo, Chen, & Ho, 2014). In the past, there are few researches about exploring the impact of cognitive load in flipped classrooms on musical instrument performance teaching. Therefore, this paper is to explore the effect of age on cognitive load when using social websites to conduct flipped classrooms on musical instrument performance teaching and provide different suggestions to teachers.

3. Research Method

3.1 Research Design

This study first conducts literature review and the design of the cognitive load questionnaire which then is inputted into the Google online questionnaire system (Google form). Then we invited an amateur erhu teacher of a music classroom in the central region of Taiwan to record the preview videos before class and uploaded the videos to video websites (YouTube) to provide students to preview. The amateur erhu teacher has taught erhu over 30 years. Also, we used the famous social websites (Facebook) to establish the class learning community to provide teachers and students online communication. Learners then watched the preview erhu videos before class, and conducted asking questions, discussions and showed their previewing results in classrooms. After the course, we invited learners to fill in the Google online questionnaire of cognitive load. Then we used the SPSS19 software to conduct the reliability analysis of the questionnaire and ANOVA analysis to explore the impact of cognitive load for different age levels of learners. Finally, the results of the analysis are verified by the feedback of the open questions. Research process is shown in Figure 2.

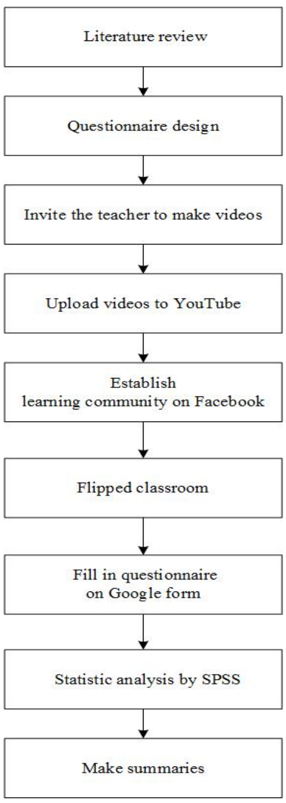

Figure 2. Research process.

3.2 *Experimental Flow*

This study divided the amateur erhu learners into three groups: young people, middle age people and old age people. The experimental duration was divided into four weeks of erhu flipped classroom teaching and one week of questionnaires at the end. The experimental flow is shown in Figure 3.

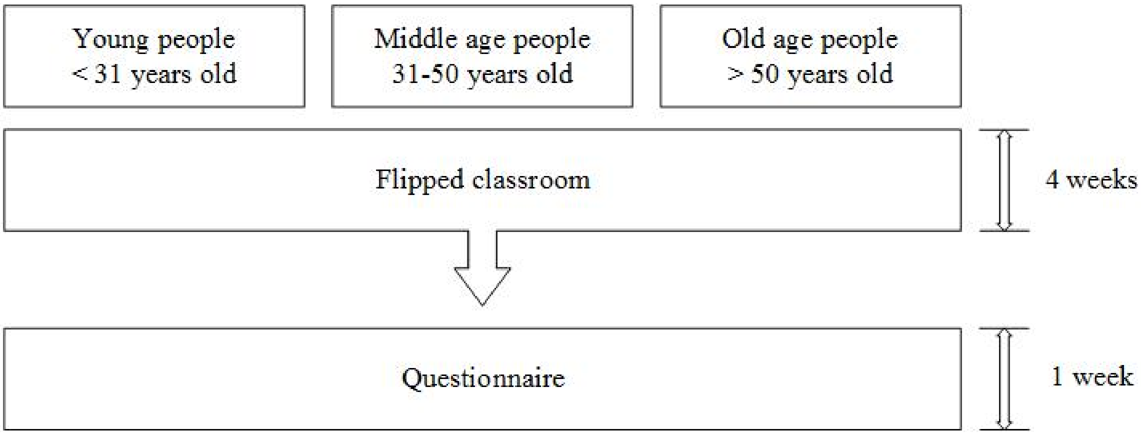

Figure 3. Experiment flow.

3.3 *Experimental Participants*

The participants of this study are 48 amateur erhu learners of a music classroom in the central region of Taiwan. There are only 34 valid samples who participate throughout. They include 7 young learners (less than 31 years old), 16 middle age learners (31 to 50 years old) and 11 old age learners (great than 50 years old).

3.4 *Experimental Tools*

The research tools of this study include pre-recorded videos before class, social websites, a cognitive load questionnaire and the SPSS statistical analysis software. Firstly, the teacher pre-recorded about 500 erhu teaching videos and uploaded the videos to YouTube video website. Then the learners can freely conduct the preview of the videos before class and discover the problem from the preview. The instructional video channel is shown in Figure 4.

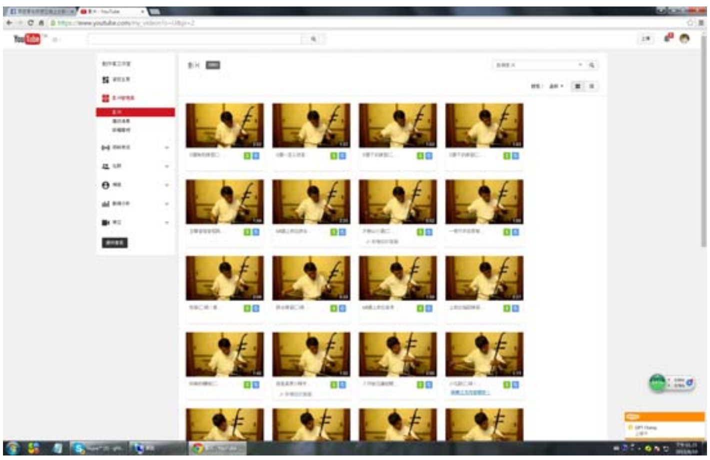

Figure 4. Instructional video channel.

Learners can ask questions and participate discusses in the learning community of social websites (Facebook) which is set up by teachers. Each class has the specific group in social websites as shown in Figure 5.

Figure 5. Social websites.

The cognitive load questionnaire mainly referred to the paper of (Hwang, Yang, & Wang, 2013). The questions of the questionnaire were divided into two categories: mental load (5 questions) and mental effort (2 questions), as shown in Table 1. The questionnaire was based on a 7-point Likert scale. After the reliability analysis, the Cronbach's Alpha values were all greater than 0.7. So, the effect of this questionnaire is well as shown in Table 2. In order to further understand the views of the learners, we also designed two open questions which are to let the learners describe the advantages and disadvantages of the teaching method.

Table 1: Questionnaire of mental load and mental effort.

Mental load
1. The music of erhu lessons is difficult to me.
2. I must spend a lot of effort and practice in order to learn the music well for the erhu lessons. It was so tired to practice the music of erhu lessons.
3. It was so tired to practice the music of erhu lessons.
4. It was so frustrated to practice the music of erhu lessons.
5. I don't have enough time to practice the music of erhu lessons.
Mental effort
1. The learning style of erhu lessons makes me have a lot of stress.
2. The learning style of erhu lessons makes me need to devote a lot of efforts in order to complete.

Table 2: Cronbach's α of mental load and mental effort.

	Cronbach's α
mental load	.761
mental effort	.771

4. Results and Discussions

In order to understand the cognitive load of learners, we conduct the cognitive load questionnaire investigation. The questions of the questionnaire include two parts: mental load and mental effort. Then, the questionnaire results are analyzed by ANOVA of SPSS. The results showed that the cognitive load of the middle age people is significantly higher than those of the young people and the old age people as shown in Table 3.

Table 3: Analysis of ANOVA of the cognitive load for young people, middle age people and old age people.

Age	N	Mean	SD	*F*	
(a) <31	7	3.40	1.04	3.99*	(b)>(a) (b)>(c)
(b) 31-50	16	4.68	1.01		
(c) >50	11	3.78	1.29		

*$p<.05$

In order to further confirm which part of the mental load or the mental effort is the main impact on cognitive load, this study continues to conduct ANOVA analysis on the two parts respectively. The results showed that there was no significant difference in mental load as shown in Table 4 while their mental effort was significantly different as shown in Table 5.

Table 4: Analysis of ANOVA of the mental load for young people, middle age people and old age people.

Age	N	Mean	SD	*F*
(a) <31	7	3.37	.96	3.23
(b) 31-50	16	4.51	.94	
(c) >50	11	3.93	1.17	

Table 5: Analysis of ANOVA of the mental effort for young people, middle age people and old age people.

Age	N	Mean	SD	*F*	
(a) <31	7	3.43	1.24	3.80*	(b)>(a) (b)>(c)
(b) 31-50	16	4.84	1.27		
(c) >50	11	3.64	1.57		

*$p<.05$

In order to explore why the mental effort of the 16 middle age learners is higher than those of the young learners and the old age learners, we analyzed the feedback of the open questions. The reasons are summarized as follows. For the 16 middle age learners, five learners (S11, S13, S14, S16, S20) did not understand the content of the videos somewhat in the process of autonomously previewing videos and can't judge whether their action of playing erhu is correct or not (A1). Three learners (S10, S12, S18) felt that the need to demonstrate in the classroom will be nervous (A2). Three learners (S9, S19, S21) thought that they must spend time before class to preview the videos in order to avoid to have a great lagged progress (A3). Two learners (S17, S23) thought that, to preview the videos and to play in the classroom, learners felt no real sense of teaching (A4). Two learners (S8, S15) thought that, to use flipped classroom teaching, it needed to use digital learning devices so that it is not convenient (A5). The feedback of open questions is shown in Table 6. The above reasons are the pressures due to the curriculum teaching mode. They are not the pressures due to the difficulty of the course itself. So, all the reasons belong to mental effort.

Table 6: The reasons of high mental effort of middle age learners.

Feedback of the open questions	Learners
A1: Not understand the content of the videos somewhat and whether the practice action is correct or not.	S11, S13, S14, S16, S20
A2: The need to demonstrate in the classroom will be nervous.	S10, S12, S18
A3: Time consuming.	S9, S19, S21
A4: To feel no real sense of teaching.	S17, S23
A5: Using the digital learning devices is not convenient.	S8, S15

5. Conclusions and Suggestions

This study recorded and uploaded teaching videos by the teacher. Then the teacher conducted flipped classroom teaching to let learners experience a new and different learning process. Finally, the questionnaire investigation of cognitive load was conducted. The results of this study showed that the middle age learners in using the flipped classroom teaching have a higher mental load than those of the young learners and the old age learners.

From the feedback of the open questions, the reasons are as follows. Most of the 16 middle age learners thought that this teaching method needed to spend time to preview at home. Although this method improved the disadvantage of the speed of knowledge internalization for every learners are different, but the cognitive load was increased. In addition, in the process of preview, if the contents of the videos did not be understood, the mistakes can't be immediately corrected. Also, in the classroom, it needed to play a demonstration so that the pressure was increased. This resulted in reducing the learning willingness. Regarding to the young learners and the old age learners, their pressures were significant lower than the middle age learners. The reasons may be that, in the flipped classroom, learners can repeatedly preview the videos and practice. It can increase the effect of knowledge internalization. For the middle age learners, because of working pressure, they were not willing to spend time to preview videos. Thereby, the pressure was created. For the young learners and the old age learners, they are students and the elders. They can effectively use the time after school and at home. They can arrange time appropriately to conduct the action of preview. The specific recommendations of this study are as follows:

- Young learners: This group of learners is the most suitable group for the use of flipped classroom mode of teaching. Because their ability of information and learning capacity could be better, they can make the best use of sparse time coolly to conduct video preview and erhu practice. Also, they can ask questions positively to specifically increase learning effectiveness and conduct knowledge internalization.

- Middle age learners: The learning cognitive load of this group is highest. The reason may be that they are going through the most important part of life and need to be worry about work and family. So, it is suggested that the progress of the flipped classroom teaching can be slightly slowed down to avoid excessive mental effort and learning pressure.
- Old age learners: This group of learners is also suitable for the use of the flipped classroom mode. They may be retirees and have more time to learn but their learning ability is not so strong than the young learners and the middle age learners. Therefore, it is suggested more previewing and practicing can deepen their impression. In addition, they can enjoy themselves by erhu so that they can memorize easily.

In the future, we will design flipped classroom activities of different levels to help learners more easily reach their goals. In addition, the relationship between classroom activities and learners will be analyzed. It is expected that deeper findings will be discovered.

Acknowledgements

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The Role of Social Presence in a Flipped Classroom to Facilitate Oral Skills of Language Learners

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Abstract: With the invention of new technologies, issues and studies concerning how the emerging technologies can be applied into educational settings to facilitate language teaching and learning have gained its prominence. While a plethora of studies have supported the application of technologies to language education, there has been little research into the effects of mobile-assisted language learning and flipped learning on EFL learners' oral proficiency. In view of this, the current study attempted to examine the impact of an online learning community in a flipped classroom, specifically via mobile platforms, on EFL learners' oral proficiency and their perceptions of the social as well as interpersonal communication in a flipped instruction. The subjects of this empirical study were 50 English-majored sophomores enrolled in two required oral training classes at a four-year comprehensive university in central Taiwan. Dual sources of data collection were used to analyze quantitative data, including pre- and post-tests on oral reading and comprehension questions, and a "Community of Inquiry" (CoI) questionnaire. The results revealed that the online learning community in a flipped instruction created a learning setting that not only supported social and interpersonal communication and collaboration but also significantly enhanced the participants' oral proficiency, making them more competent and motivated in highly interactive learning activities, such as online or in-class interaction, collaboration, and discussion.

Keywords: flipped learning, social presence, online learning community, oral proficiency

1. Introduction

With regard to language teaching and learning, English has become one of the primary languages in many fields, including academic discourse, business, technology, and international relations (Sun, Huang, & Liu, 2011; Wu, Sung, Huang, Yang, & Yang, 2011). While traditional EFL instruction has focused on vocabulary, grammar, and sentence structure, the mastery of oral ability holds the key to successful interaction in an international society, as language learning is all about learning to communicate and interact. However, the significance of speaking is not reflected at most of the instances in EFL settings, as reading and writing are highly emphasized than speaking and listening (Cheon, 2003; Tsou, 2005) and limited opportunities to speak English in non-English-speaking countries (such as Taiwan, South Korea, and Japan) remain prevalent.

Nevertheless, with technological advances that contribute to education transformation (Bishop & Verleger, 2013), technologies have become much more available and integrated into the field of language teaching and learning, with their distinctive features such as mobility, reachability, personalization, spontaneity, and ubiquity. Consequently, technology-enhanced language learning (TELL) and mobile-assisted language learning (MALL) has increasingly been the mainstream in recent years, as documented in Kiernan & Aizawa (2004). One of the alternative approaches that integrates technology into language learning and that contributes to ample opportunities for students to learn is the flipped learning (Hung, 2015; McLaughlin, Roth, Glatt, Gharkholonarehe, Davidson, Griffin, Esserman, & Mumper, 2014), where technologies (such as mobile devices) are employed to make efficient use of class time and students are given more opportunities to participate in meaningful engaging activities in an learning community, thus enhancing the learning outcomes.

In an online learning community, a learner constructs knowledge gradually as the result of interaction with the environment and with both internal and external influences (Zhang &Kou, 2012), meaning that learners develop strong relationships with others in the online setting (Murdock & Williams, 2011), where "active interaction is not listening and mirroring the correct realities, but rather participating in and interacting with the learning situation and environment in order to create a personal view of the world" (Janassen, Davidson, Collins, Campbell, & Haag, 1995, p. 20).

The flipped instruction shifts from teacher-centered lectures to student-centered learning. Instructors devote class time to creating engaging learning environments and students develop solutions via interaction with their peers, echoing the previous studies that students construct meaning and confirm knowledge in the presence of peers during online student discussions (Akyol & Garrison, 2011a, b). Online learning communities are successful and effective when "participants work in groups to solve authentic problems; participants have shared learning goals; knowledge is emergent and experts in the group are facilitators; group members operate at varying levels of mastery; there is a commitment on the part of group members to participation in the community" (Cowan, 2012, p. 12). As the educational field gradually moves toward the constructivist approach, student-centered learning, and technology-integrated pedagogy, traditional lecture-based instruction has been criticized for its sheer ignorance of leaners' active participation and its unidirectional installment of knowledge to learners.

However, there has been little investigation into English oral proficiency via MALL in an EFL setting. In light of the widespread social and educational use, what research evidences are there to indicate whether the integration of mobile technology into flipped learning can enhance students' oral proficiency? Furthermore, most online learning theories focus on the examination of structural issues rather than the probe into teaching and learning (Garrison, 2000), let alone an in-depth investigation into how social and interpersonal communication affected learning outcomes. To optimize the benefits and affordances of mobile technology and flipped learning, the current study aimed to examine the effects of an online learning community via LINE for flipped learning in an EFL oral training class.

2. Methods

2.1 Participants

The participants included 50 sophomore English-majors in two required English Oral Training classes at a four-year university in central Taiwan, mostly female and between the ages of 20 and 21. The participants had studied English for around 8 years through high school and their English proficiency was considered to be at the upper-intermediate level.

2.2 Data collection and analysis

Dual sources of data collection were employed to examine the participants' oral proficiency as the result of the online learning community and perceptions of the flipped learning experience, including (1) pre- and post-tests of oral reading and comprehension questions, and (2) Community of Inquiry survey. Figure 1 shows the issues and instruments involved in the current study, and Figure 2 displays the entire instructional and data collection process.

The pre-tests and the post-tests, respectively for the traditional instruction and the flipped learning instruction, were identical in content and the participants were asked to respond orally to paragraph reading and comprehension questions. The means of the pre- and post-tests were calculated to compare the instructional differences (i.e., flipped versus traditional). To assure higher inter-rater reliability, the current researchers adopted the *IELTS Assessment Criteria: Speaking* to evaluate against the participants' oral performance, focusing on (1) fluency and coherence, (2) lexical resource, (3) grammatical range and accuracy, and (4) pronunciation. Furthermore, a Paired-Samples *t*-Test was employed to investigate the participants' oral learning outcomes in two different instructions.

To compare the differences in social and interpersonal communication between the flipped learning and past lecture-based learning experiences, the social presence in the Community of Inquiry survey (Arbaugh, Cleveland-Innes, Diaz, Garrison, Ice, Richardson, & Swan, 2008) in the form of a 5-point Likert scale was employed.

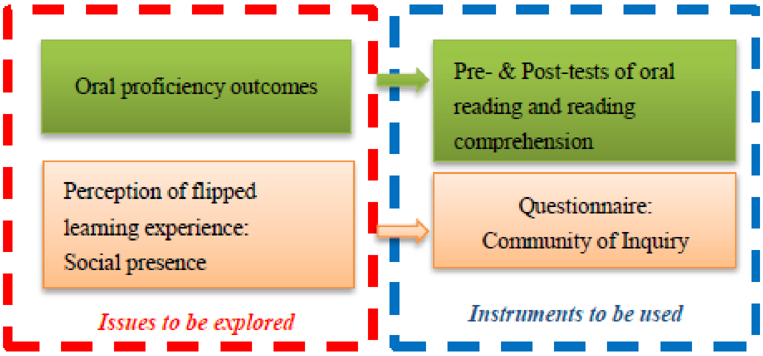

Figure 1. Issues and instruments involved in the current study.

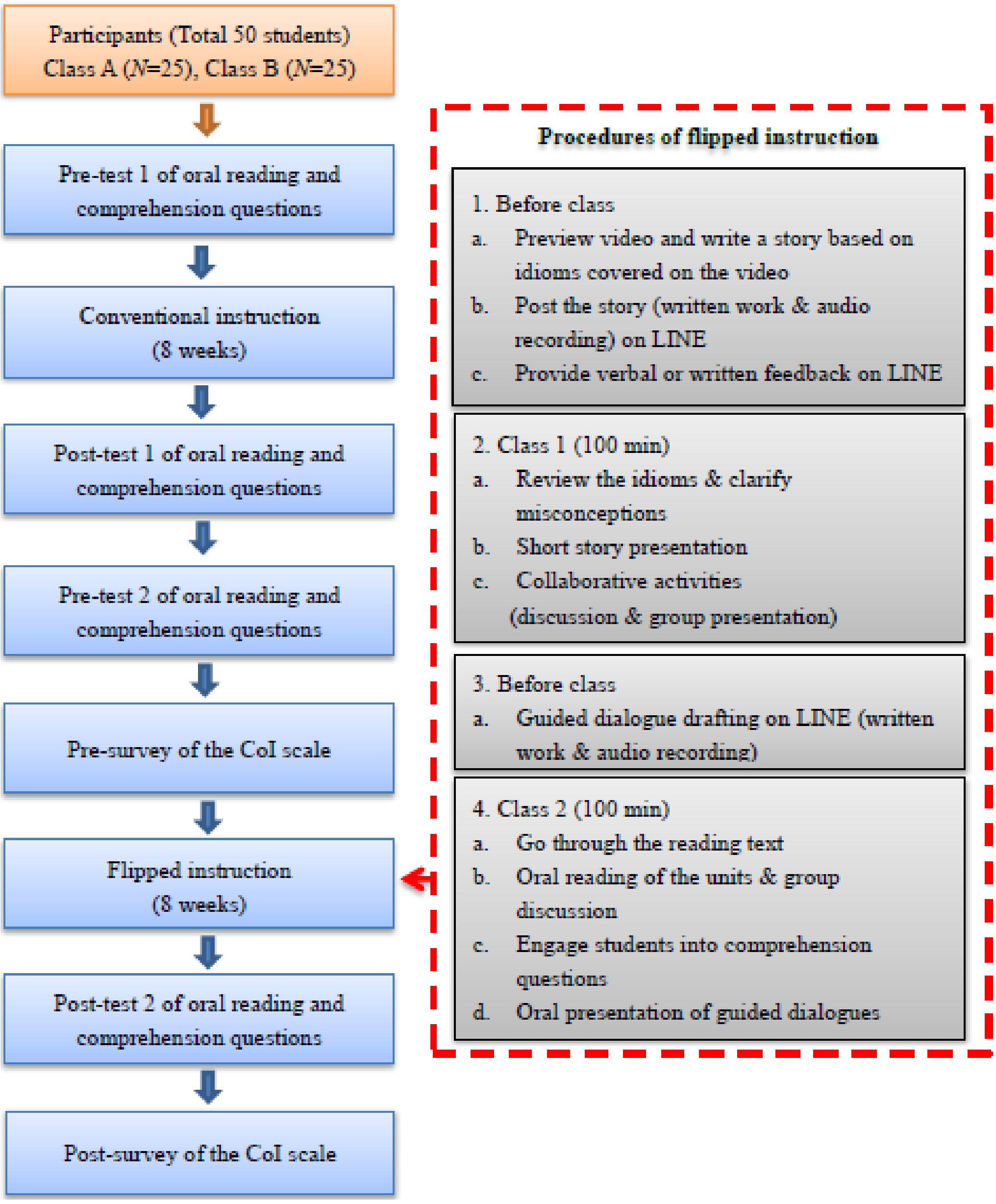

Figure 2. Procedures of the current study.

3. Results and Discussion

With respect to the evaluation of the participants' oral performance on the pre- and post-tests (i.e., oral reading and reading comprehension), the results revealed that that in both types of instruction, the mean score of the post-test was higher than that of the pre-test (see Table 1). In the post-test comparison, the mean score of the flipped learning (*M*=85.98) was much higher than that of the traditional instruction (*M*=66.6).

Table 1. Descriptive statistics of the pre-test and the post-test

Test	Instruction	N	Mean	SD	Min.	Max.
Pre-test	Flipped	50	69.94	5.80	59	83
	Traditional	50	59.29	5.98	48	74
Post-test	Flipped	50	85.98	5.58	75	95
	Traditional	50	66.6	5.92	55	82

Furthermore, in both forms of instruction, the participants performed significantly better on the post-test compared to the pre-test, and that the post-test of the flipped instruction was significantly higher than that of the traditional instruction, suggesting that the flipped instruction contributed to significantly better learning outcomes than the traditional lecture-based instruction. Such results were in line with the findings of previous studies that have shown the benefits of flipped instruction on students' learning outcomes (Hung, 2015; Strayer, 2012).

Table 2. Paired-Samples t-Test of the pre-test and the post-test

	Paired Differences							
				95% Confidence Interval of the Difference				
	Mean	SD	Std. Error Mean	Lower	Upper	*t*	df	Sig. (2-tailed)
Post (flipped) to Pre (flipped)	16.04	1.64	.24	15.57	16.52	67.901**	47	.000
Post (traditional) to Pre (traditional)	7.31	1.34	.20	6.92	7.70	37.826**	47	.000
Post (flipped) to Post (traditional)	19.38	1.32	.20	18.99	19.76	102.094**	47	.000

The results in Table 3 indicated that significant differences in the social presence were found between the flipped instruction and the traditional lecture-based instruction, as students expressed significantly positive perception of the flipped learning compared with past traditional learning, highlighting the supportive interactive context created in the flipped instruction for comfortable discussion and interaction. Therefore, the participants shared related experiences to reach a shared understanding in a collaborative learning context.

Table 3. Paired-Samples t-Test of the pre-survey and the post-survey of the social presence in CoI

	Paired Differences							
				95% Confidence Interval of the Difference				
	Mean	SD	Std. Error Mean	Lower	Upper	*t*	df	Sig. (2-tailed)
Post to Pre	.63	.55	.08	.46	.81	7.516**	49	.000

4. Conclusions

The results of the current study revealed that overall, the participants held positive perception of the flipped learning adopted in the current study. The participants benefited from the online learning community in a flipped instruction for it created a supportive learning setting that allowed for comfortable social and interpersonal communication and collaboration. Furthermore, such instructional design significantly improved the participants' oral proficiency, leading to higher competence in interactive and collaborative learning activities, such as online or in-class interaction and discussion.

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A Study of GS-Based "Factor" Collaborative Learning in a Primary School

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Abstract: This paper reports the design of a GS-supported collaborative learning environment to empower fifth graders students' conceptual learning in the primary mathematic classroom. The investigation of the effectiveness of the learning design through evaluating students' learning gains. The result indicated that the proposed design could help enhancing students' factor learning experiences. By analyzing the feedback questionnaires and interviews, finding that CSCL could promote the peers to interact positively, rely on and help with each other, and could elevate the pupils' motivation and interests in learning. Suggestions were made at the end of this paper based on the results of this research providing for reference to further studies and practice teaching.

Key Words: CSCL, Factor, Group Scribbles

1. Introduction

In mathematics learning at the primary level, developing the concept of factor in students is an important goal. Conceptual learning often poses difficulty to primary school students as it requires substantial abstract thinking. As shown in previous studies, that students hold misconceptions of factor is common occurrence (Zazkis, 1999; Shih, 2007). To address this problem, educators and researchers are making efforts to identify effective instructional designs and teaching strategies that can enhance conceptual change.

From the constructivist perspective of learning, conceptual change is triggered by cognitive conflicts that arise when existing concepts are not sufficient to explain the perceived experience (Ferrari & Elik, 2003). Processing cognitive conflicts is an indispensable step to conceptual change (Posner & Gertzog, 1982; Posner, et al., 1982). Among all the instructional approaches proposed and practiced, collaborative learning has proved effective in encouraging cognitive conflicts and empowering the resolution of these conflicts through group discussions (Putnam, 1986, Dong & Guo, 1992, Robbins, 1996, Tedesco & Self, 2000). Apart from improving learning gains and the retention of the learning gains, student collaboration is also found beneficial to enhancing motivations, learning attitudes, self-efficacy, collaboration skills, and social skills in students. Students can also develop better problem solving, knowledge integration and application skills in these processes (Brown 2001; Johnson, Johnson, & Stanne, 2000; Slavin, 1995; 1999).

To better support and sustain student collaborations, Internet and Information Technologies (ICTs) are increasingly introduced to traditional classrooms. However, incorporating the technology alone is inadequate to improve student learning experiences. From past endeavors made in designing collaborative technology-enhanced learning environments, the importance of embedding suitable activity design to foster expected cognitive activities and social interactions is acknowledged (Lin , et al., 2014). To improve the conceptual leaning of factor in primary education, in our school-based research in Taiwan, we have designed a collaborative learning environment which is specifically tailored for conceptual learning integrating collaborative learning strategies and concept teaching strategies established in literature. This study investigates the effectiveness of this collaborative learning design by examining students' learning gains, perceptions and behaviors.

2. Research Background and Goals

In this school-based research project, we integrated Group Scribbles (GS), a networked technology co-designed and developed by SRI International and Learning Sciences Laboratory to enhance student conceptual learning in primary mathematics classrooms. Based on a metaphor of whiteboard and sticky notes for collective construction of knowledge (Roschelle, et al., 2007), GS is conceived as a flexible platform for designing and enacting different forms of collaborative work via synchronous communication and interaction (Looi, et al., 2011; Chen, et al., 2012). In various classroom settings (including science and mathematics learning and language learning both at primary and secondary levels in Singapore), GS-supported collaborative learning has all proved effective in improving student learning gains, attitudes, and epistemology (Chen & Looi, 2011; Chen, Looi, & Tan, 2010; Lin , et al., 2014). Encouraged by these "successful" practices in authentic classrooms, we hoped GS could help transform traditional teacher-centered instruction to student-initiated exploration in Taiwan primary schools.

To bring collaborative learning into fruition, certain structuring or script should be embedded in the learning design to scaffold students' cognitive activities and social interactions. As factor learning has been the bottleneck for primary mathematics learning for long, various strategies for lesson design and enactment have been proposed and practiced to alleviate students' misconceptions (Zazkis & Campbell, 1996; Lin, 2002; Huang & Liu, 2002; Pape, 2004; Dias, 2005; Hsieh & Lin, 2006; Ke, 2007; Camli & Bintas, 2009). Reviewing existing literature, seven strategies, including: 1) reviewing and activating prior knowledge; 2) engaging contextualized and situated learning materials and experiences; 3) integrating hands-on experience, gaming, and multimodal representations; 4) providing timely explanations to and elaborations on word-problems (sometimes students have difficulty understanding word-problems due to deficient language proficiency); 5) providing diversified learning and practicing materials; 6) highlighting operation and verification in learning and practicing; 7) encouraging student questioning (to enable diagnostic assessment), were identified. We translated these seven strategies to the present design to promote conceptual learning. To ensure that students really learn collaboratively, that is to say there indeed is positive interdependence, individual accountability, equal and successful learning opportunity, and group processing in group collaborative work (Arends, 2004; Davidson & Worsham, 1992; Slavin, 1990a; Slavin, 1995), Students Team Achievement Division (STAD) was employed in the learning activity design. This collaborative strategy, highlighting heterogeneous grouping, class-level teaching, team study, individual testing, group recognition and rewarding, has been widely applied and proved effective in addressing well-structured problems.

3. Research Design

3.1 Participants

A fifth-grade class consisted of 27 students (14 boys and 13 girls) from a local primary school in Northern Taiwan participated in this study. The students were distributed into small groups of 3 to complete collaborative learning tasks. In grouping, heterogeneity in terms of student mathematics ability and gender was pursued. We first categorized students into High ability, Medium ability and Low ability groups based on their scores in the school mathematics test administered before the intervention. Then we randomly selected one student from each category to form a group. Altogether, 9 heterogeneous groups were composed. During intervention, the researcher shouldered the role as the teacher to ensure proper delivery of the lesson (the lesson was designed by the researcher). Being comfortable and competent in teaching with the collaborative technology (GS 2.0) and having rich experience in teaching mathematics in primary schools, the researcher was fully capable of instructing the lesson.

3.2 GS-supported collaboration

In this learning design, student collaboration was supported by both F2F communication and GS-based interaction. In GS lessons, students each were provided with a laptop with GS 2.0 installation. To encourage F2F interaction, students were seated in close physical distance. GS 2.0 user interface presents a two-paned window. The lower-pane is the private working space, the "private board" and the upper-pane is the shared working space, the "public board" (Figure 1). Users generate virtual pads of "scribbles" on the private board to draw, write and type in their ideas. All the actions enacted and all the contents displayed on "private board" are invisible to others. Scribbles crafted are shared and made public as users drag them onto the public board which is synchronized among all learning devices.

Scribbles on public board could be moved, deleted, and withdrawn to private boards for further revision. Users can select the group board that they want to visit and review by clicking the bottom on the right corner of the interface. The most striking feature of the GS technology is its synergy of autonomous cognition (on private board) and collaborative cognition (on public board). It also supports seamless switch between individual, intra-group, inter-group, and class level interaction. GS is highly customized as users can upload pictures, texts, movie clips and audios on the public board to scaffold teaching and learning. In this study, factor problems to be solved were presented in this area. Before participating in the GS lessons, all the students had undergone one session (40 minutes) of GS technical training during which they gained mastery in using the technology and developed familiarity with their group mates.

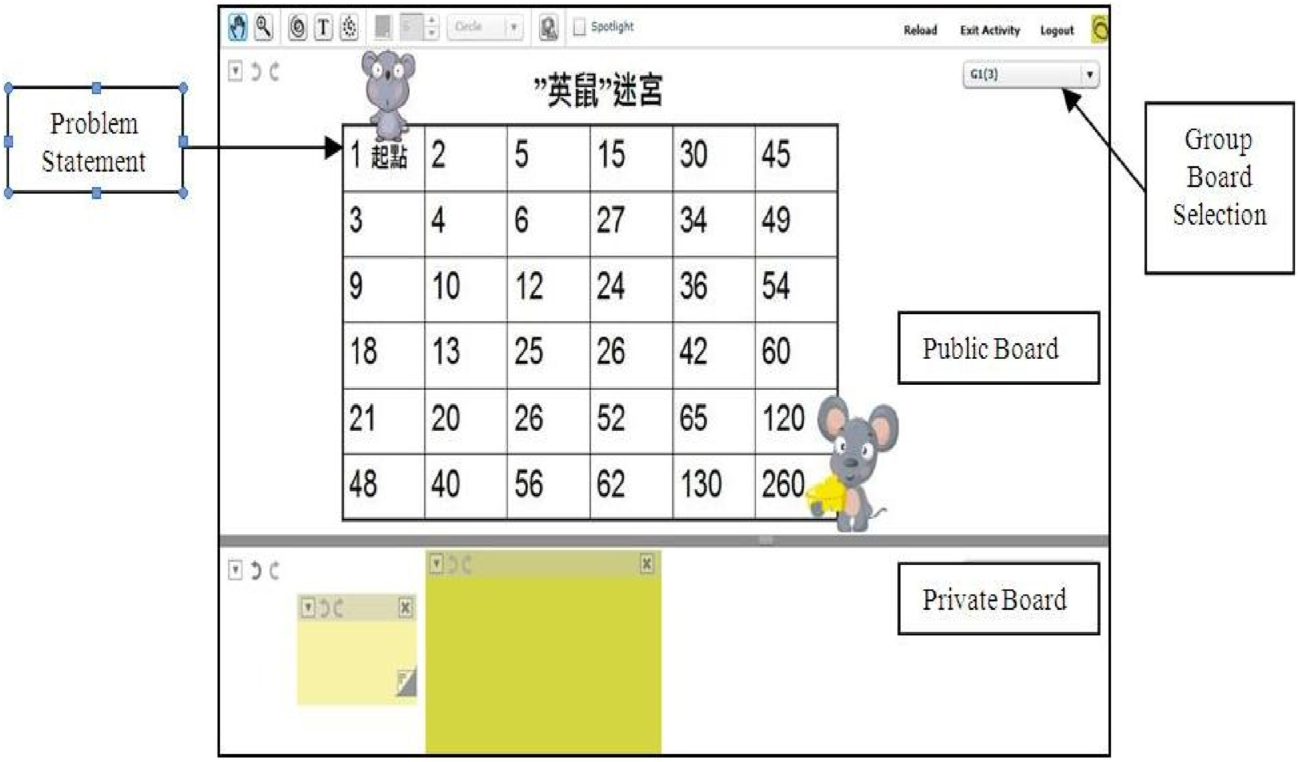

Figure 1. GS interface

3.3 Collaborative learning activity design

As aforementioned, in collaborative learning activity design, both concept instruction strategies and a collaborative strategy (STAD) were incorporated. The lesson designed was altogether 80-minute long involving three main learning activities. At the beginning of the lesson, the instructor spent 5mins introducing students the learning tasks, after which students engaged in a 15-minute reviewing activity, a 40-minute concept learning activity and a 20-minute concept application activity (see Table 1 for the detailed lesson plan) during which they gradually developed the concept of factor. The reviewing activity aimed at activating students' prior knowledge on operations (multiplication and division) that serves as a prerequisite for developing the concept of factor. In the concept learning activity, the main learning stage, two contextualized and situated problems were presented and solved via group work. In this process, students gained initial understanding of the factor concept via self-initiated exploration and collective cognition. Based on these initial ideas, the teacher further explained, elaborated and extended the concept. In the concept application activity, a game-based problem was incorporated to encourage student applying the developed concept to address real-world problems. The incorporation of gaming element could also enhance student learning motivation and interest.

Table 1: GS lesson design

Activity Flow	Instructional strategies
1. Task introduction (5 mins): Teacher provided general explanations on task requirements (finishing the problems presented via group work) and group rewarding.	
2. Reviewing activity (15 mins): Teacher explained the task requirement Students worked in small groups to solve two operation problems Class discussion Group rewarding	✓ Reviewing and activating prior knowledge ✓ Providing timely explanation to and elaboration on word-problems ✓ Highlighting operations and verification in learning and practicing
3. Concept learning activity (40 mins): Teacher explained the task requirement Students worked in small groups to solve two word-problems & verify the solutions Group working sharing Teacher summarized and commented on students' group work Teacher explained, elaborated and extended the factor of concept Group rewarding	✓ Engaging contextualized and situated learning materials and experiences ✓ Integrating hands-on experiences ✓ Encouraging student questioning
4. Concept application activity (20 mins): Teacher explained the task requirement Students worked in small groups to solve a game-based problem Group work sharing Class discussion & rewarding	✓ Engaging gaming ✓ Providing diversified learning and teaching materials

4. Data Analysis & Results

To assess student conceptual learning gains, Paired-Sample T test was conducted to see whether there was significant progress in student scores in the factor test after the GS lesson. Data analysis results proved students learning gains. Student scores in the post test were much higher than those obtained in the pretest ($t=-5.466$, $p< .01$) (Table 2). Moreover, the differences between students were narrowed after the GS lesson as the Standard Deviation decreased from 21.40 in the pretest to 11.98 in the post test. In the following, Paired-Sample T test was administered again to examine the retention of these learning gains. It was noticed that there was no significant difference between student post test scores and delayed test scores, though the delayed posttest was carried out one month after the post test ($t=1.700$, $p>.01$) (Table 3). From these statistical analysis results, the effectiveness of the proposed learning design in helping students learn mathematics concepts has been confirmed.

Table 2 :The Paired-Sample T test results (pretest vs posttest)

Variable	No. of students	Mean	Standard deviation	t	Significance
Pretest	27	68.85	21.40	-5.466	.000***
Posttest		86.99	11.98		

***p＜.0001

Table 3: The Paired-Sample T test results (posttest vs delayed test)

Variable	No. of students	Mean	Standard deviation	t	Significance
Post test	27	86.99	11.98	1.700	.101
Delayed post test		83.48	17.44		

To identify what types of students may benefit and benefit most from this learning design, we analyzed the effect of student mathematics ability on their achieved learning gains. Paired-Sample T test affirmed that, all the three categories of students-- Low ability students (t=-.4555, p< .01), Medium ability students (t=-3.531, p< .01) and High ability students (t=-2.384, p< .05) improved significantly in the post-test (Table 4 ~ Table 6). This further validated the benefits of our learning design to all the students in terms empowering learning.

Table 4: Paired-Sample T test (pretest vs posttest): Low ability students

Variable	No. of students	Mean	Standard deviation	t	Significance
Post test	9	45.013	13.453	-4.555	.002**
Post test		75.213	11.538		

** p＜.01

Table 5: Paired-Sample T test results (pretest vs posttest): Medium ability students

Variable	No. of students	Mean	Standard deviation	t	Significance
Post test	9	75.214	13.927	-3.531	.008**
Post test		91.168	6.918		

** p＜.01

Table 6: Paired-Sample T test results (pretest vs posttest): High ability students

Variable	No. of students	Mean	Standard deviation	t	Significance
Post test	9	86.326	9.245	-2.384	.044*
Post test		94.588	6.715		

* p＜.05

Further analysis was performed to find out what type of students might benefit most from this learning design. In practice, we ran an ANCOVA test (using student pretest scores as the covariant) to compare the performances of students of different mathematics ability in the post test. The assumptions of the analysis were met as the homogeneity of regression coefficients was achieved (F= .748, p> .05) (Table 5). The ANCOVA result showed that three types of students did performed significantly different in the post test (F= .232, p < .05) (Table 7). Post hoc test (LSD) found that there was no significant difference in post test scores between students of High ability and those of Medium ability (p> .05). However, students of Low ability performed strikingly different from those of High ability (p< .05) and Medium ability (p< .05) (Table 8). This result suggested that it was the Low ability students that improved most in this type of conceptual learning. This was probably the reason why the standard deviation was small in the post test compared to the pretest.

Table 7: ANCOVA test results

Source	Type III sum of squares	df	Mean Square	F	Sig.
Student Mathematics ability * Pretest score	120.237	2	60.119	.748	.486
Error	1688.386	21	80.399		

Source	Type III sum of squares	df	Mean Square	F	Sig.
Student Mathematics ability	610.383	2	305.192	3.881	.035*
Error	1808.623	23	78.636		

p< .05

Table 8: LSD test results

Student Mathematics ability	Average difference	Standard error	Sig.
High ability * Medium ability	3.432	4.484	.452
Low ability * High ability	-19.420	7.342	.014*
Low ability * Medium ability	-15.988	6.078	.015*

$p < .05$

5. Conclusion

This paper reports the design of a GS-supported collaborative learning environment to empower students' conceptual learning in the primary mathematic classroom and the investigation of the effectiveness of the learning design through evaluating students' learning gains. Through analyzing both "product" and "process", "objective" and "subjective" data, we were pleased to find that the proposed design could help enhancing student learning experiences.

In examining students' learning gains, a pretest-posttest-delayed posttest design was employed. In analyzing student test scores in a self-designed and validated factor test after the intervention, significant progress was noticed and successfully preserved as indicated in the delayed posttest. Moreover, further analysis showed that the proposed design has a general positive effect on all the students. Students, regardless of their mathematics ability, all gained better scores in the post test after the GS lesson. And it was the Low ability ones who improved most. In addition, the investigation of students' attitudes data also confirmed that this learning design could empower their learning. In accordance with the appeal to shift the focus from analyzing learning outcomes to learning processes analysis in CSCL research, the examination of student learning behaviors was also performed to further legitimize the design. Fine-grained analysis showed that students mostly demonstrated positive interactional behaviors in their group work. Individual cognition and teacher-student interaction was scarce.

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The Evaluation of Interface Elements and Game Elements in Serious Games: A Peer Assessment Approach

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Abstract: Previous studies indicated that game elements may make players have joyful experience but some research indicated that players' learning performance may not be as good as what was expected. This might be due to the fact that poor user interface presented in serious games hindered students' learning performance. Therefore, designers should not only consider game elements, but also take into account interface elements. However, there is a lack of such studies that pay attention to both game elements and interface elements when developing serious games. To this end, this study aims to investigate how interface elements and game elements are considered in the design of serious games. A peer assessment approach is applied to achieve this aim. The results from the peer assessment indicated that designers generally tended to focus on game elements and paid less attention to interface elements. Furthermore, all game elements were similarly considered but interface elements were not equally treated. In particular, designers seemed to ignore the importance of error prevention and recovery from errors.

Keywords: Serious Game, User Interface, Game Elements, Nielsen Heuristics

1. Introduction

Over the past decades, digital games have become very popular. Among various types of games, serious games are widely accepted as effective learning tools, which can be applied for inquiry, multitasking, collaboration, creativity problem-solving, and decision-making (David and Watson, 2010, Gee, 2003). This may be due to the fact that serious games provide a joyful environment, which contains multiple game elements, including storyline, game play, artistic/graphics, and sound/special effects, AI. The significance of these game elements is described in Table 1.

Table 1: Game Elements

Game Elements	Significance
Storyline	To facilitate players to develop a quick understanding of unexplored virtual worlds (Park, 2010; Busselle and Bilandzic, 2008)
Gameplay	To use rules to ensure that all players take same paths and make them feel excited about playing the game (Prensky, 2001).
Artistic/Graphic	To improve display characteristics to attract players (Prensky, 2001)
Sound/special effects,	To affect players' task performance and stress response (Hébert et al., 2005; North and Hargreaves, 1999)
AI	To provide players with feedback so that they can know their current status (Dobrev, 2012)

The game elements presented in Table 1 may make players have joyful experience but players' learning performance may not be as good as what we expected. For instance, Schrader and Bastiaens (2012) indicated that some serious games decreased students' learning performance. This might be due to the fact that user interface is not properly presented in the serious games so that some learners may need to spend additional time learning how to play these serious games. In other words, only taking into account game elements is not sufficient and there is also a need to consider usability guidelines.

Usability is widely used in system design and the aim of usability refers to making systems easier to use, pleasant to use, and matching them more closely to users' requirements (Nielsen, 1994). A number of usability guidelines can be applied to evaluate usability (e.g., Shneiderman's Eight Golden Rules of Interface Design, Norman's Design Principles and Nielsen's Heuristics). Among these usability guidelines, Nielsen's heuristics (Table 2) were first formally described in presentations in the Human–Computer Interaction conference through papers published by Nielson and Molich (1990). Since then, they have refined the heuristics based on a factor analysis of 249 usability problems to derive a revised set of heuristics with maximum explanatory power. Such heuristics are most commonly used because they can be used effectively by novices and experts alike and can be performed at any stages of the development lifecycle (Nielsen, 1994). In particular, recent studies attempted to incorporate Nielsen's heuristics into the interface design of serious games. For example, Hsieh, Su, Chen and Chen (2015) took a user-centered design approach to develop a Robot-based Learning Companion based on Nielsen's heuristics. Additionally, Mei, Ku and Chen (2015) used Nielsen's heuristics to develop problem-solving games that can accommodate learners' gaming experience.

The aforementioned studies suggested that incorporating Nielsen's heuristics into the interface design of serious games is feasible. Therefore, designers should not only consider game elements, but also take into account interface elements. However, there is a lack of such studies that pay attention to both game elements and interface elements when developing digital games, especially serious games. To this end, the study presented in this paper aims to investigate how interface elements and game elements are considered in the design of serious games. A peer assessment approach is applied to investigate game elements and interface elements provided by serious games and relationships between game elements and interface elements are also examined in this study.

Table 2: Nielsen's ten heuristics (1994)

Heuristics	Explanations
H1: Visibility of system status	The system should always keep user informed about what is going on by providing appropriate feedback within reasonable time
H2: Match between system and the real world	The system should speak the user's language, with words, phrases and concepts familiar to the user, rather than system-oriented terms. Follow real-world conventions, making information appear in a natural and logical order
H3: User control and freedom	Users should be free to develop their own strategies, select and sequence tasks, and undo and redo activities that they have done, rather than having the system do these for them
H4: Consistency and standards	Users should not have to wonder whether different words, situations, or actions mean the same thing and the system should follow platform conventions
H5: Error prevention	Even better than good error messages is a careful design, which prevents a problem from occurring in the first place
H6: Recognition rather than recall	Make objects, actions, and options visible. The users should not have to remember information from one part of the dialogue to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate
H7: Flexibility and efficiency of use	Allow users to tailor frequent actions. Provide alternative means of access and operation for users who differ from the ''average'' user (e.g., physical or cognitive ability, culture, language, etc.)
H8: Aesthetic and minimalist design	Dialogues should not contain information that is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility

H9: Help users recognize, diagnose and recover from errors	Error messages should precisely indicate the problem and constructively suggest a solution. They should be expressed in plain language
H10: Help and documentation	Even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation. Any such information should be easy to search, focused on the user's task, list concrete steps to be carried out, and not be too large

2. Methodology

2.1.1 Participants

A total of 41 individuals participated in this study. Participants were students from the some universities in Taiwan, aged between 22 and 25 years old, and they volunteered to take part in the study. These participants were randomly assigned into seven groups, each of which included five or six individuals. A request was issued to learners in lectures, and further by email, making clear the nature of our study and their participation. All participants had sufficient computing skills to act as designers to design serious games in this study.

2.1.2 Experimental Procedure

During the experiment, each group was requested to design a serious game with the Game Maker, which was chosen because it has been used as a rapid development tool in several studies (e.g., Moreno-Ger et al., 2007). Moreover, the Game Maker takes an object-oriented and event-driven approach (Overmars, 2004) so it may be easy to use for most designers. The experimental procedure was divided into two steps: (1) preliminary training and (2) peer assessment (Figure 1). The details are described below.

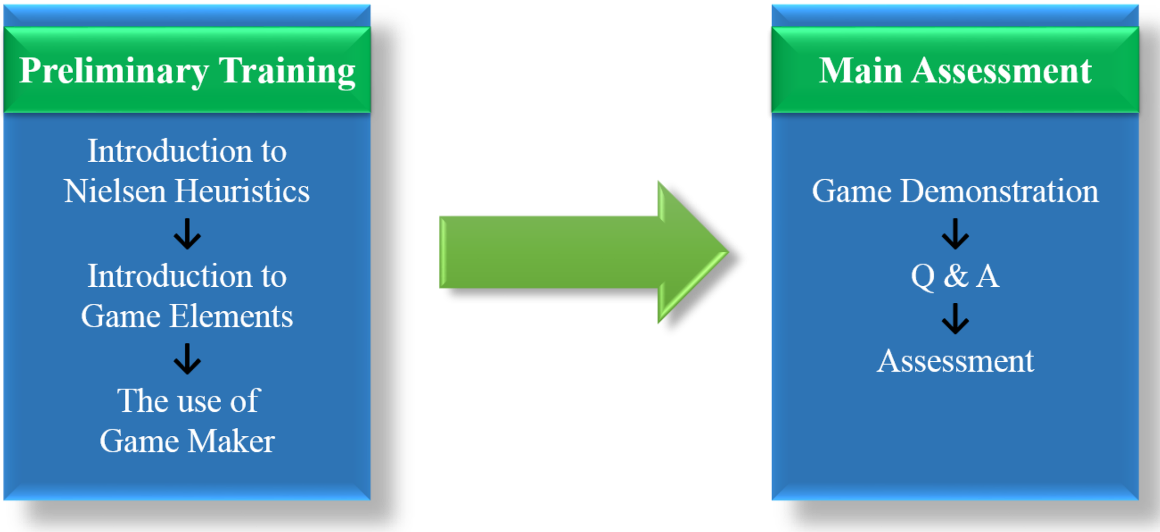

Figure 1. The experimental procedure

2.1.3 Preliminary Training

In order to ensure that every participant has proper domain knowledge, the participants were provided with preliminary training sessions, which covered three topics. Table 3 describes the details of each topic. Regardless of the topics, the participants needed to do some exercises in the end of each session so that they could review what they had learnt in each session.

Table 3: The preliminary training procedure

Topics	Learning Objectives	Length
Introduction to Nielsen's heuristics	The participants should have a basic understanding of how to use Nielsen's heuristics to assess usability	Three 60-minute sessions
The Design of Game Elements	The participants should develop skills of how to incorporate various game elements	Two 60-minute sessions
The Use of the Game Maker	The participants needed to know how to use tools and logics provided by the Game Maker	Nine 60-minute sessions

2.1.4 Peer Assessment

The assessment covered two parts. One was related to game elements while the other was concerned with user interface. During the peer assessment, each group was required to demonstrate serious games developed by them in front of remaining six groups. Additionally, they needed to present how they incorporated the game elements and interface elements into their serious games. Such demonstration and presentation took 20 minutes or so. Finally, there was a five-minute Q&A session, where the participants needed to answer questions raised by the other groups.

After listening to the demonstration and presentation and the answers to the questions, the other groups started to make assessment. More specifically, the other groups needed to fill out a mark sheet for each group. The first part of the mark sheet included five items, which were committed to assess whether the the game elements were properly implemented, i.e., G1: Storyline, G2: Game Play, G3: Artistic/Graphics, G4: Sound/Special effects, G5: Artificial Intelligence. The second part included 10 items, which were committed to evaluate whether user interface was properly designed based on Nielsen's ten heuristics. To facilitate assessment, detailed criteria were produced according to each item. Finally, the first part contained 18 criteria while the second part included 31 criteria. Irrespective of the number of criteria in each part, 20 points were assigned to each item in the first part while 10 points were given to each item in the second part. By doing so, the perfect score of each part is 100. Additionally, the higher the score was given, the more the design matches with the criteria, and vice versa.

2.1.5 Data Analysis

In this study, the independent variables are interface elements and game elements and the dependent variables are the scores obtained from each interface element and each game element. An independent t test was applied to identify differences between interface elements and game elements. Furthermore, an ANalysis Of VAriance (ANOVA), suitable to test the significant differences of three or more categories (Stephen & Hornby, 1997), was applied to analyze differences among interface elements and among game elements. By doing so, the interface elements and game elements that designers paid the most attention and those that designers paid the least attention could be identified. Additionally, Pearson's correlations were also applied to analyze relationships between the scores from game elements and those from interface elements so that the associations between these two types of elements could also be discovered.

3. Results and Discussion

Table 4 describes the mean values and standard deviations of the scores from game elements and those from interface elements. We further used an independent t test to analyze their significant difference. The results indicated that a significant difference ($t(40)=2.421$, $p<.05$) existed between the scores from game elements (Mean = 71.81, SD=17.73) and those from interface elements (Mean = 60.14, SD=13.17). In other words, designers tended to pay more attention to game elements than interface elements when they developed serious games. We further analyze how each game element (Section 3.1) and each interface element (Section 3.2) were implemented in serious games and how game elements are associated with interface elements (Section 3.3).

Table 4: The mean and standard deviation of game and interface

	Game Elements	Interface Elements
Mean	71.81	60.14
SD	17.73	13.17
Significance	t(40) = -2.421*	

Keys: * $p < .05$, ** $p < .01$

3.1 The evaluation of game elements

The results from the ANOVA indicated that no significant differences exist among scores obtained from each game element ($F(4)=.38$, $p>.05$). This finding suggested that all game elements were almost equally taken into account when designers developed their serious games (Mean = 14.36, SD=0.89). This might be due to the fact that serious games became very popular in recent years (Johnson, Vilhjálmsson, and Marsella, 2005). Accordingly, designers could have a clear understanding of all game elements so that most of them could effectively integrate these elements into the design of serious games.

Even though there was no significant difference, we still found some interesting results (Table 5). More specifically, the highest score and the lowest standard deviation (Mean=15.59, SD=2.10) were found in G2 while the lowest score and the highest standard deviation (Mean=13.46, SD=6.48) were demonstrated in G4. In other words, most of designers paid attention to G2, which refers to Gameplay, including game rules and the compatibility of the game. This finding revealed that most of the designers considered Gameplay as an important factor in the design of serious games. On the other hand, not all of designers were concerned with G4, which refers to Sound/Special effects. This finding implied that not all of designers thought that Sound/Special effects were essential for the design of serious games. In particular, one group totally ignored the Sound and Special effects and obtained zero score for this game element. In other words, designers had diverse views towards the Sound and Special effects presented in serious games.

Table 5: The score from each game element

	G1	G2	G3	G4	G5
Mean	14.76	15.59	14.44	13.46	13.56
SD	3.25	2.10	2.98	6.48	2.70

3.2 The Assessment of Interface elements

One difference between the game elements and interface elements is that a similar level of attention was paid to the former while different levels of attention were given to the latter. More specifically, the results from the ANOVA indicated that there was a significant difference among scores obtained from each interface element ($F(9)=10.63$, $p=.000$). The results from the post-hoc analyses indicated that the scores from H5 and H9 were significantly lower than those from H2, H3, H4, H6, H7, and H8. In other words, designers paid more attention to H2 (match between system and the real world), H3 (user control and freedom), H4 (consistency and standards), H6 (recognition rather than recall), H7 (flexibility and efficiency of use), and H8 (aesthetic and minimalist design), among which H4 received the most attention. Conversely, they ignored H5 (Error prevention) and H9 (Help users recognize, diagnose, and recover from errors) and H 9 was received the least attention.

The other difference lied within the fact that the score of each interface element was low (Mean = 6.01, SD=1.65). In particular, the scores given for H5 and H9 were lower than the mean value (Table 6). Additionally, high SDs existed in these two interface elements. These findings suggested that designers not only tended to ignore H5 and H9, but had diverse opinions for the assessment of these two interface elements. This might be because H5 and H9 are concerned with the reduction of errors that users may make. However, such errors need to be identified by field works. The lack of evidence from the field works may make designers have difficulties in knowing errors that users may make and helping them recover from such errors. This might be the reason why these two interface elements were ignored by the designers.

Table 6: The score from each interface element

	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10
Mean	6.17	7.11	7.16	7.96	3.69	7.12	6.88	7.35	3.13	4.22
SD	1.09	0.81	1.58	0.98	1.95	1.34	1.14	1.25	1.03	1.91

3.3 Game VS. Interface

Pearson correlations were applied to analyze relationships between each game element and interface element (Table 7). As shown in Table 7, positive relationships existed between H4 and G1 ($r=0.80$, $p<0.05$), between H7 and G2 ($r=0.78$, $p<0.05$), and between H8 and G3 ($r=0.76$, $p<0.05$). The positive relationship between H4 (Consistency and standards) and G1 (Storyline) suggest that user interface designed in a consistent way can make players immerse in the storyline of the serious game. This might be owing to the fact that the coherence of the storyline of a serious game could be clearly and easily demonstrated in consistent user interface. Accordingly, such coherence could increase the immersions of the players.

Table 7: Pearson correlation between game and interface

r	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10
G1	.42	.60	.11	**.80***	.34	.20	.69	.35	.14	.04
G2	.21	.29	.65	.63	.73	.58	**.78***	.63	.09	-.02
G3	-.04	-.23	.60	.63	.41	.29	.69	**.76***	-.07	-.42
G4	-.01	.01	-.01	.71	.27	-.10	.71	.34	.07	-.16
G5	-.13	-.08	.34	.73	.42	.10	.74	.57	.10	-.30

Keys: * $p < .05$, ** $p < .01$

Regarding the relationship between H7 (Flexibility and efficiency of use) and G2 (Game Play), the former refers to flexible manipulation and efficiency of use while the latter refers to the experience of players reaching the game's objectives (Papaloukas, Patriarcheas and Xenos, 2011). Therefore, this finding suggested that players could smoothly pursue the game's objectives when they were allowed to play the game in more efficient and flexible way. Regarding the relationships between H8 (Aesthetic and minimalist design) and G3 (Artistic/Graphics), both elements are concerned with the prettiness of user interface. This may be the reason why a positive relationship existed between these two elements. In other words, they were related to each other.

In summary, the interface design of serious games is closely associated with the entertainment of serious games. Therefore, designers may need to take into account both game elements and interface elements to improve players' gaming experience.

4. Conclusions

This study used a peer assessment approach to investigate how designers perceived the importance of interface elements and game elements in the design of serious games. Figure 2 summarizes the findings of this study. As shown in Figure 2, the results of this study indicated that designers generally tended to focus on game elements and paid less attention to interface elements. Furthermore, each game element was similarly considered though G2 (Game Play) was paid the most attention. On the other hand, each interface element was not equally treated. More specifically, designers were more concerned with H2 (Match between System and the Real World), H3 (User Control and Freedom), H4 (Consistency and

Standards), H6 (Recognition rather than Recall), H7 (Flexibility and Efficiency of use), and H8 (Aesthetic and Minimalist design). However, they seemed to take less notice of H5 (Error Prevention) and H9 (Help users Recognize, Diagnose and Recover from errors). In other words, they might ignore the importance of error prevention and recovery from error. These findings implied that future works should examine how to help designers develop a deep understanding of the importance of interface elements so that they could know how to design usable user interface for serious games. The ultimate goal is that players are able to know how to initiate serious games effectively so that their learning performance can be enhanced. In spite of the fact that the findings from this study provide the aforementioned guidance, this is an exploratory study, which included a small sample. Thus, there is a need to consider a larger sample to provide additional evidence in the future. The other limitation is that this study only takes into account Nielsen's heuristics. Thus, it is necessary for further studies to consider other usability guideline, e.g. Shneiderman's "Eight Golden Rules of Interface Design" (Schneiderman, 1986).

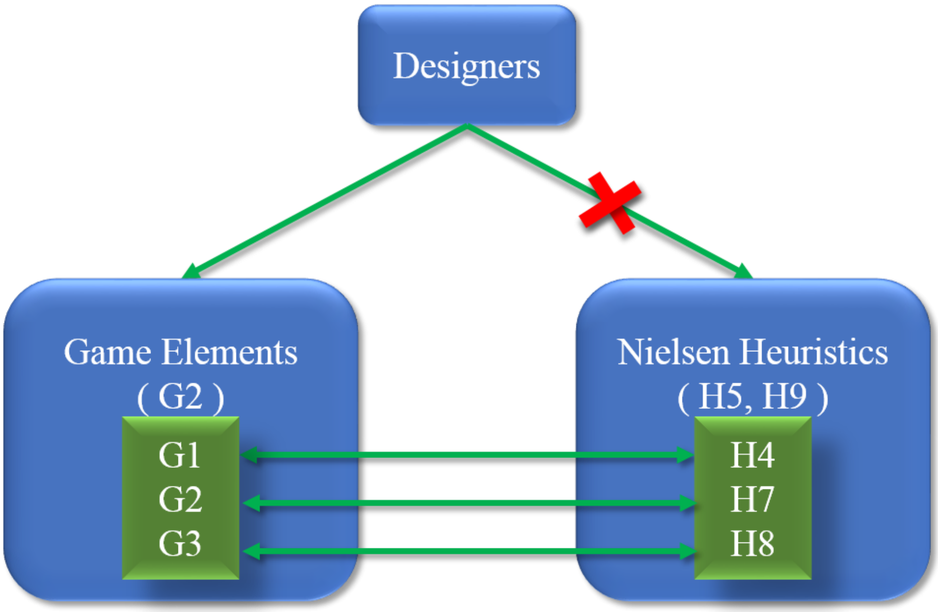

Figure 2. The Summary of the Findings

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Thai Urban School Students' Scientific Argumentation in Physics Learning Weblog

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Abstract: This study aimed to enhance Thai urban school students' scientific argumentation through physics learning weblog. The participants included 47 Grade 10 students studying in an urban large-size school, Kaennakon Wittayalai School. This study was done during the first semester of 2014 academic year. The physics learning weblog provided argumentation situations in six sub-units: (1) Force and Work (2) Energy, Kinetic Energy, Potential Energy (3) Law of Energy Conservation, (4) Apply Law of energy Conservation, (5) Power, and (6) Mechanical. A qualitative was adopted in this study. Students' expression, discourse, and tasks in physics weblog were collected to examine students' argumentation in physics learning. The Toulmin's diagram of Arguments Pattern (TAP) was used as framework to interpret students' argumentation on weblog. The findings indicated that the physics learning weblog enhanced scientific argumentation. Students could comment or express their ideas. The paper will discuss details of students' argumentation regarding on TAP's coding schema - data, claim, warrants, qualifiers, rebuttals and backing. Implications for effective situation argumentation of weblog in Thai physics context are also discussed.

Keywords: Weblog, argumentation, physics learning, TAP

1. Introduction

The Weblog (blog) is a web-based technology which contains users' comments which could be written from opinions, experiences or observations. A weblog is usually administered by a small group of people and usually displays comments or discussion in a conversational style or other informal formats. They provide individual users with an easy way to publish online and others to comment on these views. Furthermore, there is a suite of secondary applications that allow weblogs to be linked, searched, and navigated. Although originally intended for individual use, in practice weblogs increasingly appear to facilitate distributed discussions. Students learn how to share their thoughts and communicate, opinions which reflecting on real-world issue through comment on the blog (Duplichan, 2009). The weblog could provide students to generate dynamics of the conversation structures and develop their argumentation model (de Moor and Aakhus, 2003). In addition, blogs can also give the "silent student" a voice, the one that not very comfortable show their ideas in classroom. The blog can offer a "safe place" for their voices to be heard in a lower pressure environment (Luehmann and Frink, 2009). Students felt blog is "fun" and "helpful" also made them interested in using these technologies (Barlow, 2008; Columbo, 2007; & Erickson, 2009). It allows students the chance to take charge of their own learning (Luehmann and Frink, 2009).

Since 2010, the Technology for Teaching and Learning Center, under Thai Ministry of Education, have organized workshop for training Thai teachers to create blog content through "wordpress" (URL: http://www.wordpress.com); there is increasing science learning blog. This allow students could be able to study a lesson at anytime, anywhere when they are comfortable and they can share ideas with friends via the comments box lessons. These can decrease the problem of students who not dare ask the teacher, answer the question or discussion in the classroom (Sudprakone, 2012)

When students learn how to create a scientific argument and develop rationale behind the arguments. They will be able to integrate their knowledge with the actual problem better. In real life situation, when these students face to the issues, they will be able to apply the skill and apply their knowledge in specific science to solve the issue. Part of argumentation is students be able to develop sensible reason to support their argument. Quality argumentation would be greatly help in solving issues or conflicts between parties (Lin & Mintzes, 2010). Another important factor is how learning environment is setup. In order to achieve effective result of argumentation, teacher must divide students into small groups. This provides students a higher chance to participate in discussions and develop arguments effectively. There is a correlation between the quality of the student's argument and the ratio of teacher to students in the group discussion (Osborne et al., 2004). In order to provide opportunities of argumentation, students would have more social interaction among themselves, and they are tends to generate ideas until also conclusion is drawn or the problem is solved (Suksringam, 2007).

Argumentation frameworks for multi agent systems can be used for different purposes like joint deliberation, persuasion, negotiation, and conflict resolution. On this research, we are focus on argumentation-based joint deliberation among students learning in classroom. Argument-based onjoint deliberation involves discussion over the outcome of a particular situation or the appropriate course of action for a particular situation in the classroom. Students are capable of learning from experience, in the sense of past examples (situations and their outcomes) are used to predict the situation outcome. However, since individual student experience may be limited, the individual knowledge and prediction accuracy is also limited. Thus, learning students are capable of arguing their individual predictions with other agents may reach better prediction accuracy after such an argumentation process (Ontañón, & Plaza, 2007).

According to the section 24 of the National Education Act of B.E. 2542 (1999) (Office of the National Education Commission; ONEC, 1999), provide the important idea of learning process; Educational Institutions shall provide training in thinking process, management, how to face various situations and application of knowledge for obviating also solving problems. The teacher must be aware of the importance in effective strategies for teaching and learning science (physics).

Physics is a scientific subject that is important to study in order to understand phenomena that occur and introduction before study in higher education (Rosnow & Rosenthal, 1989; Aikenhead & Ryan, 1992). Most students do not like it, they are thinking physics is a difficult subject, difficult to grasp and understand especially on the calculation content. Therefore, it must be improvements in the instructional model for teaching and learning factors that affecting the increase academic achievement. When students are learning how to create a scientific argument there are reasonable to integration in thinking skills with specific knowledge related to social issues. They can develop confidence in making decisions in their lives and participate as a responsible citizen in the social responsibility and democratic (Driver, et al., 2000).

However, from the previous researcher study revealed that Thai students from urban school are scared to claim with friends and scared of express their own opinions in physics classroom. Particularly the students in urban school, they show few comment and they do not attempt to describe the situation, discussion or arguments by their own (Pimvichai et.al., 2015). The question proposed in this weblog is "Do we need scientific argumentation as a concept in learning physics weblog?" From above advantage of weblog to support the learning, researcher interesting in create this technology as a scientific argumentation for enhances argumentative teaching and learning in urban physics classroom under Thai context.

2. Aims of the research

The study aimed to enhance Thai urban school students' scientific argumentation through physics learning weblog.

3. Methodology

This study is concerning with qualitative approach. The authors interpreted students' argumentation about physics learning in the weblog. The Toulmin's diagram of Arguments Pattern (TAP) (Toulmin, 1958) were used to interpret the students' Physics from six argumentation situations which shown in the comment wall on the blog.

3.1 Participants

The participants included 47 Grade 10 students who were studying in an urban big size school (Kaennakon Wittayalai School) in the first semester of 2014 academic year. The school is the urban big size school of Khon Kaen province, northeast of Thailand.

3.2 Weblog as the instrument

The weblog [http://jirutthitikan.wordpress.com/], which concern in this study, was created by the researcher. The objective's blog setting was provided for teaching and learning of argumentation in physics classroom at the force, work and energy Unit. This blog consist of five main menus; (1) Introduction of the Unit, (2) Lesson on the Unit, (3) Argumentation situation, (4) Participants, and (5) Mind Map.

The first introduction unit menu are includes the introduction on the physics area in Thai science curriculum and the objective of learning in the force, work and energy unit. The second lesson on the unit menu that include pre-post test and six contents of the force, work and energy unit which student must learn in class are: : (1) Force and Work (2) Energy, Kinetic Energy, Potential Energy (3) Law of Energy Conservation, (4) Apply Law of energy Conservation, (5) Power, and (6) Mechanical. The third argumentation situation menu, that are included six argumentation situations which relevant with six contents in the previous menu. The fourth participant menu are provide the participant information in this study and the sixth mind map menu will to show students' task after they finish learning the unit.

3.3 Data collection and data analysis

Students' argumentation will be corrected from students' reflection on argumentative situation of the six learning unit and students' discussion. Students' scientific argumentation will be interpreted based on Toulmin's diagram of Arguments Pattern (TAP) (Toulmin, 1958). The TAP consist of six categories that include: Data, Claim, Warrants, Qualifiers, Rebuttals and Backing that shown in Table 1.

According to Table 1, TAP reflects the students' explanations of the methodology argumentation of force, work and energy. Though the elements of a scientific argument (*scientific idea, expectations generated by the idea, and relevant observations*) are always related in the same logical way, in terms of the science process, those elements may be assembled in different orders.

Table 1: Coding scheme from Toulmin's diagram of Arguments Pattern (TAP)

Discourse Move	**Definition**
Data	Students can use facts or evidence to prove their argument.
Claim	The statement being argued. Students' principle comment or an assertion made by students' brainstorm in groups. Arguments which are a simple claim versus a counterclaim or a claim versus a claim. Argument which may have several claims and counterclaims.
Warrants	A student has arguments consisting of a claim versus a claim with data, warrants or backings but do not contain any rebuttals. The general, hypothetical (and often implicit) logical, statements that serve as bridges between the claim and the data.
Qualifiers	Statements that limit the strength of the argument or statements that propose the conditions under which the argument is true.
Rebuttals	Counter arguments or statements indicating circumstances when the general argument does not hold true. Sometime students are subject to argumentation displays and extended argument with more than one rebuttal or argumentation has arguments with a series of claims or counterclaims with data, warrants or backings with the occasional weak rebuttal. Although argumentation shows arguments with a claim, with a clearly identify able rebuttal.
Backing	Statements that serve to support the warrants (i.e., arguments that don't necessarily prove the main point being argued, but which do prove the warrants are true).

4. Finding and Discussion

The information searched to identify episodes of scientific argumentation from dialogical argument. Dialog of the urban students who attend the discussion or debate comments on various issues of argument on the blog. It was frequent and also diverse missed opportunities for giving the quality of the feedback to students. The evidence on all aspects of teaching through blog investigated arguments is relied on the use of scientific argument for discussion that shown in each component of Toulmin's diagram of Arguments Pattern (TAP) as the following:

4.1 Data (D) Component

Students in the urban schools, in terms of reasoning, it was found that students used the data that they already had to make a conclusion. Some groups are answer by using the data on the website to support their conclusion, and also they had fewer counter-arguments with friends than in classroom. In addition, the data from textbooks and website were used to answer the questions, and student tried to encourage friends' discussion by using facts or evidence to prove the argument. In terms of facts and evidence, the researchers found that students rarely used scientific idea, expectations generated by the idea to facts and evidence to support their answers on the weblog. Students in the urban schools illustrated their scientific argumentative in the discussion on the weblog. They raised opinions in the discussion more than they did in the classroom. In addition, they can use facts or evidence to prove argument. It can be seen in the following dialogue: dialogue situation one of the force and work content in table two.

4.2 Claim (C) Component

In the claim component, students in the urban schools are showed high interest in answering questions via the weblog since it encouraged them to express opinions among their friends. Most of them would search for the information from the internet to help their friend come up with the answer. However, some of the students followed and agreed on the conclusion made by the wise students. To come up with a conclusion, students used information from scientific concepts, lessons, reasons, and logic to support their conclusion, as well as making references to the data source or their own experience combined with information from the internet. These shows scientific argumentative in the students since they have knowledge, they are aware of their understanding and able to apply it with the given situations on the weblog. This can be seen in the dialogue about force and work in Table three.

Table 2: The dialogue from the comment blog wall about the Law of Energy Conservation content.

NO	Student	Student discussion on weblog (Rural School)
S1 G3	loveyoubaby	Trolling a cart on an inclined plane has more work than on a flat plane because inclined planes require more force.
S2 G3	Ta13052538	Trolling a cart on an inclined plane requires more force which means more work.
S3 G3	T Tod Saramat	Trolling an object on an inclined plane has more work than on a flat plane because it requires more force.
S4 G3	Lee Yon Hwa	Trolling on an inclined plane has more work than on a flat plane because inclined planes require more force.
S4 G3	Lee Yon Hwa	Trolling a cart on an inclined plane has more work than on a flat plane because it requires more force.
S5 G3	Sirimon Didjaroen	I think moving along an inclined plane has more work because we have more force than moving along a flat plane… But I don't know. I think I agree with Lee Yon Hwa.
S5 G3	Sirimon Didjaroen	……. I have no idea. Let's take my friends' answers.
S6 G3	Nakarin	Why not?
S6 G3	Nakarin	I am already in the weblog but my picture didn't display. Well, now let's figure out the answer from our class. What would the answer be? Let's do it!
S4 G3	Lee Yon Hwa	Whatever you guys say, I'm Ok with it.

Table 3: The dialogue from the blog's comment wall about the fore and work content

NO	Student	*Student discussion on weblog (Rural School)*
S1 G3	loveyoubaby	Trolling a cart on an inclined plane has more work than on a flat plane because inclined planes require more force.
S2 G3	Ta13052538	Trolling a cart on an inclined plane requires more force, so it generates more work than flat planes.
S3 G3	T Tod Saramat	Trolling on an inclined plane has more work than on a flat plane because of more force.
S4 G3	Lee Yon Hwa	Trolling on an inclined plane has more work than on a flat plane because inclined planes require more force.
S4 G3	Lee Yon Hwa	Trolling a cart on an inclined plane has more work than on a flat plane because it requires more force.
S5 G3	Sirimon Didjaroen	I think moving along an inclined plane has more work because we have more force than moving along a flat plane… But I don't know. I think I agree with Lee Yon Hwa.
S6 G3	Nakarin	I agree with everyone ;)
S6 G3	Nakarin	You all are very good.
S5 G3	Sirimon Didjaroen	No comment. I'll take you guys' answer.
S6 G3	Nakarin	Why not?
S6 G3	Nakarin	I am already in the weblog, but my picture doesn't display. Let's find the answer. Let's think about it.
S4 G3	Lee Yon Hwa	Whatever you say, I'm ok with it.

4.3 Warrants (W) Component

In the warrants component, when students are into claim and discussion, students often have evidence for the claim and used the reliable data to support their comment questions, which are about the topic. In terms of providing reasons in Physics weblog, it was found that the students in the urban school showed high interest in answering questions via the weblog since it encouraged them to express opinions among their friends. Most of them would search for the information from the internet to help their friend come up with the answer. However, some of the students followed and agreed on the conclusion made by the wise students. To come up with a conclusion, students used information from scientific concepts, lessons, reasons, and logic to support their conclusion, as well as making references to the data source or their own experience combined with information from the internet. This shows scientific argumentative in the students since they have knowledge, they are aware of their understanding and able to apply it with the given situations on the weblog. This can be seen in the following dialogue about fore and work (table four).

Table 4: The dialogue from the blog's comment wall about the fore and work content

NO	Student	*Student discussion on weblog (Rural School)*
S1 G3	loveyoubaby	Trolling a cart on an inclined plane has more work than on a flat plane because inclined planes require more force.
S2 G3	Ta13052538	Trolling a cart on an inclined plane requires more force, so it generates more work than flat planes.
S3 G3	T Tod Saramat	Trolling on an inclined plane has more work than on a flat plane because of more force.
S4 G3	Lee Yon Hwa	Trolling on an inclined plane has more work than on a flat plane because inclined planes require more force.
S4 G3	Lee Yon Hwa	Trolling a cart on an inclined plane has more work than on a flat plane because it requires more force.
S5 G3	Sirimon Didjaroen	I think moving along an inclined plane has more work because we have more force than moving along a flat plane… But I don't know.

		I think I agree with Lee Yon Hwa.
S6 G3	Nakarin	I am already in the weblog, but my picture doesn't display. Let's find the answer. Let's think about it.
S4 G3	Lee Yon Hwa	Whatever you say, I'm ok with it.

4.4 Qualifiers (Q) Component

The results from six argumentative activities indicated that students used qualifiers to propose the conditions under, which the argument was true in physics classrooms. The blogging is rather than proposing the limitation of their friend's arguments. In this dialog of qualifiers component, students' scientific argument in scientific idea, expectations generated with idea, and relevant observations are always related in the same logical way. In the terms of the science process are those elements may be assembled in different orders. Sometimes idea comes first and then scientists looking for the scientific argument, since they are not aware of qualifiers that help them decide the argumentative answer. The students' debate are based on their experience and teachers though they never think of the condition or limitation while discussion in classroom blogging. However, when students need to use picture to explain their claim, they also draw it in the book and cannot post it on the weblog. This is the limitation of argumentation via the weblog.

4.5 Rebuttals (R) Component

In terms of argumentation in the urban schools, it was found that sometimes students made an argument more than one rebuttal because they had different ideas. Their argument contained a series of claims or counterclaims with data, warrants, or backings. Students always made a conclusion with supporting data on physics weblog. Therefore, argumentation shows how they make arguments with a claim and reasons for making rebuttals. This can be seen from the dialogue about power as shown in the Table five.

Table 5: The dialogue from the comment blog wall about power content.

NO	Student	Student discussion on weblog (Rural School)
S1 G4	Yuttapi Chaisomrit	I think Y has Kinetic Energy (Ek)=zero because the speed is zero.
S2 G4	Janita Namsaeng	In the question, we have to compare the kinetic energy and mechanical energy. So, I think Y has the most kinetic energy because Y is on the higher position than X and Z.
S1 G4	Yuttapi Chaisomrit	Could I add more to that? When we throw an object vertically with speed V, the speed of the object will decline and reach 0 on the highest position. What do you guys think? Any ideas?
S1 G4	Yuttapi Chaisomrit	I think Y has less kinetic energy than Z and more kinetic energy than X because it's in the middle of the movement.
S3 G	Lakkana Deesoi	I disagree because I think X, Y, Z has equal kinetic energy because there's no external force involved.
S2 G4	Janita Namsaeng	So, which answer should we take?

4.6 Backing (B) Component

In the backing component, students were subjected for argumentation and had arguments with a series of claims with data, warrants and backings obtained from the references of the theory energy (kinetic energy and potential energy). Even though references are reliable reason to support the comment of them, most of the students tend to support ideas from a group of other friends, rather than their own comments. Sometime they are tend to wait for the hero in the group started to comment and followed, although the answer was incorrect. This can be seen from the dialogue about power as shown in the Table six.

Table 6 The dialogue from the comment blog about power content

NO	Student	Student discussion on weblog (Urban School)
S1 G4	Mumin Tk	Normally in our daily life, it's easier to climb zigzag planes, isn't it?
S2 G4	Apisara Tewintarapakti	I think so because it's less steep. No need to change the gear. Hahaha
S3 G4	Kantaphit Boonpromma	I agree with Ying. If it's steep, the engine will work harder. It's like when walk zigzag up the stairs, we get less tired. So, I think going up zigzag planes is easier than steep planes.
S4 G4	Satinee Puangkhum	Zigzag planes would be easier because it is less steep and has less resistance, isn't it?
S3 G4	Kantaphit Boonpromma	So, I think Route 1 would be easier because we get less tired.
S2 G4	Apisara Tewintarapakti	So, the conclusion is that zigzag planes with less steep are easier to climb than steep planes.

5. Conclusions and Suggestions

This research study revealed that learned by weblog which provide the scientific content and argumentative activities could be motivate students to express their own ideas, opinions on situation's discussion. It expressed the students' argumentation and thinking on the situations that demonstrate on the post wall. The students claim on various issues commonly learning in the class. The students claim (C) on the Data (D) and warrants (W) component. Other elements comprise of the rebuttals (R) and backing (B) in which students made was based on their experience and content knowledge from the blog and their teacher. For the qualifiers (Q), students usually do not claim on each content. However, students do not show scientific argument in the qualifiers because they never think of the condition or limitation while discussion in blogging physics classroom.

Interestingly, students prefer to post the comment for discussion, and thing that, know, so they can, learn through blog. It is the new approach for them. Learning on the blog could encourage students to higher thinking from argumentation and it could reduce the problem from students who not dare get ask teacher. They could share the understanding on learning with friends via the comments box lessons. However, sometime they are aware that their comment maybe wrong, So they make them more serious and get confident before share some ideas on the blog. In addition, the study also reveal that students who learned through the lesson on web blog very satisfactory. They were exciting and fun with learning because lessons' blog are interesting, easy to use and quickly access lessons.

These findings suggest that teacher can create the scientific content blog within the argumentative activities in Physics. It's enhancing student's scientific argument in physics Thai context.

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Comparing the Self-Regulated Learning Strategy and Non-Self-Regulated Learning Strategy in Cognitive Load and Learning Effectiveness in an Exercise System

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Abstract: Knowledge of the database management system is quite important. Effectively organizing, managing and analyzing data are indispensable capabilities in a database management system. In Taiwan, the low birth rate trend leads to that university students' learning level becomes low and uneven. And, in traditional classrooms, teachers aren't able to take high or low prior knowledge students into account at the same time. Self-regulated learning can let learners set their own goals and learning strategies to achieve learning goals and to improve their self-efficacy. E-learning can let learners handle their own learning contents, time and progress, to conform to the personalized learning. Therefore, self-regulated learning and e-learning can be applied with each other coordinately. There are many researches developing self-regulated learning system for learners to enhance their learning effectiveness. But with respect to the non-self-regulated learners, self-regulated learners which have higher autonomy might spend more time with efforts to adjust the learning goals and strategies. And few studies investigated the psychological burden of self-regulated learners. Thus, this study inspected cognitive load between self-regulated learners and non-self-regulated learners. In this study, there were two classes at a university in central Taiwan, attending a database management system course and were divided into an experimental group and a control group. The numbers of effective samples were 34 and 41, respectively. The experimental group used an exercise system with self-regulated learning strategy. On the other hand, the control group applied non-self-regulated learning strategy. We had carried on an empirical research to investigate the effect of two kinds of learning strategies (self-regulated and non-self-regulated) on students' cognitive load and learning effectiveness during a semester (17 weeks). The result of this study showed that the self-regulated learning caused students achieving higher learning effectiveness but having higher cognitive load.

Keywords: Self-regulated learning, cognitive load, learning effectiveness, database management system, exercise system

1. Introduction

Information technology is indispensable to the country's development, and everyone requires IT ability. There are large and diverse messages in life. How to effectively organize, manage and analyze the received information is important (Zehra et al., 2004). A database management system can effectively integrate data, logically manage data, and facilitate analysis and use of data (Ahmad, Khan, Abd Alla, & Beg, 2010). Therefore, the importance of personnel training for the database management system technology is ineffable. The departments of universities about information mostly regard the database management system course as a required subject. However, in Taiwan, the low birth rate trend leads to that university students' learning level becomes low and uneven. Therefore, the education of the database management system course is into trouble. When teachers teach rapidly, students having the low learning level aren't able to adapt. On the other hand, when teachers teach slowly, students having the high learning level feel bored. Slavin (1990) had pointed out that when a group of students' learning ability was significantly different, the course content should be suitable for the majority of students. Most teachers could not take high and low learning effectiveness students into account at the same time. Therefore he recommended that teachers shouldn't teach students with the same progress and scoring criteria. This is because that the difficulty of achieving learning goals may affect students' learning motivation. Bandura (1977) proposed self-efficacy would affect the self-behavior, if the learning goal was too difficult, students might feel frustrated thus reducing the willingness to learn; if the goal was too easy, it might lead students lacking of motivation. To solve the above problems, the present study introduced the self-regulated learning strategy, through autonomy setting goals and identifying learning strategies to achieve their goals, and students could enhance self-efficacy (Zimmerman, Bonner, & Kovach, 1996).

The greatest advantage of e-learning is able to provide learners with personalized service. Ruiz, Mintzer, and Leipzig (2006), and Butz, Hua, and Maguire (2004, Sept.) considered e-learning allowed learners to know learning content, learning time and order of study courses well, for meeting learners' personal learning goals. Therefore, e-learning and self-regulated learning strategies can be combined to use. Huang et al. (2007) proposed students' self-learning ability was very important. They established a computer-assisted self-regulated learning model and practically applied to information courses. They found online self-regulated learning auxiliary mechanisms indeed enhanced students' self-regulated learning ability. Yang, Hwang, Yang, SJH, and Hwang (2015) mentioned that the programming was an important skill for students with the information specialty. They built a system for e-learning courses on programming, the study found that this kind of learning improved students' willingness to learn, and effectively improved the ability of students in the program design.

Hwang et al. (2015) developed an exercise system with self-regulated learning strategy for different cognitive style students in a database management system course. Students used this system to repeated practice database management system course topics in order to establish the correct concept and skills of database management. Hwang et al. hoped to enhance the students' self-efficacy and learning performance of the database management system course. However, the study only confined development and the usability evaluation of their system, so there was no analysis of the learning effectiveness in their study. Most of the students did not understand about the database management system before the course and have lower prior knowledge. Tuovinen and Sweller (1999) found that low prior knowledge students' cognitive load in database program was high. In addition, students' cognitive load might be affected by different learning styles. Self-regulated learners may spend more time with efforts to adjust the learning goals and strategies, with respect to the non-self-regulated learners. Therefore, this study used the system developed by Hwang et al. (2015) as a research tool to investigate the correlation of cognitive load and learning effectiveness for students with non-self-regulated learning and self-regulated learning strategies. In summary, this study wanted to understand whether course content causing pressure on student mental aspects, and whether the complex operating system causing on students psychological burden. The results showed that the learning effectiveness of students with self-regulated learning was better than that of students with non-self-regulated learning. However, the self-regulated learning strategy increased students' cognitive load.

2. Literature

2.1 Self-Regulated Learning

Bandura (1977) indicated that learners control their behavior which was called self-regulated. It let learners have different learning method in the past. Zimmerman et al. (1996) proposed a self-regulatory learning cycle which includes four processes, "self-evaluation and monitoring", "goal-setting and strategic planning", "strategy implementation and monitoring" and "strategic outcome monitoring". Zimmerman et al. considered that the self-regulated learning let learners set their own goals and find out learning strategies or methods to achieve goals. At any time, learners could modify their strategies or goals via monitoring their learning portfolios.

In the past, many scholars found that learners had nice learning effectiveness via self-regulated learning strategy in many different learning areas, e.g., the English language area (Chen, Wang, & Chen, 2014; Chen & Huang, 2014), mathematics area (Hackett & Betz, 1989; Malpass, O'Neil, & Hocevar, 1999; Pajares & Miller, 1994; Parker, Marsh, Ciarrochi, Marshall, & Abduljabbar, 2014), natural sciences area (Betz & Hackett, 1983; Britner & Pajares, 2006; Chen & Usher, 2013), social area (Hwang, Kuo & Hsu, 2008) and information area (Hwang et al., 2007; Hwang et al., 2014).

Hwang et al. (2015, May) developed a self-regulated learning exercise system. This system let learners set their learning goals and strategies: the pass score, days and times. Learners can modify their goals via querying their learning portfolios. The study applied this system as an experimental tool. Through the self-regulated learning system, we wanted to know whether the learners could effectively understand the contents of the course. About the system operation and the difficulty of the course, we also introduced cognitive load questionnaire to observe learners' mind.

2.2 Cognitive load

Paas (1992), and Sweller, Merriënboer and Paas (1998) thought that the cognitive load was a multifaceted concept. It includes mental load and mental effort. Mental load was psychological burden of students for difficulty of teaching material degree; mental effort was psychological burden of students for complexity of operating media. Either students felt learning contents more difficult, or students felt more difficult system operations, would increase their cognitive load. Tsai, Yang, Hsu, and Chang (2015, May) explored effects of cognitive load about collaborative learning on programming, for traditional pair programming and remote pair programming. Their research found that mental load of remote pair cooperation programming was higher than that of traditional pair cooperation programming. Tuovinen and Sweller (1999) found that while learning a database software, the low prior knowledge students with worked-example teaching method had lower cognitive load than those with exploration teaching method. Chuang, Hwang, Shih, Yang, and Chu (2009, May) used blended mobile learning method to investigate the cognitive load. The experimental group's students used Personal Digital Assistants (PDAs) as learning tools to learn local culture. Because the PDA provided a personal learning environment, students learned and repeated exercise, according to their own learning progress. Therefore, these students' mental effort was lower. On the other hand, the control group's students learned from the traditional method. But it had led to some students could not follow the progress. They had higher psychological burden. In summary, students' cognitive load might be affected by using the information technology in learning process, or using the different teaching methods.

This study used the exercise system with self-regulated learning strategy in a database management system course. The content of database management systems courses might cause students higher mental load. And, the operation complexity of the self-regulated learning exercise system might cause students higher mental effort. Therefore, we wanted to understand students' cognitive load via using a cognitive load questionnaire.

Our research questions sort out as follows:

1. Is the learning effectiveness of students with the self-regulated learning strategy different from that with the non-self-regulated learning strategy?
2. Is the cognitive load of students with the self-regulated learning strategy different from that with the non-self-regulated learning strategy?

3. Methodology

In this study, there were 112 students from two classes at a university in central Taiwan. These students attended a database management system course and were divided into an experimental group and a control group. The experimental group used an exercise system with self-regulated learning strategy. The numbers of all samples and effective samples were 49 and 34, respectively. On the other hand, the control group applied non-self-regulated learning strategy. The numbers of all samples and effective samples were 63 and 41, respectively. Students in the experimental group could perform one exercise by several tests, and could set their learning goals and strategies for each exercise. Learning goals of each exercise included the passing score (60, 70, 80, 90 points) and the time period limit (20, 30, 40 minutes). Learning strategies of each exercise included the required days and times for finishing an exercise. Students in a control group could not set their learning goals and strategies. The learning goals and strategies of a control group were fixed. Learning goals of each exercise included that the passing score is 75 points and the time period limit was 30 minutes. Learning strategies of a control group included that the required days to finishing one exercise were most 7 days (a week after the teacher completing the teaching), and one exercise could be performed most five tests.

The teaching experiment was carried out 17 weeks on a semester. The system was introduced and the pre-test was conducted for students in the first week of the semester. The content of pre-test was involved with basic computer concept. Students made use of this system during the second week to the sixteenth week. The first post-test and second post-test were conducted in the ninth week (midterm) and the seventeenth week (final examination). Students filled in the questionnaire designed by Sweller et al. (1998) with 7-point scale (Likert, 1932). The experimental flowchart is shown on Figure 1.

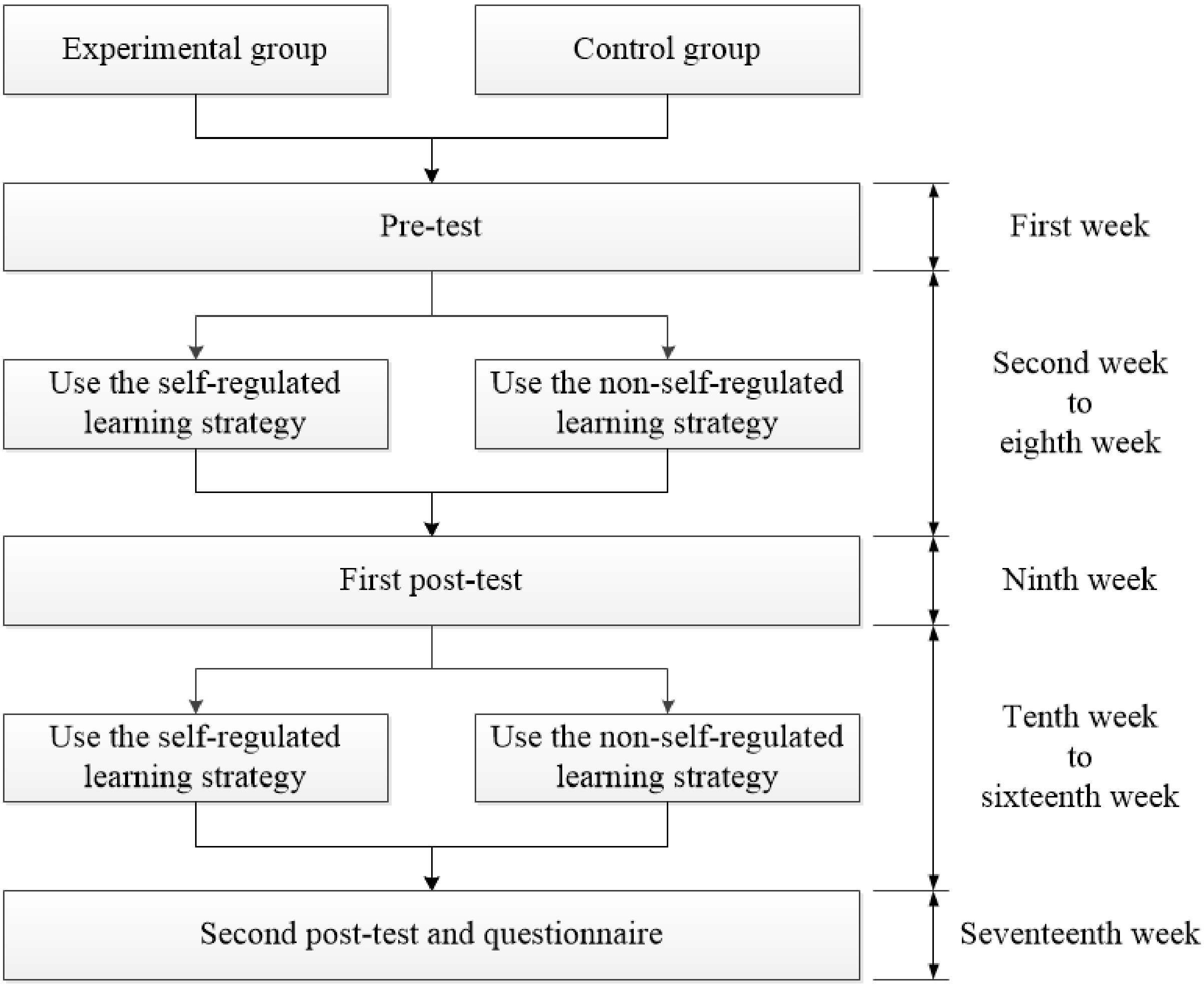

Figure 1. The flowchart of the experiment.

4. Experimental results and analysis

This study applied the questionnaire designed by Sweller et al. (1998) to understand cognitive load about students using this exercise system. The questionnaire was filled by students. The results were analyzed through independent samples *t*-test, as shown on Table 1. About mental load, the means of the experimental group and the control group were 3.64 and 2.59, respectively. The results achieved significant differences ($p < 0.001$). About mental effort, the means of the experimental group and the control group were 3.41 and 2.44, respectively. The results also achieved significant differences ($p < 0.01$). Students in Taiwan got used to getting learning goals and strategies from the teachers, therefore they easily felt confused about setting learning goals and strategies by themselves. In this study, students in the experimental group could set their learning goals and strategies, and these might lead to the higher mental load. The reason of higher mental effort may be that the operating of system for the experimental group is more complicated than the control group.

The learning effectiveness of the experiments is shown on Figure 2. In pre-test, the mean score of the experimental group was lower than that of the control group. After using the system, the mean scores of the two post-tests of the experimental group were both higher than those of the control group.

Table 1: *t*-test results of cognitive load.

Dimension	Group	N	Mean	S.D.	*t*
Mental load	Experimental group	34	3.64	1.11	4.45***
	Control group	41	2.59	0.93	
Mental effort	Experimental group	34	3.41	1.09	3.60**
	Control group	41	2.44	1.24	

***$p < 0.001$;**$p < 0.01$

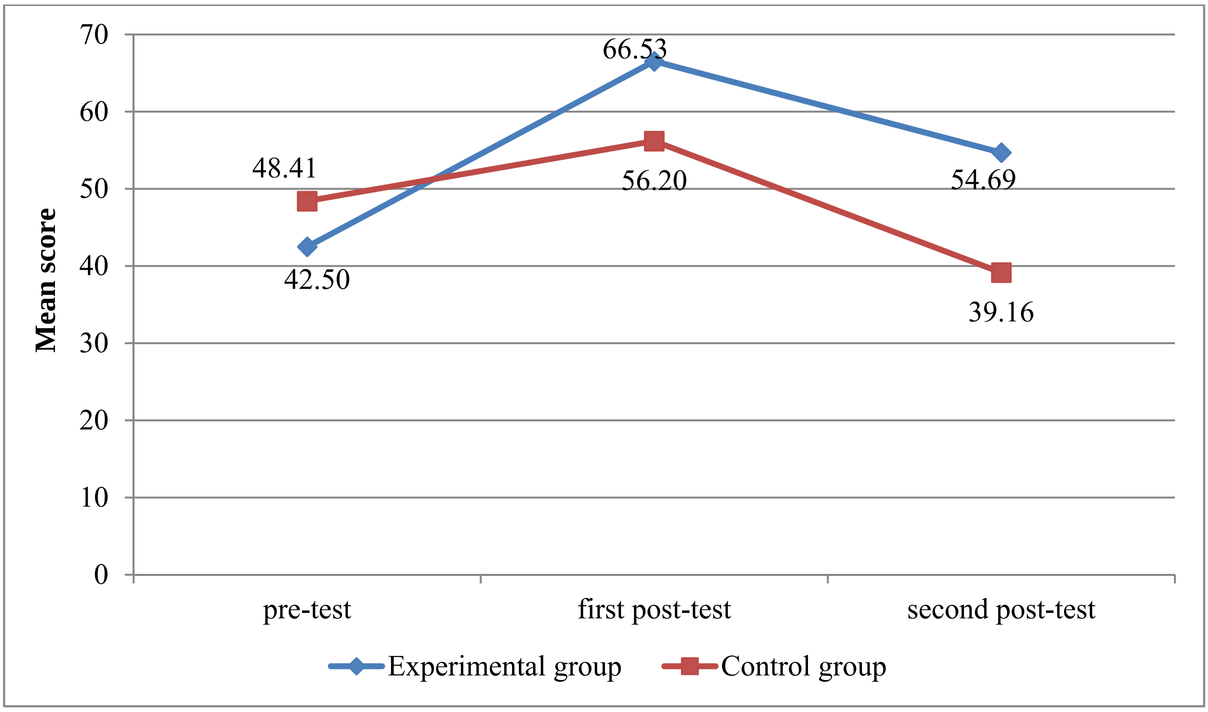

Figure 2. Line chart of the average score about three tests for two groups.

This study used descriptive statistics to analyze pre-test and two post-tests. The results revealed that these three tests were homogeneous (first post-test $p = 0.452$, second post-test $p = 0.147$, $p > 0.05$). Therefore, we further utilized ANCOVA (ANalysis of COVAriance) to excluding the influences of pre-test and post-tests. The results of ANCOVA about the first post-test ($F = 10.78$, $p = 0.002 < 0.01$) achieved significant differences. The adjusted means of the experimental group and the control group achieved significant differences. And the midterm's adjusted mean score (67.45) of the experimental group was better than that (55.44) of the control group. The results of ANCOVA analysis about the second post-test ($F = 18.28$, $p = 0.000 < 0.001$) also achieved significant differences. The adjusted means of the experimental group and the control group still achieved significant differences. And the final examination adjusted mean score (55.83) of the experimental group was higher than that (38.22) of the control group. For the adjusted mean score difference between the experimental group and the control group, the final examination (67.45 - 55.44 = 12.01) was bigger than that (55.83 - 38.22 = 17.61) of the midterm. The results are shown on Table 2 and Table 3. That is, through the self-regulated learning strategy, the learning effectiveness is effectively enhanced.

Table 2: First post-test results of ANCOVA.

Group	N	Mean	S.D.	Adjusted Mean	Std. Error.	*F value*
Experimental group	34	66.53	16.35	67.45	2.68	10.78**
Control group	41	56.20	15.57	55.44	2.44	

$^{**}p < 0.01$

Table 3: Second post-test results of ANCOVA.

Group	N	Mean	S.D.	Adjusted Mean	Std. Error.	*F value*
Experimental group	34	54.69	18.47	55.83	3.02	18.28***
Control group	41	39.16	17.73	38.22	2.74	

$^{***}p < 0.001$

5. Conclusion and Future work

This study compared the self-regulated learning strategy and non-self-regulated learning strategy in an exercise system to discuss influences of cognitive load and learning effectiveness, via students' pre-test, two post-tests and cognitive load questionnaire. Research results showed cognitive load of the experimental group is higher than that of the control group. This is because that the operating of self-regulated learning system is more complicated. The outcome is the same with research from Tsai, Yang, Hsu, and Chang (2015, May). Therefore, complex operations influence student's cognitive load.

Students using self-regulated learning strategy can make learning effectiveness better than using non-self-regulated learning strategy. The result is the same with research from Chen, Wang, and Chen, (2014), Chen and Huang, (2014), Hackett and Betz, (1989), Malpass, O'Neil, and Hocevar, (1999), Pajares and Miller, (1994), Parker, Marsh, Ciarrochi, Marshall, and Abduljabbar, (2014), Betz and Hackett, (1983), Britner and Pajares, (2006), Chen and Usher, (2013), Hwang, Kuo, and Hsu, (2008), Hwang et al. (2007). Results of the study demonstrate using self-regulated learning strategy can enhance students' learning effectiveness.

In summary, student using self-regulated learning strategy can promote learning effectiveness. However, complex operations for adjusting the learning goals and strategies increase students' cognitive load. In the future, this study will combine a goal recommendation function to help students reducing their cognitive load. Besides, the relation between self-regulated learning strategy and human factors will be discussed.

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The Effect of Human Factors on User Usability of a Customized Augmented Reality English Learning System

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Abstract: Many scholars indicated that augmented reality (AR) can effectively enhance learners' learning motivation and effectiveness. In addition, many researches showed that human factors will affect learning, such as prior knowledge, cognitive style and even gender. So, a customized AR English learning system was developed in this study. Also, we made a usability assessment analysis for this system. According to the results of the analysis, there are some significant differences between gender, education background and department when using the customized AR English learning system.

Keywords: Human factors, user usability, customized, augmented reality, English learning system

1. Introduction

Taiwan is an EFL (English as Foreign Language) English learning environment. In Taiwan, a formal exposure to English is until entering elementary schools (Lu, 2012). In the traditional teaching environments, students learned English through explaining the rigid text of the textbooks by teachers. The English learning then can be conducted. But it is passive learning (Savignon, 1988). Looi et al. (2010) have used a context-aware ubiquitous learning system to record the situation of learners. It allowed teachers to rapidly understand students' learning process and individual differences and to develop a better teaching method. By this, students can get the needed information in appropriate timing (Chen, Lien, & Lu, 2009). According to the "Spatial Contiguity Principle" and "Temporal Contiguity Principle" of 12 multimedia design principles proposed by Mayer (2009), the learning effectiveness of learners will be increased if the corresponding and associated information is able to be immediately generated beside the objects at the time of scanning real objects.

The augmented reality (AR) is a kind of technology that can combine the virtual information and the real image (Azuma, 1997). The technology allows that the learning process can more meet the above principles proposed by Mayer (2009). In addition, Chen and Macredie (2010) have proposed that human factors will affect learning, such as prior knowledge, cognitive style and even gender. So, this study has developed a customized English learning system based on AR technology, and then made a usability assessment analysis with it. According to the results of the analysis, we have found out there are some significant differences among different kinds of human factors. Based on these findings, we can design these types of AR learning systems for the different kinds of users in the future and let the system more matching the characteristics of each person.

2. Literature Review

2.1 The problems of English learning

In the past, second/foreign language learning relied upon teachers' lecturing to explain the learning materials of textbooks (Savignon, 1988). In other words, because the teaching time is limited, traditional teaching is considered unable to enhance learning motivation and interest (Brown, Collins, & Duguid, 1989). Looi et al. (2010) have indicated that learning will be able to be conducted at any time and any place when technologies of context-aware and ubiquitous learning are imported. Thus, teachers can guide students to learn actively and attract their attention, and learners' ability of observation of the real world and the ability to actually solve problems can be enhanced (Chen, Lien, & Lu, 2009).

Among the technologies of context-awareness, RFID and QR code technologies have the disadvantages of information discontinuous problems. In this study, we use AR technology to implement an English learning system, and make a usability assessment with it. It is hoped that the learning motivation and learning effectiveness of learners can be enhanced. Thus, according to the results of the analysis, we will improve the AR English learning system.

2.2 The influence of human factors in learning

Chen and Macredie (2010) have proposed that human factors will affect learning, such as prior knowledge, cognitive style and even gender which may cause different effects. The main focus of personalized learning is to understand learners' individual factors, such as their extent and learning experience. Then, according to the learners' individual differences, the learning system can adjust the learning materials (Cho, Kim, & Kim, 2003). According to the previous studies, we added personalized content into the AR English learning system; it can allow users adjust the learning environment according to their preferences. In this study, we want to explore whether there are significantly differences in system usability assessment and using attitudes between different kinds of human factors, such as gender, knowledge background, using experience, etc.

2.3 Customized AR English learning system

A customized AR English learning system was proposed and designed by Hwang, Chen and Huang (2014). For customized design, the system adds the functions of related words and 3 learning scopes, i.e., phrases, sentences and related words. In addition, an easy mode and an advanced mode are provided. User can also choose the boy’s or girl’s pronunciation in the settings menu with their preference at any time.

When learners successfully scan an object, the screen will show the main teaching material and the related material. After the learners click the object that want to learn, the corresponding function buttons will appear at the top of screen. If learners click the function button, the system will read out the materials, and the Chinese meaning will be explained in Chinese voice. In addition, all users' behavior operation process will be recorded in a portfolio database by the behavior-code. The screenshots of the customized AR English learning system is as shown in Figure 1.

Figure 1. The screenshots of Customized AR English learning system.

2.4 Nielsen usability assessment

When a system is developed, it must be tested and evaluated by users. Then, developers can improve the system according to users' needs. Virvou and Katsionis (2008) indicated that system usability will affect the learners' performance and their perception. Greenberg, Fitzpatrick, Gutwin, and Kaplan (2000) pointed out that heuristic evaluation is the most rapid, cheap, and effective way to identify usability problems. In this study, Nielsen's heuristic approach is selected because it is the most commonly used and can be effectively applied by both novices and experts (Nielsen, 1994a; Nielsen & Mack, 1994). Nielsen (1994b) assessment proposed 10 heuristics, such as interface design, system flexibility and efficiency, the system interactivity, etc. The details of the revised set of 10 heuristics (H) are as shown in Table 1. So, in this study, we hope to analyze users' opinion through the Nielsen assessment questionnaire and improve the customized AR English learning system in the future.

Table 1: Nielsen's 10 heuristics (Nielsen, 1994b).

Heuristics	Explanations
H1: Visibility of system status	The system should always keep user informed about what is going on by providing appropriate feedback within reasonable time
H2: Match between system and the real world	The system should speak the user's language, with words, phrases and concepts familiar to the user, rather than system-oriented terms. Follow real-world conventions, making information appear in a natural and logical order
H3: User control and freedom	Users should be free to develop their own strategies, select and sequence tasks, and undo and redo activities that they have done, rather than having the system do these for them
H4: Consistency and standards	Users should not have to wonder whether different words, situations, or actions mean the same thing and the system should follow platform conventions
H5: Error prevention	Even better than good error messages is a careful design, which prevents a problem from occurring in the first place
H6: Recognition rather than recall	Make objects, actions, and options visible. The users should not have to remember information from one part of the dialogue to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate
H7: Flexibility and efficiency of use	Allow users to tailor frequent actions. Provide alternative means of access and operation for users who differ from the "average" user (e.g., physical or cognitive ability, culture, language, etc.)
H8: Aesthetic and minimalist design	Dialogues should not contain information that is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility
H9: Help users recognise, diagnose and recover from errors	Error messages should precisely indicate the problem and constructively suggest a solution. They should be expressed in plain language
H10: Help and documentation	Even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation. Any such information should be easy to search, focused on the user's task, list concrete steps to be carried out, and not be too large

3. Methodology

3.1 Research design

First of all, we collected relevant literatures. Then, we confirmed the specifications of the system and started to develop the system. When the system was developed successfully, we invited about 70 students including college students and Masters of the information college to do a trial of the system, and let them fill out the Nielsen's assessment questionnaire. After the questionnaires being collected, the statistical software of SPSS 19 was used to analyze and explore the possible effect of different kinds of human factors on user usability of this system. Finally, in this paper, we will propose the amendments of system according to the analysis results and improve the customized AR English system in the future. The flow chart of our research process is as shown in Figure 2.

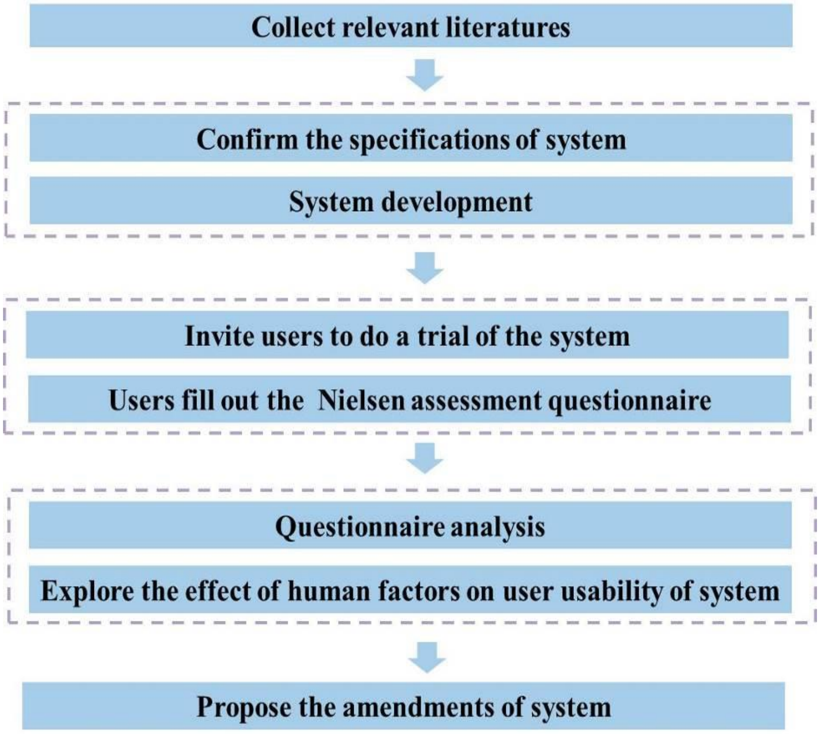

Figure 2. The research process.

3.2 Questionnaire design

In this study, the statistical software of SPSS 19 is used. And then the questionnaire is designed with Nielsen's 10 heuristics and 5-point Likert scale (Likert, 1932) where 1 is strongly disagree, 2 is disagree, 3 is neither agree nor disagree, 4 is agree, and 5 is strongly agree. There are total 60 questions in the questionnaire, which include 5 positive questions and one reverse question for each Heuristic (H).

After collecting questionnaires, in order to confirm the reliability of the questionnaire, we conducted a questionnaire reliability analysis first. As shown in Table 2, the result shows that the Cronbach's Alpha values of all heuristics (H) are all higher than 0.8. It means the reliability of this questionnaire is good enough to do the following analysis. Then, to explore whether there are significantly differences between different kinds of human factors or not, the *t*-test and the analysis of variance (one-way ANOVA) are used.

Table 2: The reliability of the questionnaire for each heuristic (H).

Heuristics (H)	Cronbach's Alpha Value
H1	0.85
H2	0.80
H3	0.84
H4	0.81
H5	0.92
H6	0.83
H7	0.89
H8	0.93
H9	0.88
H10	0.92

3.3 Population and sample

The valid participants of the experiment are 65 information college students from a university in central Taiwan, including 35 students in department of Information Networking and System Administration (INSA), 16 students in Information Management (IM) and 14 students in Information Technology (IT). Among 65 students, there are 51 male users and 14 female users. In addition, there are 46 college students and 19 master students. The reason why we chose these students is trying to find out whether there exists significantly difference in usability and using attitudes among INSA, IM and IT departments in this customized AR English learning system.

3.4 Data collection procedures

The process of the experiment is listed as shown in Figure 3. At first, all participants have to watch the system operating instruction video. Afterwards, the participants login the customized AR English learning system with their accounts and passwords to use the system, as shown in Figure 4. The participants have to fill out Nielsen's Heuristic evaluation questionnaires. Finally, for each heuristic, we interview with particular users with low mean points after the questionnaire being analyzed.

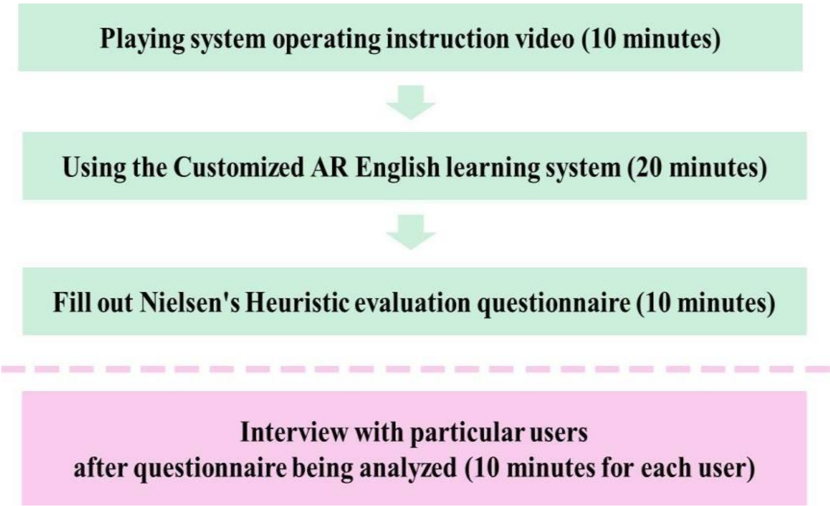

Figure 3. The process of the experiment.

Figure 4. The situation during the experiment.

4. Data analysis and Results

4.1 The 10 heuristics (H) differences between genders

First of all, in order to verify the differences of the usability evaluation between genders, *t*-test is used. According to the analysis, it is found that the recognition mean values of male users had significantly higher than those of female users on H2 and H9; with $t = 2.41$ ($p = 0.019 < 0.05$) and $t = 2.23$ ($p = 0.029 < 0.05$), and medium effect sizes $d = 0.67$ and $d = 0.62$, respectively. The recognition mean values of H2 and H9 in male users (4.60 and 4.51) was higher while those of the genders in female users (4.26 and 4.18) were relatively lower, as shown in Table 3.

Table 3: The *t*-test results for genders.

	Gender	N	Mean	S.D.	*t*	*d*
H1	male	51	4.61	0.44	1.58	
	female	14	4.38	0.58		
H2	male	51	4.60	0.43	2.41*	0.67
	female	14	4.26	0.56		
H3	male	51	4.53	0.46	1.58	
	female	14	4.30	0.61		
H4	male	51	4.36	0.53	1.67	
	female	14	4.10	0.51		
H5	male	51	4.71	0.44	1.56	
	female	14	4.42	0.65		
H6	male	51	4.45	0.48	0.92	
	female	14	4.31	0.60		
H7	male	51	4.48	0.47	0.89	
	female	14	4.31	0.66		
H8	male	51	4.25	0.59	0.43	
	female	14	4.16	0.92		
H9	male	51	4.51	0.46	2.23*	0.62
	female	14	4.18	0.60		
H10	male	51	4.54	0.51	1.87	
	female	14	4.23	0.71		

*p<.05

4.2 The 10 heuristics (H) differences between educational backgrounds

Then, in order to verify the differences of the usability evaluation between different educational backgrounds, *t*-test is used. According to the result of analysis, it is found that the recognition mean values of college students had significantly lower than those of Masters on H1, H3 and H5; with $t = -2.91$ ($p = 0.005 < 0.05$), $t = -2.80$ ($p = 0.007 < 0.05$) and $t = -2.27$ ($p = 0.027 < 0.05$) , and medium effect sizes $d = -0.73$, $d = -0.66$ and $d = -0.56$, respectively. The recognition mean values of H1, H3 and H5 of educational backgrounds in Masters (4.78, 4.69 and 4.83) were higher while those of educational backgrounds in college students (4.47, 4.40 and 4.58) were relatively lower, as shown in Table 4.

Table 4: The *t*-test results for different educational backgrounds.

	Educational background	N	Mean	S.D.	*t*	*d*
H1	college student	46	4.47	0.51	-2.91**	-0.73
	Master	19	4.78	0.32		
H2	college student	46	4.48	0.52	-1.50	
	Master	19	4.64	0.33		

H3	college student	46	4.40	0.55	-2.80**	-0.66
	Master	19	4.69	0.29		
H4	college student	46	4.26	0.56	-1.21	
	Master	19	4.43	0.44		
H5	college student	46	4.58	0.54	-2.27*	-0.56
	Master	19	4.83	0.32		
H6	college student	46	4.43	0.53	0.14	
	Master	19	4.41	0.46		
H7	college student	46	4.40	0.54	-1.13	
	Master	19	4.56	0.44		
H8	college student	46	4.31	0.68	1.49	
	Master	19	4.04	0.61		
H9	college student	46	4.40	0.54	-1.25	
	Master	19	4.57	0.42		
H10	college student	46	4.41	0.61	-1.71	
	Master	19	4.64	0.44		

*p<.05; **p <.01

4.3 The effect of 10 heuristics (H) among different departments

Next, in order to verify the differences of the usability evaluation among 3 departments (INSA, IM and IT) in the information college, analysis of variance (one- way ANOVA) is used as shown in Table 5. The results showed that the recognition mean values of H8 (aesthetic and minimalist design) among 3 different departments has significantly difference in multiple comparisons (LSD) (p=0.41 < 0.05, F = 3.36). The recognition mean value of H8 of departments in INSA is 4.31, while that of departments in IM is 3.88 and that of departments in IT is 4.29. It means that, for H8, the level of acceptance of students of INSA is higher than that of IM. And the level of acceptance of students of IT is higher than that of IM. But there is no significantly difference between INSA and IT.

Table 5: The results of ANOVA for different departments on H8.

	Department	N	Mean	S.D.	*F*	Multiple comparisons (LSD)
H8	(a) INSA	35	4.31	0.67		(a>b)
	(b) IM	16	3.88	0.70	3.36*	(c>b)
	(c) IT	14	4.29	0.53		
	Total	65	4.23	0.67		

*p<.05

Finally, the results showed that H1 (visibility of system status), H3 (user control and freedom) and H10 (help and documentation) have significantly differences among 3 different departments in Post-Hoc test (Games-Howell), as shown in Table 6. The recognition mean (S.D., standard deviation) values of departments in INSA on H1, H3 and H10 were 4.48 (0.46), 4.36 (0.51) and 4.45 (0.52), while those of departments in IM were 4.48 (0.59), 4.51 (0.58) and 4.26 (0.74), and while those of departments in IT were 4.85 (0.23), 4.75 (0.24) and 4.80 (0.31). It means that, for H1 and H3, the level of acceptance of the students of IT is higher than that of INSA. For H10, the level of acceptance of the students of IT is higher than those of INSA and IM. But there are no significantly differences between INSA and IM.

Table 6: The results of ANOVA for different departments on H1, H3 and H10.

	Department	N	Mean	S.D.	*F*	Post Hoc (Games-Howell)
H1	(a) INSA	35	4.48	0.46	3.63*	(c>a)

	(b) IM	16	4.48	0.59		
	(c) IT	14	4.85	0.23		
	Total	65	4.56	0.48		
	(a) INSA	35	4.36	0.51		(c>a)
H3	(b) IM	16	4.51	0.58	3.28*	
	(c) IT	14	4.75	0.24		
	Total	65	4.48	0.50		
	(a) INSA	35	4.45	0.52		(c>a)
H10	(b) IM	16	4.26	0.74	3.71*	(c>b)
	(c) IT	14	4.80	0.31		
	Total	65	4.48	0.57		

*p<.05

5. Discussions

Firstly, we found that the recognition mean value of male users (4.60) is higher than that of female users (4.26) on H2. It means that male users feel the system is more in line with real-life logic than female users. In addition, the recognition mean value of male users (4.51) is also higher than that of female users (4.18) on H9. After interviewing with 2 male and 2 female users, the 2 female users pointed out that system operating instructions button can add some captions to make the explanation clearer. The 2 male users thought that the buttons and menu contents shown in the system can be used in common sense easily. This result is coincided with theory proposed by Misu (2001), i.e., the male users often have more positive attitude than female users when using computer technology for learning and female users need more detailed documentation when using the computer technology. So, we can added more detailed explanations in this kind of customized AR English learning system for the female users in future to enhance the usability and satisfaction of the system.

Secondly, we found that the recognition mean values of college students and Master users were 4.47 and 4.78 on H1, while those of them on H3 were 4.40 and 4.69, and while those of them on H5 were 4.58 and 4.83. For all these three mean values of heuristics, Masters have higher values than college students. After interviewing with 8 college students and 8 Master users, for H1 (visibility of system status), all college students thought that it is difficult to recognize the "real learning object" and "virtual related learning object" when learning with this system. Conversely, the Master users thought it can easily recognize which "object" they were learning with the Chinese text materials. For H3 (user control and freedom), the respondents of college students said that they had no particular views on the choice of pronunciation style, but whether the pronunciation can be heard clearly or not is most important when learning with this system. However, the respondents of Master users thought that since the functions of this system are developed mainly for 5-6 grade elementary school students, this kind of design can make these students focus on system operating more intently due to the personalization setting functions. For H5 (error prevention), the respondents of college students suggested that the system can provide more text prompts on the inputted screen of the accounts and passwords before login the system. But, the Master users thought that the documentation for instructions has provided detailed explanation in the "system explanations interface". From the above, the Master users have deeper observation and analysis than college students. The reason may be that the system development experiences and logical reasoning ability of the Master users in the information college are stronger than college students. This result is coincided with theories proposed by Chen and Macredie (2010) and Virvou and Katsionis (2008), i.e., the prior knowledge will affect the views of the system usability to this system.

Thirdly, we found that the recognition mean value of departments in IM (3.88) is lower than in INSA (4.31) and IT (4.23) on H8 (aesthetic and minimalist design). There were 3 respondents for each department. According to the results of interviews, all respondents of IM thought that the system's graphic design are not perfect and can be more refined. However, the respondents of INSA and IT thought that it is interesting of learning with AR technology while graphic design is secondary consideration. The reason for this situation may be the students of IM take art-related courses more than those of INSA and IT. In addition, the students of IM were enrolled to school in commercial category more than those of INSA and IT.

Finally, we also found that the recognition mean values of H1, H3 and H10 on departments of IT were 4.85, 4.75 and 4.80 which were higher than those in departments of INSA and IM. The reason for this situation may be the students in the departments of IT take more programing courses than the students on the department of INSA and IM. Overall, most of users thought that the usability of this customized AR English learning is very well and interesting.

6. Conclusions & Future Works

This study has developed a customized augmented reality English learning system and completed a usability assessment of it. According to the results of the analysis, we found that some human factors (gender, educational background and departments) will certainly cause significant difference when using this type of AR learning system, and we will improve the current system from the results.

In the near future, we will invite 2 teachers in an elementary school in central Taiwan to provide 100 English vocabularies suitable for grade 5 students and to conduct experimental teaching. The experimental subjects are 100 students of 4 classes, and the time for experiment is about total 8 weeks for 2 hours per week. All the operation process will be recorded in database so that further personalized preference analysis can be conducted in the future.

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The Effects of Drug Experience on Learners' Reaction to a Game-based Anti-Drug System

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Abstract: In this study, we proposed a game-based anti-drug system to assist people to understand the danger of drug abuse. In addition, we also examined how people's drug experience affected their reactions to the game-based anti-drug system. Thirty people, aged from 23 to 39, participated in this study and was classified into two groups, i.e., addictive people (N=14) and non-addictive people (N=16). Log files and a perception questionnaire were employed to collect and analyze participants' learning behaviors and learning perceptions, respectively. The results revealed that drug experience might affect people's reactions to the game-based anti-drug system. More specifically, the addictive people more focused on anti-drug materials while the non-addictive people emphasized on digital games, regardless of learning behaviors or learning perceptions.

Keywords: Drug experience, game-based learning, anti-drug materials

1. Introduction

In recent years, the spread of drugs endangers the life and health of the public. For example, the World Health Organization (2012) reported that there were 183,000 drug-related deaths around the world in 2012. Additionally, the sharing of injecting equipment among drug users made them particularly vulnerable to HIV (UNODC, 2014). Therefore, approaches, such as media broadcast news (e.g., Wakefield, Loken, & Hornik, 2010) and digital education programs (e.g., Longshore, Ghost-Dastidar, & Elickson, 2006), have been generally adopted to disseminate anti-drug materials and help people understand the harm caused by drug abuse. However, these two approached have some limitations.

For example, Wakefield, Loken and Hornik (2010) found that people' attitudes towards or behaviors related to drugs were not positively changed by watching a national antidrug media campaign. On the other hand, Thangrattana, Pathumcharoenwattana and Ninlamot (2014) found that youth preferred anti-drug materials delivered by interactive activities, such as games, instead of being delivered by formal education programs. Therefore, there is a need to find another approach to deliver anti-drug materials effectively and enhance people's understandings of the dangerous side effects of drugs.

Among various approaches, game-based learning seems a potential approach to address the above issue. This is due to the fact that digital games are engaging and adaptable to many subjects (Feldman, Monteserin, & Amandi, 2014). For instance, Meluso, Zheng, Spires, and Lester (2012) incorporated science context into an RPG online computer game and examined the relationships between science learning context and learners' learning performance and self-efficacy. The results indicated that learners' performance and self-efficacy in science were greatly improved after they played the game. In addition, Padrós, Romero, and Usart (2012) employed the MetaVals game to help post-graduate students learn finance concepts. Their results suggested that this game improved their finance concepts and there was an increase in common finance knowledge convergence. The aforementioned findings indicated that game-based learning could help learners gain knowledge from learning materials via game context. Due to such benefits, this study develops a game-based anti-drug system (GADS), where digital game-based learning is incorporated into anti-drug materials. In other words, the GADS provides two elements, i.e., anti-drug materials and digital games.

On the other hand, game-based learning contains rich and complex media elements, such as visual and audio elements, which may increase learners' cognitive load due to the processing of these elements (Nelson & Erlandson, 2008). Accordingly, it is also necessary to consider the risk of overloading a learner's working memory in game-based learning. In particular, not all of learners have such a capacity to cope with cognitive overload. For example, addictive people's neurocognitive functions may have been seriously damaged, including decision making and working memory. Regarding decision making, Brand, Roth-Bauer, Driessen, and Markowitsch (2008) examined how people with opiate dependence and health people performed differently while they played with a gambling game (i.e., the Game of Dice Task). Their results revealed that those with opiate dependence demonstrated abnormalities in decision-making and they chose the risky alternatives more frequently than the healthy subjects. Regarding working memory, Fernández-Serrano, Pérez-García, Río-Valle, and Verdejo-García (2010) analyzed the differential contribution of alcohol versus cocaine, heroin and cannabis use on the performance of working memory. The results indicated that substance-dependent individuals had significantly poorer performance of working memory than healthy control individuals.

To address aforementioned issues, the target learners of the GADS not only include people without drug addiction (or drug abuse) but also those with drug addiction. Therefore, diversities may exist between these two kinds of leaners, in terms of capabilities or experience. To this end, the aims of this study are two-folded. One is to develop a GADS while the other is to examine the effects of drug experience on learners' reactions to the GADS. More specifically, two research questions are examined in this study:

How does drug experience influence learners' learning behaviors when they interact with the GADS?

How does drug experience influence learners' learning perceptions when they interact with the GADS?

2. Methodology Design

To correspond to the aforementioned research questions, an empirical study was conducted to evaluate the effects of the game-based anti-drug system. The details are described in this section, including the implementation of the game-based anti-drug system, participants, questionnaire, experimental procedure, and data analysis.

2.1 The Implementation of Game-based Anti-Drug System

In order to deliver anti-drug materials through a game-based learning context, this research developed a game-based anti-drug system (GADS), where a drug dictionary was employed to present drug information. Unlike traditional anti-drug systems, the GADS allowed learners to customize four game elements, i.e., drug information, story mode, music/sound, and game hints so that the GADS could accommodate the needs of diverse learners.

- Drug Information: The information presented in the drug dictionary (Figure 1) consisted of three categories: drug pictures, side effects, and other information. As advised by Hsu and Chen (2010), adaptive ordering was adopted to allow users to modify the sequence of drug information based on their own preferences. Thus when users click one of the categories on the right side, the relevant drug information will be presented on the left side.
- Story Mode: As suggested by Wouters, Van Oostendorp, Boonekamp and Van der Spek (2011), the storytelling of games could increase learners' curiosity in game-based learning. Thus, users with the GADS could either choose a text-mode instruction or a story-mode instruction (Figure 2) to understand the scenarios, the goals, and the rules of the games.
- Music/Sound: As shown by Nacke, Grimshaw and Lindley (2010), music and sounds could help players engage in a game. Accordingly, six kinds of music were offered for the option of background music, including classic, blue, dancing, pop, metal, and horror, based on users' preferences. On the other hand, sounds will be used as alerts while users make errors. Furthermore, users could also turn on/off background music and sounds or modify their settings during the gaming process (Figure 3).

- Game Hints: The GADS includes three game tasks, i.e., farm management, drug dictionary and sheep curing. As indicated by Marchiori, Del Blanco, Torrente, Martinez-Ortiz, and Fernández-Manjón (2011), game hints could facilitate players to complete tasks so game hints were applied to provide additional support to help players accomplish these game tasks (Figure 4).

In summary, the design rationale of the GADS was learning by doing. While playing with the GADS, users' drug knowledge could be enhanced by completing the game tasks. By doing so, the GADS could help them realize the harm caused by drug abuse.

Figure 1. Drug Dictionary

Figure 2. Story Mode

Figure 3. Music/Sound

Figure 4. Game Hints

2.2 *Participants*

Thirty people, aged from 23 to 39, participated in this study. All of them have completed at least the high school education and have the basic computing and Internet skills to use the GADS. They were divided into two groups: addictive learners (N=14) and non-addictive learners (N=16). The former were recruited from the members of a nonprofit detoxification organization while the latter were selected from university students in Taiwan.

2.3 *Questionnaire*

To investigate how drug experience influenced learners' responses to the GADS in this study, we developed a questionnaire, which majorly included two parts to collect learners' preferences. The first part contained 30 questions with five-point Likert scale, ranged from 1 "strongly disagree" to 5 “strongly agree”. Thus, learners were required to indicate the level of agreement or disagreement with each statement that most closely reflected their opinions.

Furthermore, these questions were concerned with three topics, i.e., (1) the presentation of content and materials, such as “I like to see that the rules of the game are presented in a text-based way.”, (2) the operation and elements of the system, such as “Music can help me be more immersed in the game.”, and (3) the integration between materials and the game, such as “I have enough time to read the drug dictionary during the gaming process”. In other words, the design rationale of these topics was based on the key elements of the GADS, i.e., anti-drug materials and digital games, to capture learners’ perceptions to the presentations of anti-drug materials and the operations and elements of digital games.

The second part consisted of six open questions, which focused on identifying their experience about using the GADS. Therefore, learners were required to describe the problems they came across during the gaming process and their perceptions to the anti-drug materials and game elements offered by the GADS. The reliability of the questionnaire was found to be acceptable (α=0.78).

2.4 Experimental Procedure

To achieve the aims of this study, the procedure of this study consisted of two stages. Initially, all participants were introduced about the GADS and instructed how to use tools provided by the GADS. Subsequently, all participants were required to complete the game tasks by interacting with the GADS, and their playing behaviors were recorded in log files. After completing the game tasks, they needed to fill in the questionnaire to express their perceptions.

2.5 Data Analyses

The independent variable of this study was students’ drug experience whereas the dependent variables were their learning behaviors and learning perceptions. Learning behaviors were extracted from learners’ log files, such as the frequencies of using game hints, the frequencies of modifying music categories, and the frequencies of using the drug dictionary. Learning perceptions were determined by their responses to the closed and opened questions presented in the questionnaire. In other words, the results of this study consisted of both quantitative measurement and qualitative evaluation. The former was collected from the closed questions and analyzed with an Independent T-test, which is suitable to test “the difference between the means of two independent groups” (Howell, 2007), to identify differences between addictive learners and non-addictive learners. The level of significance was set at $p < .05$ for all comparisons.

The latter was collected from the opened questions of the questionnaire, and the responses of each group (i.e., addictive learners and non-addictive learners) were coded under the following categories: (1) the presentation of content and materials, (2) the operation and functions of the system, and, (3) the integration between the materials and games. Such qualitative evaluation can be applied to explain the results obtained from the quantitative measurement so that this study can obtain comprehensive information to clearly differentiate the needs and preferences of addictive and no-addictive learners.

3. Results and Discussion

To answer the research questions presented in Section 1, both learning behaviors (Section 3.1) and learning perceptions (Section 3.2) were analyzed in this study. Regarding the former, the effects of learning behaviors were extracted from the log files. Regarding the latter, students’ learning perceptions were examined with quantitative measurement and qualitative evaluation, which were conducted with the closed and opened questions of the questionnaire, respectively.

3.1 Effects on Learning Behaviors

Learners' learning behaviors were described by the log files of the GADS. According to the log files, significant differences were found between addictive learners and non-addictive learners (Table 1 and Table 2). More specifically, addictive learners made more clicks to complete game quests related to anti-drug materials, such as selecting antidotes to heal addictive sheep, while non-addictive learners made more clicks to complete game quests associated with digital games, such as planting fruits and shaving sheep. In brief, these findings implied that the addictive learners focused on the anti-drug materials while the non-addictive learners emphasized on digital games.

Table 1: Game quest related to anti-drug materials.

Variables	Drug Experience	*M*	*SD*	*t*	*p*
The frequencies of healing the addictive sheep	addictive learners	226.57	85.19	2.665	.013*
	non-addictive learners	161.81	44.07		
The frequencies of attempting to select the antidotes	addictive learners	33.64	11.53	2.576	.016*
	non-addictive learners	24.31	8.22		

* $p<.05$

Table 2: Game quest related to digital games.

Variables	Drug Experience	*M*	*SD*	*t*	*p*
The frequencies of planting fruits in the garden	addictive learners	366.07	228.57	-3.214	.003*
	non-addictive learners	697.75	321.20		
The frequencies of shaving the sheep	addictive learners	29.14	20.624	-3.258	.004*
	non-addictive learners	49.13	10.77		

* $p<.05$

3.2 Effects on Learning Perceptions

3.2.1 Quantitative Measurement

An independent T-test was conducted to examine whether addictive learners and non-addictive learners made different responses to the closed questions of the questionnaire. It was interesting to see that significant differences between addictive learners and non-addictive learners were found in the aspects of anti-drug materials and digital games. Regarding anti-drug materials, significant differences existed in Q12 and Q16 (Table 3), which were applied to examine learners' responses to the content and presentation of anti-drug materials provided by the GADS.

As shown in Table 3, the addictive learners would more prefer to read all the information provided by the GADS even though some of the information might not be helpful for them to heal addictive sheep, as suggested by the results of Q16 (*I would read all the side effects of the drug dictionary even some of them could not be applied to heal the sheep which is addicted*). Conversely, the non-addictive learners majorly focused on game activities which might not be related to anti-drug materials. More specifically, the non-addictive learners would relatively ignore the drug information which was not associated with the game quests during the gaming process, as implied by the results of Q12 *(I would not read the drug information which would not be applied to complete the game quests even I have enough time*).

Furthermore, the non-addictive learners would only favor to read the information of side effects that could be used to play the quests, e.g., to heal addictive sheep. Such responses from the non-addictive learners echoed their learning behaviors presented in Section 3.1, which indicated that the non-addictive learners paid more attention to playing digital games. Regarding digital games, a significant difference was found between the addictive learners and non-additive learners in their responses to Q27 (*Completing the game tasks is the most important thing during the game process*). More specifically, the non-additive learners would more strongly consider that completing the game tasks was the most important thing when interacting with the GADS, compared with the addictive learners (Table 3). Once again, this findings suggested that playing the digital games was what the non-addictive learners were very concerned.

Table 3: Learning perceptions of addictive and non-addictive learners.

Variables	Drug Experience	*M*	*SD*	*t*	*p*
Q12	addictive learners	3.29	0.99	-2.303	.029*
	non-addictive learners	4.06	0.85		
Q16	addictive learners	3.21	1.00	-2.621	.014*
	non-addictive learners	2.13	1.26		
Q27	addictive learners	2.43	1.22	-3.093	.004*
	non-addictive learners	3.81	1.22		

* $p<.05$

In brief, the addictive learners and non-addictive learners focused on different elements of the GADS. The addictive learners showed major interests in the anti-drug materials of the GADS so they would like to read all the anti-drug materials while completing the game quests. On the other hand, the non-addictive learners majorly concentrated on the digital games of the GADS and the information related to the game guests. Such a difference might be because the addictive learners and non-addictive learners had different past experience. More specifically, the addictive learners ever took drugs so the anti-drug materials provided by the GADS were linked to their past experience. However, the non-addictive leaners so far did not touch drugs so the anti-drug materials were not associated with the experience of the non-addictive leaners.

3.2.2 Qualitative Evaluation

Based on the responses from the opened questions, qualitative evaluation was conducted to illuminate the aforementioned phenomena identified in the quantitative data, which revealed that the addictive learners focused on the anti-drug materials while the non-addictive learners concentered on digital games. On the other hand, the qualitative results indicated that (1) the addictive learners would spend effort to remember the information displayed in the drug dictionary during the gaming process, (2) they perceived that the GADS could help them learn more about drugs, and (3) they did not pay attention to the game elements that were irrelevant to the anti-drug materials, as shown in Table 4.

Conversely, the game tasks were the focus of the non-addictive learners and their immersion and anxiety could be affected by the outcomes of digital games, as shown in Table 5. Such qualitative findings were not only consistent with those from the quantitative measurement presented in Section 3.2.1, but also might explain why the addictive learners and non-addictive leaners were interested in different aspects of the GADS.

Table 4: The perceptions of addictive learners.

	Qualitative information	
Addictive Learner	●	Anti-drug Materials
	1.	I try hard to remember the information of the drug dictionay during the gaming process .
	2.	The game help me learn more information about drugs.
	3.	I do not pay much attention to the game elements because these elements are not related to the drug imformation.

Table 5: The perceptions of non-addictive learners.

	Qualitative information	
Non-addictive Learner	●	Digital Games
	1.	I focus on completing the game tasks so I do not read the drug dictionary carefully.
	2.	I feel nervous if sheep eat drugs and become ill so I do not read the drug dictionary carefully.
	3.	I am immersed in taking care of sheep so I did not pay too much attention to drug information.

3.3 Discussion

As shown in the previous sections, drug experience has impacts on learners' learning behaviors and learning perceptions when they interacted with the GADS. More specifically, the addictive learners favored to read the whole information of anti-drug materials even though some information was irrelevant to the game quests of the GADS while the non-addictive learners were more concerned about the digital games of the GADS so they paid less attention to the anti-drug materials that were not helpful to complete the game quests of the GADS. In other words, learners might have different characteristics, which might influence how they used the GADS.

Therefore, there is a need to provide personalization so the design of game-based anti-drug systems could support the needs of diverse learners. More specifically, the drug dictionary should be personalized. The addictive learners could complete the game quests (e.g., the healing of addictive sheep) with partial drug information while the non-addictive learners should use complete drug information presented in the drug dictionary to play the game quests. By doing so, the addictive learners could perceive the entertainment provided by the GADS whereas the non-addictive learners could use the GADS to improve their understandings of drug information.

4. Conclusion

We proposed a game-based anti-drug system (i.e., the GADS) to assist people to understand the side effects of drugs and investigated how people reacted to the GADS. In addition, people' drug experience was also considered in this investigation. Accordingly, two research questions were examined in this study. Regarding the first research question, i.e., how does drug experience influence learners' learning behaviors when they interact with the GADS, the results suggested that the addictive learners more concentrated on anti-drug materials whereas the non-addictive learners put more emphasis on digital games.

Regarding the second research question, i.e., how does drug experience influence learners' perceptions when they interact with the GADS, likewise, the results revealed that the addictive learners were more interested in the anti-drug materials while the non-addictive more focused on digital games, regardless of quantitative measurement or qualitative evaluation. These aforementioned results provided interesting findings on how drug experience affected learners' reactions to a game-based anti-drug system and such findings could be employed in the design of personalized game-based anti-drug systems that can accommodate people with different characteristics, skills and background. However, this study is conducted with a small-scaled sample so a large-scaled sample should be undertaken in future work to provide more evidence.

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Assessment Differences between Teachers and Students in the Context of Peer Response: A Cognitive Style Approach

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Abstract: Peer assessment is useful for the improvement of English writing. However, individual differences exist between students and might affect how they assess peers' works. Hence, individual differences need to be considered in peer assessment. Among various individual differences, cognitive styles have essential impacts on student learning. Thus, this research investigated assessment differences between teachers and students in the context of peer response from a cognitive style perspective. The results suggest that there were no assessment differences in the first draft but assessment differences did exist in the revised drafts. This might be because students might feel difficult to identify improvement due to their insufficient experience. On the other hand, Holists usually paid more attention to the content at a superficial level while Serialists had difficulties in the connection between topics and the content. In brief, the findings from this study demonstrated that each student took a unique way to do assessment. Furthermore, such findings can guide instructors to deliver effective peer assessment in the future.

Keywords: Peer assessment, peer response, cognitive styles, assessment differences

1. Introduction

In the past decade, peer assessment is considered as an effective strategy to improve student learning (Dochy, Segers and Sluijsmans, 1999; Ballantyne, Hughes and Mylonas, 2002). In particular, it is useful for the improvement of English writing (Rollinson, 2005, Hyland and Hyland, 2006). Due to such advantages, researchers attempted to incorporate peer assessment into technology-based learning (Shih, 2011; Woo, Chu and Li, 2013; Wichadee, 2013; Chwo, 2015) in recent years and they found that such online peer assessment had positive effects on English writing. For example, Shih (2011) investigated the effect of incorporating peer assessment and Facebook on English writing and the results indicated that the peer assessment continuously enabled students to self-examine, review, observe, and make comments on each other's work. Furthermore, they also gained more detailed knowledge from other works. By doing so, students' abilities could be improved, in terms of organization, grammar and structure, content, vocabulary, and spelling. Similar results were found in Woo, Chu and Li (2013), who used the Wiki to support collaborative writing in a Chinese primary school in Hong Kong and the results indicated that the more comments posted, the more revisions made. Additionally, the more revisions made, the better the quality of students' writing. Likewise, Wichadee (2013) also found that the students paid more attention to their written works when they realized that such work would be reviewed or read by their peers. Consequently, students' writing performance was significantly improved.

However, some studies indicated that peer assessment had negative effects (Nicolaidou, 2013; Hoogeveen and Gelderen, 2013; Wang, 2014; Ruegg, 2015). For instance, Hoogeveen and Gelderen(2013) argued that students with limited mastery of writing so it is difficult for them to pay attention to revising the works and to giving constructive comments simultaneously. Additionally, they might emphasize on rule-based comments (e.g. subject/verb agreement and pronoun agreement), and ignored non-rule based suggestions (e.g. inappropriate word choices and awkward sentence structure) due to limited English proficiency. Hence, the authors might not be able to perceive usefulness of peer feedback (Wang, 2014). Furthermore, the peers' feedback was not always correct and sometimes it was repetitive in the sense that more than one person identified the same mistake (Nicolaidou, 2013). For instance, Ruegg(2015) found that the surface-level grammar feedbacks given by peers were highly inaccurate and were ineffective in improving grammatical accuracy even though the students gave more surface-level grammar feedbacks than the teachers.

On the other hand, individual differences exist between students so they have distinctive strengths and weaknesses, which might affect how they assessed the peers' works. Among various individual differences, cognitive styles have essential impacts on student learning (Chen and Liu, 2011). In particular, Pask (1979) Holism/Serialism is considered as an influential cognitive style in student learning (Chen and Chang, 2014; Huang, Hwang and Chen, 2014). In general, learners with a holistic style prefer tened to take a global learning approach while those with a serialistic style prefer to use a local learning approach. Additionally, Jonassen and Grabowski (2012) claimed the Holists prefer to a "whole-to-part" approach to process information whereas the Serialists prefer to take a "part-to-whole" sequence to process information. Due to such differences, recent studies attempted to put effort to investigate how Holists and Serialists reacted differently to technology-based learning. For instance, Chan, Hsieh and Chen (2014) investigated how Holists and Serialists used electronic journals via mobile devices, and found that Holists favored to use the Basic Search that can obtain an overall picture while Serialists preferred to use Boolean operators to obtain specific details via the Expert Search. In brief, great differences exist between Holists and Serialists. Nevertheless, paucity of research examined their differences in the context of peer assessment. Thus, this study attempts to address this issue. To this end, the aims of are two-folded. One is to examine assessment differences between students and teachers while the other is investigate how Holists and Serialists assess peers' works differently. By doing so, this study can not only identify differences between students and teachers in the context of peer assessment but also fill the gap where cognitive style was ignored in peer assessment by past research.

2. Methodology

2.1 The Peer Assessment of Writing System

The design features of the Peer Assessment of Writing System (PAWS) included Convenience, Flexibility and Helpfulness. The details are described in subsections below.

(A) Convenience: The PAWS was implemented on the Internet Information Services (IIS). Thus, both authors and assessors can access the PAWS via the browsers with convenience. By doing so, the authors can write academic papers conveniently and the assessors can easily give comments as well. Moreover, the PAWS provided favorable functionalities for authors and assessors. More specifically, the authors could not only re-examine the suggestions obtained from students and teachers but also reviewed their previous drafts anytime when they did the revision. On the other hand, the assessors can re-check their previous comments to do the assessment correctly.

(B) Flexibility: The PAWS provided two approaches to deliver comments, such as Comments with the tags and Comments within the content. Regarding the former, assessors could tag the mistakes or flaws based on three aspects, i.e., Logic, Grammar and Vocabulary. Regarding the latter, they could also compose the comments or revise the errors within the content of articles. By doing so, the students could not only follow the criteria of three aspects (Logic, Grammar and Vocabulary) to give precise comments, but also they could give additional comments within the content. Thus, the assessors could deliver comments based on their own preferences and the authors could receive various advices, with which they can do comprehensive revision.

(C) Assistance: In order to facilitate Learning by Doing, the PAWS provide various resources to help students to evaluate the academic papers, including Writing Guidance, English Grammar and Marking scheme.

- Writing Guidance: to help reviewers to identify the quality of the drafts, including Writing skill (i.e., to describe what a high-quality paper is), Contents presentation (i.e., to describe how to structure a paper) and Logical relationships (i.e., to describe how to make a logical link between each sentence and between each paragraph). .
- English Grammar: to help students to improve their understandings of English grammar, such as preposition, basic English grammar, the rules of speech, ambiguous vocabularies, as well as the use of relative pronouns and relative adverb.
- Marking scheme: to provide marking criteria so that the students can know how to assess each work.

In brief, all of the above resources can not only be applied to help students give precise comments, but also to be employed to improve their writing abilities.

2.2 Study Preferences Questionnaire(SPQ)

To compare the assessment of Holists and Serialists, this study used the Chinese version of the Study Preferences Questionnaire (SPQ) to identify students' cognitive styles. This is due to the fact that the SPQ has been used in several studies (Clewley, Chen and Liu, 2010; Mampadi et al., 2011) in past research. The original version of the SPQ was produced by Ford (1985), who created 17 item-inventory and each inventory comprise two statements. The students were asked indicate their degree of agreement with either statement. If half of their statements are related to Holists, they are identified as Holists. Conversely, if half of their statements are related to Holists, they are identified as Serialists.

2.3 Marking Sheet

The marking sheet was divided into two parts: (1) Personal information (2) Marking scheme. The first part contains students' registration numbers and names. The second part was adopted from the IELTS, which is a worldwide mechanism to assess the English language proficiency and is widely applied in various schools or universities in English-speaking countries. In particular, the IELTS was applied in the EAP (English for academic purposes), which is a professional organization in English training (Green, 2005, Morton, Storch and Thompson, 2015). Hence, the IELTS criteria were applied in the second part of the marking sheet, including Task achievement, Coherence and cohesion, Lexical resource and Grammatical range and accuracy. Task achievement is about whether the writers fully address all parts of the academic papers. Coherence and cohesion are concerned whether the authors can make clear links between sentences and paragraphs skillfully. Lexical resource is to appraise whether the authors use a wide range of vocabulary and seldom make minor errors. Finally, the Grammatical range and accuracy is to evaluate whether the writers uses a wide extent of grammar structures with flexibility and accuracy. Each of the aforementioned aspects is out of 25 marks so the full mark is 100.

2.4 Experiment Procedures

A total of 16 individuals participated in this study. These participants were students at the northern university in Taiwan, and they had basic computing and Internet skills to use the PAWS. At the initial stage of the experiment, the SPQ was applied to identify their cognitive styles. The results of the SPQ indicated that there were eight Holists and eight Serialists. In order to help the participants know how to act as assessors, they were provided a series of three-hour training courses at the second stage. The training courses lasted for ten weeks, each of which was three hours long, including English grammar, English paper reading, and the assessment of English academic works. In the end of the training courses, the participants were instructed how to use the PAWS to do assessments. After completing the training courses, the participants started to do the assessment at the third stage. The assessment included four activities, the details of which are described in Table 1.

To enhance the reliability of the results from this study, the assessment activities described in Table 1 took place twice. Accordingly, the students and teachers need to assess eight papers, including four first drafts and four revised drafts. Thus, the assessment differences between the students and those from the teachers were discovered via these four first drafts and four revised drafts.

Table 1. Four activities at the third stage

1	To write the first draft	The authors needed to compose the first draft, which introduced their own research topics.
2	To assess the first draft	Both of the students and teachers gave comments via the PAWS and filled out the marking sheet for the two first drafts that the teachers randomly chose.
3	To do the revision	Authors had to revise the first drafts according to the comments from the students and the teachers.
4	To assess the revised draft	Both of the students and teachers gave comments via the PAWS and filled out the marking sheet for the two revised drafts.

2.5 Data Analysis

To examine the reliability and validity of peer assessment, the assessment differences between teachers and students were examined. Data analyses included two parts: (1) quantitative measurement, and (2) qualitative evaluation. The first part, which was collected from scores of the students and the teachers that were assigned for the four first drafts and four revised drafts, was administered with the Independent T-test so that the significant difference between scores from the students and those from the teachers could be identified. This is due to the fact that the Independent T-test was suitable to compare the means of two Independent samples (Stephen and Hornby, 1997). The second part was collected from comments collected via the PAWS and such comments were categorized into Task achievement, Coherence and cohesion, Lexical resource as well as Grammatical range and accuracy. By doing so, such comments can be applied to support the results of quantitative measurement so that the comprehensive information could be obtained to clarify the assessment differences between the students and teachers.

3. Results and Discussion

This section describes the results of this study, which are divided into two parts: (1) Overall Scores and (2) Detailed Scores (Task achievement, Coherence and cohesion, Lexical resource, Grammatical range and accuracy). Each part includes differences between all students' scores and teachers' scores, between Holists' scores and teachers' scores, as well as between Serialists' scores and teachers' scores.

3.1 Overall Score

Table 2 and Table 3 display scores differences in the first draft and those in the revised draft, respectively. Both of them covered the scores given by the students and those obtained from the teachers. No significant difference was found between the scores from the teachers in the first draft while there was a significant difference in the revised draft. This might be due to the fact that the author lacked sufficient understandings of how to write academic papers so both students and teachers gave low scores for their first draft. However, authors' understandings could be enhanced after they received the peers and the teachers' feedbacks, which could help them make improvement in their revised works.

Table 2: The independent t-test of first draft of overall score.

Capacity	Mean	SD	t	Sig.
Students vs. Teachers				
Students	67.596	10.513	-0.477	0.635
Teachers	69.469	9.790		
Holists vs. Teachers				
Holists	66.258	11.289	-0.733	0.469
Teachers	69.469	9.790		
Serialists vs. Teachers				
Serialists	68.933	9.681	-0.139	0.890
Teachers	69.469	9.790		

Table 3: The independent t-test of revised draft of overall score.

Capacity	Mean	SD	t	Sig.
Students vs. Teachers				
Students	69.796	10.527	-2.301	0.025*
Teachers	78.594	6.233		
Holists vs. Teachers				
Holists	69.208	11.271	-2.250	0.031*
Teachers	78.594	6.233		
Serialists vs. Teachers				
Serialists	70.383	9.885	-2.222	0.033*
Teachers	78.594	6.233		

On the other hand, teachers and students had different levels of experience in reviewing authors' revised works. Teacher had a high level of experience whereas students had a low level of experience. Accordingly, it was easy for teachers to identify the improvement that authors made but students might feel difficult to identify such improvement. This might be the reason why a significant difference was found in their revised works. More specifically, the score of the revised draft from the Serialists was higher than those from the Holists. This might be due to the fact that Serialists were used to focusing on procedural details so that they paid more attention on the micro level of academic papers. Conversely, Holists emphasized the macro level. Hence, Serialists could more easily identify the improvements that the authors made in the revised works than Holists did. This is reason why the Serialists gave higher scores than Holists.

3.2 Detailed Scores

3.2.1 Teachers vs. Students

Table 4 and Table 5 display the difference between scores from teachers and those from the students in each part of the marking scheme, including Task achievement, Coherence and cohesion, Lexical resource and Grammatical range and accuracy. The results appeared similar to those of the overall scores presented in Section 3.1, where the significant difference between the students and the teachers did not exist in the first draft while the significant difference were found in the revised work. As mentioned above, the authors lacked adequate experience of writing academic papers so that both students and teachers gave low scores for their first drafts. In most of the parts, the scores from the students were lower than those from the teachers in the first draft. However, an exception was found in the part of grammatical range and accuracy, where the scores from the students were higher than those from the teachers. , This might be owing to the fact that teachers possessed a higher level understanding of English grammar so that they could identify most of grammar errors while students could not discover certain grammar errors due to poor understandings of English grammar.

Table 4: The independent t-test of first draft of detailed score by students and teachers.

Aspects	Capacity	Mean	SD	t	Sig.
Students vs. Teachers					
Task Achievement	Students	17.368	3.300	-1.724	0.089
	Teachers	19.436	2.060		
Coherence and Cohesion	Students	16.520	3.745	-0.053	0.958
	Teachers	16.594	3.105		
Lexical Resource	Students	16.846	2.252	-0.430	0.647
	Teachers	17.219	2.707		
Grammatical Range and Accuracy	Students	16.862	2.582	0.640	0.524
	Teachers	16.219	3.331		

Table 5: The independent t-test of revised draft of detailed score by students and teachers.

Aspects	Capacity	Mean	SD	t	Sig.
Students vs. Teachers					
Task Achievement	Students	17.983	3.126	-2.545	0.013*
	Teachers	20.875	1.885		
Coherence and Cohesion	Students	17.358	3.312	-1.800	0.076
	Teachers	19.531	2.140		
Lexical Resource	Students	17.333	2.534	-2.205	0.031*
	Teachers	19.375	1.711		
Grammatical Range and Accuracy	Students	17.120	2.758	-1.677	0.098
	Teachers	18.812	1.898		

Regarding the revised draft, significant differences were found in the Task achievement and the Lexical resource parts. Regarding the Task achievement part, the scores from students were lower than those from the teachers. On the other hand, the results from qualitative data indicated that the students gave very few comments related to the Task achievement. In particular, the number of comments for the Task achievement was lower than that of the Coherence and cohesion though these two parts are concerned with the logic relationships of academic papers. These findings suggested that students could not do what teachers did because they could not precisely identify the connection between the topic and the content presented in the revised works. In brief, the students seemed to struggle for giving scores in the part of the Task achievement so a significant difference existed between the scores from teachers and those from students.

Regarding Lexical resource, the scores from students were also lower than those from the teachers. The authors modified the first draft according to comments from the students and the teachers so plentiful vocabularies were displayed in the revised draft. On the other hand, teachers, who were familiar with diverse vocabularies, could precisely evaluate academic papers. However, students were short of competence to identify such vocabularies so that they had an obstacle to assign the scores. Thus, they could not uncover the improvement that the authors made, which resulted in a significant difference between the scores from teachers and those from students.

3.2.2 Holists vs. Serialists

Table 6 and Table 7 display the difference of scores between Holists and teachers and between Serialists and teachers in the first draft and the revised draft, in terms of Task achievement, Coherence and cohesion, Lexical resource and Grammatical range and accuracy. The results was also similar to those presented in Section 3.1, where significant differences between Holists and teachers and between Serialists and teachers did not exist in the first draft, but significant differences were found in the revised draft. Although there was no significant difference in the first draft, there was an interesting finding. More specifically, the scores from Holists and Serialists were lower than those teachers but two exceptions were found. One was the Serialists gave higher scores than the teachers in the part of Coherence and cohesion while the other was the Serialists assigned higher scores than the teachers in the part of Grammatical range and accuracy. Regarding the former, Serialists tended to take an depth-first approach where the assessment of Coherence and cohesion emphasized on an breadth-first framework. Thus, they were not good at the evaluation of Coherence and cohesion. This is reason why the Serialists gave higher scores than the teachers. Regarding the latter, Serialists usually used a local approach to learning so they may merely focused on the grammar error in a single sentence, instead of the grammatical correctness in the whole draft. Conversely, teachers were able to consider both conditions so that they could identify almost all grammar errors. Thus, the teachers would give lower scores than the Serialists.

Table 6: The independent t-test of first draft of detailed score by Holists, Serialists and teachers.

Aspects	Capacity	Mean	SD	t	Sig.
Holists vs. Teachers					
Task Achievement	Holists	17.318	3.372	-1.687	0.100
	Teachers	19.436	2.060		
Coherence and Cohesion	Holists	16.175	3.636	-0.297	0.768
	Teachers	16.594	3.105		
Lexical Resource	Holists	16.717	2.532	-0.491	0.626
	Teachers	17.219	2.707		
Grammatical Range and Accuracy	Holists	16.050	2.802	-0.146	0.885
	Teachers	16.219	3.331		
Serialists vs. Teachers					
Task Achievement	Serialists	17.417	3.283	-1.647	0.108
	Teachers	19.436	2.060		
Coherence and Cohesion	Serialists	16.867	3.881	0.183	0.108
	Teachers	16.594	3.105		
Lexical Resource	Serialists	16.975	1.967	-0.287	0.775
	Teachers	17.219	2.707		
Grammatical Range and Accuracy	Serialists	17.675	2.086	1.176	0.271
	Teachers	16.219	3.331		

Table 7: The independent t-test of revised draft of detailed score by Holists, Serialists and teachers.

Aspects	Capacity	Mean	SD	t	Sig.
Holists vs. Teachers					
Task Achievement	Holists	17.867	3.011	-2.674	0.011*
	Teachers	20.875	1.885		
Coherence and Cohesion	Holists	17.125	3.340	-1.924	0.062
	Teachers	19.531	2.140		
Lexical Resource	Holists	17.425	2.751	-1.898	0.066
	Teachers	19.375	1.711		
Grammatical Range and Accuracy	Holists	16.792	3.015	-1.793	0.081
	Teachers	18.812	1.898		
Serialists vs. Teachers					
Task Achievement	Serialists	18.100	3.284	-2.277	0.029*
	Teachers	20.875	1.885		
Coherence and Cohesion	Serialists	17.125	3.340	-1.924	0.062
	Teachers	19.531	2.140		
Lexical Resource	Serialists	17.242	2.342	-2.401	0.022*
	Teachers	19.375	1.711		
Grammatical Range and Accuracy	Serialists	17.450	2.482	-1.439	0.159
	Teachers	18.812	1.898		

Regarding the revised draft, the significant differenced were found in Task achievement and Lexical resource parts. Regarding Task achievement part, both scores from the Holists and the Serialists were higher than those from the teacher. As mentioned above, Serialists usually focused on a local aspect. However, the assessment of Task achievement needs to be conducted with a global approach. Furthermore, the results from qualitative data revealed that the Serialists did not give any comments of Task achievement in an academic work. These findings suggest that Serialists might meet difficulties in the assessment of Task achievement so they also could not identify the improvement that authors made, which resulted in the scores from Serialists were lower than those from teachers.

After examining the comments from Holists, we found that they usually paid more attention to the content at a superficial level so the comments are not deep enough in the revised draft. These findings revealed that the Holists could not identify in-depth improvement that authors made. This may be the reason why the scores from the Holists were lower than those from the teachers. In addition, the diversity existed between the score from the Holists and those from the Serialists, where the Holists gave lower scores than the Serialists. This might be due to the fact that the assessment of the Task achievement, which emphasized on whether the content of the academic papers was relevant to the topic, needed to have an overall picture of the subject content. Thus, Holists, who utilize global approach to learning, are more suitable to evaluate the part of Task achievement than Serialists presumably. Therefore, Holists were able to identify the mistakes in the part of Task achievement so they assigned the lower scores than the Serialists.

Regarding Lexical resource, only one significant difference was found between the Serialists and the teachers. More specifically, the scores from the Serialists were lower than those from the teachers. According to results obtained from the qualitative data, Serialists seemed to misunderstand the definition of Lexical resource, which emphasized on the use of vocabularies. However, they considered all vocabulary changes as lexical resources. For example, tense and singular and plural nouns should be regarded as grammatical errors, instead of lexical resources. Hence, they found more errors in the part of Lexical resource so that the scores from them were significantly lower than those from the teachers.

4. Conclusions

This research aims to investigate assessment differences between teachers and students in the context of peer response from a cognitive style perspective. Among various cognitive style dimensions, we focused on Holism/Serialism. Our results indicated that there were no assessment differences in the first draft but assessment differences did exist in the revised drafts. This might be due to the fact that the students did not have sufficient experience so they were not able to identify the improvement that authors made in the revised drafts.

Regarding the revised draft, assessment differences were found in the Task achievement and the Lexical resource parts. Regarding the Task achievement, the students could not precisely identify the connection between the topic and the content presented in the revised works. Furthermore, Holists and Serialists met different difficulties in this aspect because of their different characteristics. Regarding Lexical resource part, the students were short of competence to identify vocabularies used in peers' works. Thus, they could not uncover the improvement that the authors made and could not assign the scores precisely. Moreover, Serialists seemed to misunderstand the definition of Lexical resource so they considered all vocabulary changes as Lexical resources. Accordingly, they found more errors in the Lexical resource and their scores were significantly lower than the teachers'.

Such results might help instructors understand students' difficulties in peer assessment. Subsequently, instructors can know how to provide students additional support based on their cognitive styles. However, this research has several limitations. Firstly, the sample is small so further works need to use a bigger sample to verify the findings presented in this research. Additionally, only one cognitive style was identified so future works should consider other cognitive styles to obtain more comprehensive results.

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Online Student-Constructed Test versus Online Student-Generated Questions: Students' Relative Preference, Perceived Effects for Promoting Learning, and Perceived Difficulty

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Abstract: Primary school students' relative preference, perceived effects for promoting learning, and perceived difficulty regarding online student-constructed tests (SCT) and student-generated questions (SGQ) learning activities were examined. Three fifth-grade classes (N=82) participated as part of their science learning activities for eleven weeks. An online system was adopted to support the associated learning activities. Five important findings were obtained. First, the majority of the participants did not associate SGQ or SCT with the feeling of difficult or very difficult, after being exposed to both tasks for an extended period of time. Second, a substantial proportion of students regarded SGQ and SCT as at the optimal challenging level. Third, X^2 tests indicated that participants' preferences toward SGQ and SCT were not statistically significant (X^2 =0.7), but were significant in perceived effects for promoting learning and perceived difficulty, with more participants selecting SGQ over SCT. Fourth, SGQ's facilitating effects for better promoting learning were well perceived despite that predominate percentage of the participants regarded SGQ as more difficult than SCT. Fifth, SCT's potential for knowledge integration and elaboration was rarely recognized by the participants. Implications for instruction are offered.

Keywords: online learning activities, perceived difficulty, perceived effects for promoting learning, revealed preference, student-constructed test, student-generated questions

1. Introduction

In contrast to traditional assessment approaches where learners are predominately assessed by teachers using paper-and-pencil achievement tests, in response to contemporary education paradigms, student-generated questions approach (hereafter called SGQ) has attracted the attention of an increasing number of researchers and practitioners since the past decade. Under the umbrella of multiple assessment, SGQ prides itself on providing students with opportunities to reflect back on what they view as relevant and important in the study material and generate question items around the identified areas for self- and peer-assessment. With its focus on learners and assessment for learning, and strong theoretical bases (e.g., information-processing theory, constructivism, and metacognition), empirical studies for its effects on various aspects (e.g., academic performance, attitude toward the learned subject, learning motivation, use of cognitive and metacognitive strategy) have generally been positive (Yu, 2012).

In view of its prevalent learning effects, in an attempt to further promote its fluidity, flexibility, and effectiveness, different arrangements and designs of SGQ have been proposed, for instance SGQ with online prompts in the form of key terms (Yu and Pan, 2014), SGQ under a cooperative learning situation (Yu, Wu and Hung, 2014), and SGQ with access to online database with peer-generated questions (Yu and Yang, 2014). Along this line of thought, some researchers experimented the ideas of having students construct tests around the study material (i.e., student-constructed tests, called SCT), and promising results for its support for learning and assessment have been obtained. For instance, Yu (2013) examined undergraduates' perceptions toward SCT and traditional teacher-constructed tests. Results from this preliminary study showed that the distribution of preferences for and perceptions of these two approaches were statistically significant (X^2=48.11, X^2=22.11). Specifically, more than three-quarters of the participants selected SCT as the preferred approach for learning assessment, and more than 60% of the participants felt SCT as having better learning effects. Further constant comparative analysis of students' responses to a questionnaire regarding their experience to SGQ relative to SCT and content analysis of all items contained in the SCT all pointed to SCT's pedagogical potential for knowledge integration and elaboration (Yu and Su, 2013a, b). In another study, Yu and Wu (2015) examined the comparative effects of SCT and SGQ and empirically attested SCT' superiority for the promotion of knowledge construction in term of the breadth, depth, and interconnectivity of knowledge.

While recognizing SCT's distinct potential and effects for learning, the aforementioned studies involved undergraduate students. In view of the fact that the cognitive development and processing capability of students at different age levels are different, and that the range of tasks to be attended to during SGQ and SCT are vary (i.e., relevancy, importance, correctness of wording and punctuation, and clarity of meaning and logic of each question generated as the focus of SGQ while complete and appropriate coverage of main ideas, and appropriate item sequencing as the focus of SCT, on top of those associated with SGQ), SCT's applicability to younger age groups warrant further investigation. Hence, this study involved primary students, and their revealed preference, perceived effects for promoting learning, and perceived difficulties with regard to online SCT as compared to online SGQ were examined.

2. Methods

Three fifth-grade classes (N=82) participated in this study in the school's science lab. Two units were covered during the study: properties of an aqueous solution (e.g., PH, conductivity), and forces and motion. Three 40-minute instructional sessions were allocated for science each week. The learning activities (SGQ and SCT) were introduced to support students' science learning. Considering their predominate presence in primary school settings and students' familiarity with their forms, two question types were selected for the activity: yes/no and multiple-choice.

A four-session training session was arranged in two weeks to equip the participants with the needed knowledge and skills associated with SGQ and SCT. Topics introduced include: locating the main ideas of the study material and generating questions around the identified target in conformance with a set of criteria; generating yes/no questions in the adopted SGQ system with reference to the set criteria; generating multiple-choice questions in the adopted SGQ system with reference to the set criteria; constructing a test based on generated questions in the adopted SCT system with reference to the set criteria.

For the actual study, as a routine on a weekly basis, students were directed to individually generate five yes/no and multiple-choice question items according to the learned science material covered in the current week in the adopted online SGQ space at the last 20 minute of the instructional time. Basically, students first located areas they deemed important and relevant. Then, they generated questions around the identified areas. Finally, they keyed in their generated questions in the SGQ system using their I-pad mini, which is consisted of three fields—question (for multiple-choice questions, question is constituted of a question stem and four options), answer key, and annotation.

As a conclusion of each science unit, students were requested to construct a test, either based on questions already stored in the SGQ, or they could generate new items in the online SCT system, at the last instructional session (40 minutes). Essentially, for SCT, using their I-pad mini, students first decided the number and scoring scheme for each of the question type (i.e., test-planning stage). Students then viewed and selected any questions to be included in a test, or generated new yes/no and multiple-choice items, if feeling the need to ensure test comprehensiveness (i.e., test-compilation stage). Finally, students re-arranged the relative sequence of questions both within and between question types before submission (test-setting stage).

After participants experienced two cycles of SGQ and SCT activities, which lasted nine weeks with a total of 26 sessions, they were asked to complete a five-item questionnaire soliciting their preferences and perspectives with regard to the exposed online SGQ and SCT learning activities. They are:

Q#1 Overall, what do you feel about the difficulty level of SGQ activity: 1 (very difficult) to 5 (very easy).

Q#2 Overall, what do you feel about the difficulty level of SCT activity: 1 (very difficult) to 5 (very easy).

Q#3 Which learning activity do you prefer: SGQ, SCT, no preference? Please explain (any particular aspects that make you like it better).

Q#4 Which learning activity do you think better help your learning: SGQ, SCT, no difference? Please explain (any differential effects it had on you, e.g., learning process, behavior, thoughts, emotions).

Q#5 Which learning activity do you think are more difficult: SGQ, SCT, no difference? Please explain (any specific areas that made the activity more difficult, challenging).

Descriptive statistics (frequencies, percentage, mean) and chi-square (X^2) tests were used for quantitative data collected from the 80 participants attended the last session of this activity. Constant comparative method was used for analyzing descriptive responses provided by the 80 participants.

3. Results

As shown in Table 1, approximately one-tenth of the participants felt that SGQ or SCT was difficult or very difficult. In fact, approximately half of all participants regarded SGQ as easy or very easy (47.50%), and more than 60% of the participants felt SCT as easy or very easy (62.50%).

Table 1: Frequencies (%) and mean of students' response regarding the difficulty of SGQ and SCT (N=80).

	1* *f* (%)	2* *f* (%)	3* *f* (%)	4* *f* (%)	5* *f* (%)	4+5 *f* (%)	Mean
Q#1 Overall, the difficulty level of SGQ	3 (3.75%)	6 (7.5%)	33 (41.25%)	20 (25%)	18 (22.50%)	71 (47.50%)	3.55
Q#2 Overall, the difficulty level of SCT	2 (2.5%)	4 (5%)	24 (30%)	29 (36.25%)	21 (26.25%)	74 (62.50%)	3.79

*1: very difficult; 2: difficult; 3: moderately difficult; 4: easy; 5: very easy

As shown in Table 2, for Q#3, approximately one-third of the participants preferred SGQ (30%), another one-third preferred SCT (37.5%), and the remaining one-third felt no preference to either approach (32.5%). A X^2 test further indicated that participants' preferences toward SGQ and SCT were not statistically significant (X^2=0.7). Constant comparative method done on students' written responses as to why they preferred SGQ revealed two major themes—its cognitive effects on promoting learning outcomes (e.g., academic performance, comprehension, creative thinking, reflecting thinking, active learning, metacognitive strategies, cognitive strategies) and its affective effects (e.g., heightened attitude toward science, learning satisfaction, test-efficacy, self-concept). Particularly, more than one-third (n=9, 37.5%) pointed out explicitly that SGQ engaged them in activities like reviewing, identifying main ideas, and monitoring their understanding of the science material, while 50% participants (n=12) appreciated SGQ's affective effects on making science learning more fun, interesting and easy. On the other hand, among those preferring SCT, more than 85% (n=26, 86.67%) pointed to its affective effects such as easy, fun and interesting, contrasting it with SGQ's more cognitive- and time-demanding nature. Finally, as for those indicating "no preference" (n=26), two distinct sub-groups emerged: liking both (n=23, 88.46%) and liking neither (n=3, 11.54%). For those liking both approaches, all acknowledged the distinct learning effects offered by different approaches. For those disliking both, the main reason was due to the many tasks involved (especially typing), which frequently resulted in uncompleted work and unpleasant feeling.

Students' responses to question #4 showed that nearly two-thirds of the participants selecting SGQ over SCT (63.29%), with only less than 5% selecting SCT over SGQ (3.8%), and a bit shy of one-third of the participants (32.91%) felt no differences (Table 2). X^2 test on perceived effects for promoting learning was statistically significant (X^2=41.95, p < .05). Among those selecting SGQ, most emphasized its cognitive and affective potential for learning, as described previously. When all written responses to this question were analyzed altogether, one major theme emerged—creating versus selecting/compiling. Nine students associated SGQ with creation and SCT with compilation that attributed to different perceived effects for learning.

When it comes to task difficulty (Q#5), the majority of the participants regarded SGQ as more difficult than SCT (53.75%), less than one-fifth of the participants felt the other way around (17.5%), and the rest of the participants felt no difference (28.75%) (Table 2). The X^2 test on this question was statistically significant (X^2=16.53, p < .05). Data analysis on descriptive comments again highlighted SGQ's cognitive, time- and effort-demanding nature for locating main ideas, monitoring personal understanding, and typing in items in the system while adhering to the set of criteria and within set time. In contrast, tasks, such as further screening and selection of item quality, sequencing in terms of item difficulty, and additional operational procedures associated with SCT were identified as what made it more difficult as compared to SGQ.

Finally, in view of the findings of past studies pointing to SCT's potential for promoting knowledge elaboration and integration, all written responses were analyzed as a whole. However, only a handful of comments noticed the additional cognitive potential prompted by SCT. Explicitly, among those (n=239), only three comments were about SCT providing opportunities for further item revision and refinement (i.e., an indication of elaboration), and six mentioned SCT for enabling students to re-examine the entire unit and to ensure that the test cover them appropriately (i.e., an indication of integration).

Table 2: Students' perspectives toward SGQ and SCT regarding their preference, perceived effects for promoting learning, and difficulty (N=80**).

	SGQ *f* (%)	SCT *f* (%)	No difference *f* (%)	X^2
Q#3 Preferred	24 (30%)	30 (37.5%)	26 (32.5%)	0.700
Q#4 Perceived as better promoting learning	50 (63.29%)	3 (3.8%)	26 (32.91%)	41.95*
Q#5 Perceived as more difficult	43 (53.75%)	14 (17.5%)	23 (28.75%)	16.53*

* p < .05; ** missing data: 1 for Q4

4. Discussion and Conclusions

In view of cognitive elaboration theory, effective elaboration techniques aid cognitive processing and structuring (Reigeluth, 1992, 1999). The additional tasks associated with SCT (e.g., test-planning and -setting ahead of and after the test-compilation stage to ensure that the constructed test covers and assesses all subject-matter content of importance, and that all included items are adequately arranged) should encourage greater and deeper active manipulation of the received information, leading to knowledge growth. Yet, how primary school participants, who are at a younger age, thus with limited cognitive and metacognitive capacities, reacted to this learning arrangement was examined in this study. As noted by technology adoption theorists (e.g., Davis), users' subjective attitudes would one area not to be ignored, if technology is to be accepted and actually used in the diffused setting in the long run (Davis, 1993). In particular, primary school students' preference, perceived effects for promoting learning, and perceived difficulties regarding SCT, as compared to SGQ, were investigated. Several important findings were obtained with their implications for instruction presented below.

First of all, despite the fact that studies have found that the majority of college students viewed SQG as difficult or very difficult when first encountering this activity (Yu and Wu, 2014), the majority of participating primary school students did not associate them with the feeling of difficult or very difficult, after being exposed to SGQ and SCT learning tasks for an extended period of time (i.e., eleven weeks). In fact, a substantial proportion of students regarded them as moderately difficult, that is, an optimal challenging level with optimal motivational level, as suggested by Malone and Lepper (1987). In view of the fact that for most students the perceived difficulty level of SGQ and SCT resided within the manageable scope (i.e., not very difficult, difficult), and many regarded them as optimal challenging, both arrangements can be considered as alternative assessment and learning approaches to promote learning even for primary school students. Also, in consideration that some students regarded SGQ and SCT as very difficult or difficult, instructors interested in adopting either approaches should pay special attention to the needs of these students. Designing and provision of learning aids, such as modeling appropriate response, procedural prompts, checklists, criteria, cue card, group work (rather than individual work) (Rosenshine, Meister and Chapman, 1996), and extra-training in associated skills (e.g., typing) for SGQ and SCT may be essential for associated learning effects to manifest.

Secondly, as reflected in participants' responses, SGQ's potential for promoting comprehension, motivation, cognitive and metacognitive strategy development, active learning behavior, diverse and flexible thinking, and positive attitudes toward the subject matter studied, and so on, confirmed existing studies (e.g., Brown and Walter, 2005; Rosenshine, Meister and Chapman, 1996; Yu, 2012) to support SGQ as a promising teaching and learning approach.

Lastly, even though prior studies with undergraduates highlighted SCT's potential for knowledge integration and elaboration (Yu and Su, 2013a, b; Yu and Wu, 2015), in this study, very few participants articulated these effects. While the underlying reasons for the observed results await to be investigated, instructors interested in SCT may want to consider the provision of additional training (e.g., for grasping the overall structure of the study content via concept-mapping) and explicit instruction on the distinct aspects and performance criteria of SCT to ensure that even primary school students can make the most of engaging in SCT learning activities.

Acknowledgements

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Effect of Knowledge Building Pedagogy on Studentô Reading Comprehension

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Abstract: The purpose of this study was to investigate the effects of knowledge building pedagogy on grade4 students' reading comprehension. Data sources mainly came from experimental group and control group' average scores on PIRLS (Progress in International Reading Literacy Study). and data analysis was done by using an independent-samples t-test to compare average PIRLS' scores between the experimental group and the control group. The results are as follows: Experimental group and control group' PIRLS scores significantly increased in eighteen weeks and there was a statistically significant in that the experimental group outperformed the control group in terms of the pre-post increased PIRLS scores.

Keywords: Knowledge building, reading comprehension, PIRLS

1. Introduction

Knowledge building is a social process in which people work collaboratively to create and improve ideas of value to their community (Sun, Zhang & Scardamalia, 2010). The knowledge building pedagogy aims to help groups produces increasingly powerful explanations about the world and transform classrooms into knowledge building communities (Scardamalia and Bereiter, 1994).The purpose of this study was to investigate the effects of knowledge building pedagogy on grade 4 student' reading comprehension. To this end, knowledge forum (KF) technology was used to provide a computer-support learning environment; KF support students and record the process of idea generation, idea co-construction, and idea improvement.

This study adopted experimental research design. Participants in the experiment group were 25 grade 4 students, and in the control group were 28 grade 4 students. The experiment group was engaged in a class which used knowledge building pedagogy to enhance student' reading comprehension for eighteen weeks. The control group had their reading instruction using as teacher directed instruction.

3. Knowledge of and Knowledge About

Modern society does not emphasize to much on accumulation of knowledge, but instead highlight the importance of creating new knowledge. Students not only need to develop knowledge building competencies but they also need to see themselves and their work as part of the civilization-wide effort to advance knowledge frontiers (Scardamalia & Bereiter, 2006). Knowledge acquisition is the process of extracting, structuring and organizing knowledge from one source, usually textbooks or human experts. However, knowledge creation has to work with and use knowledge in various contexts, to explore and question, and to connect not only with other explicit ideas but also with implicit idea (Scardamalia and Bereiter, 2010). Knowledge acquisition highlights authoritative content itself, while knowledge creation is emphasize the importance of real-life experiences by learners.

Learning about various concept is the traditional way in accumulating knowledge. However, learning to create and work innovatively with ideas is the modern way in creating knowledge. Both concepts and ideas are originally from human beings, and are used for. Table 1 below show the differences and similarities between learning about concepts and learning to work with ideas. We can see that concepts are more organized and can be categorized. In contrast, ideas are usually emergent and not organized but can be more creative. Through idea-improvement, learning is a never ended process.

Table 1. Similarities and differences in terms of learning from concepts and ideas

	concepts	ideas
Similarity	Coming into forms from some human beings	
	Used for problem-solving	
	Basic of thinking process	
Difference	Can be organized and can be categorized	Difficult to organized due to their intuitive nature
	Concepts are usually proved facts based on some theoretical or empirical evidence	Ideas are usually not proved solutions for a problem
	Concepts can be easily structuralized	Ideas are more creative thoughts than some known concepts

4. Method

This study adopted quasi-experimental design. In the experiment group, the participants were 25 of grade 4 students, and in the control group, the participants were 28 grade 4 students. The experiment group engaged in class which knowledge building pedagogy was used to enhance reading comprehension among students for eighteen weeks. The control group had their reading class under teacher-directed instruction. The control group's teacher stands in front of a classroom and presents information of text books, usually clearly outlined the academic content. PIRLS (Progress in International Reading Literacy Study) tests were used to assess children's reading comprehension. Students took PIRLS tests at the first week and the last week as their pre-test and post-test.

A research observed the experiment group in class for eighteen weeks with each class lasting for 40 minutes once a week. The researcher also observed how student worked creatively in Knowledge Forum (KF), in order to see if the experimental intervention improved students; reading comprehension. Knowledge Forum is a cross-sector, cross-age, cross-cultural problem-solving space where the focus is on the continual improvement of ideas. The heart of Knowledge Forum is a multimedia community knowledge space. In the form of notes, participants contributes ideas, and propose working models, make plans, search for evidence, identify reference materials, and so forth in this shared place (Scardamalia, 2004a). Participants in the experiment group can also use Knowledge Forum to make their thinking visible by using some graphical tools.

In Knowledge Forum, students post notes to show their views or ideas raise questions, others students can not only read their own notes but answer questions or refine ideas (Fifure1). Except for posting notes, scaffold in Knowledge Forum can be customarily designed to provide procedural facilitation for fostering expertise in writing (Scardamalia, 2004a). Students used scaffolds to improve their understanding. Scaffolds are metacognitive prompts that guide knowledge construction (Niu & van Aalst, 2009). Students will understand how to improve ideas when using scaffolds like " My theory" " I need to understand" "New information" "This theory cannot explain" "A better theory" "Putting our knowledge together". They can classified their ideas and try to find solutions when facing problem that they don't understand, like searching authoritative sources.

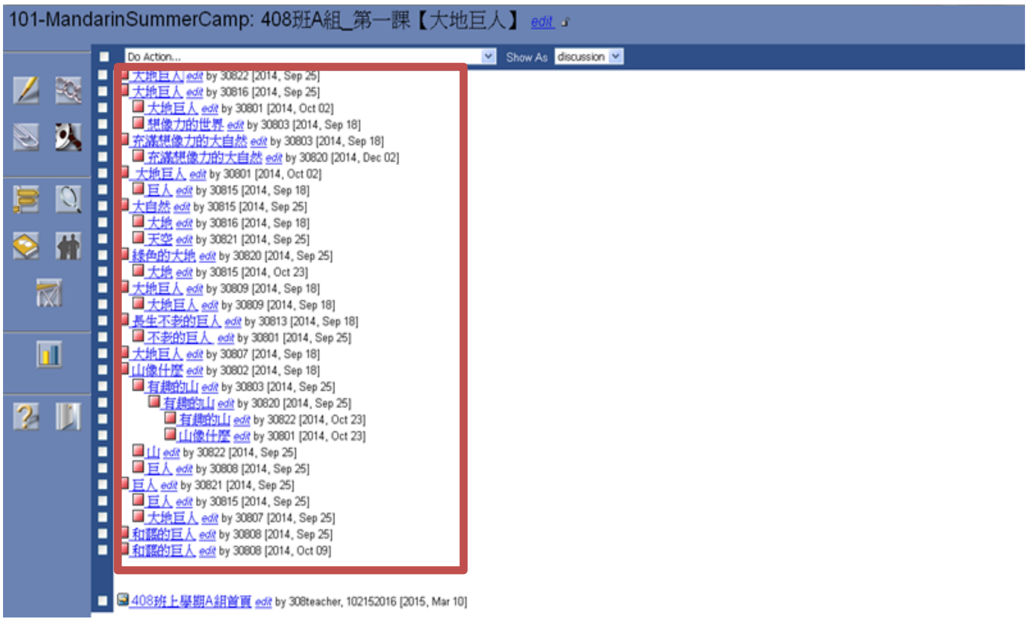

Figure 1. Student's notes in Knowledge Forum

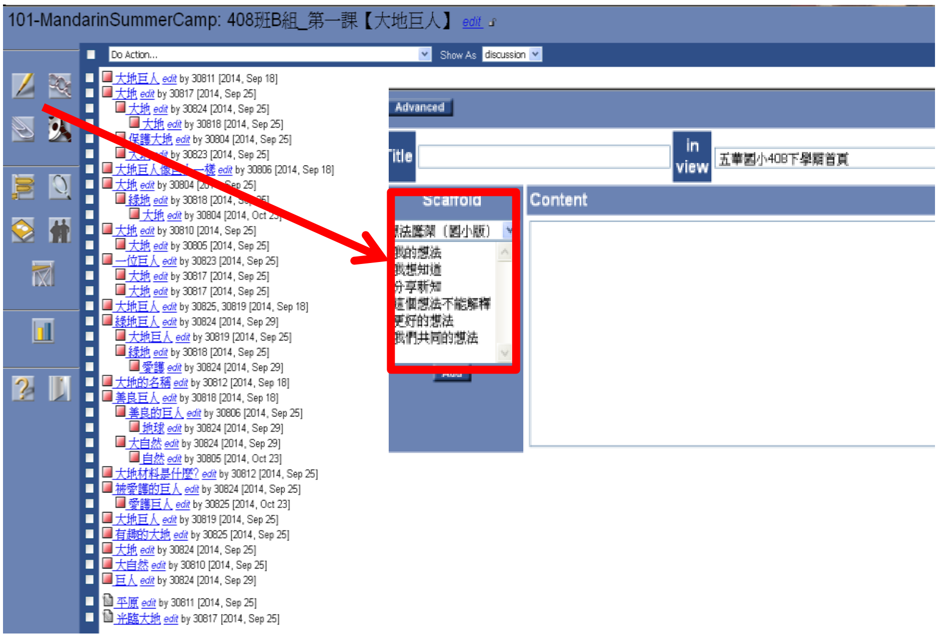

Figure 2. Scaffolds in Knowledge Forum

5. Conclusion

In this study, the experiment group was engaged in class which used knowledge building pedagogy to enhance student' reading comprehension for eighteen weeks. Figure 3 shows, the average PIRLS' scores between the experimental group and the control group. In the pre-test, the experiment group's mean score (M=23) was higher than the control group's mean score (M=22.68). And the experiment group's standard deviation (SD=5.63) was slightly higher than the control group's standard deviation (SD=4.27). It means that there was no significant differences between the experiment group and the control group'.

After eighteen weeks of different teaching methods between the two groups, The experiment group's mean score (M=26.28) in the post-test was significantly higher than the control group' s mean sore (M= M=23.07). It can be concluded that participants in the experiment group were able to improve their reading comprehension due to the experimental intervention.

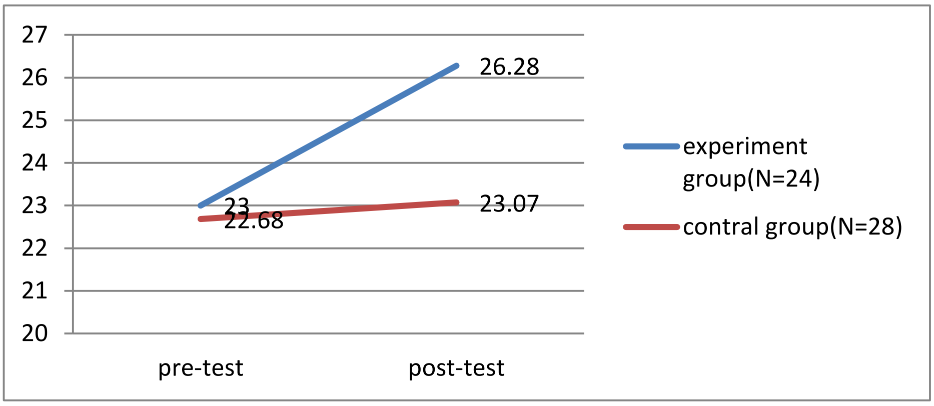

Figure 3. PIRLS reading achievement

Except for the change in PIRLS' average scores, an independent-sample t-test was conducted to compare average the PIRLS' scores in both the experimental group and the control group. A table 1below show, there was no statistical significant at the beginning of the experiment. Represent that there is no differences between the experimental group and the control group in reading comprehension level. After eighteen weeks using knowledge building pedagogy, as table 2 below show, there was a difference in the average score in terms of post- test score for the experimental group (M=26.28, SD=3.87) and control group (M=23.07, SD=3.13) conditions; t (50) = 3.33, p = 0.002.These results suggest that the experimental treatment really does have an effect on PIRLS' reading comprehension achievement.

Table 1. pre-test' t-test results comparing experimental group and control group

	experimental group		control group		t-test	95% CI	
Variable	M	SD	M	SD		LL	UL
Pre-test score	23	5.63	22.68	4.27	.82	-2.44	3.08

**p<0.05

Table 2. post-test' t-test results comparing experimental group and control group

	experimental group		control group		t-test	95% CI	
Variable	M	SD	M	SD		LL	UL
Post-test score	26.28	3.87	23.07	3.13	.002 **	1.28	5.14

**p<0.05

Additionally, qualitative data show positive effects of the knowledge building pedagogy. Analysis of Knowledge Forum posting revealed that students were able to improve their ideas by posting and questing ideas in the online environment. Figure 4. presents the number of student's posting in each lesson tend to increase. Regarding the increasing trend, present students in the experimental group were motivated by knowledge-building activities. Students was engaged in collaborative learning and creating new ideas.

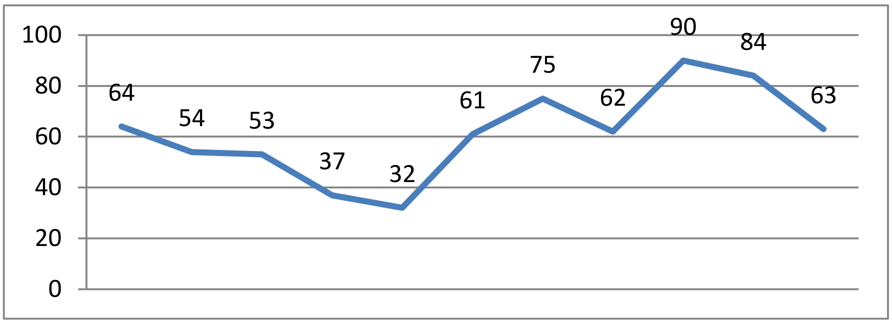

Figure 4. The number of student's posting in each lesson

6. Reference

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A Study of Attention Difference between Traditional and Digital learning Materials Using Brainwave Measuring Devices

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Abstract: Attention is an important factor of learning because a focused learner shows better learning efficiency. Attention also reflects the teaching quality of a teacher, so if a teacher understands the attention level of a learner, he can improve the teaching method to enhance attention and interest in the course. With the development of computer and internet technology, teaching materials have also been developed in different ways. In addition to traditional printed materials, various digital materials are now options for learners. However, the type of teaching material used to grab the attention of learners should also be considered. Therefore, this study used subject of Algorithm as an example. The same topics were presented by both traditional printed materials and digital materials. Electroencephalogram (EEG) was used while the learners were reviewing, and the collected data were analyzed. The results showed the attention levels to traditional printed materials and digital materials and can be used as a reference for teachers.

Keywords: Attention, Dual-coding Theory, E-Learning

1. Introduction

Learning is a necessity in life. However, depending on the personality, interests and values of different learners, they will have different ways of absorbing knowledge to learn. Therefore, understanding the motivation of the learners and providing appropriate teaching methods to stimulate their desire to learn are vital. Research by Petri showed that motivation induces and sustains learning and leads the learner to pursue learning objectives. Stronger motivation also causes better performance (Petri, H.L., 1986). Furthermore, Keller proposed the ARCS model of motivation, which states that strengthening motivation requires four key elements that form a mutually dependent loop. The ARCS model consists of Attention, Relevance, Confidence and Satisfaction. Attention refers to the initial stimulation to the learner, making the learner realize the interesting part of learning; relevance refers to making the learner realize that he/she needs instruction; confidence refers to learners thinking that they are capable of learning certain knowledge; and satisfaction refers to the intrinsic reinforcement and extrinsic rewards after spending efforts to master certain knowledge (Keller, J. M., 1983)(Keller, J. M., 1996).

In the ARCS model of motivation, learning is initiated by stimulating the learners' attention, thus making attention level very important. Hans Berger found that a normal human brain emits four types of frequency, of which the β wave is most associated with attention (Berger, H., 1929). In the modern age of technological development, brainwave measuring equipment has evolved from large and heavy equipment using vacuum tube technology to advanced equipment that bears similarity to a set of headphones in terms of size and usage. Therefore, this study aims to measure learning attention when studying different teaching materials using EEG.

2. Literature Review

2.1 Dual-Coding Theory

In the concept of dual-coding theory, Paivio believed that in the cognitive process, information is coded in two different ways: the Verbal System that controls language and words and the Nonverbal System that controls visuals sounds, etc. (Paivio, A.,1986).

The two systems are connected in three ways, which are Representational Connection, Referential Connection and Associative Connection (Figure 1).

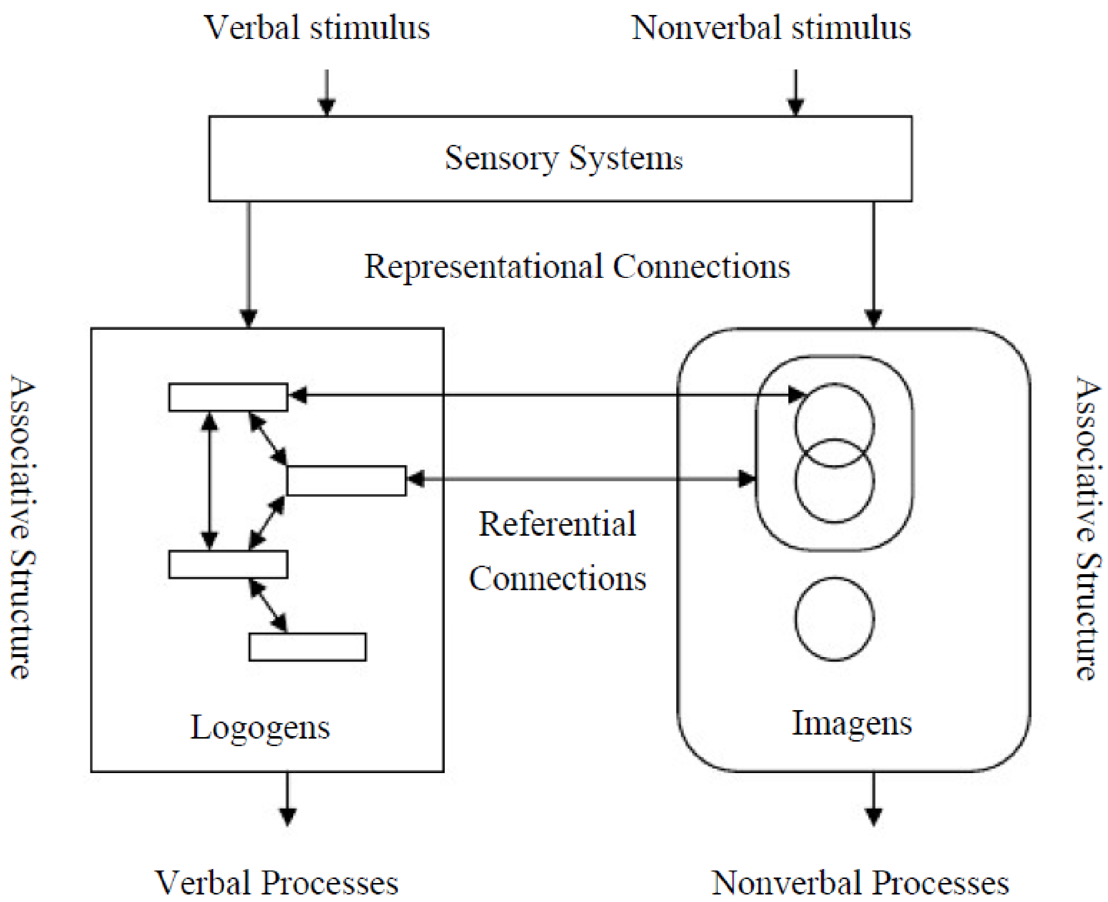

Figure 1. Dual-coding theory (Paivio, A.,1986)

The Representational Connection refers to the initial characterized action when the individual receives the stimulus. The Referential Connection refers to the connection between the verbal system and non-verbal system to form the association. The Associative Connection refers to the connections made between elements that share the same characteristics within the same system (Paivio, A.,1986).

The dual-coding theory has been proven in many studies. Presentations in words and pictures are much more effective than learning simply by words. One study (Mayer, R. E. & Anderson, R. B., 1992) that used digital materials made by computers found that the learning performance is much better in the presentation of both words and pictures compared to only words. In another study (Mayer, R. E. & Sims, K., 1994), digital materials was used for a multimedia teaching experiment, the results of which share common ground with the dual-coding theory.

2.2 Learning Attention

Since 1970, attention has been a popular research topic in the field of psychology. Attention refers to the inner response to focus and concentrate on an important issue to quicken cognitive process or ensure accuracy (James, W., 1983). When the entire mind is put into a certain object or issue, this is known as attention (Solso, R. L., 1995). In cognitive psychology, learning is considered a complex cognitive process when the learner actively pays attention, senses, understands, and networks (Jensen, A. R., 1998). When a learner shows ambition to learn, that enhanced focus also positively affects learning performance (Corno, L., 1993).

Because attention affects learning performance, using such methods as self-monitoring to train the attention level of the learner can assist underperforming learners and enhance their learning outcomes (Steinmayr, R., Ziegler, M. & Tra¨uble, B., 2010)(Purdie, Hattie, & Carroll, 2002). Furthermore, attention level can be used as a reference for learning performance. The rapid development of the internet has led to the possibility of online self-learning, an important factor of which is self-regulation, which affects learning performance. Therefore, self-regulated learning has become very important. Researchers have also incorporated attention evaluation into self-regulated learning, leading to the formation of the attention-based, self-regulated learning mechanism (ASRLM). By using EGG measurement, (Sturm, W., 1996) categorized attention into Alertness, Selective Attention, Sustained Attention, and Divided Attention. Of these, sustained attention was compared among participants with and without the wearable attention level measuring equipment. Research has shown that learners who wore the equipment have a better understanding than those who did not wear the equipment (Chen, C. M. & Huang, S. H., 2013)(Sturm, W., 1996). Furthermore, researchers have also investigated how attention level affected learning by different types of teaching materials. This study aims to compare teaching materials of the same content in traditional print format versus digital format and investigate the difference in attention levels (Chen, C. M. & Wu, C. H., 2015).

2.3 Application of Brainwaves

Brainwaves were first discovered by Richard Caton after detecting a low level of electrical impulses on the cerebral cortex of animals. This initiated the field of brainwave research. The official name “brainwaves” was coined by Hans Berger and Richard Caton. The measurement of electrical signals of the human brain is called Electroencephalogram (EEG). Based on the different frequencies of brainwaves, Hans Berger found theα, β, δ and θ waves and that out of the four, theβwave is most closely associated with attention (Berger, H., 1929). Furthermore, the two scholars later found that when a change occurs in a certain region of the brain caused by the change in brainwave, it can be measured and is called Magnetoencephalography (MEG). Both EEG and MEG are commonly used in medical fields (Caton, R., 1875)(L. F. Haas)(Tudor, M., Tudor, L., Tudor, K. I. & Hans Berger).

Application of brainwaves in medicine has developed into non-invasive monitoring and analysis of the brain, including technology such as the Magnetoencephalography (MEG), Single Photon Emission Tomography (SPECT), Transcranial Magnetic Stimulation (TMS), and Optical Imaging. Furthermore, due to the constant improvement of technology in recent years, brainwaves can also be applied to teaching research. In some studies (Chen, C. M. & Wu, C. H., 2015)(Sun, J. C. Y., 2014), brainwave data were used as a tool to measure learning effectiveness.

Two common methods involving brainwaves are used to measure attention. The first method asks the subject to complete a questionnaire regarding attention after the test, but the subjects are aware of the purpose of the questionnaire and thus may provide inaccurate answers. The second method collects physiological data using equipment that measure physiological signals and then analyzes the data statistically. This method overcomes the limitation of subjective perception that exists in the first method. This study used the second method to measure learning attention with EEG.

3. Research method

3.1 Hypotheses

- Hypothesis 1: The attention level is higher when studying digital materials compared to traditional printed materials.
- Hypothesis 2: When doing the Lightning Round, the learners are more focused.
- Hypothesis 3: When learners empty their mind, it affects their attention level.
- Hypothesis 4: When watching an interesting video, the level of attention is the highest.

3.2 Subjects

The subjects were bachelor students in their 3rd or 4th year and postgraduate students in their 1st or 2nd year in the Department of Informational Engineering in the School of Engineering of a technology university.

3.3 Equipment

This study used NeuroSky EEG to measuring the level of attention. As shown in Figure 2, the equipment collects physiological signals from the brain via special sensor electrodes and transfers the signals to the ThinkGear chip to filter and enhance the useful information. The equipment then uses a patented algorithm to interpret wavelengths of the brainwave and analyzes the frequency of each wave. Computers and mobile phones are used to record the data and discover relevant information using statistics (Buduan, P. J. L., 2012).

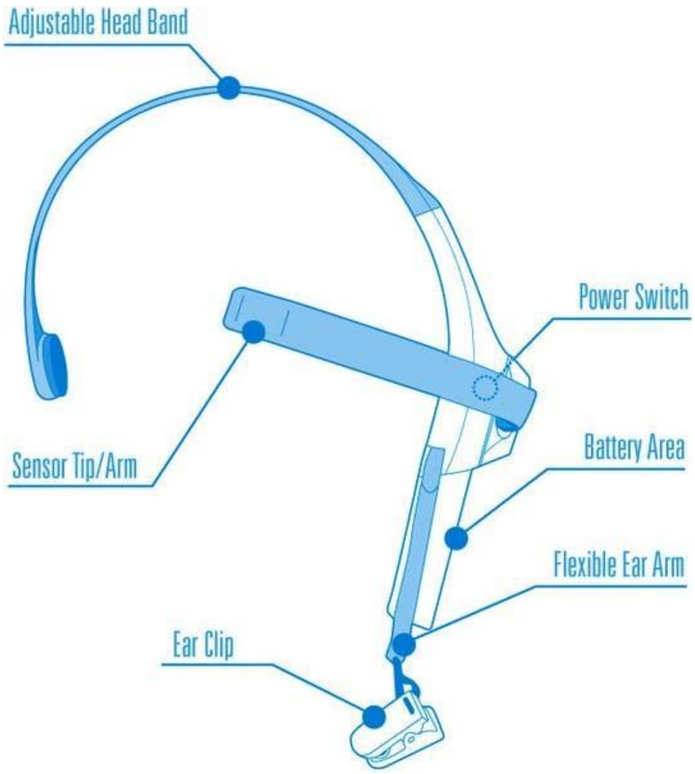

Figure 2. NeuroSky MindWave (Buduan, P. J. L., 2012)

3.4 Teaching Material Design

The teaching material was based on "Foundations of Algorithms Using C++ Pseudocode" 3rd edition by Richard E. Neapolitan and Kumarss Naimipour. The design materials adapted Mayer's cognitive theory of multimedia learning and was evaluated by three internal or external experts of the field. The experts approved the design's content validity, which was then used in the test.

3.5 Experimental Design

This is a quasi-experimental study using algorithm courses. The content of the traditional printed materials and digital materials is identical. EEG was used when the learners were reviewing the material. The learners were evenly distributed to the control and treatment groups based on their past scores of algorithm tests. The content of the review consisted of Prim's and Kruskal's algorithms. The review time was based on the situation. Figure 3 shows the experimental design.

As for "Lightning Round", the students are asked some questions that are easy but need a little attention, such as 2+3=? For "empty their mind", the students are asked to stay in any condition to totally relax, such as closing their eyes. For "watching interesting video", the students are asked to watch the videos they are interested in.

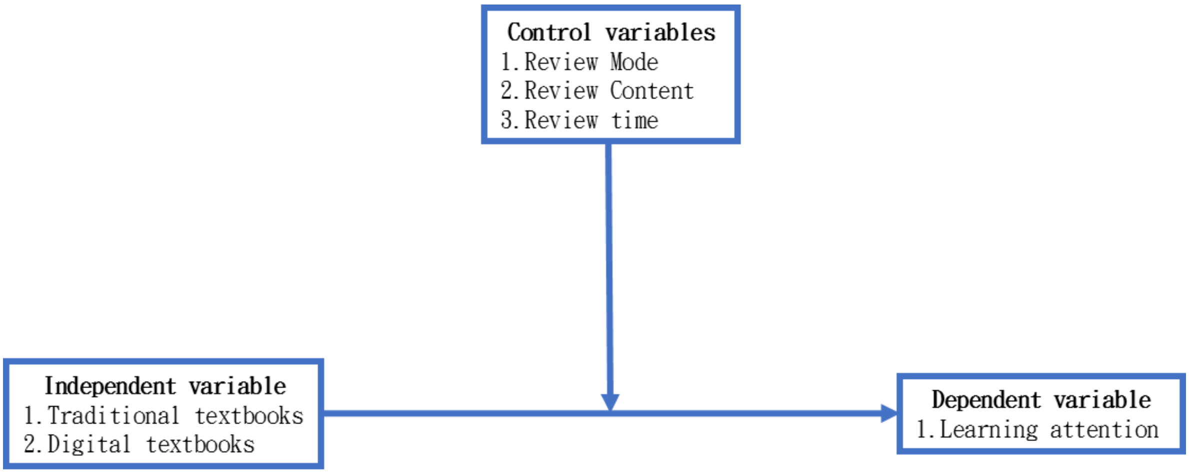

Figure 3. The experimental design

3.6 Experimental Procedure

The experimental procedure is divided into the following six stages:

Stage 1: Before the test starts, the experimental procedure was explained to the participants to minimize uncertainty. Pre-test questions, were given to assess learning performance. Participants were given 10 minutes for the pre-test and have to record the time they took to complete it. The questionnaire can be completed afterwards. A 5-minute break was given.

Stage 2: Teaching materials in the print and digital format were designed to contain a similar level of difficulty for Prim's and Kruskal's algorithms. Four teaching materials were used: digital material on Prim's algorithm, print material on Prim's algorithm, digital material on Kruskal's algorithm, and print material on Kruskal's algorithm. The test was continued when the treatment group was randomly given the digital material on either Prim's or Kruskal's algorithm to assess attention level and relaxation level. The control group was given the printed material on the other unchosen algorithm to assess the same factors. The test took five minutes, and a break of exactly 5 minutes was given with no early continuation allowed.

Stage 3: The participants were then asked to label the attention ladder diagram based on their impressions made in Stage 2. The post-test was then conducted to investigate learning performance. Early submission of the test paper was not permitted for this 5-minute test.

Stage 4: After the 5-minute break, the treatment group repeated the process of the control group and vice versa for the control group. The process was video-recorded. An attention ladder diagram was given to each participant to label, followed by another post-test to investigate learning performance. Early submission of the test paper was not permitted for this 5-minute test.

Stage 5: The participants were asked to complete a questionnaire regarding their own level of attention. The questionnaire should take approximately 3 minutes.

Stage 6: The participants were asked to wear EEG and watch an interesting video, do the Lightning Round, and close his/her eyes and empty his/her mind; each activity took one minute. This stage is performed to determine if the three test curves match the previous test curves.

4. Results

Due to the number of experimental EGG and complications of the experimental procedure, only four participants have completed the test. Two participants studied the traditional print material followed by the digital material. The results are shown in Figure 4. The y-axis represents the average attention during 5 minutes, and the x-axis represents the participants. Kruskal_T1 means that the participants studied the traditional print material on Kruskal's algorithm first. Prim_D2 means that the participants studied the digital material on Prim's algorithm afterward. The other two participants studied the digital material followed by the traditional print material. The results are shown in Figure 5. The y-axis represents the average attention during 5 minutes, and the x-axis represents the participants. Prim_D1 means that the participants studied the digital material on Prim's algorithm first. Kruskal_T2 means that the participants studied the traditional print material on Kruskal's algorithm afterward.

First, we tested Hypothesis 1: The attention level is higher when studying digital materials compared to traditional printed materials. In our four subjects, only one person showed opposite results to Hypothesis 1. A possible reason may be that the person prefers reading print, causing a higher level of attention when studying traditional printed materials compared to digital materials.

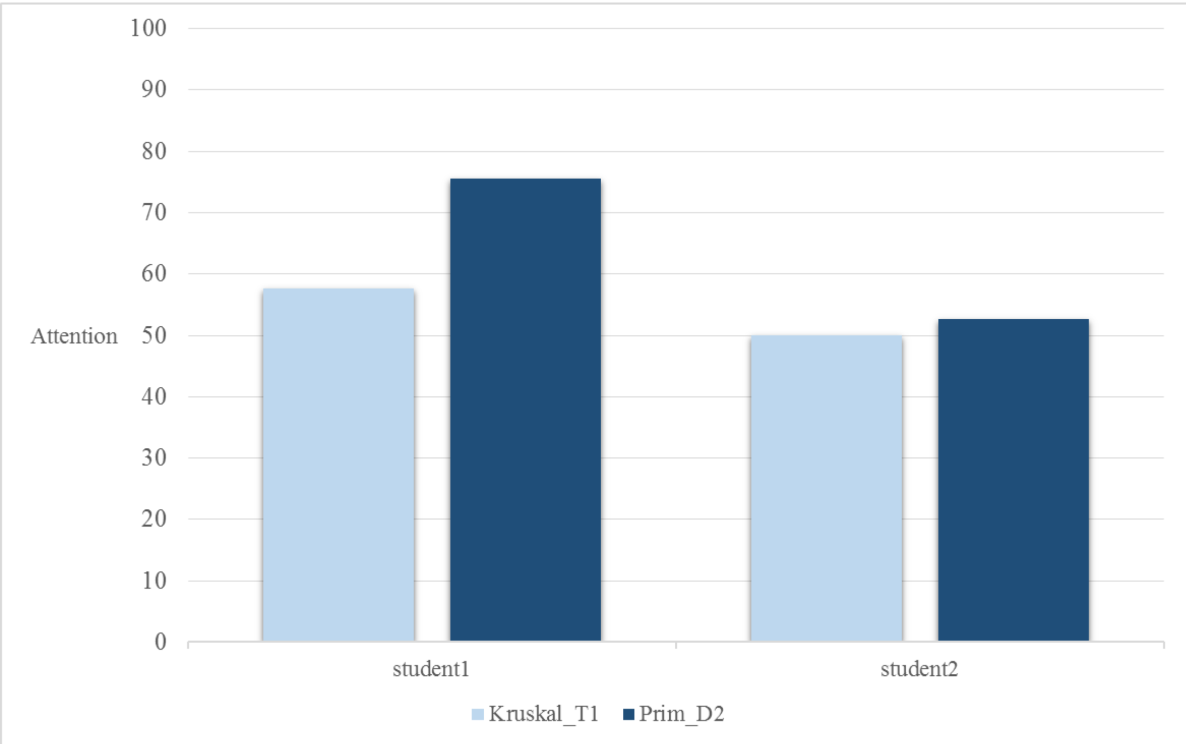

Figure 4. Average attention of students when watching traditional printed materials first and digital materials after

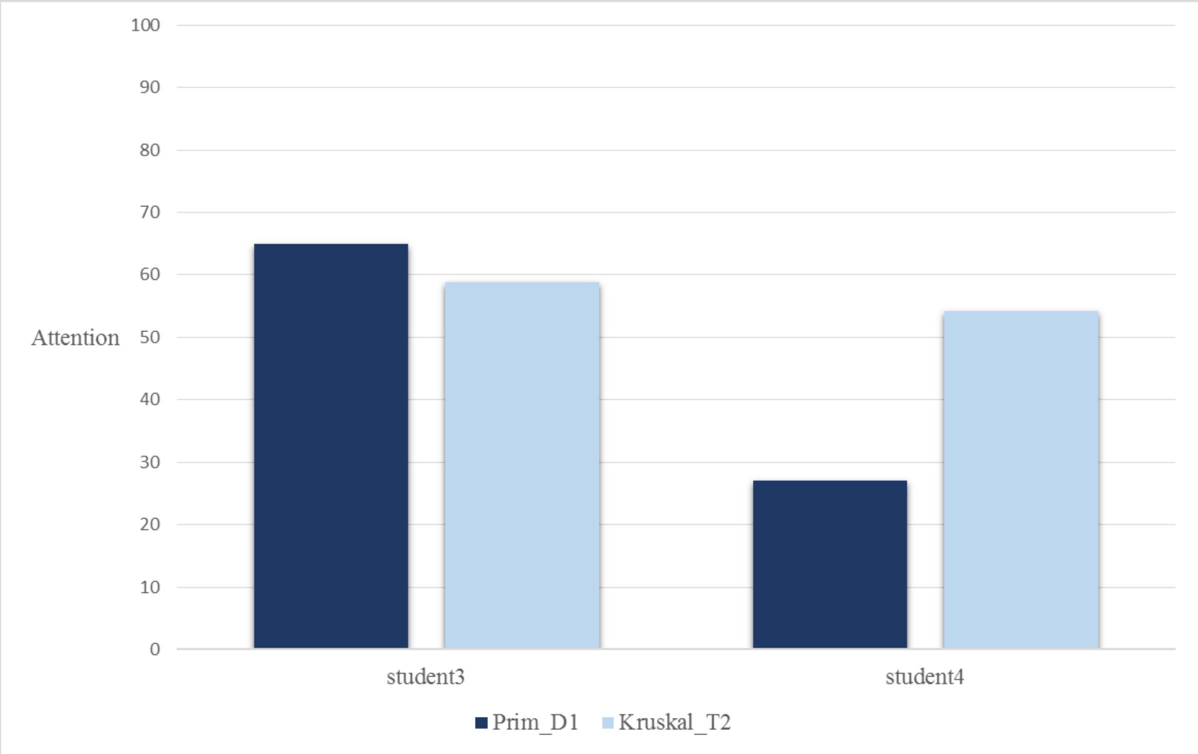

Figure 5. Average attention of students when watching digital materials first and traditional printed materials after

We then tested Hypothesis 2 and Hypothesis 3: When doing the Lightning Round, the learners are more focused, and when learners empty their mind, it affects the attention level. This study found opposite results. The level of attention is relatively lower than when the learners empty their mind. Figure 6 shows that learners do not focus when doing the Lightning Round. We believe this phenomena is due to the questions that were asked being too easy and could be answered without much thinking; hence, the learners did not need to pay attention. As for the higher level of attention when the learners empty their mind, we believe that the learners were still thinking during the test and thus showed high levels of attention. The results are shown in Figure 7.

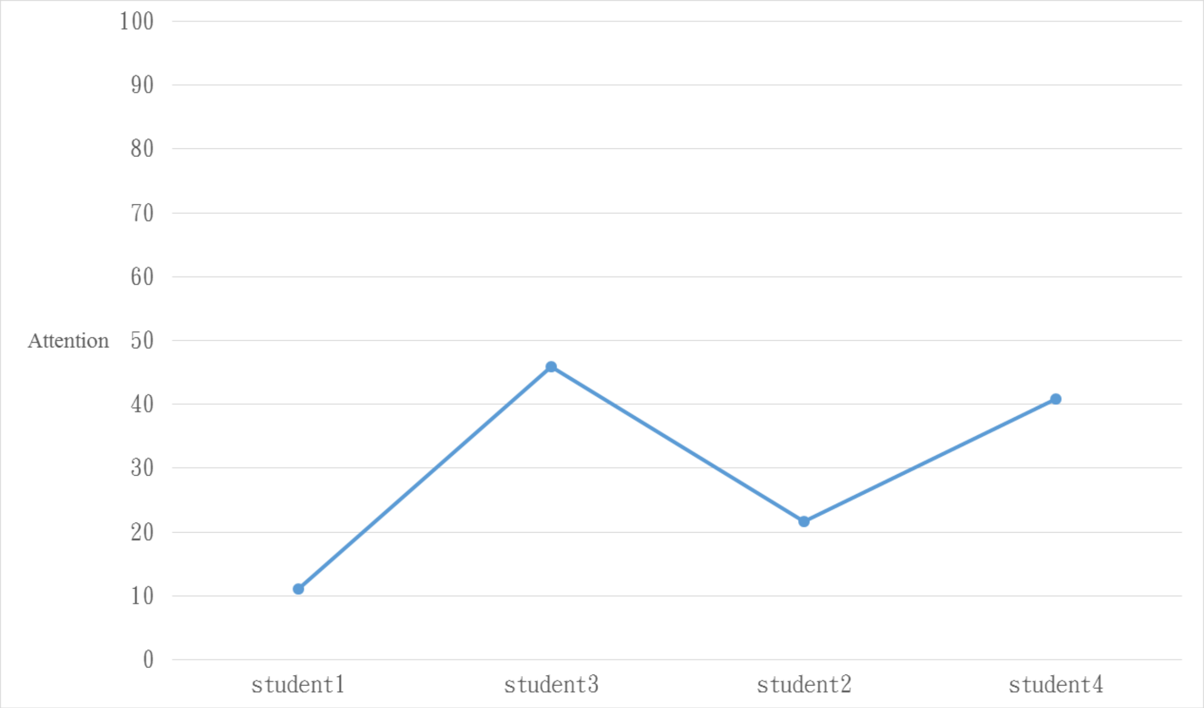

Figure 6. Average attention of students during Lightning Round

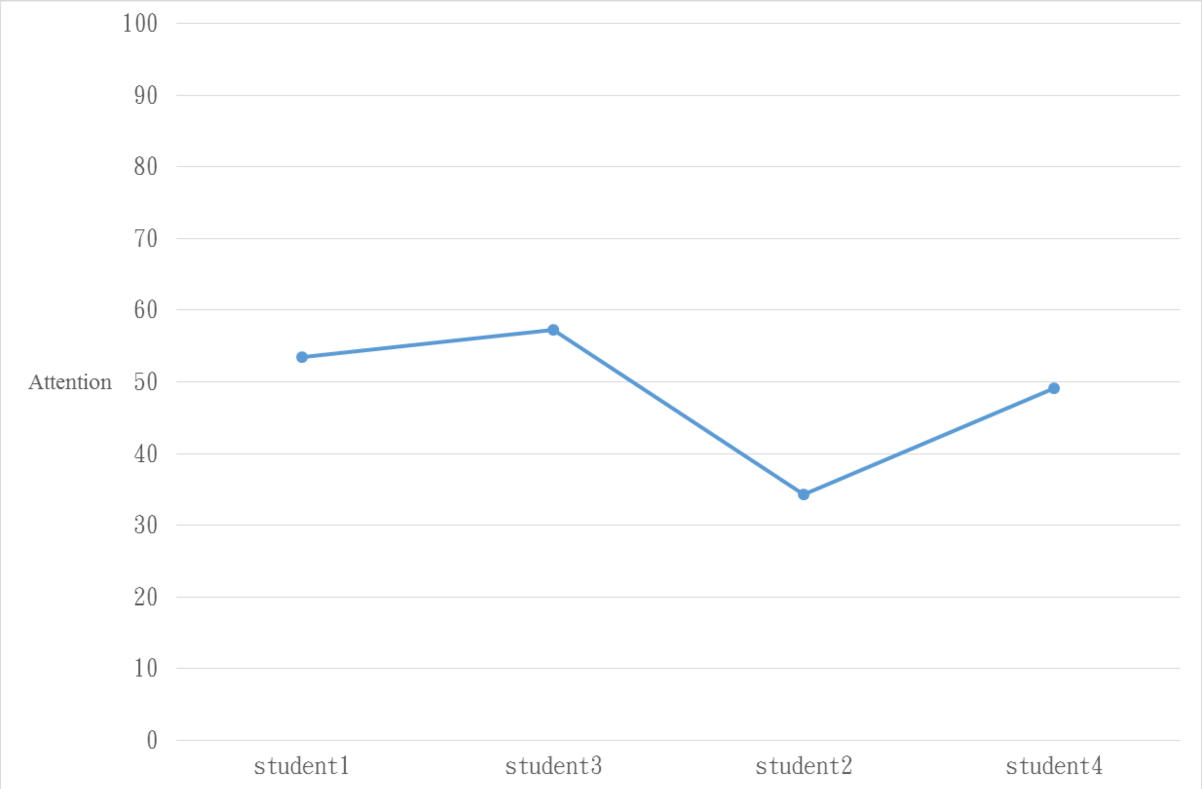

Figure 7. Average attention when students empty their minds

We tested Hypothesis 4: When watching an interesting video, the level of attention is the highest. Three out of the four participants conformed to Hypothesis 4. The learning performance results showed that learners who could do the pre-test could answer even more difficult questions correctly. The participant who did not show a high level of attention still showed a considerably decent level of attention. However, it was no higher than that when asked to empty their minds. This study also found that level of attention drops when the participants laughed. The results are shown in Figure 8.

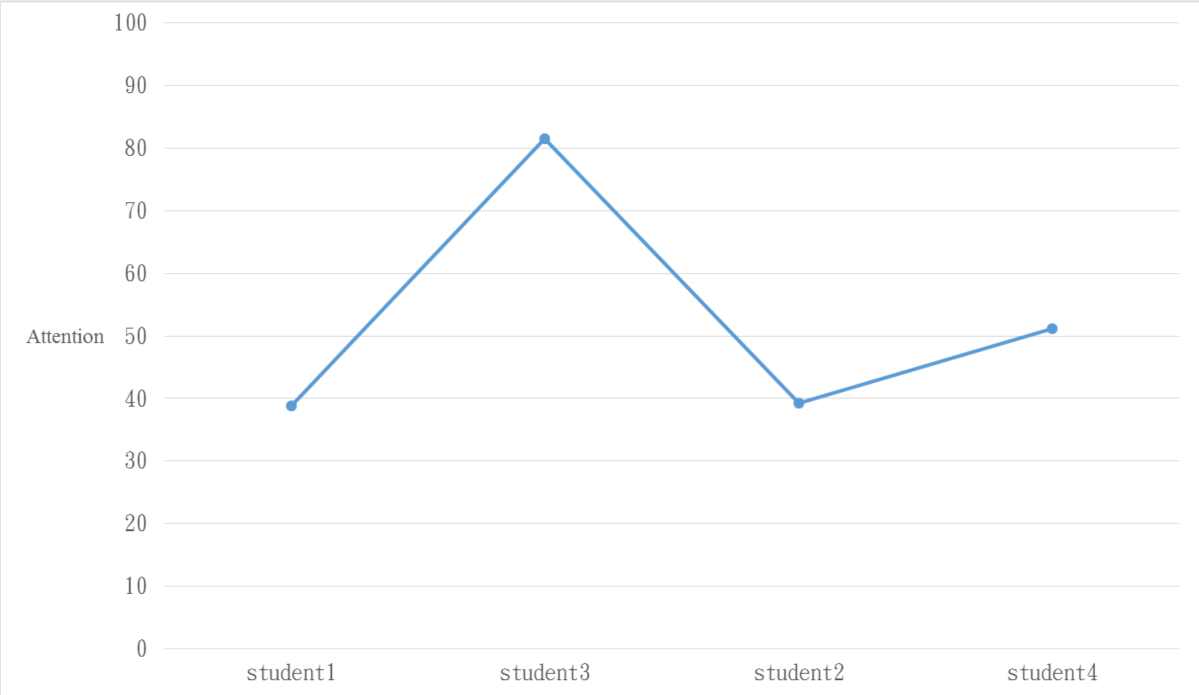

Figure 8. Average attention of students when watching interesting videos

5. Conclusion

This study aims to understand how different types of teaching materials affect learners' attention. Learners were asked to study with traditional printed materials and digital materials with a similar level of difficulty, while EEG was used to measure the brainwaves. The data were analyzed, and the results generally coincided with the expectations in the hypotheses. This study has only completed preliminary experiments and will continue to investigate further.

Acknowledgement

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Building Project-Based Learning Platform for the Capstone Project

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Abstract: The goal of capstone project is to train students to be able to apply the required knowledge and skill to collaboratively complete the assigned work. The project-based learning (PBL) is a popular strategy used by teachers to guide students to organize teams to solve problem collaboratively and to enhance students' creative and problem solving abilities in capstone project. However, the traditional PBL strategy cannot effectively enhance the students' abilities because the previous good cases cannot be easily shared and reused. Therefore, our idea is to develop a good platform to be able to share and reuse the cases together with portfolios to motivate student's imaginative power and creativity and the teachers can easily assess the students' learning achievements. Because Case-Based Reasoning (CBR) techniques consisting of cases retrieve, reuse, revise and retain can be used to model the computer reasoning, we develop a project-based learning platform using the CBR techniques to provide the case scaffoldings and reserve the learning portfolio. We further design an experiment based upon our learning platform to complete the e-book visual creative design. The experimental result shows that the given appropriate learning scaffoldings can guide students to improve the creative and problem solving abilities.

Keywords: problem solving learning, project-based learning, case-based reasoning, capstone project.

1. Introduction

The goal of capstone project is to train students to be able to apply the required knowledge and skill to collaboratively complete the assigned work (Gardner and Van der Veer, 1998; Brown, 2004; Todd et al., 1995). Through the capstone project, students should have the ability to solve complex problems with effective communication ability. As we know, project-based learning (PBL) is a popular strategy used by teachers to motivate students learning and to develop students' professional knowledge and problem solving abilities (Hung et al., 2014; Barrows, 1996). In general, the PBL strategy is often used to guide students to organize teams to solve problem collaboratively and to enhance students' creative and problem solving abilities in capstone project in the last year of the students' undergraduate study.

However, the traditional PBL strategy cannot effectively enhance the students' creative and problem solving ability (Barab & Luehmann, 2002; Barak & Dori, 2004; Barron et al., 1998; Edelson et al., 1999; Solomon, 2003) because the previous good cases cannot be easily shared and reused. Therefore, in this paper, our idea is to develop a good platform to be able to share and reuse the cases together with portfolios to motivate student's imaginative power and creativity to guide students learning, and therefore the teachers can easily assess the students' learning achievements.

In recent years, capstone project of learning design or e-book design has become a hot topic in many information management related departments. With our observations, students can hardly complete their project in e-book production, because they usually lack creative and problem solving abilities to present the ideas and effects of design. Therefore, having creativity to present idea and problem solving abilities to solve these problems is very important.

For creative and problem solving abilities learning, establishing a set of standards process should be able to improve the students' learning motivation and learning effectiveness. Although PBL is indeed a good learning strategy, applicable techniques are still needed to improve the learning effectiveness

(Hwang, Shi, & Chu, 2011; Mora Luis et al., 2014). Because case-based reasoning (CBR) techniques consisting of cases retrieve, reuse, revise and retain can be used to model the computer reasoning (Aamodt & Plaza, 1994), we develop a project-based learning platform using the CBR techniques to provide the case scaffoldings and reserve the creative and problem solving abilities learning portfolio in capstone project. Depending on the students' characteristics and learning portfolio to retrieve appropriate cases as creative learning framework and trigger students' creative thinking to assess the achievements of the capstone project.

In this paper, we focus on creative design of e-book in the capstone project consisting of story design phase, style design phase, and layout design phase. Each phase needs its appropriate creative and problem solving abilities to achieve a complete visual creative design of e-book. Since multi-phase design thinking needs to consider the design links and consistency between the design phases, the creative brainstorming activity is not easy for students. Hence, there often exist inconsistencies between idea and the final productive result.

Our project-based learning platform is a spiral model; each spiral corresponds to a design phase; each design phase consisting of four steps: similar case inquiry, brainstorming, collaborating and discussing. For assisting students' brainstorming activity, the processes of the cases and teams' learning portfolio are stored. For different design phase, according to the characteristics of case, we also define the similarity functions to retrieve appropriate cases. CBR case retrieve, reuse or revise, and retain techniques are used to assist students to solve the difficulties in case inquiry, brainstorming, and discussing, respectively.

We further design an experiment based upon our learning platform to complete the e-book visual creative design with capstone project. The students are divided into experimental group and control group. The experimental group used the project-based learning platform in each e-book production phase and the control group only used the traditional PBL learning strategy to develop their e-book. The experimental result shows that the given appropriate learning scaffoldings can guide students to improve the creative and problem solving abilities.

2. Related Works

PBL has been proved to be an effective learning strategy (Blumenfeld et al., 1991; Huang et al., 2002). In the capstone project, the students are grouped into several teams, each of which should complete a project and develop their core abilities through interaction and collaboration with other students (Edward, 1995; Jang, 2006a; Jang, 2006b; Johnson & Aragon, 2002; Prince & Felder, 2007; Chang & Lee, 2010). With the progress of new era, e-PBL (PBL joins the IT technology) is used as a powerful tool to simulate the dangerous or expensive projects and provide scaffolding assist students learning (Rienties et al., 2012; Chu & Hwang, 2010; Heo et al., 2010; Raud & Vodovozov, 2010; Rooij, 2009; Domínguez & Jaime, 2010; Keser & Karahoca, 2010). The e-PBL can improve the effectiveness of learning by the following steps (Barron, 1998; Edelson et al., 1999; Solomon, 2003; Chang & Lee, 2010):

1. Inquiring: Students inquire and collect of various materials
2. Reflection: Reflect and learn about the original subject
3. Selection: Select the appropriate solution
4. Presentation: Present the project result
5. Analysis: Analyze the capstone project process and final result
6. Conclusion: Discuss and share findings and conclusions

However, without good platform, the previous cases cannot be properly stored and reused, and the achievement cannot be easily assessed. Therefore, in the capstone project learning, PBL using CBR techniques can provide appropriate learning scaffolding to assist students and improve learning performance.

3. Capstone Project Learning Platform

Good strategies with the appropriate learning scaffolding can allow students to obtain the creative and problem solving abilities with the consideration of the viewpoints of person, the process, the product, and the environment (Torrance, 1993; Sternberg, 1999). Brainstorming is often used to shorten the design process (Yu et al., 2011). But, these previous good cases cannot be easily shared and reused without appropriate learning platform.

In this paper, we use CBR techniques consisting of cases retrieve, reuse, revise and retain to model the workflow of the traditional capstone project. Creative thinking, which is the first task in the capstone project, should be free and unrestricted in theory. In reality, the learning resources are limited in the school's learning environment. For improving students' creative and problem solving abilities, we apply case retrieval techniques to assist students to achieve learning objectives from previous good cases, and also design the appropriate learning scaffolding to assist students learning in capstone project. In the rest of this paper, we use the e-book creative design capstone project as an example to elaborate our method.

As shown in Figure1, the creative design of e-book can be divided into story design phase, style design phase, and layout design phase, each of which can be beneficial from project-based learning platform using CBR techniques. To facilitate the brainstorming and ensure the entire e-book visual creative design integrity, the platform provides the case scaffoldings and reserves the creative and problem solving abilities learning portfolio from capstone project repository. The capstone project repository consists of case file and learning portfolio file. The case file consists of the previous good cases and the learning portfolio file consists of the teams' learning portfolio. For the animated fairy tale e-book, the case and learning portfolio are defined as below.

Case = < c-id, story-kw, user, synopsis, style-kw, style, layout-kw, layout, member, role, task >
where c-id is used to denote the id of the case,
story-kw is used to denote the keywords about the story design phase of the case,
user is used to denote the users that the e-book is created for,
synopsis is used to denote the synopsis of the story,
style-kw is used to denote the keywords about the style design phase of the case,
style is used to denote the style of the case,
layout-kw is used to denote the keywords about the layout design phase of the case,
layout is used to denote the layout of the case,
member is used to denote the members of the students,
role is used to denote the role of the member in the team,
task is used to denote the members' task in the team.

Learning portfolio = < c-id, $(P_1, S_1, M_1, T_1, O_1)$, $(P_1, S_2, M_2, T_2, O_2)$, ⋯, $(P_i, S_j, M_j, T_j, O_j)$, ⋯, $(P_3, S_4, M_4, T_4, O_4)$ >
where c-id is used to denote the id of the case,
P_i is used to denote the i-th phase of the platform, for i=1, 2, 3,
S_j is used to denote the j-th step of the phase, for j=1, 2, 3, 4,
M_j is used to denote the members who participate in j-th step of the phase,
T_j is used to denote the members' task in j-th step of the phase,
O_j is used to denote the outcomes in j-th step of the phase.

For different design phase, according to the characteristics of case, we also define the similarity functions to retrieve appropriate cases. The values of the similarity function are between 0 and 1. The higher the value is, the greater the similarity.
Story similarity function = story-kw*0.5+user*0.2+ synopsis *0.3
Style similarity function = style-kw*0.7+style*0.3
Layout similarity function = layout-kw*0.7+layout*0.3

The project-based learning platform based on e-PBL consists of four steps: similar case inquiry, brainstorming, collaborating, and discussing, where the modified CBR including Case retrieve, reuse/ revise, produce collaboratively, and retain techniques is used to assist students to solve the difficulties in similar case inquiry, brainstorming, collaborating, and discussing, respectively. The relationship between platform and the modified CBR techniques is shown in Table1. Thus, the platform can provide creative thinking and make up the traditional PBL strategy.

Table1. The relationship between platform and the modified CBR techniques.

Steps	The problem-based learning platform	e-PBL steps	Modified CBR techniques
1	Similar Cases Inquiry	Inquiring	Case Retrieve
2	Brainstorming	Reflection, Selection	Case Reuse or Case Revise
3	Collaborating	Presentation	Produce collaboratively
4	Discussing	Analysis, Conclusion	Case Retain

Step1. **Similar case inquiry**: According to students' characteristics and learning portfolio, CBR case retrieve technique is used to inquire appropriate learning scaffolding in the learning process. This step corresponds to e-PBL inquiring step.

Step2. **Brainstorming**: According to the learning scaffolding, CBR case reuse or case revise technique is used to assist students to brainstorm and trigger creativity in the learning process. This step corresponds to e-PBL reflection and selection steps.

Step3. **Collaborating**: Students collaborate to stimulate their creativities in the learning process. This step corresponds to e-PBL presentation step.

Step4. **Discussing**: CBR case retain technique is used to clarify the capstone project and assist students to discuss and share their experiences in the creative process. This step corresponds to e-PBL analysis and conclusion steps.

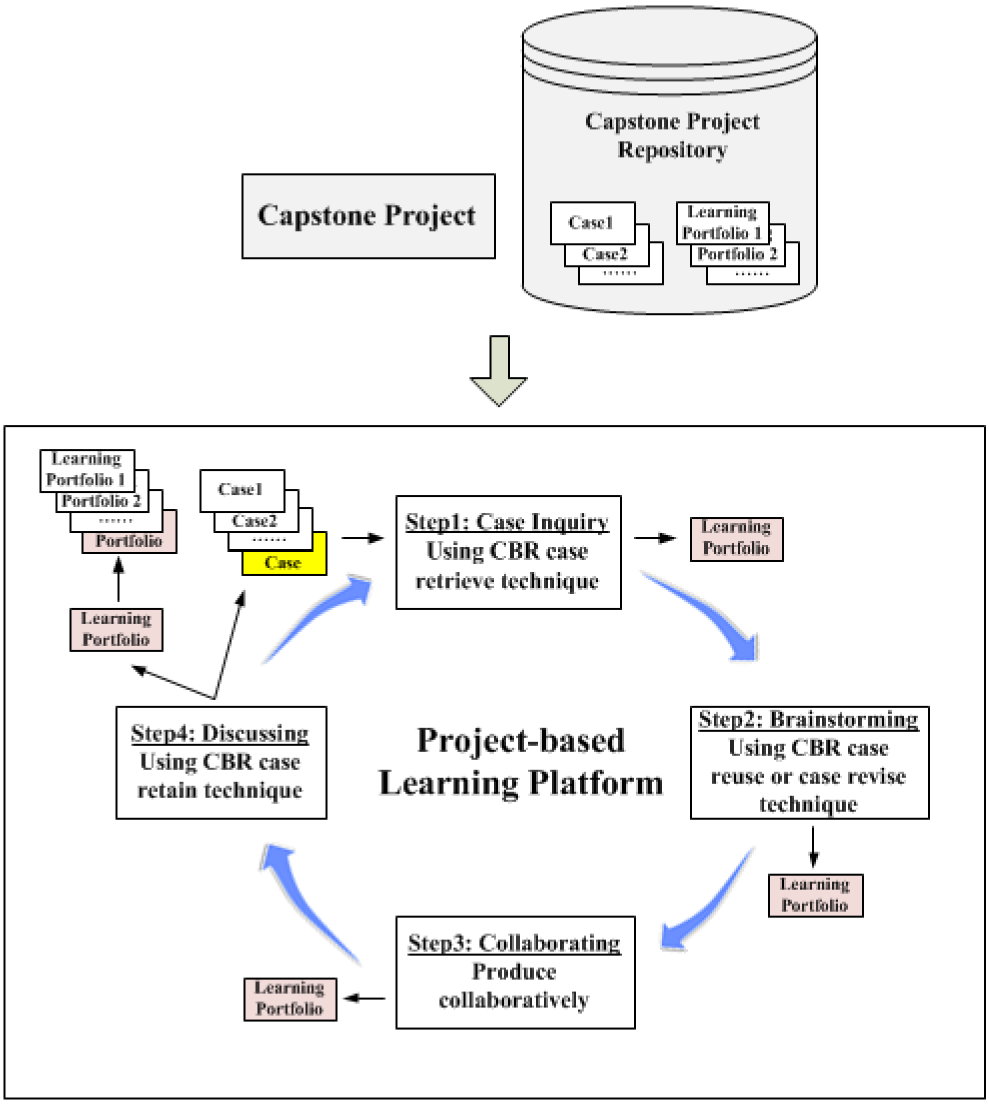

Figure 1. Project-based learning platform using CBR techniques

The project-based learning platform is a multi-step spiral learning model, as shown in Figure2. In the spiral creative learning model, the learning objectives can be gradually achieved from outside to inside, where each spiral consists of similar case inquiry, brainstorming, collaborating and discussing to be able to preserve the integrity of design and creativity in e-book production process.

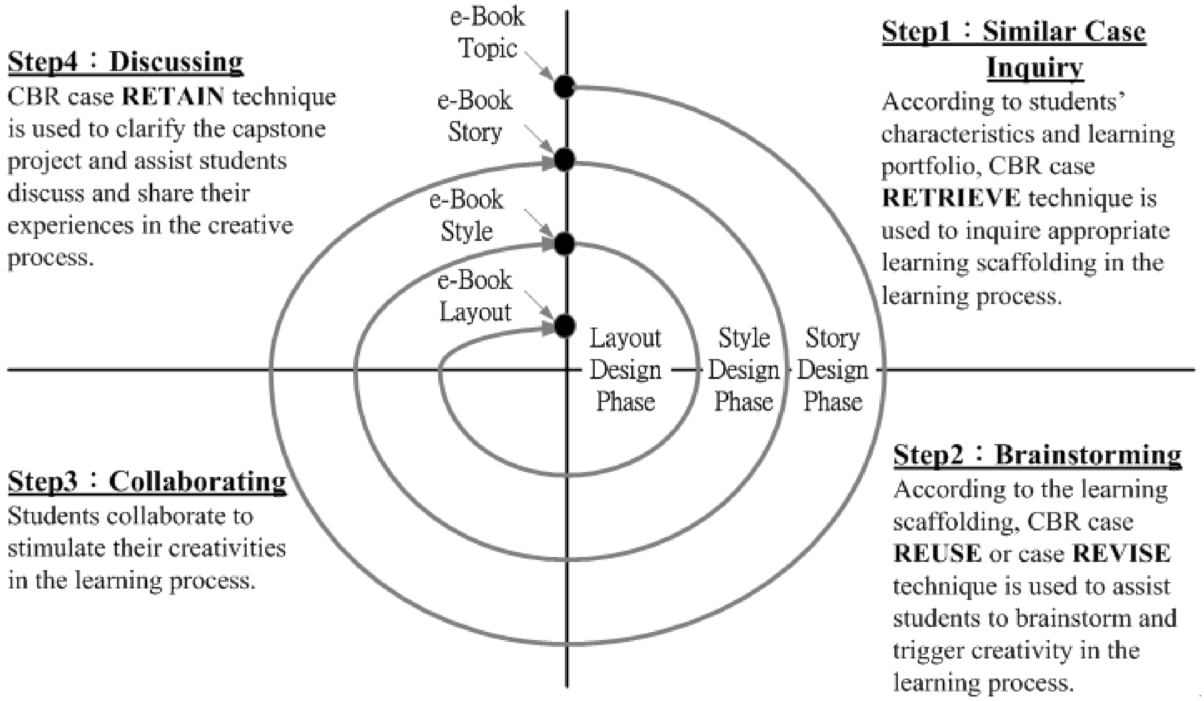

Figure 2. Multi-step spiral PBL learning model

In the animated fairy tale e-book project, the team has four members to produce the e-book in accordance with the story design, style design, and layout design in capstone project.

Story design phase

Step1. Similar Case Inquiry

This fairy tales of the e-book is created for children. In the beginning of the production, the team members discussed and decided the protagonist of the story is bear cub and the story type is "Explore"; the bear cubs are the main material of the e-book; the story keyword could be "Explore", "Fantasy" or "Journey". Then, appropriate cases with high story similarity will be retrieved as the scaffolding.

Step2. Brainstorming

Using the learning scaffoldings retrieved from step1, the team members can create a variety of story synopsises through reusing or revising the scaffoldings.

Step3. Collaborating

The team members collaborate to consolidate a variety of story to a final version.

Step4. Discussing

In this step, the team members discuss and clarify the learning process of the design phase and share their experiences with each other. The teacher observes and records learning performance as the reference of the next stage. After this step, the team will go back to step1 and start the next learning process.

Style design phase

Step1. Similar Case Inquiry

The team members discuss and decide the style of the story is "Interstellar". The story keyword could be "Star", "Astronomical" or "Universe". Then, appropriate cases with high style similarity will be retrieved as the scaffolding.

Step2. Brainstorming

Using the learning scaffoldings retrieved from step1, the team members brainstorm a variety of style through reusing or revising the scaffoldings.

Step3. Collaborating

The team members collaborate to consolidate a variety of style to a final version.

Step4. Discussing

In this step, the team members discuss and clarify the learning process of the design phase and share their experiences with each other. The teacher observes and records learning performance as the reference of the next stage. After this step, the team will go back to step1 and start the next learning process.

Layout design phase

Step1. Similar Case Inquiry

For the creation of animated style fairy tale story, "Kids' story house" is retrieved from the case repository to be the learning scaffolding in this phase. As shown in Figure3, this is the 1-1-2 frame. The page is divided into upper and lower parts. The upper part of the page is divided into left and right areas. The left area is the logotype area and the right area is the function area. The lower part of the page is content area displaying the contents of the page.

Figure 3. Inquiring the learning scaffolding by CBR case retrieval technique

Step2. Brainstorming

Using the learning scaffolding retrieved from step1, the team members create a variety of different schemes, as shown in Figure4. The more schemes, the higher the degree of the students' creativity is stimulated. We find that the schemes have the following common features: (1) bear cubs, (2) 1-1-2 frame. We believe that the learning scaffolding retrieved from step1 has a great impact on the students' production.

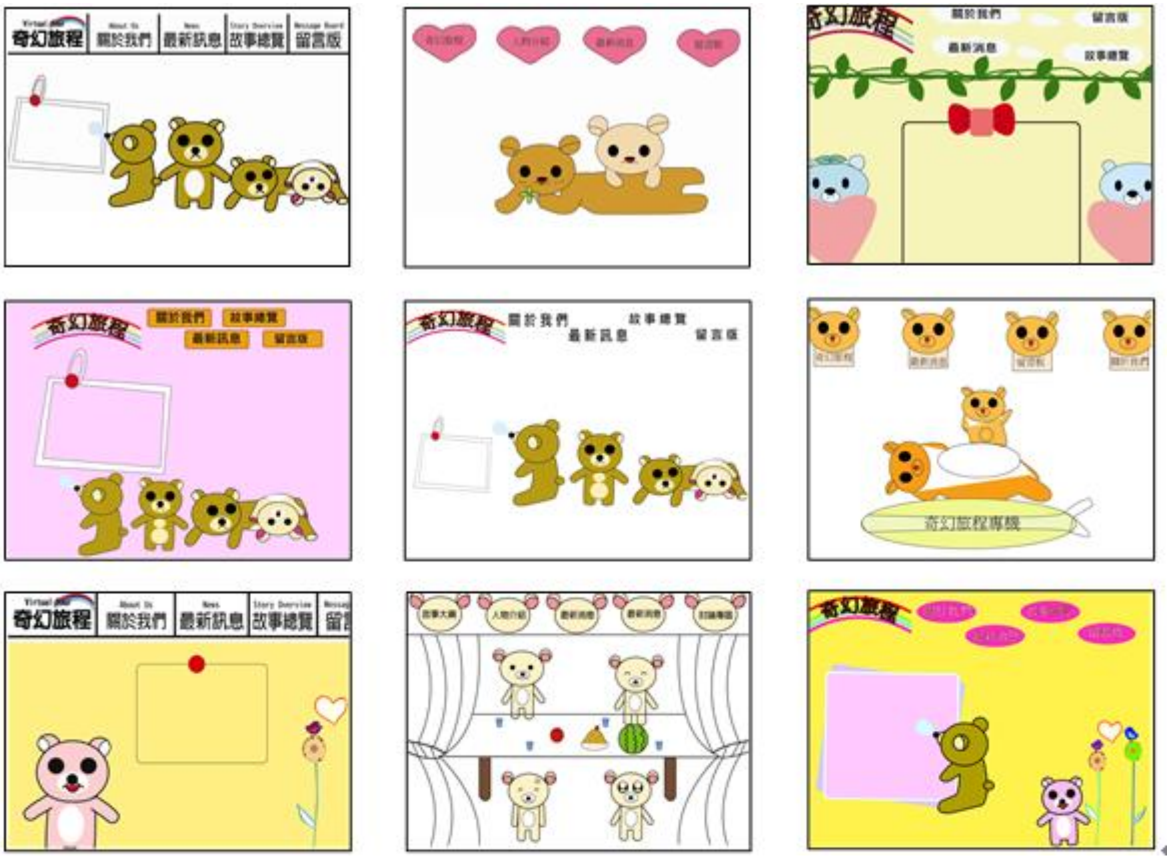

Figure 4. A number of schemes for the layout design of the animated fairy tale story

Step3. Collaborating

All of the members participate in this step. Team members state the creative ideas about the schemes generated in step2. Through voting or asking teacher for advice, consolidate these schemes into feasible solutions, as shown in Figure5.

Figure 5. Converging collaboratively a number of schemes into one scheme

Step4. Discussing

In this step, students discuss and clarify the learning process of the design phase and share their experiences with each other. The teacher observes and records students' status and learning performance as the future reference.

4. Experiment and Findings

4.1 Experiment

Eight students who study the capstone project course are divided into experimental group and control group to complete the e-book visual creative design in the experiment. In accordance with the story design phase, style design phase, and layout design phase to complete the e-book visual creativity, each phase lasts for a week for two groups of students, where the experimental group used the project-based learning platform in each e-book production phase and the control group only used the traditional PBL learning strategy to produce the e-book.

The experimental result shows that the number of creative ideas proposed in the experimental group is more than that in the control group in the design phases of visual creativity, as shown in Table2.

Table2. The comparison of the quantities of creative ideas between the experimental group and control group

	Story Design Phase	Style Design Phase	Layout Design Phase
Experimental Group	8	9	14
Control Group	2	4	3

For understanding the students' inner thoughts and feelings, we designed a questionnaire and performed an in-depth interview about the capstone project process. The questionnaires consisting of 6 items were revised from Wang and Hwang (2012) and Hwang et al. (2013) questionnaires. The questionnaire result shows that the experimental group thought that the learning scaffolding could benefit the brainstorming, and the final result of the design is consistent with the initial design idea. With the guidance of learning scaffolding, the pressure and discomfort of the students in the capstone project process can be reduced, and the experimental group felt more confident in the learning process. Such a feeling is very important for e-book production. In particular, the students believed that the relationship among the team members is better than before.

According to the in-depth interview results, the experimental group thought that in the story design phase, the creativity is not easy to present due to the difficulty of use of the unfamiliar software. The students are more proficient and more creative in the style design phase and layout design phase. We may conclude more learning scaffoldings are needed to inspire students thinking and to motivate the frequent interaction between the team members.

During the capstone project process, the experimental groups are apt to help each other to create a number of different schemes due to the understanding of each member's status. In many schemes, there are also some good creative ideas, and the team members can then collaboratively work out the final solution. During the discussions step, students express their views and ideas and record it as the reference in the next learning process.

On the contrary, the control group said they sometimes could not easily show up their ideas and could not design the outcome that they desired. Students sometimes asked the teacher to give advises, but most of the time they searched the relevant works to reference. The control group students could complete the tasks finally without collaboration in the capstone project process, so their design products are most likely worse than those of the experimental group's.

4.2 Findings

We have two findings:

1. The students sometimes have insufficient creativity in the capstone project, and they need good learning scaffolding as a seed to inspire. Thus, exploring an appropriate case as learning scaffolding can inspire students' creativity and problem solving brainstorming.
2. Learning the conducting of a capstone project can be divided into many phases, each of which has its creative target. The students' learning performance can be improved in our proposed multi-phase learning process.

5. Conclusion

For creative and problem solving abilities learning, we have developed a project-based learning platform which is a spiral model using the CBR case retrieve, reuse, revise, and retain techniques to assist students to solve the difficulties in case inquiry, brainstorming, and discussing, respectively. Therefore, it can provide the case scaffoldings and reserve the creative and problem solving abilities learning portfolio in capstone project. According to the students' characteristics and learning portfolio, the platform can be used to trigger students' creative thinking and assist teacher to easily assess the students' achievements of the capstone project. The experimental result shows that the given appropriate learning scaffoldings can guide students to improve the creative and problem solving abilities. In the near future, we will focus on the acquisition and analysis of the learning portfolio.

Acknowledgements

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The Effect of a Mobile Mathematical Game on the Mathematic Learning of the Student with Intellectual Disability

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Abstract: Taking into account of students with intellectual deficits and special needs in concept learning, this research designed a digital game for a fourth grade elementary student with mild intellectual disability to learn the concept of triangle. The participant's experience of learning from the game and the impact of the game on his learning gains on the introduced concepts of triangle were explored. This study adopted the A-B-A' research design of the single-subject model. One 4th grade elementary student with intellectual disability was recruited as the research participant. The experiment included three stages: the baseline, the intervention, and the retention. The participant's level of satisfaction towards the game was collected via observation and interview using the game satisfaction questionnaire. Moreover, the participant's performance on the tests embedded in the game was collected throughout the experiment. Two major conclusions are obtained. The participant is satisfied with digital game-based learning process. The designed digital game is effective in helping elementary students with intellectual disabilities to learn the concepts of triangle.

Keywords: Mobile game, intellectual disabilities, mathematical game

1. Introduction

Students with intellectual problems usually suffer from inattentive, short-term memory deficit, low logical thinking, and feel difficult in concept generalization (Drew, Hardman, & Logan, 1996; Langone, 1990). While learning, they are easily distracted, not being able to concentrate on the important messages delivered by the instructor. They also have difficulty in processing and memorizing the declarative knowledge and procedural knowledge (Crane, 2002). Specifically, they are deficient in synthesis, reasoning and learning abstract concepts. Those physical limitations lead to their difficulty in understanding and applying the basic mathematical principles to solve complex mathematical problems, which further results in their failure and frustration in learning mathematics. Therefore, it is necessary to provide them with individualized learning support and guides to accommodate their special learning needs.

As suggested by the literature in the special education, organization and presentation of the learning content, workout examples and constant practice might help to facilitate the learning process (Katai & Toth, 2010; Ministry of Education, 2011). First, the short-memory deficit limit the amount of the content the students could process simultaneously; therefore, task-analysis is usually adopted to break the content into even smaller meaningful pieces to avoid the cognitive overload. Then the contents are re-chucked based on students' cognitive structure. Second, more concrete worked examples are essential to help them understand the meaning and generalization of complex concepts. Multimedia presentation of contents might attract their attention and help them to visualize the concepts such as geometric figure and solid figure. However, since the students are easily distracted, message irrelevant with the learning content should be avoided. Third, constant and deliberate practice with timely feedback becomes essential to their mastery of the learning content.

A well-designed mobile game, such as breaking-through-the-barricade game, in which the idea of drill-and-practice is embedded, could serve as a learning tutor for the students with intellectual disabilities. The content to be learned in the game could be reorganized into smaller pieces and re-chunked according to the structure of the concepts to be learned and students' cognitive structure. Besides, the learners are allowed to observe and interact the multimedia presentation of the content. Moreover, the test-items presented in each barricade could be sequenced based on the item-difficulty. The game could offer the students with constant practice and instant feedback to help clarify any misconception about the content.

Taking into account of these students' problems, this research aim to design a mobile game for a 4th grade elementary student with intellectual disabilities to learn the concept of triangle. The impact of the designed game on the participant's learning gains and his experience of learning from the game were explored.

2. Method

2.1 Research Participant

One 4th grade elementary student with mild intellectual disability is recruited as the research participant. His performance in the Wechsler Intelligence Test is 67. In math learning, she reports difficulty in understanding the concepts of geometry. Specifically, despite the facts that she can describe the definitions of several types of geometry graphs, when given several geometry graphics, she are not able to identify the correct graphics of a specific type of geometry. Moreover, she has difficulty in reasoning through a complex problem.

2.2 Research Design

The A-B-A' design of the single-subject model was adopted. The instructional goal of the designed mobile mathematics game (intervention) is to develop the subject's knowledge in regard to triangle. The experiment included three stages: the baseline, the intervention, and the retention. (1) The baseline stage: The subject received traditional instruction on the topic of triangle in class for two weeks. Her performance on the test of triangle is collected 5 times after instruction. The data is used as the baseline data. (2) The intervention stage: The subject received individualized instruction with the designed mobile mathematic game implemented after class for five weeks. Her performance on the test of triangle was collected 15 times during this period. (3) The retention stage: After the intervention, the subject's performance data of the same topic was collected again. Additionally, the participant's level of satisfaction towards the game was collected via observation and interview using the game satisfaction questionnaire as well. The implementation procedures are described as follow:

2.2.1 Intervention: the Mobile Mathematical Game

The game is designed to facilitate the player's understanding of three units: types of triangle, the features of triangle, and congruent graphics, including congruent triangles, square, parallelogram etc.). In corresponding to the special needs of the participant, the texts and explanation delivered in the game is written by a teacher with expertise in special education and mathematics. Besides, the participant is deficiency in catching the abstract concept, such as "rotation of the graphic"; therefore, animations are used to visualize the rotation of different introduced graphics. Furthermore, the practice with instant feedback was designed in the game.

The mobile mathematic game is developed using the App Inventor 2 and the game could be used in the Android-based mobiles. The starting page of the game includes four icons:

(1) the "story" icon directs the player to read the story and the mission of the player; (2) the "help" icon directs the player to access the instruction of playing the game; (3) the "game-start" icon directs the player to start the game journey and (4) the "game-record" icon allows the player/instructor to retrieve her performance in the game.

Three barricades corresponding to the three units were embedded in the game. In each barricade, the player starts learning the concepts with the instruction and explanation which are presented by animated graphics and texts (see figure 1). Then the player proceeds to take a practice, containing 5-10 question-items. She has to answer the item within time limit (ie., the time left is shown in the right-upper corner of the figure 2). The “hint” button presented at the right allow the player to decide whether to read the hint before answering the question item. Once the player answer the question and click the submit button, she will be given 10 second to examine the mistake if her answer is wrong. Then, the detail explanations for the four options of the question are provided as the feedback. The score of the whole practice is updated with each question answered. After the practice, she has to take a test in order to break thought the barricade and proceed to the next one. The goal of game for the player is to break through the three barricades embedded in the game.

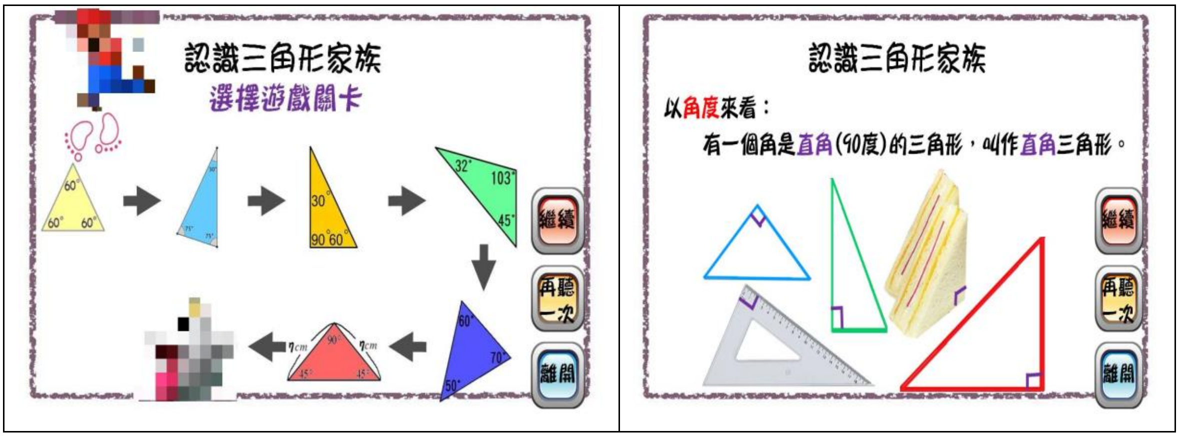

Figure 1. The Interface of Unit1: Triangle

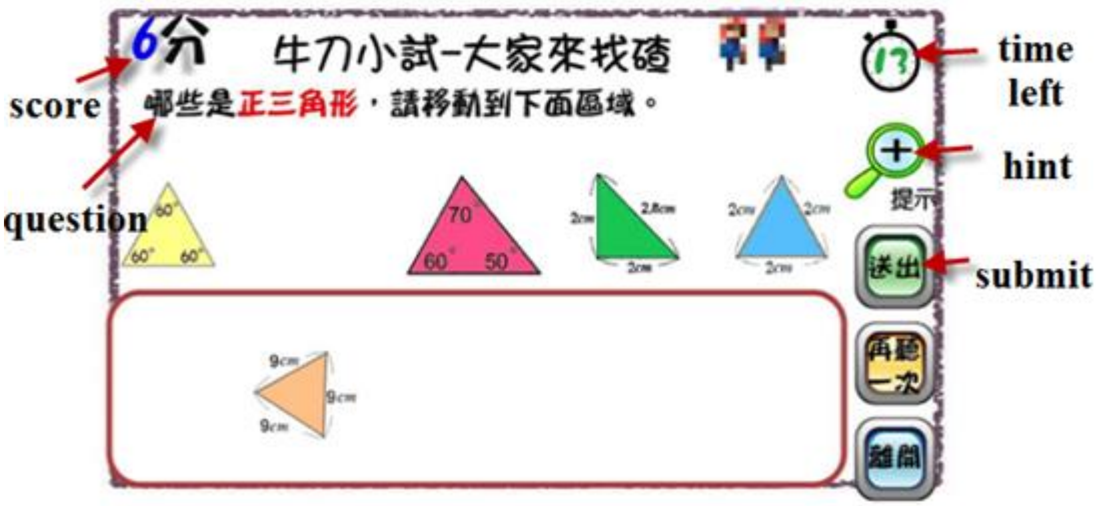

Figure 2. The Example of the Question-item Presented in the Practice

2.2.2 Dependent Variable

Two dependent variables examined in study are level of satisfaction toward the game, and mathematics performance. First, the level of satisfaction is defined as the ease of the operation, usefulness of the game and perception toward this type of learning. The data was collected via interview and the interview protocol was modified from the game-satisfaction questionnaire developed in the study of Hwang, Sung, Hung, Yang & Huang (2012). Second, the mathematics performance is defined as the scores gained on the ten test-items of each unit (i.e. types of triangle, the features of triangle, and congruent triangles)

3. Results

3.1 Level of Satisfaction toward the Game

The interview results showed that the subject felt the ease of operating the game and learning the concept of triangle within the game interface. Besides, she reported that the animated graphics facilitated her understanding of the complex concepts of triangles. With the game mechanism such as time limit, hint and feedback, she concentrated on taking the practice and test in order to break through the barricades. Last, she felt that it was more interesting to learn mathematics in this way. She likes the game and would recommend this game to her classmates.

3.2 Mathematical Performance

As shown in figure 3 which presents the learning curve of unit1, in the baseline stage, the participant's performance is very low with the average score at 18. In the intervention stage with the game introduced, the performance scores are increasing to 82.67. In the retention stage, the average score (86) is higher than those in the baseline stage. The results supported the positive effect of the game on the participant's learning of unit 1.

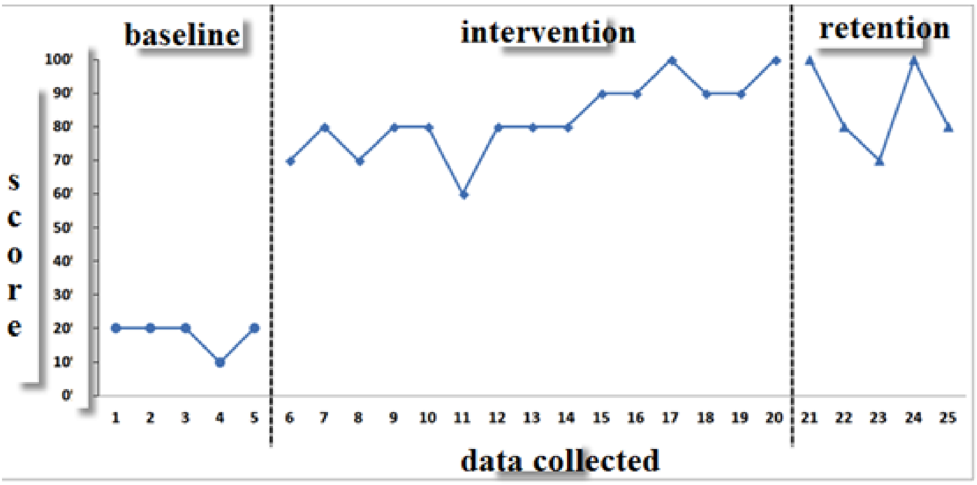

Figure 3. Performance Data Distribution at Unit 1

As shown in figure 4, which presents the learning curve of unit2, in the baseline stage, the participant's performance is low with the average score at 21. In the intervention stage, the performance scores are increasing to 85. In the retention stage, the average score (94) remains high. The results supported the positive effect of the game on the participant's learning of unit 2.

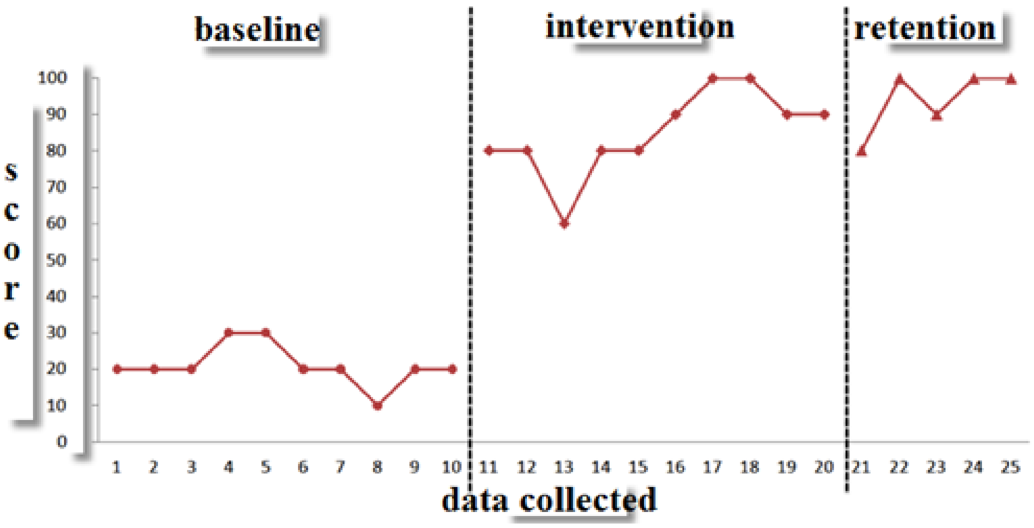

Figure 4. Performance Data Distribution at Unit 2

As shown in figure 5, which presents the learning curve of unit3, in the baseline stage, the participant's performance is low with the average score at 19.23. In the intervention stage, the performance scores are increasing to 84.29. In the retention stage, the average score (82) is remains high. The results supported the positive effect of the game on the participant's learning of unit 3.

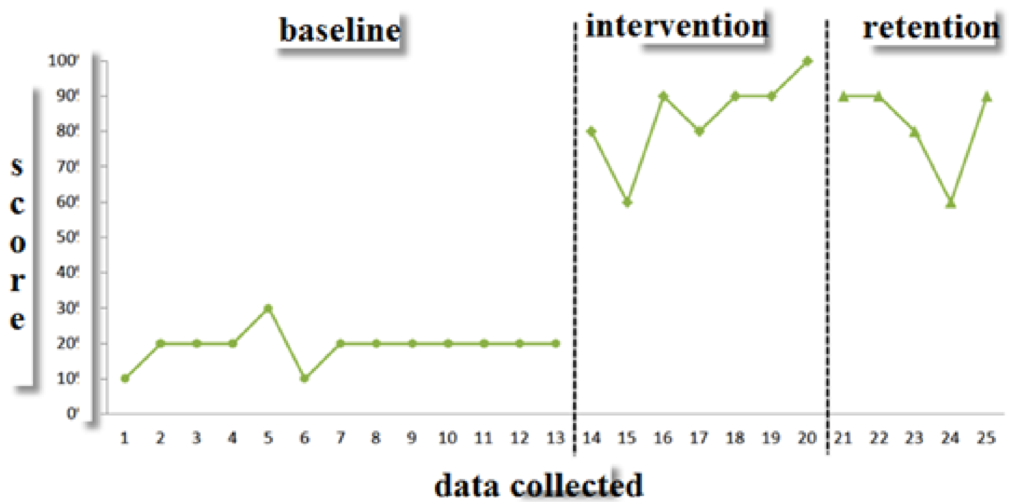

Figure 5. Performance Data Distribution at Unit 3

4. Conclusion

Two major conclusions are obtained. The participant is satisfied with the mobile game and the game-based learning process. As reported by the participant, it is easy to operate the game and interesting. The "barricades" design and the pace of the game could keep the participant concentrate on the gaming process, especially on answering questions. Her perception of the usefulness of the game also motivated her in learning the math with the game. Moreover, the designed mobile game is effective in helping the elementary student with intellectual disabilities to learn the concepts of triangle. The visual presentation of the abstract concept and principles helps the participant to understand the complex concept of triangle. Besides, the participant could observe diverse examples of triangle, which facilitates her in concept generalization. The design of barricades offers her the opportunity of constant practice with feedback, which helps her to process and memorize the concepts and clarify misconception.

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Contextualizing the Learning of Circuits under Biological System: Applying the Yenka Software for Student-Centered Modeling Practices and Self-Assessment

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Abstract: The goal of the project was to introduce a computer-supported modeling activity for biology majors to apply to their understanding of neurons. The activity stressed students' practice of modeling a biological system to learn physics concepts, or vice versa. We introduced an innovative computer-assisted activity to promote the appropriate integration of physical models that could motivate students to see the relevance of physics to a biological system for self-assessment purpose during the learning process. Students manipulated the values of circuit elements experimentally using Yenka software, which allows easy access to simulated science laboratory activities, in order to highlight underlying concepts. The learning activity was tailored for life sciences majors taking introductory biology in their freshman year (n_b = 164). We leveraged students' prior knowledge of the underlying mechanism that drives sensory or motor action (e.g., vision or muscle reflex) and applied that understanding in constructing the circuit simulation on Yenka software. Three electrical models were provided on Yenka for students to manipulate in order to simulate the *equilibrium potential*, *membrane potential*, and *action potential* in neurons. Based on response to an end-of-session question, more than three-fourths of the life sciences majors (75.6%) perceived the modeling activity to be at least 'somewhat helpful' for their learning experience. This study is important because it presents a computer-assisted technology used in teaching/learning physics or biological phenomena in class and in the laboratory. It supplements conventional instruction of neuron or circuits with simulations, computer modeling, experimental data processing, and analysis of graphics obtained during the activity. Educational implications are discussed.

Keywords: computer-supported modeling, Yenka program, neuron, circuit, simulation

1. Introduction

Models and modeling practices are crucial in scientific reasoning and inquiry and are often used as simplified representations for describing or visualizing micro- and macro-level phenomena (Cheng & Brown, 2015; Gilbert, 2006). In addition, appropriate integration of physical models motivates students to see the relevance of physics to biological systems. In view of this, a project to introduce a computer-supported modeling activity for biology majors to apply to their understanding of neuron and circuits was proposed, where the practice of modeling a biological system to learn physics concepts or vice versa is stressed. This project investigates students' perceptions toward practicing their interdisciplinary modeling knowledge with the assistance of computer technology, using a student-centered assessment approach. To achieve this goal, the laboratory activity is designed in a way so students can connect with their prior knowledge of biological phenomena. In other words, the biology or physics concepts were not linearly introduced from a textbook but were included in the computer-assisted modeling activities as it became necessary to understand the target phenomenon. Concepts are believed to be retained better by learners in this way (Gilbert, 2006). In addition, it brings out the important task of a scientist to create models, so that students not only acquire declarative knowledge but the procedural knowledge through model-building.

Science concepts are usually represented as simplified models to help people perceive the world. We used Namdar and Shen's definition (2015) of model—"a human construct used to describe, explain, predict, and communicate with others a referent such as a natural phenomenon, an event, or an entity." (p.994) scientific models can be found in the form of diagrams, physical replicas, mathematical representations, analogies, and computer simulations. (NGSS Lead States, 2013). We adopted the computer simulation as our means of constructing scientific models. An innovative computer-assisted activity was introduced in this study to promote the appropriate integration of physical models that could motivate students to see the relevance of physics to biological system. Students' prior knowledge of the underlying mechanism that drives biological senses and action (e.g., vision or muscle reflex) was leveraged and applied to the construction of scientific models.

Without a proper scaffolding process in constructing models, however, students often encounter problems during the modeling process because it is believed to associate with more sophisticated reasoning (e.g., intentional integration and establishment of connections among data, causal-effect relationships, transfer between dynamic and static representations, etc.) (Gobert & Clemen, 1999). Educators agree that careful scaffolding and context-oriented modeling is essential to guide students to use relevant explanations and models to account for phenomenon in their daily lives (Gilbert, 2006; Krell, Reinisch, & Krüger, 2015). Computer-assisted learning tools are thus introduced to facilitate the scaffolding processes; while the contextualization of physical models of a biological system provides context-oriented modeling, and also avoids students perceiving textbook models as isolated, non-transferrable facts. One of the purposes of adopting a computer-assisted modeling practice is to allow the classroom instructors to shift away from rote memorization of scientific principles.

In this study, we aimed to create a scaffolding activity in which students could behave as scientists and approach phenomena as scientists approach them by modeling biological systems and applying that in understanding the physical models on the computer-assisted learning environment. The modeling practice is not only applied in the biology lab but also contextualized in understanding the phenomenon. We will focus on the discussion of adopting neuron models by constructing circuits in this study.

2. Methods

2.1 Computer-Assisted Modeling—The Yenka Software

Yenka is a modeling and simulation software platform for mathematics and sciences education. It allows students to build circuits using a set of basic electrical components (see Figure 1). Notice that the background image with channel proteins embedded on neuron membrane were either retrieved from the textbook *Principles of Biology* (Nature Education, 2014) or created by instructor. An electrochemical gradient governs the movement of ions across the membrane of a neuron. The electrical properties of neurons can be readily modeled by an electrical circuit. The concept of the electrical potential in a physical science textbook was introduced in the context of the driving force behind the electrons.

Students manipulated parameters associated with the Yenka models, with possible predictions beforehand. For instance, the resistances in the equilibrium potential model represented concentrations of the ions (see Figure 1). Students could change the inside and outside concentrations to see how this affected the equilibrium potential. They could make a plot of the ratio of the inside to outside concentration versus equilibrium potential and then draw conclusions. Another example is for the membrane potential. The parameters were the equilibrium potentials of the two ions represented by batteries and the permeabilities of the two ions represented by resistances. Students manipulated these and saw the effect on the membrane potential. For instance, students could choose a scenario where the leakage channels of potassium were blocked by one-half by a certain venom and see the effect on the membrane potential. The students collected data to see how the membrane potential varied with each parameter. These could be plotted, discussed and subsequent conclusions could be drawn. The main purpose of all these activities for us was for students to query the models to get a deeper knowledge of the underlying biological phenomenon. The Yenka models could be applied with different objectives, such as a way to design an artificial neuron.

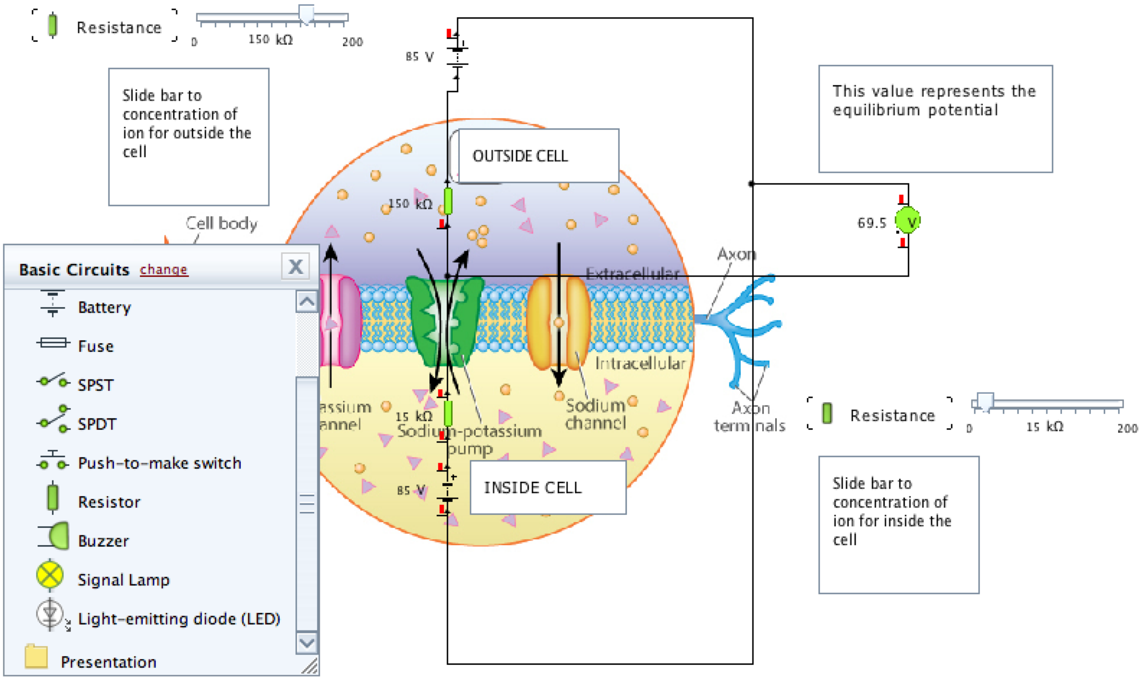

Figure 1. The figure shows some basic components for constructing basic circuits enlisted in the pop-up window entitled "Basic Circuits."

Borrowing the analogous concept of electrical potential in a circuit context and the nervous system, the instructors were able to provide the context-oriented learning environment in order for learners to understand the three different kinds of potential under discussion—equilibrium potential, membrane potential, and action potential.

2.1.1 Equilibrium Potential

The equilibrium potential of an ion is when the diffusion and electrical gradients acting on that ion species are balanced. No net movement of that ion across the membrane is detected. In the Yenka software, the computer simulation is set up as in Figure 1, where the concentration of the designated ion is represented as the resistance inside and outside of the cell without the sodium pump involved. When both of the ion concentrations, inside and outside of the membrane, equal each other the equilibrium potential is 0 mV, meaning that there is no potential difference across the membrane, thus, no net movement of an ion of its kind in the neuron.

To scaffold the scientific modeling process, guiding questions were posed to direct their interaction with the Yenka software. Some representative questions to scaffold the understanding of equilibrium potential are provided below:

Example question #1: Manipulate the concentrations of potassium inside and outside of your Yenka model for equilibrium potential as shown in Table 1 and record the resulting equilibrium potential. Plot and insert an Excel chart representing K+ equilibrium potential as your Y axis (dependent variable) and the inside/outside K+ concentration ratio as your X axis (independent variable).

Table 1: Effect of the K+ concentration inside and outside a neuron on K+ equilibrium potential.

Concentration of K+ INSIDE (mM)	Concentration of K+ OUTSIDE (mM)			
	10	100	1,000	10,000
10				
100				
1,000				
10,000				

Example question #2: What is the actual concentration of potassium inside and outside a neuron for a human? What is the resulting equilibrium potential?

In example question #1, students were asked to manipulate the concentration of ions and to present their data graphically, while question #2 asked students to find and use the actual ion concentrations found in neurons. The immediate application of simulated results helped connect the physical models with the biological systems.

2.1.2 Membrane Potential

The membrane potential of a neuron indicates the difference in electric potential inside and outside the cell. It is different from the equilibrium potential because it is a cumulative effect of all ions that are permeable to the membrane instead of "one particular ion." Two important features for the establishment of a membrane potential are the *ion-specific leakage channels* (passive action) and Na^+/ K^+ pump (active action). Specifically, when neurons are not sending signals, the membrane potential is said to be at *resting membrane potential* (or *resting potential*). The resting membrane potential is about -70mV for humans, where interior is more negative than exterior. It is the result of the fact that there are more K^+ leakage channels than Na^+ ones. So, the resting potential is closer to the equilibrium potential of K^+.

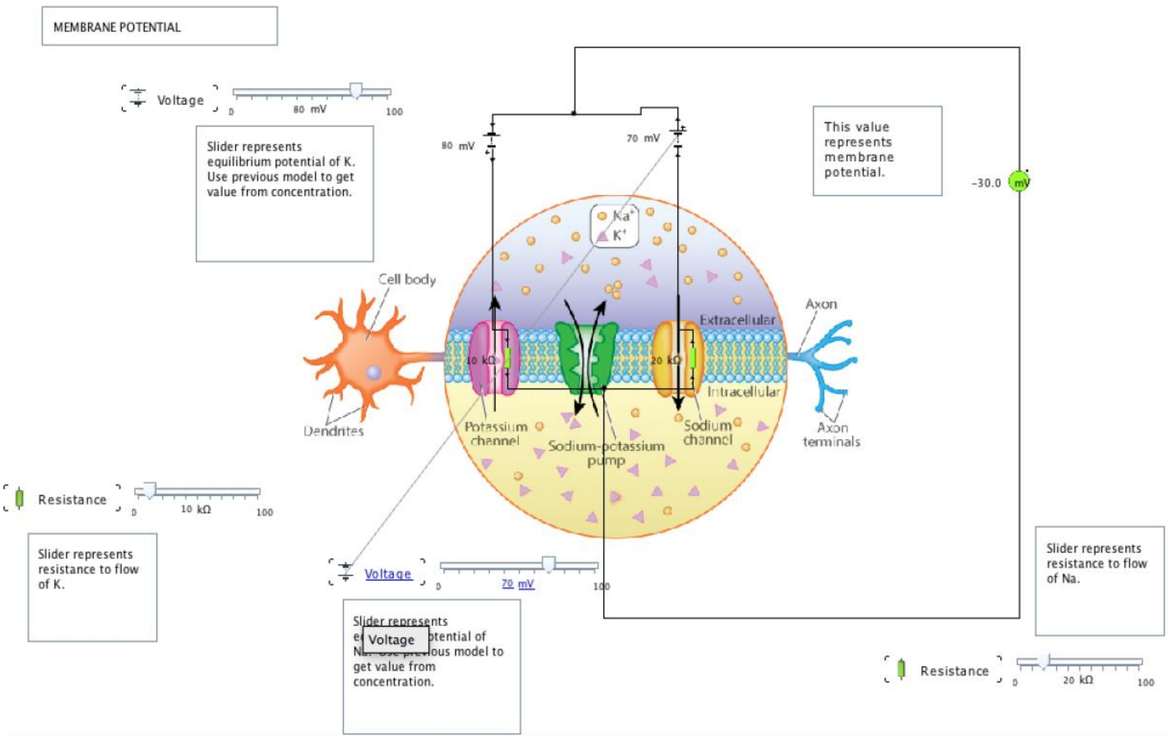

Figure 2. The circuits models the membrane potential of the neuron in Yenka software.

In the Yenka software, the computer simulation was set up as in Figure 2. In addition to using the resistance as the representation of the flow of ions, students were able to change the value of *equilibrium potential* by adjusting the "Voltage" slider. The value is derived from the computer simulation model of the previous activity (e.g., Example question 1 in 2.1.1).

Some representative questions to scaffold the understanding of membrane potential are provided below:

- Manipulate the permeability of the membrane such that it is equally permeable to sodium and potassium. What is the resulting membrane potential?

Table 2. Effect of the relative permeability of the membrane to sodium and potassium on the membrane potential

	Membrane permeability to **potassium**		
Membrane permeability to **sodium**	High	Medium	Low
High			
Medium			
Low			

- Manipulate the permeability of sodium and potassium channels such that the resting membrane potential is equal to -70mV. Calculate the corresponding ratio of sodium/potassium permeabilities.

2.1.3 Action Potential

Action Potential is one of the two types of changes in neuron's membrane potential. It is triggered when voltage reaches threshold with the onset of depolarization and then hyperpolarization. Depolarization indicates the opening of Na^+ gated channels, while hyperpolarization indicates the opening of K^+ gated channels. (see Figure 3a).

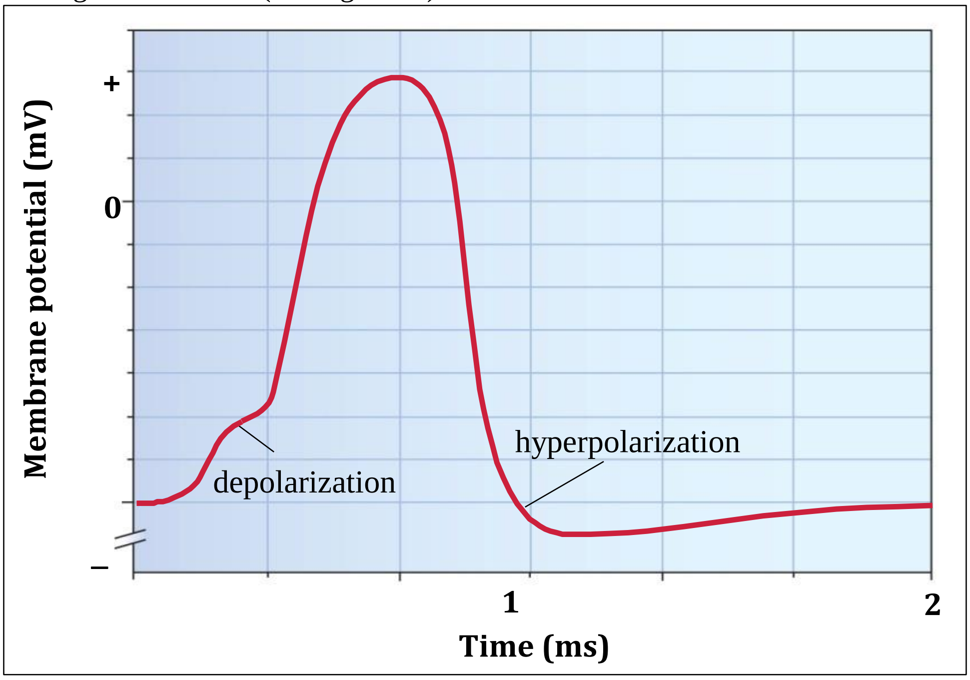

Figure 3a. The change of membrane potential in an all-or-none action potential with the progression of time (ms).

In the Yenka software, the computer simulation was set up as shown on Figure 3b. In this setting, a new feature was introduced for students to observe simultaneous graph plotting while they turn on and off the switches that represent the voltage-gated sodium/potassium channels.

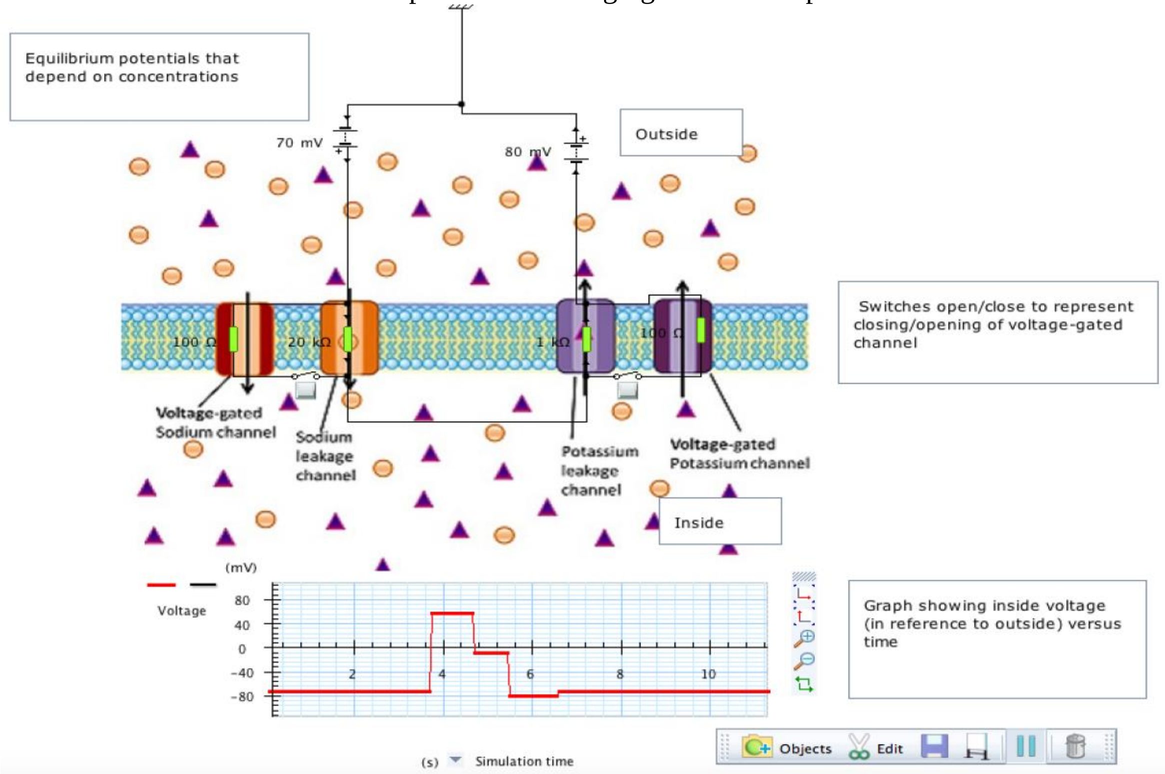

Figure 3b. The circuit simulation model that replicates the action potential of the neuron in Yenka software.

The following question was provided to scaffold the application of the circuit model in order to replicate the action potential using the Yenka software:

Open and close voltage-gated sodium and potassium channels by following the order in which they open and close during an action potential. You can record the voltage changes over time by clicking Yenka/edit/pause. Insert a screenshot of your Yenka model. Note that the x-axis in an actual action potential is represented in ms; however, in the simulation seconds were used. The depolarization and hyperpolarization was correctly represented by the Yenka simulation plot, however, the plateau around the fifth second is due to the delayed closure of voltage-gated sodium channel.

2.2 Participants

The learning activity was tailored for life sciences majors in a small college in the Southeastern United States of America. The students were taking introductory biology in their freshman year (n_b = 164). In one class meeting students discussed and presented analogies of neuron physiologies, and the next session was spent on the Yenka activity.

2.3 Data Collection and Analysis

We administered 10 questions related to neuron concepts as pretest and posttest. To determine whether students' performance on both tests were significantly different after Yenka activity, we applied paired samples T-test to analyze the data. Students' perceptions toward the three Yenka activities were collected by an end-of-session 5-level Likert-Scale question: What do you think about the "Yenka Models of neuron physiology" activity in the lab? (e.g., extremely helpful, very helpful, moderately helpful, somewhat helpful, and not helpful).

3. Results and Discussion

There was a significant difference in the scores for pretest (M = 3.30, SD = 1.501) and posttest (M = 4.54, SD = 2.067), $t(152) = -4.691$, $p = .000$. The preliminary result indicated that the students understanding of neuron was better after the learning activities in class. However, we did not have the performance of a control group as baseline data to see whether students' achievement was better than previous year. The percentage for students' perceived helpfulness for Yenka activities was: extremely helpful (16.5%), very helpful (14%), moderately helpful (18.9%), somewhat helpful (14%), and not helpful (24.4%).

More than three-fourth of the participants perceived the student-centered modeling practices on Yenka software to be at least 'somewhat helpful' for them to learn different potential concepts. This finding is substantial in the following ways. First, because students not only actively engaged in modeling practices, but also continuously carrying out the self-assessment about their understanding of neuron model on Yenka by manipulating the parameters. However, there was still approximately a quarter of students who found Yenka activity to be 'not helpful' for their learning. This finding could be due to several reasons: First, because the modeling activity was introduced late in the semester, not enough time was allotted for students to fully explore the Yenka activity in the laboratory. Besides, one of the sessions encountered technical difficulty when opening Yenka software, so even less time was designated for that particular group to participate in Yenka in a meaningful way. Even with time constraints, in order to receive constructive feedback to their model modification, more professional training for instructors to take advantage of modeling practices was recommended.

Second, even though we guided students with step-by-step scaffolding questions during the neuron modeling practices, some students were still not able to appreciate the inclusion of a model during learning processes. Since this process was mainly done through the worksheet in this study, we recommend that more in-time face-to-face scaffolding process could be adopted by instructors. In this way, more structured personal communications as means of scaffolding processes can be introduced and incorporated during students' Yenka activity in order to supplement the relatively passive scaffolding (i.e., written responses on the worksheet).

Third, the participants in this study had not been introduced to physical sciences concepts related to circuits. We plan to revisit the neuron concepts longitudinally when these freshman life science majors take physics class in the third year as a spiral curriculum design. In this very first exposure to the modeling practice, brief introduction of how the unfamiliar physical sciences terminologies are used in nervous system should be provided prior to Yenka activity. For instance, *potential, voltage, resistance, and concentration gradient of ions*, etc, might not be readily comprehensible by life sciences majors. This might supplement the application of such concepts in understanding neuron. Future research should be done on more careful curriculum design to foster such interdisciplinary collaboration and understanding.

Because the student participants in this study had not taken the physics course, explicit contextualization of each concept on the Yenka model as well as how such understanding could be applied to understand biological systems would be highly recommended. Such conduct would gradually foster the habit of mind to think and create models beyond disciplinary constraints, as most of the real life problems transcend well-defined disciplines.

The study is important because it presents the computer-assisted technology used in teaching/learning physics or biological phenomena in class and in the laboratory. The scaffolding processes in the form of guiding questions were provided as reference for other educators who wish to adopt the learning of neurons with computer simulations. It supplements conventional instruction of neuron or circuits with simulations, computer modeling, experimental data processing, and analysis of graphics obtained during the activity.

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An e-Learning System for Programming Languages

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Abstract: In this paper, we describe an e-Learning system that can help novices to learn how to develop some workable programs in a short period of time and assess their performance. The system takes advantage of computer and network technologies and combines the concept of flipped classroom to help the instructor and students in their teaching and learning activities. The preliminary study shows that the platform can indeed assess the students' performance and consequently help the students to learn programming languages more effectively and efficiently.

Keywords: programming language, e-Learning system, flipped classroom, student-centered learning

1. Introduction

Recently, the new concepts of the flipped classroom, student-centered learning (Jones, 2007), (Hannafin and Hannafin, 2010), (Johnson, 2013), (Crumly, 2014), (Young and Paterson, 2007), and problem-based learning in combination of advances in computer technology have led to a renewed interest in developing e-Learning systems (Richey, 2008), (Garrison and Anderson, 2003), (Nikhilesh and Karforma, 2012). In an extreme case, student-centered learning requires students to set their own goals for learning, and determine resources and activities that will help them meet those goals (Jonassen, 2000). However, in practice, this idea case may not happen very often unless the students are highly motivated by themselves. Therefore, in most practical cases, an instructor may use various blended learning methods for his pedagogical strategy. In particular, with the help of computer and network technologies, it is possible to develop an e-Learning system that can easily incorporate the concepts described above to form an interesting learning environment. In this paper, we develop such a system to effectively and efficiently help college students to learn how to write programs in an "introduction to computers" course.

In section 2, we briefly review the related concepts used in our system, such as flipped classroom, student-centered learning, and problem-based learning (Hmelo-Silver and Cindy, 2004), (Schmidt, Henk, Rotgans, Jerome, Yew, Elaine, 2011), (Neville and Alan, 2009). In section 3, we discuss the ideas of designing the e-Learning system. In section 4, we show how the system is used in practice, assess students' performance, and how the system can effectively and efficiently help the students to learn a programming language. In section 5, we describe the results of our experiments of the system. In section 6, we discuss the advantages and disadvantages of the system. Finally, we give conclusions in section 7.

2. Related Background

As far as an instructor is concerned, it is much easier to simply present whatever materials are in the textbook than to do something else such as diagnosing students' learning problems and making efforts to help each individual student. Therefore, traditionally, most instructors prefer to give lectures rather than any other teaching activities. Consequently, in the traditional model of classroom instruction, the teacher typically gives lectures, is the central focus of a lesson, and is fully in control during the class time. Since the instructors simply disseminate the knowledge in the textbook, normally students do not really find too much difficulty to learn the pure knowledge. In particular, in most Asian countries normally students just passively listen to the lectures and keep quite instead of actively asking questions in classroom even though they do have some problems with the materials the instructor teaches. In other words, most classroom are didactic and entirely content oriented without considering whether the students really learn what they are supposed to learn. In order to ensure that the students really learn the teaching materials, instructors normally assign some homework for the students to take home and exercise the related works. Generally speaking, students typically do not really find any problems with the learning materials until they are asked to apply whatever they learn to solve a real problem. In other words, they usually find difficulty when they do their homework that are assigned to them to do after class.

The concept of flipped classroom is an attempt to remedy this problem. It is an instructional strategy of blended learning that reverses the traditional class arrangement by delivering the learning contents outside the classroom, often on-line, and moving the activities such as doing homework and discussing specific problems in the classroom. In this case, whenever they encounter any problems, they can simply ask the instructor or classmates right away and are able to learn more than that in the traditional class. This arrangement also fits itself into the concepts of problem-based learning and student-centered learning.

However, in this case, the instructor may still face the problem that students may be doing something else instead of really working hard on their assignments. In particular, when there are many students in the classroom, it is virtually impossible for the instructor to assess every student's work simultaneously. As a result, many students may be working on something else that may be more interesting to them, such as a game. Eventually, the students' performance may not be as good as what we originally expected.

Therefore, we set out for developing an e-Learning system that can easily assess every student's performance implicitly and explicitly so that the instructor can always know the learning status of every student. Consequently, the instructor can do whatever is necessary to help the students in learning activities.

3. The Ideas of Designing the e-Learning System

Generally speaking, a student in an information engineering department of a university is supposed to take a programming language course in which he should learn how to write a workable program. However, currently in Taiwan, many students still can not develop a workable program after taking such a course. In fact, this is one of difficult problems we are facing in most universities. Based on our experiences, the major reason that causes this problem is that students who fail to do so do not really try hard enough to write a program and test it by themselves. Instead, whenever they encounter some problems, they simply quit and simply plagiarize other classmates' work with minor modification so that their programs do not look exactly the same as others. In some cases, the students may indeed try to write a program. However, they encounter a lot of problems and nobody can really sit next to them to help them to solve the problems. In this case, the plagiarism seems to be unavoidable. Since it is difficult and time consuming for the instructors or teaching assistants to really check through all the students' homework to find whether there is any plagiarism, those students can usually get away with it. Consequently, those students still can not write a workable program after finishing the course. We believed that if we make use of computer and network technologies in combination with the concept of flipped classroom, we should be able to solve the problem to some extent.

The features that we want the system to have are the following: (1) We should try to somehow "force" the students to really write and debug a program on their own. (2) We should somehow assess whether they are really do the work. In other words, we should make use of computers to collect formative data for monitoring and assessing the students' performance as much as we can. (3) Since the students are novices, most of them have difficulty to discern what is a good/bad program, how to solve a specific problem, and so on. Therefore, we should have a mechanism to show them some real examples done by some students and explain to them about some key points so that students can fully understand how to solve a real problem and how to avoid some mistakes. (4) We should try to make use of the concept of the flipped classroom which suggests that we should try to teach less in the classroom and ask students to do exercises and discuss various problems in the classroom. The students can study some more learning materials after class by themselves. In particular, as far as programming languages are concerned, there is no profound theory behind them. All the programming languages just have a lot of rules that can be easily understood if the instructor can emphasize the important concept in his lecture. The real difficulty of the programming work is the applications of those rules in a real case. In other words, we do need to use some real examples to explain to the students about the insight into the applications of programming languages. Therefore, what the students should do is to really exercise the programming work.

4. How the System is Used in Practice

At the beginning of each class, the instructor can click at the "上課" button and "出席狀況" button as shown in Figure 1.

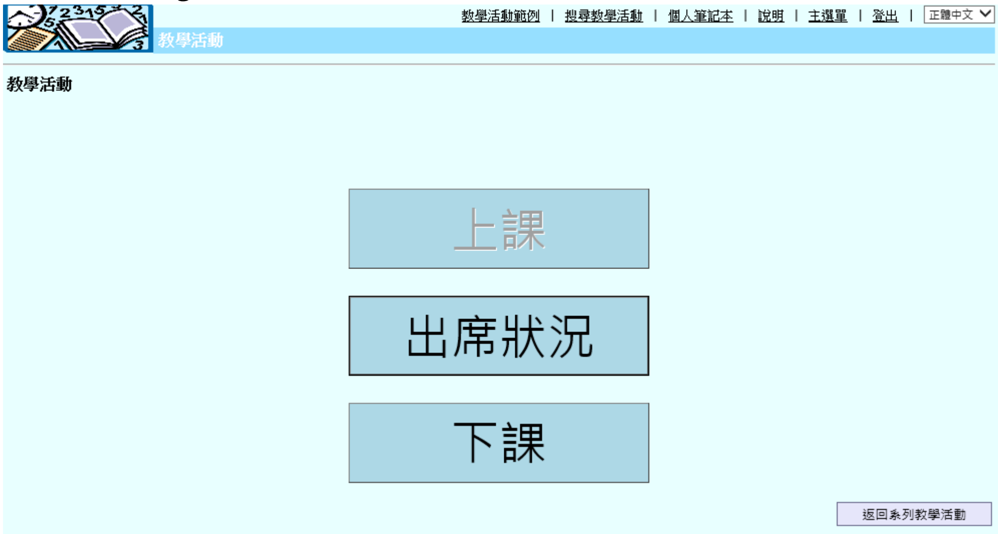

Figure 1. The webpage for starting out the class

The system will show all the students' names in the webpage as show in Figure 2. As time goes on and the students log in the system, the students' icons will be lit up to show that the students attend the class. In this case, the fourth student from the left has logged in. The instructor can check the attendance situation of the class.

Figure 2. The system will show the students' names in the webpage.

In each class, the instructor gives a short lecture to explain the essence of a program statement, such as a “for” loop. Then, a simple example is given to explain how the “for” loop really works in practice. At this point in time, the students should have a basic idea about a “for” loop without any difficulty in most cases. The instructor can begin to give a question and ask the students to write a program to solve the problem. For instance, the question can be “accept a natural number from the user and compute the sum of even numbers that are less than the given natural number”. The instructor can click at the button circled by the red rectangle in Figure 3.

Figure 3. The webpage for the instructor to give an assignment

The instructor can select whether he wants to give an oral question, an existing exercise question, or generate a new exercise question. For instance, he can give an existing exercise question in the exercise database. The exercise database is organized in a hierarchical structure as shown in Figure 4.

Figure 4. The existing exercise questions are organized in a hierarchical structure

The instructor can select which types of the questions he wants as shown in Figure 5.

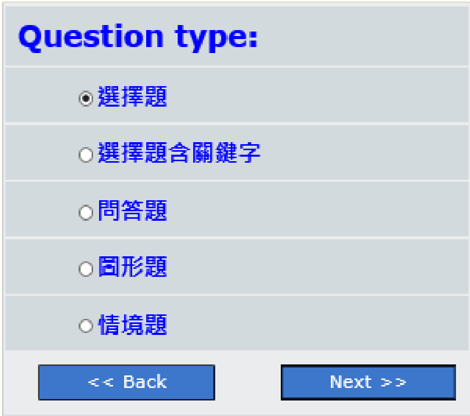

Figure 5. The different types of the questions in the system.

The instructor can select one of them for this short quiz or exercise. The system will show the contents of this exercise for the instructor to confirm whether this is really what he wants. The instructor can also give an assignment on the spot if he wants. If the instructor confirm this exercise, the system will ask the instructor to set the time duration for this exercise as shown in Figure 6.

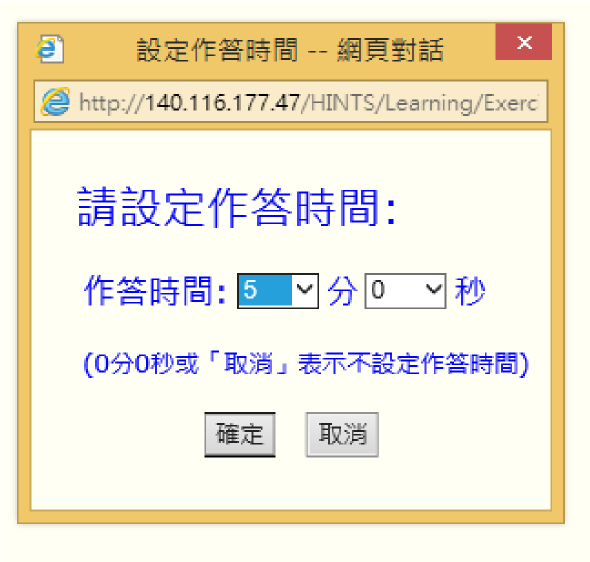

Figure 6. The instructor can set the time duration for the current exercise.

If the instructor gives two questions in a row, the students will see that the first two exercise questions are open as shown in Figure 7. The students can begin to work on their programs (the exercise) on their computers in the computer room in the department. During this time period, the instructor can go around the computer room, look for students that need help, and help them to solve the problems immediately. When the students finish up their programs, they should upload their programs by clicking at the button “”.

Figure 7. The first two questions are open and one student has submitted the first answer to the question one.

The system will show their submission status for each exercise so that the instructor can see how the students perform. If the time is almost up and most of the students are still working on the program, the instructor can extend the time period so that the students can continue to work on it. When the time is up, the system will show the exercise is closed and the students can not upload their programs. At this time, the instructor can further extend the time period if he wants by clicking a button. The instructor can also select whether the students can see each other's program or not. If they can, the students can click at a button to see other students' programs. If they can not and the instructor wants to show the students' programs, the instructor can select one student's program to show all the students and explain the good/bad points in the program to all the students. In Taiwan, all the computers in the computer room are equipped with a share mechanism for the instructor to show the contents of his screen to all the students by clicking at a physical button. Therefore, it is very easy for the instructor to make use of the students' program as a real example to explain mistakes that usually made by the students or virtues of good programs.

5. The Results of the Experiments of the System

Since the system will automatically compute the statistics of the time duration of the students spent on each exercise and the submission rates of each exercise, the instructor can easily understand how the students perform. The students are told that their performance will be assessed by the system automatically. Since the students are asked to work on their programs in the computer room, they are much more likely to really work on their programs in particularly while the instructor is going around the computer room. Furthermore, the students can easily get help from the instructor or other classmates whenever they need the help. The instructor can also check the students' programs at the same time and understand how the students perform.

At the very beginning of the class, when the students were asked to work on a program, the students were still not used to the new learning style and were not eagerly work on their programs. They were just hanging around there to wait and see what is going to happen. In other words, they still thought that the exercise was similar to other laboratory work in which students were normally chatting or joking around while doing some experiments.

After the first exercise, they realized that everything, such as whether they submitted the results, was recorded. They could see through the system who had submitted a program and who has not. Furthermore, the instructor could see the submitted programs and even showed someone's program anonymously to the whole class and made comments on it. As time went on, they realized that the system would record everything and the instructor could check who was not really working hard if he did not really submitted his programs. They gradually realized that they could no longer fool around just like what they did before. There is no kidding. The system was actually for real. Therefore, they were getting serious about each exercise and gradually became more and more active learners, and really tried hard to finish up their programs. As a result, the submission rate became higher and higher as time went on.

We could also easily observe this situation from the rates at which the students asked questions. As time went on, more and more students began to ask questions although traditionally Asian students tend to hesitate to ask instructors for the problems they encountered in their study. However, in our case, the students were under the pressure to finish up their exercises as soon as possible, they did break their silence and more vigorously asked questions in an attempt to solve their problems. Furthermore, in order to encourage the students to ask good questions, the instructor did give extra bonus points if a student asked an interesting or meaningful questions. This arrangement indeed worked very well since many good questions were asked in the classroom and many students' misconceptions were indeed found. In Figure 8, the instructor and students can check the datamining webpage to see all the data collected by the system. The instructor can select what kind of statistics he wants to see.

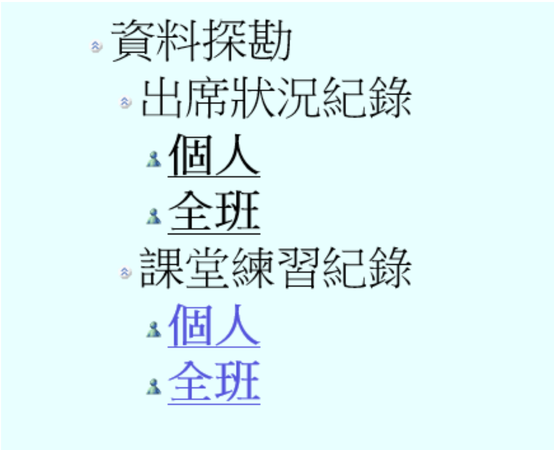

Figure 8. The datamining webpage of the system.

The instructor can check the attendance status for each class as shown in Figure 9.

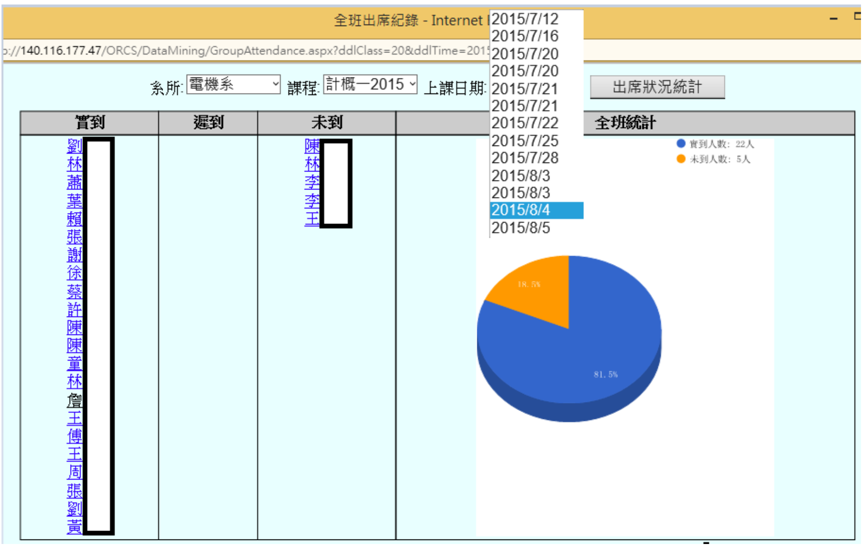

Figure 9. The system shows the attendance status of the class.

The instructor can also see the attendance status of every class as shown in Figure 10.

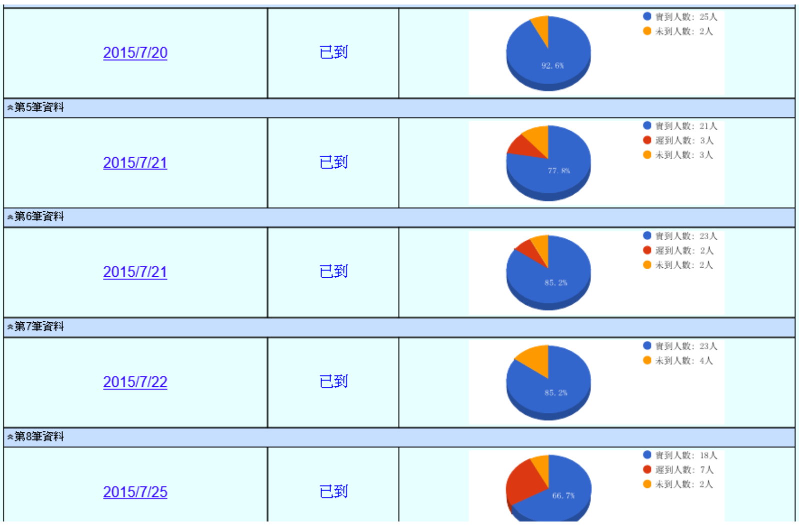

Figure 10. The attendance status of each class.

The attendance statistics of each student can also be seen in Figure 11.

使用者名稱	準時到課	遲到	未到	實到(%)
劉	8	0	5	8(61.5%)
林	8	0	5	8(61.5%)
陳	3	0	10	3(23.1%)
蕭	6	1	6	7(53.8%)
葉	8	2	3	10(76.9%)
賴	8	3	2	11(84.6%)
張	6	3	2	9(81.8%)
林	0	2	11	2(15.4%)
謝	7	0	6	7(53.8%)
徐	5	1	7	6(46.2%)
李	3	2	8	5(38.5%)
李	6	0	7	6(46.2%)
蔡	6	2	5	8(61.5%)
許	8	1	4	9(69.2%)
陳	7	0	6	7(53.8%)
陳	8	1	2	9(81.8%)

Figure 11. The attendance statistics of each student.

In Figure 12, the system shows the submission status of each class. We can see that at the very beginning, the submission rate is almost zero. As time went on, the submission rate did increase dramatically.

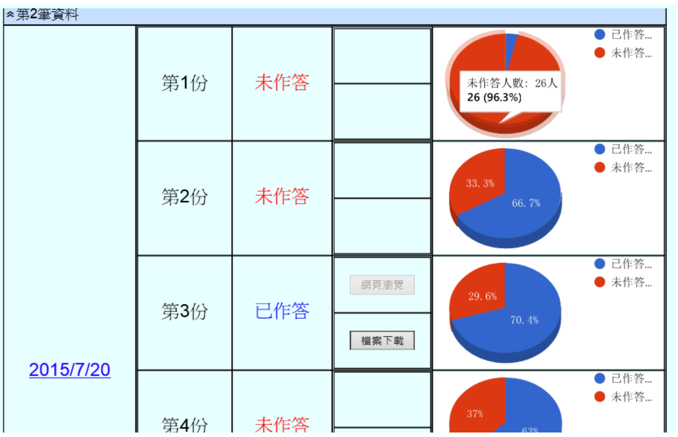

Figure 12. The submission rates of the exercises are displayed.

Since the system will automatically compute the statistics of the time duration of the students spent on each exercise and the submission rates of each exercise, the instructor could easily understand how the students perform. The students were told that their performance would be assessed by the system automatically to some extents. The students could easily get help from the instructor or other classmates whenever they needed the help. The instructor could also check the students' programs at the same time and understood how the students performed.

6. The Advantages and Disadvantages of the System.

6.1 The Advantages of the System

The students feel that although this learning style kind of "forces" them to do the programming work, they can learn the work more quickly and easily. The programming work is really not as hard as what they originally thought. Whenever they have problems in the programming work, they have opportunities to ask the instructor or classmates directly to solve the problems immediately instead of getting frustrated and giving up eventually. The formative data we collected during the class time and the statistics we computed show that the students indeed keep improving their programming skill as well as the motivation to learn. This formative assessment instead of a summative assessment can play an important role to monitor students' performance and really improve students' programming skills over time. As the students keep improving their programming ability, they are more interested in writing programs and have much strong sense of achievement whenever they make their programs workable. Consequently, they become more active learners and even try to develop programs with more features than what was given by the instructor.

6.2 The Disadvantages of the System

The downside of this learning style is that the instructor who make use of the system should (1) be enthusiastic about teaching and (2) have enough real experiences about the developments of software systems. For the first point, since the instructor should go around the classroom and look for the students' needs for help, this task is much harder than simply deliver the lecture of the learning materials that are in the textbook and he is familiar with. For the second point, since most professors focus on the theoretical aspects of teaching materials and may forget about all the detailed programming skills, it is hard for most professors to go back to the nitty-gritty details of the programming work that they did maybe more than ten years ago. This may pose a big challenge to a professor who is not really enthusiastic about the teaching and is normally evaluated about his research work instead of the teaching efforts by the institute that he is affiliated to. Furthermore, some students' programs may have some strange bugs. The professors may have to really spend time on the students' programs and have enough experiences to find bugs and solve the problems for the students.

7. Conclusions

From the data collected by the system, we can see that the students do become much more active learners. We also find that the students can really develop workable programs that they were not able to do in the past. The system can really assess the students' performance and help the students to learn programming languages effectively and efficiently. Students' programs or other example codes can be stored as learning scaffolding. Furthermore, the students' works can be stored as their portfolios that may be beneficial to improve students' learning achievement in the long run. The system, as it stands today, still has some problems that need to be corrected in the future. First of all, the system is not able to automatically check whether the students get right answers or not. This may not be a difficult work to do in most cases since we can automatically generate some random numbers as the input to a program that is a correct one and compute the correct answer. Then, we can compare the correct answers with the students' answers. Consequently, the system may be able to check the correctness of the studnets' programs to some extents. Secondly, based on the current technology, we are still not able to automatically diagnose the students' programs if something does go wrong in their programs. We still need to rely on human efforts to do the diagnosis which may be a difficult and time consuming work. We believe that we might be able to solve the first problem in the near future and make the system even more useful in the future.

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ICT in Educational Transformation for 21st Century Pedagogies in Emerging Developing Countries within the Asia-Pacific Region

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The education landscape has gone through several transformations throughout the years. Of late, what and how students should learn has taken the center stage in debates on education, sparking further concerns on how to create innovative teaching approaches through dynamic curriculum. Iterative reformations have gradually shaped pedagogical approaches that put students accountable of their own learning and recognize them as the producers of knowledge (Law & Miura, 2015).

In emerging developing countries, educational transformations ensue in a multitude of forms. With the aim to provide students with 21st Century learning experiences, these countries undertake several initiatives to bring their education system to the next level. Often, ICT takes place in ramping up innovative pedagogical approaches as it has a "multiplier effect throughout the education system" (UNESCO Institute for Statistics, 2014, p. 6) because of its versatility in accommodating learning advancements and teaching practices.

In response to the growing research diversity among emerging developing nations within the Asia-Pacific region, the Fourth International Workshop on ICT Trends in Emerging Economies (WICTTEE 2015) is held in conjunction with the 23rd International Conference on Computers in Education, Hangzhou, China. WICTTEE 2015 is organized by the SIG on Development of Information and Communication Technology in the Asia Pacific Neighbourhood—DICTAP. The visions of DICTAP are to:

1. Share ideas and best implementation practices related to government policies and incentives aimed at promoting human resource development, technology transfer, effective e-learning strategies and implementation, software and content development suitable for each member of the Asia-Pacific neighborhood;
2. Coordinate and promote community-based e-learning activities, global sharing and management of information and knowledge. Examples of such communities are the Asia-Pacific Society on Computers in Education (APSCE) and the Association of South East Asian Nations (ASEAN); and
3. Coordinate and promote student and staff exchange among Asia-Pacific neighborhood member nations to promote more effective sharing of knowledge and practices.

The missions of DICTAP are to:

1. Connect researchers from emerging developing countries within the Asia-Pacific region to share scholarly findings and professional insights in ICT development in the field of education;
2. Establish networking opportunities among researchers, reduce the research gap between the researchers from more developed and less developed countries; and
3. Foster, enhance and sustain collaborations among these researchers.

WICTTEE 2015 is the fourth workshop that we are organizing in the hope to realize the aforementioned visions and missions. The workshop is a continuation of our relentless effort to provide a dynamic platform for practitioners and researchers alike to come together to share their country experiences.

We are extremely pleased that practitioners and scholars with university affiliations from Thailand, Malaysia, and Indonesia will be congregating in Hangzhou, China to present their research findings and share their views at WICTTEE 2015. A total of six papers will be presented in a half day workshop.

We would like to take this opportunity to thank all the authors who submitted their papers to WICTTEE 2015. We would like to record our sincerest appreciation to our Program Committee Members who dedicated their time and expertise to the most challenging and demanding task of reviewing the paper submissions. Last but not least, we would like to thank DICTAP's Advisory Committee Members for their wisdom and guidance in making WICTTEE 2015 a reality.

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Flash Animation-Based Learning Media to Improve Learning Outcome of the Electronics Subjects

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Abstract: This research analyzed the benefit of flash animation-based learning media on improving the learning outcome of the Electronics subjects in study program physics education, University of Muhammadiyah Prof Dr HAMKA Indonesia. The study focused on the transistor chapter of the Electronics subjects.. This research used quantitative method in the form of quasi experiment with Nonequivalent Control Group Design. The research result showed: (1). Control class and experiment class were balance because there were no significant difference on the average learning outcome in both class which was observed before the learning process (13 ≈ 12.95). (2). There were improvements in both classes observed after the learning process. (3). Learning outcome in the class that used animation as learning media was higher than the class that did not use animation as media (21.55 >17.35). (4). The gain in learning outcome in the class that used animation as learning media was 0,71 which was included as the category high. The gain in the class that did not use animation media was 0.19 which was included as the category low.

Keywords: animation learning media, animation teaching material, animation transistor.

1. Introduction

Learning media is something that needs to be noted in teaching and learning process. Especially in the Electronics subjects that needs imagination because of the characteristic of electronics which is invisible. This is in accordance with with the field data from the research done by Winarno (2013) that stated the use of interactive learning media in the subject of electronics can facilitate teachers in explaining the learning materials to the students.

The initial interview done to the lecturers of electronics in study program physics education in University of Muhammadiyah Prof Dr HAMKA Jakarta, showed the high level of difficulty on delivering the electronics subjects because of the characteristics of electronics which is actually invisible to be seen directly by naked eyes. Electronics system contain many physical characteristics that can only be felt its symptoms so that students should picture i with imagination. Moreover associated with electric current, electron movement, electrical field and various basic symptoms when happen in this electronics incident. The result of initial interview with the lecturers of basic electronics stated that almost 40% of students have not achieved maximum target in the learning process of electronics.

This is compounded with the students' low interest in reading to the exact lesson, based on the previous research done by Restina (2011) that the students' interest in reading towards the lecture materials presented in writing is still low. This condition effect on the low learning outcome of the students. Only around 60% of the students were able to achieve satisfactory grade with reference to the results of the assignments given by lecturers after students were given the task to read the teaching materials.

The formulation of the problem in this research include: (1). Are there any difference in the learning outcome of the students within the class that used the learning media Flash Animation before the treatment was done?, (2). Are there any differences on the learning outcome of students in the class that did not use the learning media Flash Animation before and after the treatment was given?, (3). Are there any differences in the learning outcome of the students in the class that used flash animation-based learning media before and after treatment was given?, (4). Are there any differences in the students' learning outcome between the class that used and did not use flash animation-based learning media after treatment was given?, and (5). Are there any differences in the gain of students' learning outcome between the class that used and did not use flash animation-based learning media?

Kozma (1991:2) elaborated the most obvious characteristic of learning media is technology, mechanical aspect and electronic that determines function, form, and other physical characteristics. Burden and Byrd (1999:137) defined learning media as the conveyor of learning information. Sadiman, et al. (2008:7) defined learning media as the distributor of learning message. Agina (2003:1-4) explained that the use of animation in the learning activity can improve the quality of learning process and outcome. Hegarty (2004:343) explained that the development of animation technology has been able to provide visual displays that are stronger than various phenomena and abstract information so that it can act to improve the quality of learning process and outcome. Bogiages dan Hitt (2008:43) explained that the improvement of understanding skill in a group and interest in learning are also an added value for the utilization of animation in learning. Harrison dan Hummell (2010:21-22) explained that animation is able to enrich experience and students' competence on various teaching materials.

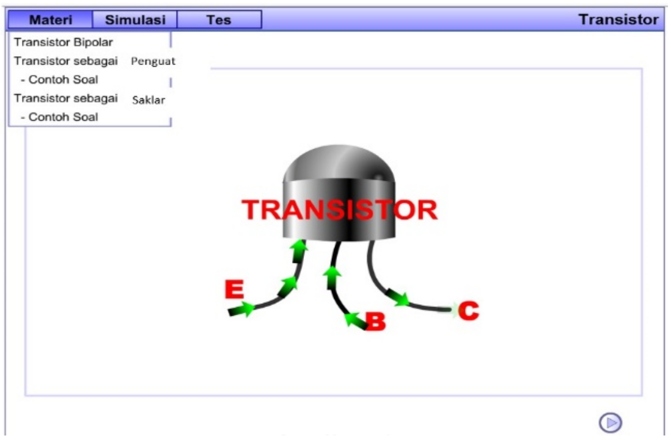
The use of animation in learning, other than it had been known to have many benefits, but on the other side it is still considered to have several flaws. Highlighted about the avalability of supporting factors such as room and tools used to display animation in learning activity. Agina (2003:4) criticized the factor of supporting tools quality such as software capability, memory capability on supporting media such as laptop, computer, LCD and the aspects of the adjustment to the curriculum. Lowe (2004:558-559) observed from the aspects of the process of preparing the material which could potentially lead to inefficiencies. Sadiman, et al. (2008:69) criticized on the production cost which is relatively expensive so that it is very difficult to achieve all learning objectives.

The Electronics subjects in study program Physics Education in the Faculty of Pedagogy and Education, University of Muhammadiyah Prof Dr HAMKA is a compulsory subject. This Electronics subjects has a study load of 2 credits in the odd semester. One of the topics in the subject of electronics is about Transistor. Transistor as an electronic component semiconductor has a dynamic characteristic, on one condition it can become a conductor (conductor of electricity) and in other condition it can become isolator. Because of this dynamic characteristic, the electronic symptoms that happen in this component also vary. This varied symptom needs visualization and simulation so that it is easy to be understood by the students.

2. Flash Animation-Based Learning Media for the Topic of Transistor

Initial Display of Main Menus

The applied flash animation-based learning media for the topic of transistor consists of three main menus which are: Material, Simulation and Test. Whereas for the Material menus itself contains 5 displays which are: Bi-Polar Transistor, Transistor as amplifier, Sample problem for transistor as amplifier, Transistor as switch and the display of Sample problem for transistor as switch.



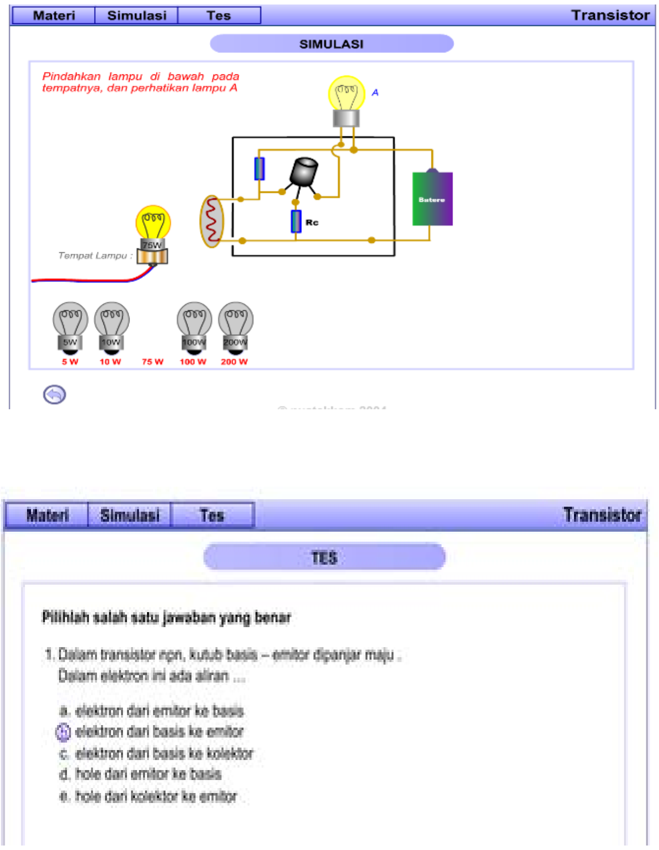
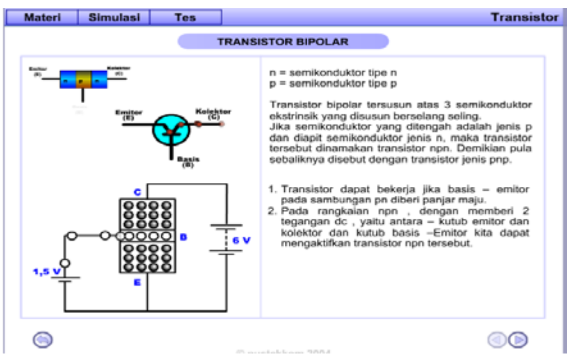
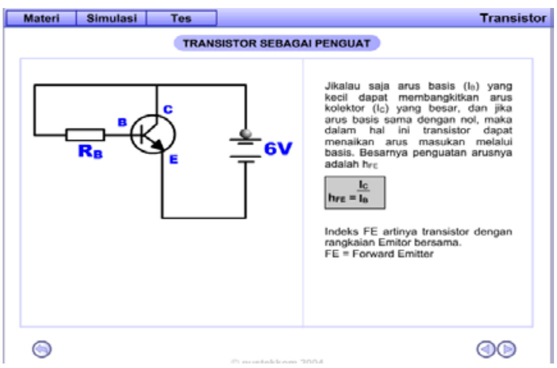


Figure 1. Example of the display for 3 main menus of learning media with the topic transistor

Contents Display of the "Material" Menus

The contents of the Material menus in the applied flash-based learning media explain about: (1). The characteristics of bi-polar transistor as contained in the Material menu bi-polar transistor, (2). Direction of the electric current on the foot of transistor and the formula of the amplification of the electric current in the circuit of Forward Emitor as contained in the menu transistor as amplifier, (3). Sample problem of the amplification of electric current as contained in the Material menu sample problem of transistor as amplifier, (4). Theory, concept and how the transistor works as switch as contained in the Material menu Transistor as switch, and (5). Sample problem on how to place resistor (load) in the transistor circuit as a switch as contained in the Material menu sample problem of transistor as switch.





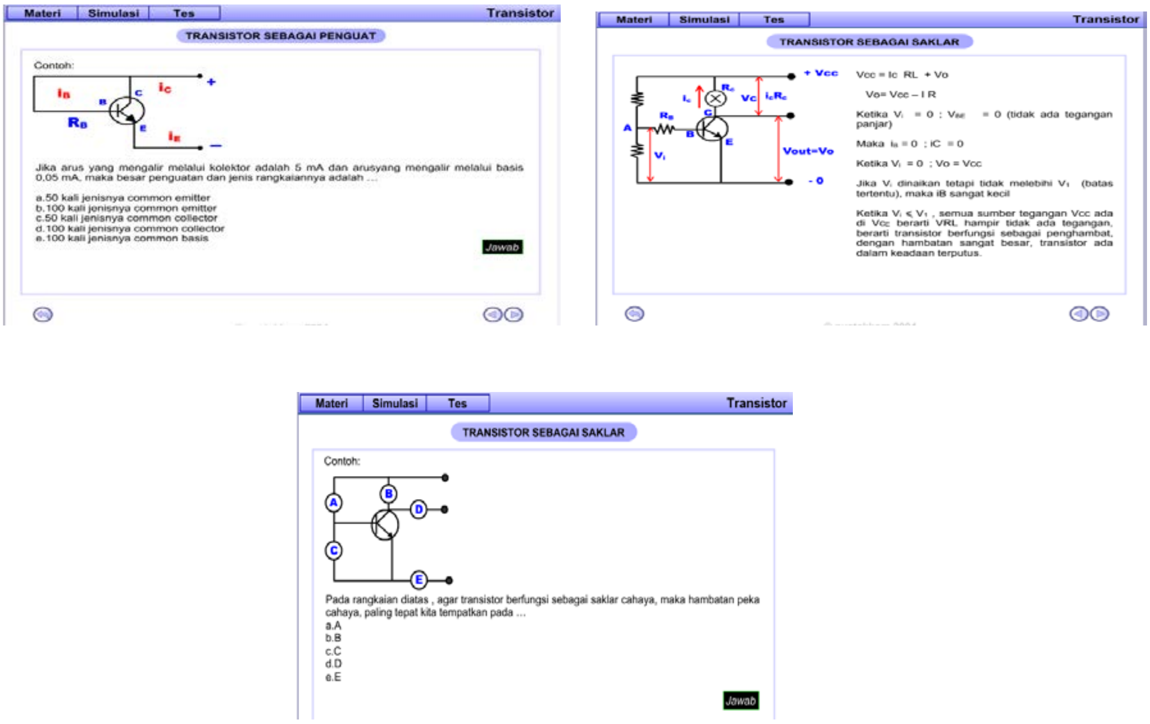


Figure 2. Contents of the Material menus on the subject transistor based on flash animation

3. Research Method

This research was done in Study Program Physics Education, Facullty of Pedagogy and Education, University of Muhammadiyah Prof Dr HAMKA. The population in this research is all students from semester IV (80 Students). The research was conducted in the first semester of 2014. Precisely in September until December 2014. The sample of this research was taken from two classes with the details of one class as an experiment class consisting of 20 students and one class as the control class consisting of 20 students. The research method used was quantitative method in the form of quasi experimental design. The form of quasi experimental design used was Nonequivalent Control Group Design.

Experiment class is the class that received the implementation of flash animation-based learning media. Pre-test was done before the implementation of the learning media to figure out the initial capability possessed by the students in experiment class about the topic. Post-test was done to figure out the capability possessed by the students in control class about the topic after receiving the implementation of flash-based learning media.

Control class is the class that did not receive the implementation of flash-based learning media. Pre-test was done before the conventional lesson started to figure out the initial capability possessed by the students in control class about the topic. Post-test was done to figure out the capability possessed by the students in control class about the topic after receiving conventional lesson.

The learning media used in this research was flash animation-based learning media that discussed the topic of Transistor in the course of electronics semester IV.

The data analyzed in this research consisted of main data in the form of students' test result data, and supporting data in the form of interview result on the response of teachers and students towards the use of learning media. The data analysis technique used was difference test using Non-parametric statistical test of Mann Whitney and Wilcoxon test.

4. Result and Discussion.

Control Class

The result of Pre-test in control class showed the initial capability possessed by the students had an average grade of 13 with the standard deviation of 2.27. The lowest grade of the pre-test from 20 students in control class was 10 of 25, achieved by one student. The highest pre-test score achieved by the students in control class was 18 of 25, achieved by one student. The grade of pre-test that were mostly achieved by the students in control class was 11 of 25, achieved by 7 students.

The result of post-test in control class showed the final capability of students after receiving the implementation of conventional lesson had the average grade of 17.35 with the standard deviation of 1.84. The lowest grade of the students in control class was 14 of 25, achieved by one student. The highest post-test grade in the control class was 20 of 25, achieved by three students. The most achieved grade score in control class was 18 of 25, achieved by 4 students. After conventional lesson, an improvement of leearning outcome was achieved but relatively small which was an increase in average of 4.35. If meticulously detailed, there was a decrease in learning outcome of one student with the point of decrement of -1. An improvement of learning outcome happened to 19 students, with the biggest increase happened to 3 students with the increment point of +6.

Experiment Class

The result of Pre-test in control class showed the initial capability possessed by the students had an average grade of 12.95 with the standard deviation of 2.13. The lowest pre-test grade from 20 students in the experiment class was 9 of 25, achieved by one student. The highest pre-test score achieved by the students in experiment class was 17 of 25, achieved by one student. The most pre-test grade score achieved by the students in experiment class was 11 of 25, achieved by 5 students.

The result of post-test in experiment class showed the final capability of students after receiving the implementation of flash animation-based learning media had a quite high average of 21.55 with the standard deviation of 2.04. The lowest grade of the students in experiment class based on the post-test result was 17of 25, achieved by one student. The highest post-test grade in experiment class was 24 of 25, achieved by two students. The most achieved grade score in experiment class from the post-test result was 23 of 25, achieved by 7 students. After the lesson using flash-based animation media, a relatively high increase in learning outcome was achieved, which was an average increase of 8.60. If meticulously detailed, there were no students that experienced a decrease in learning outcome. The increase in learning outcome happened to all students. The biggest increase happened to 5 students, with the increment point of +10.

Table 1: Comparison of the results of the Pre-Test and Post-Test.

VARIABLE CLASS	PRE-TEST			POST-TEST			NORMALITY GAIN
	Mean	Low Score	High Score	Mean	Low Score	High Score	
Control	13	10	18	17.35	14	20	0.19
Experiment	12.95	9	17	21.55	17	24	0.71

Discussion

The average grade of the pre-test in control class and experiment class was almost the same (13 ≈ 12,95). This showed that the potential ability between control class and experiment class was equal. The lowest pre-test score in control class was better from experiment class (10 > 9).

Likewise, the highest pre-test score in control class was better than experiment class (18 >17). This showed that even if the average score was equal, but the control class even owned a little bit of potential advantage than experiment class.

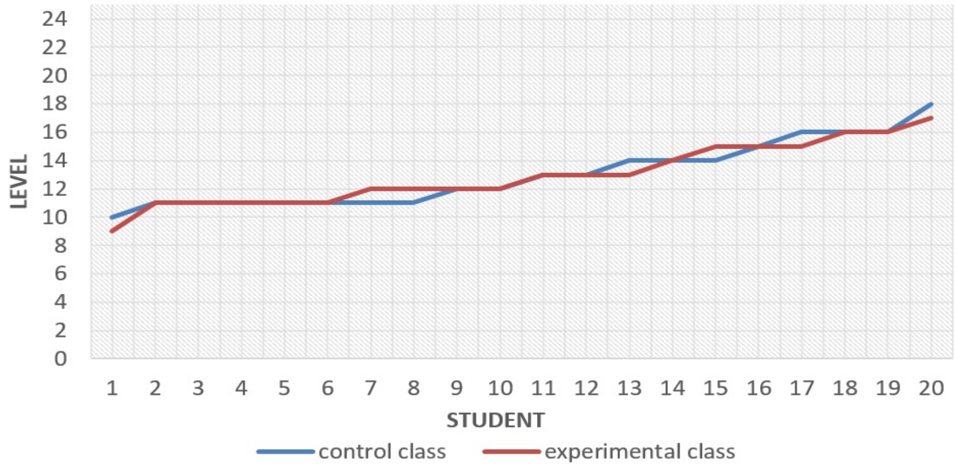


Figure 3. Pre-Test Result.

The lowest post-test score in experiment class was higher than the control class (17 > 14). Likewise, the highest post-test score in experiment class was higher than control class (24 > 20). The change of learning outcome in experiment class was also better than the control class (+10 > +6), this showed decisively that in the class that using flash animation-based learning media, a far better learning outcome was achieved compared to the learning outcome of the class that did not use flash animation-based learning media.

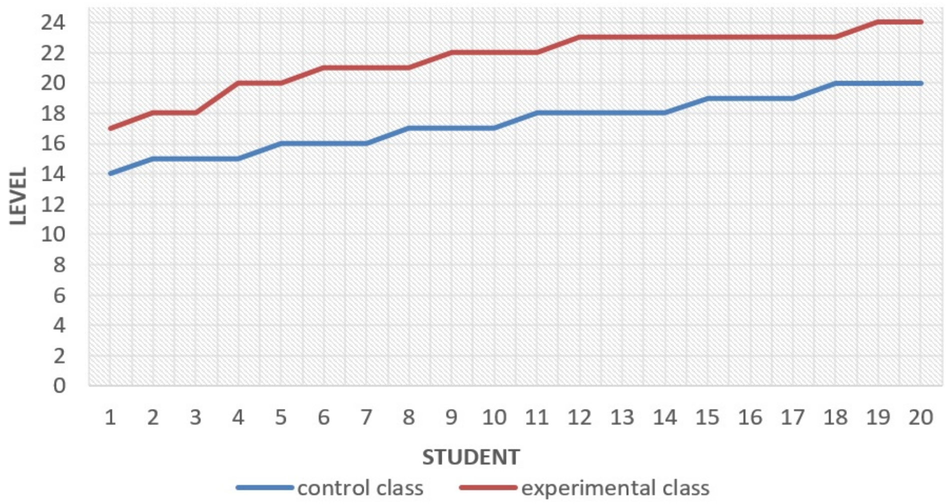


Figure 4. Post-Test Result

The calculation of the gain in learning outcome of the experiment class and control class both had an increase in learning outcome. However, the experiment class had a higher gain, which was 0.71 (high category), compared to control class that only experienced a gain of 0.19 (low category).

The hypothesis test showed that: (1). There were no significant differences of the pre-test result in the class that used as well as did not use flash animation learning media, this showed that the sample taken had equal potential. (2). There was a difference (improvement) of learning outcome in the class that did not use flash animation media (control class) but relatively small (average of 4.35 points). (3).There was a significant difference (improvement) of learning outcome in the class that used flash animation-based learning media (average of 8.6 points).

(4).There was a significant difference between the increase of learning outcome in the class that used flash animation-based learning media and the class that did not use flash animation-based learning media (8.6 compared with 4.35). (5).There was a significant difference on the gain of students' learning outcome between the class that used flash animation-based learning media and the class that did not use flash animation-based learning media (0.713 compared with 0.19).

5. Conclusion.

The conclusion that could be drawn from the result of the research done were: (1).The two classes that were the research sample were equal because they have the potential and basic capability that are relatively similar before the learning process was done. This can be seen from the average score of pre-test in the experiment class as well as in control class (the class that used as well as did not use flash animation-based learning media) that were almost the same (12.95 ≈ 13). (2).There was an increase in the learning outcome of the class that did not use flash animation media, observed from the comparison of the average score from pre-test and post-test in control class, but the increment was relatively small, which was 4.35. (3).There was a significant increase of learning outcome (pre-test compared with post-test) on the class that used flash animation-based learning media (experiment class) with the average increase of 8.6. (4).There was a significant difference between the learning outcome (post-test) of the class that used flash animation media with the learning outcome (post-test) of the class that did not use flash animation media. The learning outcome (post-test) of the class that used flash animation media was better compared to the learning outcome of the class that did not use flash animation media (21.55 >17.35). (5).There was a significant difference between the gain of learning outcome of the class that did not use flash animation media and the gain of learning outcome of the class that used flash animation media. On the class that used flash animation-based learning media, the gain of learning outcome was higher compared to the class that did not use flash animation-based learning media (0,71 >0,19). The gain of learning outcome of the class that used animation media was higher than 0.7 which was included in the high category. Whereas the gain of learning outcome of the class that did not use animation media was less than 0.3 which was included in the low category.

The results of this study also indicated that the subjects in the animation got the highest posttest scores. In the future need to be multiplied animation-based learning material in various subjects. Animation-based learning material is believed to enhance the students' understanding, which in turn can improve learning outcomes. Subjects' learning outcomes may have been influenced by the knowledge domain. Therefore, further research within different disciplines is also recommended.

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Factors Analysis of Technology Leadership in Thailand Royal Awarded School

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Abstract: Technology leadership is extremely important for these days. Education technology leadership is a key element to be successful in using technology in education. Often education technology, under the direction of an effective education technology leadership, is used as a change agent in school improvement initiative. The purposes of this research were to develop the school administrators' technology leadership scale using an exploratory factor analysis and confirmatory factor analysis. The samples were 380 administrators (principals, vice principals, and head of subjects) in Thailand royal awarded school. The research instrument was the technology leadership scale. Cronbach's alpha internal consistency was estimated for the reliability of scale. The exploratory factors analysis was examined to determine the number of factors and indicators. The confirmatory factor analysis was performed to determine the construct validity by using Mplus 6.11. The major finding were as follows : 1) internal consistency scale was .87, 2) the exploratory factor analysis indicated that the technology leadership was composed of 6 factors : technological vision, technological support, promoting technology in teaching, administrative management technology, assessment and evaluation technology, and ethics technology and 3) the confirmatory factor analysis found that the model fit the structure from the exploratory factor analysis.

Keywords: Technology leadership, confirmatory factor analysis, exploratory factor analysis, Thailand royal awarded school

1. Introduction

The ministry of education in Thailand emphasizes the importance of the computer and technology. While also taking into account of the benefits and potential of information technology development and application for students to learn and develop their skills in an advanced level. Including the way to think and to analyze the effects that may occur from the use of the technology in an inappropriate ways; this is based on the principles of moral and sufficient economic.

We are living in a time that has been characterized as the Digital Age and the Knowledge Age. The rapid advancement in information and communication technologies (ICT), coupled with the demand of the knowledge society, has a huge impact on education. Although instructional technology has been a part of the educational landscape for several decades, technology integration in classroom still falls short of the expectations for its use (Cuban, 2001). Multiple studies identified the role of principal leadership as one of the most important factors affecting the integration of technology in classrooms (Devaney, 2010). Leadership, especially from the principal, is generally acknowledged as an important influence on a school's effectiveness, a belief that is supported by empirical evidence (Leithwood & Riehl, 2003). Studies of school improvement also point to the importance of principals' leadership in such efforts. (Fullan, 2003)

Technology leadership of the executive management behavior of leaders who face the challenge of changing challenges of technology. While often focuses on the leadership skills of the school administrators, the study of education technology leadership also considers about sources of leadership from other education stakeholders, including teachers, technology coordinators, parents, students, and community members as well. The attributes of leader in the administrative process to adjust the behavior of the leadership and organizational behavior modification in accordance with the change, which caused the corporation of colleagues. The work is achieved by placing. Flanagan and Jacobson (2003) have provided significant technology leadership of school administrators that the behavior of the leaders with a pupil engagement is a steadfast mission to organize the learning experience to students. The use of appropriate technology. A vision for the use of technology for education. A professional development effectiveness professional development to promote the professional development consistently focus on teaching and learning. Including the use of technology in various occasions. All students have access equally. Synthesis technology leadership component of school administrators, the context of education in Thailand Royal Awarded school, given by the theories and research related Yee (2000), Schiller (2003), Haslam (2006), Kozloski (2006), Redish and Chan (2006), Nikom Nakkai (2006), Chawalit Kerttip (2009) has 6 factors of technology leadership are 1) technological vision; this component encouraged leaders to facilitate the development of a share vision and to cultivate an environment that will realize that vision., 2) technological support; this is standard focused on the need of leaders to demonstrate their technological savvy as they model, support, and lead technology integration., 3) promoting technology in teaching; this standard encouraged leaders to ensure the effective integration of teaching, learning, and technology., 4) administrative management technology; this is need for leader to develop, implement, and monitor technology policies, human and financial infrastructure, and plans., 5) assessment and evaluation technology; this is described how leaders should use technology to collect and analyze data regarding appropriate uses of technology and to inform instructional decisions., and 6) ethics technology; this is highlighted the leaders' responsibility to understand the social, legal, and ethical issues to promote the responsible use of technology.

2. Literature Review

2.1 Definition of Technology Leadership

The definition of technology leadership that is that a capable of leading in management, and using technology to cut expenses of investment products. This capability is called the product cost competence, it is emerging as a new product which is in demand all the time (marketable products), which is capable in managing this so-called innovative competence. Flanagan, & Jacobson (2003) provided significant technological leadership of school administrators that is the behavior of a leader with a mission to student (pupil engagement) is a steadfast mission to organize the learning experience for students by the use of appropriate technology. A vision for the use of technology for an education, an effective professional development to promote continuous professional development is consistent focus on teaching and learning, including the use of technology in various occasions. All students have access equally.

In summary, from the viewpoint of all the above, a summary definition "technology leadership of school administrators" refers to behavior or characteristics of school administrators that expresses the vision of technological system planning director of media technology to achieve the vision. Promote a culture of accountability and policy support to developing innovative technology continuously. Supporting teacher for use of technology in teaching, and use technology in administration, use technology to measure and evaluate and ethical use of technology**.**

2.2 Global Technology Leadership

While leadership as a scientific construct emerged in the scholarly literature as early as the 1930s (House & Aditya, 1997) and has received extensive attention since then, the evolution of "the 21st century technologist". Bertoline (2011) presents a need for a new type of leadership model and a new method for education leaders. Global technology leadership is emerging as a scholarly discipline that seeks to integrate specific, contextual knowledge related to high-technology industries and integrate it with the ability to operate and lead in not only a multinational, but the synthesized global environment far more common and growing in technology fields (Daugherty et al., in press). This discipline is relatively new as an area of academic research, however, and there is great need among scholars to begin the task of modeling the global technology leader and the nature of implementing global technology leadership into educational and organizational settings. As such, the research team sought out industries and academic programs throughout the world providing education and employment in this innovative area. Using ethnographic research methods (Lindlof & Taylor, 2002), researchers gathered data by observation and interview with the goal of analyzing this data and developing a synthesized model of the nature and future of global technology leadership as an innovative educational and industrial managing construct.

Technology leadership is newly evolving as a scholarly discipline that synthesizes historic research in multiple areas of leadership with the complexity and contextual factors unique to the technology organization. Bozeman and Spuck (1994) suggested that educational technology leaders should be able to use technology in solving real problems in their schools. Before starting full technology implementation, principals should be aware of the challenges and barriers inherent in almost technology programs. These challenges can easily undermine the confidence of even the most professional leaders (Lashway, 2003). According to Valdez (2004), leadership of technology includes a combination of many leadership qualities and the ability to implement change, resources, professional development, emerging techniques, equipment and software. As such, the present study examines how technology leaderships, learning abilities as well as other individual characteristics and perceptions could affect school leaders' behavioral intentions.

Information technology development and innovation, computers, the Internet, and other information technologies are becoming important learning tools in students' everyday lives. Principals play various roles such as a change agent, lifelong learner, main supporter, and resource provider in relation to ICT implementation in schools (Han, 2002). Therefore, principals need to understand the capacities of the new technologies to have a personal proficiency in using technologies, and be able to promote a school culture which encourages exploration of new techniques in teaching, learning and management (Schiller, 2003). The studies showed that when administrators act as technology leaders, the teachers will integrate and use technology more successfully (MacNeil & Delafield, 2007). The International Society for Technology in Education published Technology Standards for School Administrators, including the following categories:

(1) Leadership and Vision; Included in this standard is that a technology leader has the ability to inspire a shared vision among stakeholders and foster changes that maximize the use of digital resources to support instruction, learning, and student performance. Finally, the standard of visionary leadership details how effective school technology leaders advocate for policies, programs, and funding to support the vision and planning efforts related to technology.
(2) Digital-Age Learning Culture; This standard describes how school administrators must ensure that instruction improves digital-age learning and that the school and classrooms are sufficiently equipped with digital technologies that support individual student needs. Additionally, school technology leaders should "be model and promote the frequent and effective use of technology for learning"
(3) Excellence In Professional Practice; this standard focuses on the leaders' role to empower educators to enhance students learning through technology. Standard three describes how school technology leaders must ensure time and resources are devoted to technology-focused professional development of teachers. Technology leaders must also participate in technology-related professional development themselves.
(4) Systemic Improvement; Central to this standard is data-driven decision-making that includes collaborating to collect data, analyses data, interpret findings, and share results around staff and student performance. The fourth standard also describes how school technology leaders must recruit and retain technology-savvy teachers and staff.
(5) Digital Citizenship; This standard focuses on the school leaders' responsibility for ensuring equitable access to digital tools as well as promoting, modeling, and establishing "policies for safe, legal, and ethical use of digital information and technology".

Lastly, besides visions and planning, managing technology resources has become a critical role in effective technology leadership. Principals need to manage personnel, time, support, and funding. Effective principals observe any of technologies, including teachers' technologies use, and technology infrastructure to ensure the successful technology integration.

2.3 The School Administrator as a Technology

In the majority of literature reviewed, the school technology leader is assumed to be the role model of school administrators including principles or superintendents. Both Superintendents and Principals were effective education technology leaders. These effective leaders often shared common tendencies. A supportive administrator took staffs inputs into consideration when developing school schedules or organizing school activities; engendered a high level of communication, encouragement and support that was felt by individuals; devoted resources needed to replicate successful programs; developed and supported partnerships between school and universities and corporations to stimulate the use of technology; empowered their staff; was flexible and insured that technology was accessible to teachers and students; had a commitment to professional development; respected every student as individual learners. In contrast, it is found that if it is not enough administrative support, it could limit professional growth and structure.

A survey of elementary school principals revealed that all the Principals agreed that technology was an important aspect of learning, the schools that had the highest technology-use rating had shared one characteristic: strong and enthusiastic principal technology leadership. Principals who exhibited education technology leadership were instrumental in modeling the use of technology in classrooms. They understood how it could support the best practices in instruction and assessment, and they provided teachers with guidance for its use. Principals also had to participated in professional development activities that related to education technology and provided opportunities for teachers to learn how to use those resources.

When administrators supported teachers in using technology with development staffs and on-going dialogue about technology integration in the context of teaching and learning, their teachers exhibited maintained technology integration in the curriculum. Wilsmore and Betz (2000) stated that "technology will only be successfully implemented in schools if the principal actively supports it, learns as well, provides adequate professional development and supports his/her staffs in the process of change".

While literature was found that identifies the school principal as a key factor in bringing about successful change in schools (Fullan, 2003), Schiller (2003) claimed there is very little research on the relationship between education leadership and technology. Additional research in the area of leadership and the implementation of instructional technology was found to be needed (Wilsmore & Betz, 2000; Yee, 2000).

3. Research Method

Research Objective

This study is aimed to develop the technology leadership scale using an exploratory factor analysis and a confirmatory factor analysis.

Samples

The population comprised 7,426 administrators (principals, vice principals, and head of subjects) in the royal awarded school. The samples group size was 380 principal, vice principal, and head of subject based on the table of Krejcie and Morgan and selected by the stratified random sampling method.

Instrument

The instrument used in this study was the questionnaire for the administrators (principals, vice principals, and head of subjects) in the royal awarded school which was divided into 2 sections as follows:

Section 1 – This is the checklist for general information of the respondents. There are 5 questions for age, gender, position, education level, and work experience.

Section 2 – This included 28 five-scale rating question for the technology leadership questionnaire was used to measure school administrators technology leadership on 6 elements: technological vision (TV), technological support (TS), promoting technology in teaching (PTT), administrative management technology (AMT), assessment and evaluation technology (AET), and ethics technology (ET).

Data Collection and Analysis

The researchers first submitted an official letter asking for permission to collect data and carried out the data collection in the royal awarded schools. The researchers had collected the completed questionnaires in the first time total 250 forms and after that collected again and again later until got 330 forms back (100%). The researchers analyzed the questionnaire data by using computer software programs as follows: (i) The general information of the respondents was analyzed by means of descriptive statistics to find frequencies and percentages, (ii) The exploratory factors analysis was examined to determine the number of factors and indicators, and (iii) The confirmatory factor analysis was performed to determine the construct validity by using Mplus 6.11.

4.0 Result and Discussion

Analysis of school administrator technology leadership in Thailand Royal Awarded school that overall average in the "high" level, which can show the mean, standard deviation, minimum score, and maximum score in table 1

Table 1 : Descriptive data analysis of school administrators technology leadership

Technology leadership	mean	S.D.	Minimum	Maximum
Technological vision	4.441	.444	1.000	5.000
Technological support	4.423	.386	1.000	5.000
Promoting technology in teaching	4.511	.271	2.000	5.000
Administrative management technology	4.464	.430	1.000	5.000
Assessment and evaluation technology	4.407	.368	1.000	5.000
Ethics technology	4.382	.419	1.000	5.000

4.2 Exploratory factor analysis of technology leadership

The exploratory factor analysis of technology leadership is analyzed by the Kaiser-Meyer-Olkin index measures of sampling adequacy : KMO is .810, indicating that they are qualified to be analyzed at a good level, and Barlett's test of sphericity test results showed that the variables were correlated statistically significant ($p<.01$); so indicates that the variables can be analyzed. The principal component analysis found communality value of each variable used in the analysis of technology leadership have 21 factors (ranged .551 - .712). The results of the rotation element angle (oblique rotation) with Promax method composition of 6 elements, each element has a eigenvalue than 1. Percentage of of 72.395, which results factor technology leadership by Malcolm questions in table 2.

Table 2 : Factor loading of technology leadership

Item	Factors of technology leadership	Factor loading
Factor 1 Technological Vision (TV) Eigenvalue = 14.112, % of variance = 16.506		
1	Focus on the use of technology in education	.711
2	Technology has contributed significantly to the development and enhance the quality of education	.709
3	Policy and planning technology rationality	.678
4	Learning and development of information technology in management	.559

Item	Factors of technology leadership	Factor loading
Factor 2 Technological Support (TS) Eigenvalue = 14.001, % of variance = 15.007		
5	Procurement and preparation of technology for learning	.704
6	Promoting the use of technology in education development	.667
7	Budget planning for adequate management technology	.609
Factor 3 Promoting Technology in Teaching (PTT) Eigenvalue = 13.404, % of variance = 14.241		
8	Further support for teachers in using technology in teaching	.712
9	Deciding which technology is appropriate for teaching	.677
10	Encourage teachers to develop information technology skills continuously	.605
11	Manage the learning conducive to use of technology	.553
Factor 4 Administrative Management Technology (AMT) Eigenvalue = 10.109, % of variance = 10.453		
12	The technology involved in the administration	.709
13	Development of information technology to management regularly	.694
14	Use of media and technology in the teacher development	.605
Factor 5 Assessment and Evaluation Technology (AET) Eigenvalue = 9.445, % of variance = 9.746		
15	Use technology as a tool in assessing the performance of teachers	.698
16	Evaluation of the use of technology in the teaching and learning of teachers	.669
17	Use technology to evaluate student achievement, and to enhance the quality	.613
18	Use of technology as a tool to develop the school quality assurance system	.588
Factor 6 Ethics Technology (ET) Eigenvalue = 7.172, % of variance = 6.442		
19	An example of using technology in a creativity	.679
20	Used with caution, as necessary	.654
21	Responsibility for the consequences arising from the use of technology	.551

4.3 Results of confirmatory factor analysis of technology leadership

The relationship between observed variables using Pearson's correlation coefficient, it was found that: the variable that indicates the technology leadership all have significant statistics ($p<.01$). The correlation coefficient were .604 - .788 and the Bartlett's test sphericity, which is the test of the hypothesis that correlated between the correlation matrix and the identity matrix equal to 4,381.564 ($P<.000$). The correlation between matrix shows that the variables differ significant from the identity matrix in accordance with statistical analysis, the value of sampling adequacy measures : KMO is .786. Test results show the two sets of variables. In this data set are related to levels sufficient and appropriate to analyze the factors. The Details are shown in table 3 and the results of confirmatory factor analysis model to measure technology leadership in table 4.

Table 3 : Mean, standard deviation, and Pearson correlation product moment of technology leadership factors

Variables	TV	TS	PTT	AMT	AET	ET
TV	1.000					
TS	.767**	1.000				
PTT	.745**	.765**	1.000			
AMT	.755**	.689**	.746**	1.000		
AET	.788**	.645**	.689**	.782**	1.000	
ET	.761**	.763**	.604**	.639**	.674**	1.000
Mean	4.441	4.423	4.511	4.464	4.407	4.382
S.D.	.472	.386	.271	.430	.368	.419
Bartlett's test of sphericity = 4,381.564 df = 19 p = .000 KMO = .784						

Table 4 : Results of confirmatory factor analysis model of technological leadership of the royal awarded school administrators

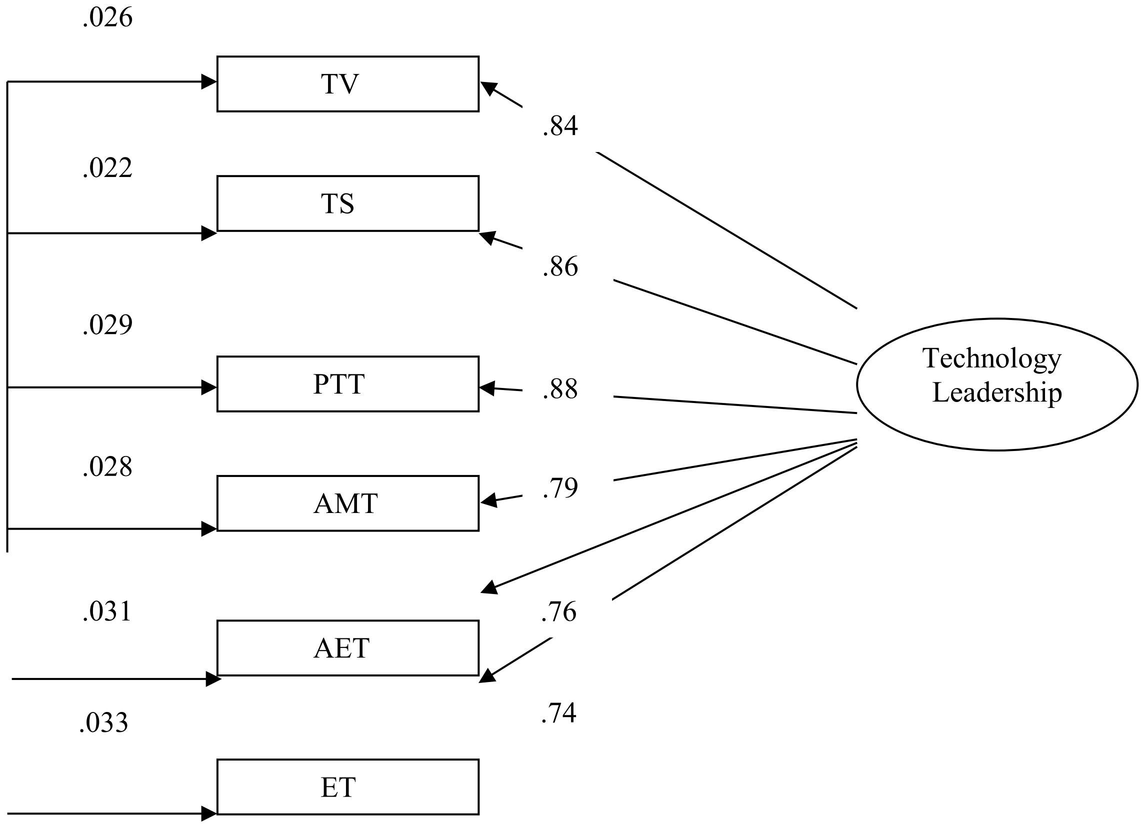
Variables	Factor Loading		T	R^2	The coefficient factor scores
	b(SE)	B			
1. Technological vision	.580(.027)	.844	21.334***	.771	.226
2. Technological support	.497(.023)	.863	21.686***	.762	.356
3. Promoting technology in teaching	.566(.027)	.881	20.432***	.642	.481
4. Administrative management technology	.671(.030)	.790	18.116***	.688	.189
5. Assessment and evaluation technology	.557(.028)	.762	21.665***	.793	.167
6. Ethics technology	.489(.029)	.740	17.801***	.619	.206
Chi-square = 3.505; df = 5; p = .752; GFI = .987; AGFI = .998 ; RMR = .002					

*** p<.001

From table 4, considering the weight of each component in the standard observed variables in the model, measurement technology leadership found: All factors are positive weights ranging from .740 to .833 and all with statistical significance level .001. The variable weight from high to low of loading score are promoting technology in teaching, technological support, technological vision, administrative management technology, assessment and evaluation technology, and ethics technology respectively. The 6 variables are Indicates of technology leadership significance statistical. Indicators of technology leadership shown in the equation:

$$\text{Technological Leadership} = .226^{***}(TV) + .356^{***}(TS) + .481^{***}(PTT) + .189^{***}(AMT) + .167^{***}(AET) + .206^{***}(ET)$$

Shows the validity of the model measuring technology leadership in Figure 1



Chi-square = 3.505, df = 5, p-value = 0.752, RMSEA = 0.000

Figure 1 : The Validity of The Model Measurement Technology Leadership

5. Conclusion

The administrator in the 21st century need to catch up with present technologies. They need to improve their skill in using technology due to technology plays important role in education. To be technological leaders of the administrators or principles or teachers in schools would be more effective in both studying inside and outside classrooms, it affects to a school's permanent excellence. Piceiano (2005) has indicated that technology plays an important role that may affect to education in school. Also, technological staffs have to perform many duties in school too, especially in 1) teaching 2) technique 3) analysis 4) leadership.

The result from Technological Leadership analysis in this study, it is found in 6 elements, that is; Technological vision, Technological support, Promoting technology in teaching, Administrative management technology, Assessment and evaluation technology, and Ethics technology. Which conforms with the research study of Bunjob Boonjan (2011), who studied about elements of technological leadership of the administrators or principles, and it was found that there are elements of technological leadership, that is 1) using technology in teaching 2) using technology in administration 3) using technology in evaluation 4) moral in using technology, and also it conforms to the regulation of teacher's council in the issue of professional moralities 2013 in 5 aspects; 1) self morality 2) professional morality 3) customer morality 4) colleague morality 5) social morality. Moreover, it conforms to American Institute for Research: AIR (2009) which identified National Educational Technology Standard for Administrators: NETS-A about Digital-Age Learning Cultural, which covered that the administrators must have knowledge and confidence in using technology in education development to be a role model and support using technology in education continuously and effectively, to provide vary sources of technologies which suit for each student's desires, to apply technology in teaching effectively and conform well with the curriculums. Besides, it encourages the communities to join in education by using innovation. As well as Kozloski (2006) who studied element of technological leadership of the administrators of principles in many schools in 45 states of the United State of America and the result of the study, it is found that each state has identified technological standard which affect the movement in present. It is; there is an encouragement to encourage every of the administrators in schools to have technological leadership of the administrator follow the identified standard responsibly. Meanwhile, business section now need the graduates who has proficiency in technology to work in their companies. Those expectation and desires would be successful if the administrators emphasize on the importance of using technology and encourage students to use technology effectively in schools and in communities. Those are important to education and economic in 21st century. Element of technological leadership of the administrators includes 6 aspects; 1) Leadership and Vision 2) Digital-Age Learning 3) Excellence In Professional Practice 4) support management and performance 5) evaluation 6) social, laws, and morality issue. This study surveyed principals technology leadership in Thailand Royal Awarded School. Additional studies are needed to included World Standard School.

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Virtual Learning Environment and Use: Perceptions of Malaysian Teachers

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Abstract: This research explored the experiences of teachers using the FROG VLE, a virtual learning platform adopted by the Ministry of Education for all its 10,000 schools nationwide. This initiative is part of the 1BestariNet project under the newly released Malaysian Education Blueprint. It is aimed at upscaling the quality of education through ICT. The research adopted a qualitative approach using an open-ended survey. Several themes related to the benefits and challenges of teaching and learning through the virtual learning environment emerged from the findings. Several suggestions are proposed to improve the uptake of the VLE among the teachers in Malaysia.

Keywords: virtual learning environment, school teachers, perceptions, benefits and challenges

1. Introduction

The year 2013 saw the launch of the Malaysian Education Blueprint which is a detailed document that enlists the plan of actions to be taken place in the education landscape for the next 13 years (2013-2025). The preliminary report before the launch of the Blueprint stated that there was no evidence to suggest that ICT is being used to promote skills such as creativity, problem solving and critical thinking (Ministry of Education, 2012). One of the many initiatives identified under the first wave of the MEB (2013-2015) includes the setting up of the 1BestariNet project. It is a project led by the Ministry of Education (MOE) to provide access to cloud-based virtual learning platform known as the Frog Virtual Learning Environment (Frog VLE) and high-speed internet connectivity by June 2014 to all its 10,000 public schools. Its implementation will be carried out in three phases with the first phase running from 2013 till 2015. This phase includes access to ICT devices, the VLE and internet connection in all schools and provision of basic competency in ICT to all the teachers. Having assumed all the teachers have the necessary knowledge and skills by now, the second phase will strengthen its implementation by encouraging innovative ways of using ICT and the sharing of best practices. Finally, the last phase will witness ICT fully integrated in all the classrooms.

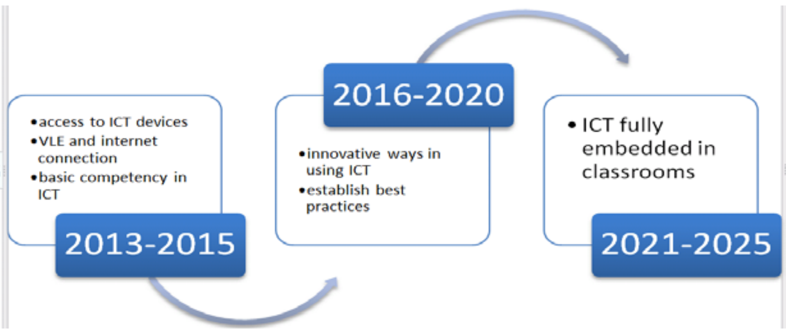


Figure 1: 1BestariNet Implementation Time Frame

2. Statement of the Problem

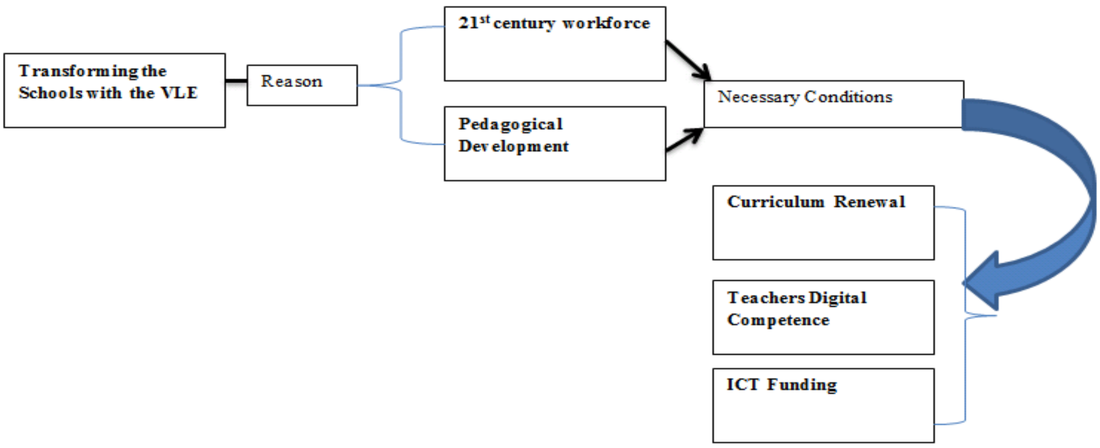
Despite the implementation of the 1BestariNet, teachers are still not showing progress in how they teach. The Auditor General Report (2013) revealed that only 5% are using the Virtual Learning Environment (VLE) platform. The report also found that usage was only between 0.01 and 4.69 percent among the teachers in the country.

Though electronic communications and digital networks are transforming our lives yet little has changed in the way schools work. In the Malaysian school setting, we are yet to experience this transformative effect in our teaching and learning. Schools are only now beginning to experience the VLE in its early forms and have much more to learn of its inherent capabilities. The VLE which encompasses e-learning is not simply another technology or add-on that will be quietly integrated or ultimately rejected (Garrison & Anderson, 2003). It has the opportunity to improve our teaching and learning experiences. More so in our Malaysian school context, with its high teacher student ratio, VLE enables us to cater for differentiated instructions in mixed-ability classrooms.

Still at its infancy stage of the web-enhanced learning environment in Malaysian educational environment, more studies that look at teachers' perceptions are needed because ultimately any educational change to a large extent will depend upon what teachers think and do. Perceptions is defined as interpretation of events among teachers due to past experiences, current understanding, present situation and information. Cuban (1990) in his seminal write-up observed that teachers will use technology based on their personal perspectives. The extent of their technology adoption lies within their goals and perceptions. In other words, teachers' perceptions of the VLE will determine its usage. Implementation from top-down without considering their perceptions will result in dissatisfaction (Wong, Hamzah & Hamzah, 2014). In fact, much of teachers' dissatisfaction arises from the challenges that are preventing them from fully embracing the technology. Consequently, poor usage of the RM4.077 billion adoption has caused unhappiness in the nation. This study aimed at exploring teachers' perceptions, which will lead to the understanding of what is preventing teachers from using the system. Perhaps, a more effective and reliable solutions can hopefully arrest the issue of lack of VLE usage.

Findings will provide policymakers and the other stakeholders, of information on what is working or missing in the school. As such, better design and implementation of both the teacher education curriculum and the continuous professional development programmes can be achieved. Perhaps as teachers gain better understanding of the VLE's potential and strength, it will be more welcoming in our classrooms. The FROG VLE has come to the second year of implementation. Teachers would have by now more feedback to offer regarding its benefits and challenges. It is against this context that this study is undertaken.

3. Importance of the Study



(adapted from Yang, 2012)

Figure 2: Theoretical Framework

Figure 2 visualises the need of a systemic approach in order to sustain any new innovation. According to Yang (2012), in order to transform our teaching and learning, we need to consider aspects like curriculum renewal, teachers' digital competence and sufficient funding. Without renewing the curriculum, teachers may have no reason to change their practices. Asking teachers to change their practices, without sufficient training, would not sustain the change. Adequate bandwidth, access to computers and technical experts, are among some of the pertinent factors in sustaining any new innovation. However, there are many other issues or aspects that only the key players are aware or concern with. As such, teachers' views and perceptions are of our main concern in this study.

At the point of study, there are limited studies on the adoption of the learning management system known as the FROG VLE in Malaysia (Sa'don, Mohamed Dahlan & Zainal, 2013; Junus, 2013; Cheok & Wong, 2015). The general aim of this study is to contribute to the existing knowledge in the integration of the VLE usage in schools. Research studies on the use of the VLE in school environment have become necessary so as to enable the stakeholders to advance its usage significantly. The findings may also be useful when developing Continuous Professional Development (CPD) programmes for teachers so that they are armed with appropriate knowledge, skills and resources. Only then the VLE's transformative power and capacity can be realised.

4. Benefits and Challenges of VLE for teachers

The VLE is an information system that facilitates e-learning which is used to support face-to-face learning (Mamat, Yusoff, Abdullah & Zaidi, 2015). Effective use of the VLE needs teachers to understand how to weave the VLE with pedagogy and content. Being able to do this requires substantial amount of time and effort from the teachers involved. Through the VLE, teachers can incorporate a variety of digital media in the instructional process. This heightens the interest level of students besides allowing them to have more access to learning materials in a flexible manner. Collaboration and construction of knowledge then becomes an enjoyable process. Teachers should design learning materials that can exploit the affordances made possible through VLE. It is a reflection of the technological advancement and changes that are happening in our day-to-day lives.

However, according to Umar and Yusoff (2014), though Malaysian teachers are highly competent in using the internet application for searching and sharing information, using the word processor, spreadsheet and slide presentation, they lack skills in doing the more advanced applications like producing graphics, animations and multimedia design. The biggest challenge to e-learning seems to be the lack of competent academics and to make this scenario worse, nearly two third of academic members in public universities have reported low motivation to incorporate e-learning tools in their teaching and learning (Adnan & Zamari, 2012).

5. Method

The data was collected between April 2015 and June 2015. It was obtained from 60 teachers from three primary schools in the form of an open-ended questionnaire. There were 17 male and 53 female teachers involved where most of them having a degree, except for 12 with a diploma and 10 with a postgraduate degree. As for their age, mainly were in the 31-40 years of age as shown in Table 1.

Table 1: Distribution of Participants' Age in the Survey

Age Range	Percentage
< 30	14%
31-40	59%
41-50	20%
51-60	7%

The mode of data collection is through an open-ended questionnaire that elicits information on the respondents' views of the VLE's implementation. The questions that were asked are as following:

1. What are your views on the role of the VLE in improving teaching and learning?;
2. What kind of support does the school administrator provide?;
3. What do you think are the challenges in teaching using the VLE in schools today? What challenges affect you most?

Thus, the objectives of the study are as the following:
1. To understand teachers' perceptions towards the VLE's effectiveness in teaching and learning;
2. To describe the kind of support teachers receive in schools;
3. To identify the challenges to VLE adoption.

All data were analysed according to exploratory approach and later refined into themes (Burnard, 1999). This analysis took into account the theoretical perspective of Ertmer's (1999) first and second order barriers to ICT integration. Ertmer (1999) has categorised two types of barriers that are preventing ICT integration. According to her the first level includes access, time, support, resources and training. These barriers are easier to arrest as compared to the second order intrinsic barriers like attitudes, beliefs, practices and resistance.

6. Findings

This section reports the findings from the open-ended questionnaire.

6.1 Perceptions towards Effectiveness of the VLE in Improving Teaching and Learning
Ninety percent of the teachers agreed that the VLE is effective in improving teaching and learning. Comments given include that the VLE increases learning as lessons become more interesting, students become more attentive during lessons. The different modalities available through the VLE were able to attract students with different learning styles and preferences. Students also became more responsible as it caters for self-access mode. Their tasks could be carried out at the comfort of their homes and paced accordingly. Teachers assigned tasks on the VLE as to fulfill the requirement by their school leaders. Both the students and teachers ICT skills will ultimately become more skillful as with more usage and exposure.

6.2 Support and Incentives Provided

To be given award during school meetings was one type of support teachers received. The award will be given to the teachers with the most amount of logging-in usage. On the other hand, teachers who has not logged-in will also be highlighted during the meetings. So teachers mentioned that most of them will resort to logging-in to the VLE website for the sake of logging-in but will continue with their other work. Teachers also mentioned that facilities are provided; the VLE, the internet connection and a computer lab. However, Chromebook was only provided to selected schools. Some of the facilities are not sufficient and are not running efficiently. All the teachers mentioned they have received at least half-day training on how to log-in to the website. In the FROG VLE, teachers must upload their own lessons. There are also contributions from other teachers who shared their teaching plans on the website. To them, peers played an important role in helping them with their usage. There is a teacher in each school who is responsible for disseminating information, knowledge and skills pertaining to the VLE. How much is provided will depend to a large extent on how proactive is the person in-charged of the e-learning and the school leaders.

6.3 Challenges of VLE Implementation in Schools

One of the common themes to emerge from the data was that it is a challenge to run e-learning lessons among young primary school students. It is a common sight in Malaysian government aided schools to see a huge number of students in a class. At times the number reaches 45. Having insufficient computers made this almost an impossible task for teachers. So teachers resort to uploading task sheets onto the system and students will have to do them at home. Slow internet connection made it time consuming for teachers. A lot of time is wasted either when logging-in or when wanting to view a video. About 75% of them mentioned that if the internet connection is not a problem, then chances are most of them would be using the system. Lack of ICT seems to be the main problem especially among the senior teachers. Training sessions have to be planned according to teachers' needs, and not the same one across the nation. Continuous professional development programmes that are based on needs assessment of every teacher in the school would result in more relevant sessions for them. Finally there is the curriculum to be considered. In the analyses, teachers highlighted concern regarding the same curriculum and assessment to be used. This shows teachers are in a dilemma as to why their practices have to change when the core aspects which are the curriculum and assessment remained unchanged.

7. Discussion

As indicated by previous sections, the focus of this research is to understand perceptions towards the VLE implementation among teachers in three primary schools from a state in Malaysia. The primary aim of this study is to find out ways to increase usage of the VLE in schools. Findings from this study seem to suggest that there is no issue about the usefulness of the VLE in teaching and learning as well as its potential in enhancing teachers' ICT skills. These correlates well with study by Davies and Sinclair (2013) who have acknowledged the vital role that e-learning plays. Teachers benefit a great deal from the adoption of the VLE by being able to use it in ways which the traditional face-to-face can never achieve. However, problems and challenges in the daily routines of teachers have prevented teachers from fully exploiting the rewards of the VLE adoption. Workload and time consuming (Cheok & Wong, 2014; Khambari, Moses & Wong, 2009), lack of technological knowledge and skills (Umar & Yusoff, 2014), are among the hindering factors.

Teachers would benefit in trainings that cater specifically to their subject matter. Instead of giving and exposing the available resources and information in general regarding the VLE, it would be of more value for them to be able to see how the VLE can be integrated in their subject specific context. Provision of time for teachers to working collaboratively and learning from each other; have been shown to help teachers to adopt a technology. Provide time and place where teachers can meet and carry out professional discussion and sharing sessions. During training, activities carried out must have a direct relationship to teaching their subject matter. Generic training divorced from subject matter will not come down well with the teachers (Barton & Haydn, 2006). This is because as mentioned in the findings, teachers are already bogged down with so many other administrative and clerical tasks. As any form of change will initially add burden to a teacher's job, activities that can be applied immediately in his or her lesson would have more chances of being applied and carried out in the classroom. According to Mamat, Yusoff, Abdullah and Razak (2015), there are teachers who are reluctant to use due to their own lack of self-efficacy in utilising the VLE.

The current lack of professional development training just added to the difficulty in attracting more teachers to embrace the VLE. Mere investment in resources and infrastructure do not automatically create new teaching and learning practices. As mentioned by Niemi, Kynaslahti and Vahtivuori-Hänninen (2012), equipping teachers must be at the forefront of any planning before school cultures and learning experiences can be expected. Any innovation must be accompanied with professional development programmes that upgrade both the pedagogical and technological knowledge and skills over a sustained period of time. Building a community of network can also help them to learn from one another especially on issues pertaining to instructional planning. As mentioned by Fullan (2007) the most effective source of help for teachers are other teachers.

Organisational difficulties include getting to use the computer room, and their busy schedules. As there are no LCD in the classroom, to have a lesson integrated with ICT would require them to take the class of about 40 to 45 students to the computer lab. This would easily cost the teachers and students to lose precious time walking from their classes to the lab (Attaran, Alias & Siraj, 2012). ICT facilities should be made readily available to teachers when the need arises. Another difficulty is with the inadequate bandwidth in schools. The long buffering time needed to view a video for example has put off many teachers in using the VLE.

The mismatch between their beliefs that the VLE can transform teaching and learning and their lack of usage of the VLE requires us to understand the impact and restrained of external influences; curriculum, and assessment in order to make sense of the situation. Relevance to assessment will influence teachers' judgement of any new technology even more so in highly exam-oriented country like Malaysia. Therefore, a change in the assessment, one that aligns with the VLE might result in a more positive change.

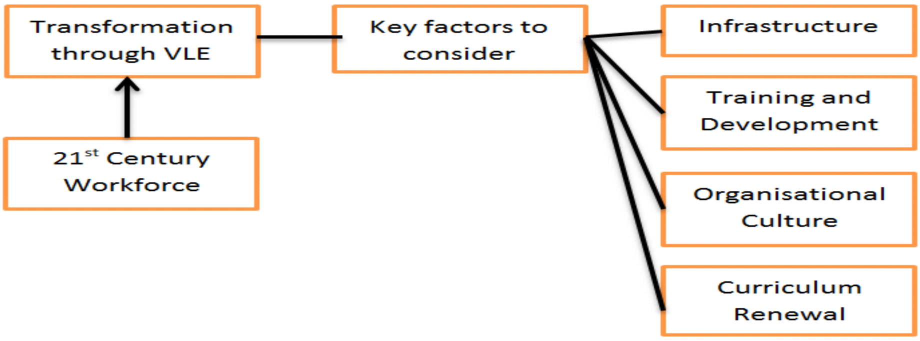


Figure 3: Factors to be Considered in VLE's Implementation

Figure 3 summarises the findings and discussion of this paper. In line with features of case studies, it is not the aim of the current research to generalise its findings to other contexts. The respondents' cases exemplify the current phenomenon studied within its real-life context (Yin, 2003). Findings indicate that despite coming from three different schools, barriers faced remained the same. Aspects like the infrastructure, poor internet connection, lack of basic ICT facilities like the LCD projector, and computers need attention. Their cry for more training to help them cope with the integration of the VLE in their lessons, are real issues that the MOE must attend to. Being able to surf the internet for entertainment and social purposes are clearly different from having to use the technology for pedagogical and learning purposes. They need to be taught the 'how' and 'why' to use technology in meaningful ways (Gorder, 2008). However, internal administrative support in schools, are of equal importance. The collaboration and support will help teachers survive the initial struggle as in any new intervention. Threats and warnings must be replaced with genuine concern to support and listen to teachers' feedback.

8. Conclusion

The findings clearly suggest that teachers have greater awareness of what e-learning constitutes as a result of this nationwide adoption. This exploratory research has paved the way for further research to be conducted to better understand factors that are inhibiting teachers from integrating the VLE in their classrooms. Indeed there are still work to be done after the adoption and initial implementation. On-going needs assessment and the VLE diffusion stage of each and every school need to be carried out so as to replace the one-size-fits-all treatment with a more reliable and effective corrective measures in schools. Besides availability of reliable resources, a supportive organisational culture must be present. Lastly, instead of complaining, perhaps teachers and school leaders could also take a more proactive stance by taking the necessary steps towards realising the aims of a better ICT uptake in our education system. Teachers can make the change within the confine of their classrooms, while school leaders should also do the same within their schools. There are many exemplary best practices from outside Malaysia that can be adopted. It is also hoped that more empirical studies on the e-learning in the Malaysian schools would take place so as to provide better knowledge, thus practices.

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Thai Students' Higher Order Thinking in Blended Learning about Circulatory system

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Abstract: Blended learning about circulatory system combines various activities in class and online learning for scientific inquiry and enhancing higher order thinking (HOT). The online learning provided simulations and interactive activities about circulatory. In order to develop students' HOT, this study will take six thinking hats technique of De Bono (1992) into biology inquiry. Participants included twenty six Grade 6 students of the primary school in a rural area of Khon Kaen which is located in the North East of Thailand. Higher order thinking representation was collected and interpreted from worksheets, assignments and open-ended questionnaire. Data analysis, the researcher investigated, analyzed, interpreted, and grouped the patterns of HOT answers. The finding revealed that the target group had frequency in expressing their HOT representations in "circulatory system". Majority of students held analytical thinking. These implications for instruction and the design of blended learning are discussed.

Keywords: Blended learning, higher order thinking, biology, primary school student

1. Introduction

It seems that Thai teachers had difficulties to build inquiry environment for science classroom. Not only teacher' knowledge and skills of providing scientific inquiry activities but also the limitation of time to cover the authorized curriculum through inquiry should be considered (Yuenyong, Tupsai, & Yuenyong, 2015). The advancement of internet technology gives teacher chance to build inquiry environment in science classroom. However, for Primary School Students, the web- based instruction was limited to them since children of this age, wanted freedom to learn as well as support (Kinawong, 1990). The web-based instruction probably carefully is managed for children.

The blended learning is a kind of knowledge management model including face-to-face, and online learning by combining equal part from each, into a unit of learning experience management (Thorne, 2003). The blended learning approach is considered on implementing an interactive, standards-based, and online curriculum. This will allow more time for meaningful scientific inquiry in the classroom setting as compared to traditional, face-to-face instruction (Singh and Reed, 2001).

2. Designing a blended learning environment.

2.1 Definition of blended learning

Blended learning was perceived and defined by educators in various ways. Clark (2006) summarized that blended learning was the norm for learners because learning will be constructed through variety of different situations. Blended learning instruction usually have been organized include both face to face and online teaching. Normally, 30 – 79% of the content is provided online (Allen, Seaman, & Garrett, 2007). The goal of blended learning is to combine the best features of in-class learning with the best features of online learning to deliver a valuable educational experience to students (Gilbert & Flores-Zambada, 2011). However, the combination of learning modalities goes beyond layering or repetition because true blended learning requires a meaningful integration of the face-to-face and online learning experiences (Garrison & Kanuka, 2004).

2.2 Designing a blended learning for science classroom

Osguthorpe and Graham (2003) suggested six specific goals for designing a blended learning environment. These included: 1) pedagogy have to be redesigned to improve student learning, 2) providing variety of online resources, 3) Social interaction is vital during both face-to-face and online learning, 4) learning activities should allow students could be able to make choices related to their own learning, 5) cost effectiveness, and 6) ease revision should be considered.

Designing the blend-blended learning is not just about mix of technologies or media to access content but the design should be considered the nature of subject knowledge. The blended learning should consider rethinking and redesigning the teaching and learning relationship (Garrison & Kanuka, 2004). Aim of Science Teaching was not only for students to develop their knowledge and comprehension but also their higher-order thinking (HOT) included the analytical thinking, critical thinking, creative thinking, logical thinking, and scientific thinking (The Institute for the Promotion of Teaching Science and Technology; IPST, 2008). Therefore, the social interaction in both face-to-face and online learning should enhance students' higher order thinking in order to provide learning environment of scientific inquiry. Personal relevance also should be considered in science blended learning; therefore, the online science activities have to integrate with daily life issues. Scientific explanation and reasoning should be enhanced through interactive simulations, formative assessments, and discussion.

3. Methodology

Participants

Participants included twenty six Grade 6 students of the primary school in a rural area of Khon Kaen which is located in the North East of Thailand.

Circulatory System Blended Learning

Classroom instruction for circulatory system provided various activities in class and online learning for scientific inquiry and enhancing higher order thinking (HOT). Students required imagination and HOT in learning because the circulatory system is not visible. The online learning provided simulations and interactive activities about circulatory. In order to develop students' HOT, this study will take six thinking hats technique of De Bono (1992) into biology inquiry. The HOT representations of studied were mental representations of mental models based on Brewer's (1999) viewpoint by focusing on HOT of The IPST (2008) and blended learning of Driscoll (2002) combining between face-to-face learning and online learning in learning proportion 50:50 by organizing activities emphasized on enhancing complex thinking through six thinking hats technique of De Bono (1992).

Data Collection and Analysis

Students completed the open-ended questionnaire about HOT for circulatory system. The researcher also collected the worksheet, field note and participant observation to examine the HOT representation. Then, further interview probe students' HOT representation. Data analysis, the researcher investigated, analyzed, interpreted, and grouped the patterns of HOT answers. Then peers were interpreted one more times as peer debriefing. The valid is confirmed by member checking.

4. Results and Discussion

According to analysis and interpretation in responding the worksheets, assignments and open-ended questionnaires, found that the target group had frequency in expressing their HOT representations in "circulatory system", as shown in Table 1.

Table 1: The target group's frequency of HOT representations in " ***circulatory system*** " from worksheets, assignments and open-ended questionnaires.

HOT representations	Frequency from worksheets	Frequency from assignments	Frequency from open-ended questionnaires	Total
Analytical thinking	15	23	18	56
Critical thinking	6	10	8	24
Creative thinking	14	16	15	45
Logical thinking	4	11	6	21
Scientific thinking	13	2	15	30

From Table 1, shown that the target group had frequency of their HOT representations from worksheets on analytical thinking more than the creative thinking, scientific thinking, critical thinking and logical thinking, respectively. Frequency of target group HOT representations from assignments on analytical thinking more than the creative thinking, logical thinking, critical thinking, and scientific thinking respectively. Frequency of HOT representations from open-ended questionnaires on analytical thinking more than the creative thinking, scientific thinking, critical thinking, and logical thinking respectively.

According to the analysis and interpretation of findings in HOT representations titled "circulatory system", the target group had frequency of HOT representation on creative thinking in higher level than the analytical thinking, logical thinking, critical thinking, and scientific thinking respectively. It was supported by the findings of De Bono (1992), Pramlerk (2001), Komuitikanonth (2001), Saiwong (2001), and Chuenchitapirom (2007), that six thinking hats technique could improve students' thinking process which led to creative thinking, critical thinking, analytical thinking, systematic thinking and searching for guidelines of solution with reasons. Furthermore, the target group's HOT representations in "circulatory system" patterns, expressed by descriptive form, illustration with explanation, flow chart, diagram writing, table writing, chart writing and calculating technique. The highest level of frequency of HOT representations pattern was descriptive form because the students lacked of skill and experience in expressing their representations. It was supported by Wong-In's findings (1994) that those who were skillful in using the representations, would create the figure chart as concept and principle as well as be confident in representatives of media as connector with the problem whereas those who were not skillful would be confident in the problem sentence as wording language without using the meaning or other forms of information. Moreover, the founded behaviors of representations in thinking were: the using in symbol, picture drawing, table writing and diagram writing. In addition, it also found that students are interested and enthusiastic to learn as well, work completed as scheduled, creating a learning community network, and reflect on learning both directly and indirectly through social networking. It was supported by Gulsecen (1999) and Rovai and Jordan (2004), that blended learning could improve students'enthusiastic, motivation, attendance rate, interest in learning, and created learning community.

5. Conclusions

In utilizing research findings for the most benefit, the students should be provided opportunity in expressing their HOT representations regularly. Before using this study, the school context should be considered whether it is ready for instrument and media such as computer and internet. During online learning, the students should be taken care thoroughly by teachers so that every one of them would accomplish objectives of online learning. They should also were given an orientation in blended learning for knowing and comprehending together truly. They should be trained and stimulated for being responsible in attending online lesson regularly and get more opportunities to use high-order representations such as models, analogy, symbol, diagram, graph, chart, table and mind map in order to train their own reflection in thinking. The teachers might show their students various HOT representations regularly.

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An Exploration of Relationship between Motivation and Perceptions in Physics Learning of Light through Game-like Simulation and Its Impact on the Gender Gap

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Abstract: With regarding the benefit of digital game-based learning in promoting students' motivation to learn science and the potential of computer simulation in visualizing invisible features of scientific phenomena, this study conducted a pilot study by implementing an innovative learning environment, called "game-like simulation" for promoting secondary school students' physics learning about light phenomena. The aim of this study was to examine the relationship between physics motivation and perception toward the game-like simulation of light. 86 eleventh-grade students were recruited to participate in this study. The results indicated that there was a significant correlation between physics motivation and perception toward the game-like simulation. The results showed that intrinsic motivation was not related to enjoyment; career motivation was not related to perceived playfulness; self-efficacy was not related to perceived playfulness and enjoyment. In additions, the findings showed that there was an impact of gender difference on perceived ease of use. Moreover, the students trend to have positive perception of physics learning after interacting with the simulation. To the last, finding of this research implied that the game-like simulation could be used to promote students' learning in physics of light by regarding existing physics motivation.

Keywords: Digital game for education, physics motivation, perception

1. Introduction

Currently, the effect of technology influences to human in daily life has been investigated. From the part, instructional education was learning with text-book which is obsolete learning, the most instruction was learn from a book in which information is static. Also, technology has been developed for instructional education such as educational computer game and computer simulation. Educational computer game is digital technology industries and digital gaming immerse several environments. In addition, computer simulation has become increasingly powerful and available to science teachers over the last three decades (Srisawasdi and Kroothkeaw, 2014). The principal features of educational game are challenging to achieve the outcomes, rewarding to engage and motivation and give a situation in which learner plays as the players (Meesuk and Srisawasdi, 2014; Papastergiou, 2009). In recent years, researcher developed digital games for developing students' problem solving and learning motivation. For example, Yang (2012) revealed that the digital game could foster students' learning motivation and problem solving. Moreover, game-based learning approach had significant effectiveness in improving the students' learning performance (Sung and Hwang, 2013). In other hands, computer simulation, which can display microscopic level or high abstract of things for the better students' learning, can help students adjust variable in simulation and observe the phenomena (Chen-Chung Liu, 2011). However, the computer simulation does not have challenge. Such that the digital game-based learning might address this issue. Moreover, blending the digital game and computer simulation has been challenging to support students' learning (Borro-Escribano, Del Blanco, Torrente and Fernández-Manjón, 2013).

Although, there are many digital games that can use to support the learning of physics. The students still lack of ability to construct knowledge. Because the games only include information without learning by doing. In fact, physics not only has lecture-based but also has laboratory. Therefore, using learning environment combining the digital game and computer simulation called game-like simulation might help students increase learning performance, motivations, and perceptions in physics learning. In other words, the aim of this research is to employ the game-like simulation as an inquiry tool to support learning physics in the light topic. Specifically, the research questions were following:

- How do game-like simulation influence students' perception?
- How are the influences of gender toward perceptions after playing the game-like simulation?

2. Literature Review

2.1 Digital game-based Learning

The new media and digital technology industries and digital gaming engage several environments, especially in educational environment. Digital games consist of dazzling and sophisticated images and sounds, alongside textual communication. Players get engagement which is both pleasurable and challenging. The educational digital game keep players immersed in digital worlds, knowledge, information, and skill development become increasingly accessible outside confines of formal education (Castell, Jenson and Taylor, 2007). Currently, educators used the digital game involving content of subject matter for educational objective. Many researches presented empirical evidences that the educational digital games have positive effect on student learning.

From the past, game create only for entertainment but recently educational researchers have attempted to apply games for learning which call educational games or serious game and use to study in classroom (Sorensen and Meyer, 2007; Stone, 2009). The game that composed of challenge, control, curiosity and fantasy could motivate persistence and enjoyment (Toro-Troconis and Partridge, 2010). The educators have developed games for three objectives such as students can learn from playing the game, students' learning can be encouraging from an apart of game and students have motivation to learn when they learning by playing the game (McNamara, Jackson, & Graesser, 2010). Game-based learning is a master of constructivist-based active learning. Based on the learning research, Watson, Mong and Harris (2011) found that using game in classroom made a shift of teaching from teacher-centered learning environment to student-centered learning environment.

2.2 Computer Simulation

Computer simulations can more increase and available to science teachers. In instruction of computer simulation is visualized in a cognitive level for encourage students' learning in science classroom which displays dynamic data or simplified form in real-world, processes and provide students to observe, explore, create, and receive feedback about data, phenomena and processes such as simulation-based conceptual learning tools were utilized to support activities of observation, and reflection helps in facilitating the learning of abstract concepts (Chen et al. 2011; Colella, 2000; de Jong and Van Joolingen, 1998) and providing data in real-time shows related to a dynamic data on how certain parameters change synchronously to accommodate thinking of high level (de Jong and van Joolingen, 1998; Ronen and Eliahu, 2000).

3. Methods

3.1 Participants

This research joined up 86 students who are studying in eleventh grade and range of age is between 17 and 18 years in a local school at northeast region of Thailand. Program which is science and technology in the classroom is enrolled by them. Properties of light was not taught in the semester when the experiment was conducted.

3.2 Research instruments

This study used two instruments that is questionnaire for explore physics motivation of student and perception toward game-like simulation. First, the questionnaire of motivation scale has 25 items by developing from Science Motivation Questionnaire (Srisawasdi, 2013). This instrument was a Likert-type scale putting items that five motivation components such as Intrinsic Motivation (IM) that consists of five items, Career Motivation (CM) that is consists of five items, Self-determination (SD) that consists of five items, Self-efficacy (SE) that consists of five items, and Grade Motivation (GM) that consists of five items. Students answer the questionnaire to each item on a five-point-scale of ranging from "never" (1 point) to "always" (5 point). Table 1 shows example information of item on the questionnaire.

Table 1: Subscale description and sample items of the Physics Motivation Questionnaire (Srisawasdi, 2013)

Subscale	Description	Sample items
IM	Which involves learning physics for its own sakes	Learning physics is interesting.
CM	Which involves learning physics as a means to an end	Understanding physics will benefit me in my career.
SD	Which refers to students' confidence that they can achieve well in physics	I put enough effort into learning physics.
SE	Which refers to students' confidence that they can achieve well in physics	I believe I can master physics knowledge.
GM	Which refers to the debilitating tension	I like to do better than other students on

	some students experience in association with grading in physics	physics tests.

Second, the students' perception questionnaire was developed by Tao & et al. (2009) that have six components such as Perceived learning (PL) that consists of three items, Perceived ease of use (PEU) that consists of two items, Perceived flow (PF) that consists of three items, Perceived playfulness (PP) that consists of three items, Enjoyment (E) that consists of two items and Satisfaction (S) that consists of five items. Table 2 shows that subscale description and sample items of the students' perception questionnaire.

3.3 Learning Material

The game-like simulation is designed and named "LIGHTs". It was implicated to content of lights' properties. The game defines twelve missions to students. However, this research provides three missions to students for the exploratory phase. The style of the game is shooting game. The goal of this game wishes students understand concept of lights' properties (reflection) and provides information about lights' properties. Actually, students were asked to interact with the game. Figure 1 presents overall learning activity through the game. Moreover, Figure 2 shows examples of user interface.

3.4 Data Collection and Analysis

The participants consist of 86 students. The researcher provides physics motivation questionnaire to students around 15 minutes. After finishing the questionnaire, they played the game around 20 minutes. After finishing the game, the students were asked to complete the perception questionnaire. The data was analyzed using SPSS 22.0 to depict correlation between motivation toward physics and perception toward the game-like simulation.

Figure 1. Learning circumstance through the LIGHTs

Table 2: Subscale description and sample items of the students' perception questionnaire.

Subscale	Description	Sample items
PL	Extent to which student can get the new understanding, subjective evaluation of learning by learners themselves.	• The game-like simulation allows me to complete my studies faster. • The game-like simulation increases

Subscale	Description	Sample items
		my learning efficiency.
PEU	Extent to which using to easy and help to science easier.	• The game-like simulation is easy to use. • Using the game-like simulation to complete course related tasks are easy.
PF	Extent to which a state of deep concentration in which thoughts, intentions, feelings, and all of the senses are focused on the same goal	• I was very involved in the game-like simulation. • When I played I did not think of anything else.
PP	Extent to which students feel happy and attentiveness.	• It is interesting to use game-like simulation. • I feel like exploring more information when I use game-like simulation.
E	Extent to feeling of student when used game-like simulation.	• I had fun playing the game-like simulation for learning science. • I feel relaxed to use game-like simulation for learning science.
PS	Extent to which the individual awareness of how well a learning environment supports academic success.	• The use of the system makes this learning activity more interesting. • I like to learn new skills by using business simulation game-like simulation.

Figure 2. Example of physics learning activity on properties of light: (a) display shows starting game; (b) After click to play game, student has to select mission that each to mission sets minimum of stars for pass to play game; (c) After click to select the mission, this game provides the story about light; (d) this chapter provides student play game by using light to reflect reach a goal of this game

4. Results

4.1 Correlation between physics motivation and perception toward game-like simulation of light

This research investigated the correlation between motivation toward physics and perception toward the game-like simulation. Table 3 displays Pearson's correlation of motivation toward physics questionnaire such as Intrinsic Motivation (IM), Career Motivation (CM), Self-determination (SD), Self-Efficacy (SE) and Grade Motivation (GE) and of perceptions toward game-like simulation such as Perceived Learning (PL), Perceived Ease of Use (PEU), Flow (F), Perceived Playfulness (PP), Enjoyment (E) and Satisfaction (S).

Observing Table 3, Intrinsic Motivation (IM) was not related to Enjoyment (E). Career Motivation was not related Perceived Flow. Self-Efficacy (SE) was not related to Perceived Flow (PF) and Perceived Enjoyment (E). These results specified that the students had positive motivation to learn physics and positive perception toward game-like simulation. it suggested that the game-like simulation could be used for some students even if they have a negative or positive motivation toward physics.

The findings from the past research exposed that the educational computer game improves perception motivation of student in context of digital game-based learning experience (Meesuk & Srisawasdi, 2014; Nantakaew & Srisawasdi, 2014). But we do not know about the correlation between motivation toward physics and perception toward game-like simulation. In this study shows that the results specified that perception toward the game-like simulation does depend on motivation toward physics except to Intrinsic Motivation (IM), Career Motivation (CM) and Self-Efficacy (SE). Also students negative or positive motivation toward physics except to Intrinsic Motivation (IM), Career Motivation (CM) and Self-Efficacy (SE), they could learn physics by the game-like simulation.

Table 3: Correlation between motivation toward physics and perception toward game-like simulation

Subscale	IM	CM	SD	SE	GM	PL	PEU	PF	PP	E	S
IM	1										
CM	.589**	1									
SD	.605**	.479**	1								
SE	.641**	.434**	.595**	1							
GM	.448**	.394**	.462**	.580**	1						
PL	.505**	.301**	.345**	.389**	.235*	1					
PEU	.445**	.341**	.379**	.359**	.308**	.666**	1				
PF	.230*	.177	.266*	.167	.252*	.668**	.574**	1			
PP	.487**	.344**	.454**	.355**	.346**	.722**	.696**	.695**	1		
E	.188	.272*	.292**	.068	.224*	.475**	.620**	.581**	.601**	1	
S	.402**	.374**	.379**	.292**	.264*	.625**	.671**	.575**	.780**	.674**	1
Mean	16.99	16.81	16.69	15.52	19.05	14.33	10.64	14.44	11.06	11.10	15.03
SD	2.733	3.476	2.600	3.432	2.998	2.204	1.701	2.140	1.778	1.922	2.485

$^{**}p < 0.01$; $^{*}p < 0.05$

4.2 Comparing students' perception toward game-like simulation regarding gender

In this study, the data is analyzed for comparing female and male students' perception by MANOVA, as shown in Table 4. It was found that the gender does not significantly effect on perceptions toward the game-like simulation. Also, males or females could learn physics with the game-like simulation.

Table 4: Descriptive and correlation for gender and perception toward game-like simulation

Subscale	Gender	N	Mean	SD	F	Sig.	η^2
Perceived Learning (PL)	Males	32	14.500	2.316	.317	.575	.004
	Females	56	14.232	2.157			
Perceived Ease of Use (PEU)	Males	32	11.167	1.555	4.315	.041*	.049
	Females	56	10.357	1.721			
Perceived	Males	32	14.533	2.177	.000	.988	.000

Subscale	Gender	N	Mean	SD	F	Sig.	η^2
flow (PF)	Females	56	14.939	2.138			
Perceived playfulness (PPF)	Males	32	11.233	1.794	.267	.606	.003
	Females	56	10.964	1.778			
Enjoyment (E)	Males	32	11.533	1.925	1.538	.218	.018
	Females	56	10.875	1.898			
Satisfaction (S)	Males	32	15.433	2.515	.785	.378	.009
	Females	56	14.821	2.465			

$^{*}p < .05$

Table 4 shows the multivariate MANOVA from the impact of gender to perception toward the game-like simulation consists of Perceived Learning (PL), Perceived Ease of Use (PEU), Perceived Flow (PF), Perceived Playfulness (PPF), Enjoyment (E) and Satisfaction (S). It was found that PEU relate to gender. The results from multivariate MANOVA specified that the impact of gender to perception toward the game-like simulation on PL (F = .317, partial η^2 = 0.004), PF (F = .000, partial η^2 = 0.000), PPF (F = .267, partial η^2 = 0.003), E (F = 1.538, partial η^2 = 0.018), and S (F = 0.785, partial η^2 = 0.009). Only one subscale having correlation significant (p < .05) is PEU (F = 4.315, partial η^2 = 0.049).

Moreover, Figure 3 shows correlation for genders and perceptions toward the game-like simulation. It was found that all parts of perceptions from males' mean are greater than female, but perceived flow. Overall, males had better perceptions toward the game-like simulation than females. The genders related to Perceived Learning (PL), Perceived Flow (PF), Enjoyment (E) and Satisfaction (S). But genders do not relate to Perceived Ease of Use (PEU). Obviously, males and females perceived that the game-like simulation is easy for using in learning of light concepts.

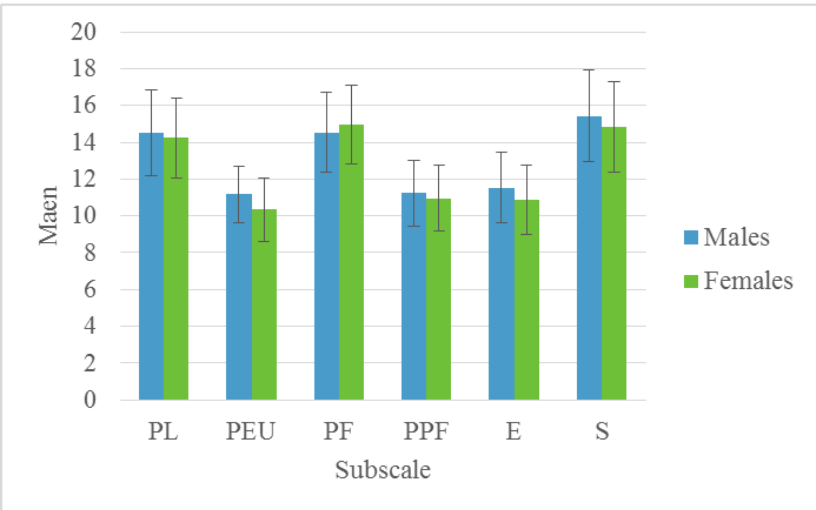

Figure 3. The graph shows that correlation between gender and perception toward game-like simulation

5. Conclusions

This study investigated the impacts of combining digital game with computer simulation named Game-like Simulation on physics motivation and perception. From the previous study indicated the educational computer game improves perception motivation of student in context of digital game-based learning experience (Meesuk & Srisawasdi, 2014; Nantakaew & Srisawasdi, 2014). The findings revealed that the game-like simulation could improve students' perception and physics motivation. Moreover, it could be used to support learning in Light by females and males. Because the game-like simulation was designed basing on game and computer simulation grounded theory. That is fun, encouraging, challenging, adjusting parameter, and visualizing invisible phenomena. The findings from this study could be used attempt to develop technological tool for supporting learning in Light on physics course.

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The Mix that Works for the SMARTBoard Integration in an American Elementary School: What We Can Learn from Them

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Abstract: The function of school and the important role of community involvement on technology integration are areas that are given little attention in the fields of research in educational technology in Malaysia. This study, which explores the aforementioned areas specifically on the integration of the SMARTBoard Technology, attempts to shed an insight into how Malaysian schools can learn from an American elementary school that is well known for its successful integration of the SMARTBoard Technology. Framed by the Cultural Historical Activity Theory and the Theory of Diffusion of Innovations, this study centers on the mix that works for the success from the social, cultural, and historical lenses. Two technology embracer teachers were the participants in this study. The findings that emerged from this study revealed that the school's pledge is the key innovation that was necessary in the school for the success of the SMARTBoard Technology integration, which also came as another innovation. These innovations was made swift through the school's community practices, which are *community building, developing routines,* and *balancing act*–the mix that was necessary for the school to successfully diffuse innovations into its system and function efficiently as a community. Reciprocally, the innovations themselves have enforced such practices and made the practices all the stronger.

Keywords: Interactive whiteboard, SMARTBoard technology, Cultural Historical Activity Theory, Theory of Diffusion of Innovations, innovation, activity system

1. Introduction

Whenever technology is integrated in a classroom, there is a debate on defining the mode of instruction taken by the teacher on whether it should be teacher-centered or student-centered (Taylor, Harlow, & Forret, 2010; Kershner, Mercer, & Warwick et al., 2010; Northcote, Mildenhall, & Marshall et al., 2010; Şad & Özhan, 2012; Md. Khambari, Hassett, & Thomas et al., 2014). In this paper, we argue that technology should be regarded as a tool rather than as a substitution for effective teaching. Rather than trying to define one's mode of instruction with technology, this study offers an understanding of teachers' daily work and how they manage their classroom to attain specific goals while juggling with several obligations. Using the Cultural Historical Activity Theory (Engeström, 1999), this study is able to unravel the complexity of a school system and its classrooms in their most natural context. The Theory of Diffusion of Innovation (Rogers, 2003) is used to explain the processes of innovation diffusion in a social system as it unearths the conflicts and issues that arise among the communities of a social system when innovations are imposed onto them. Finally, both theories are combined to provide an analysis on the way the school community behaves in response to the way they are operating. These include addressing teachers' concerns, philosophy, and pedagogical beliefs that influenced their use of interactive whiteboards and other technological and non-technological tools.

2. Research Purpose, Questions, and Methods

This study centralizes on illuminating the concept of technology as a tool used (or may not be used) by teachers to mediate their actions to achieve their goals. Tools are "any device available to teachers for use in instructing students in a more efficient and stimulating manner than the sole use of the teacher's voice" (Cuban, 1986, p.4). This concept can be understood through the lens of the Cultural Historical Activity Theory. This study also offers an in-depth insight of teachers' nature of work by providing detailed climate, culture, and context of the teachers in their working environment. These are all made possible through the lens of the Theory of Diffusion of Innovation. These lenses shield the teachers from being blamed or deemed a failure just because their pedagogical beliefs may not be in congruence with the technology imposers' expectations. Since the interactive whiteboard technology has a lot of affordances and requires its users to be creative and imaginative, this study serves to remind us that there should be no right or wrong method in the way it is being used. Most importantly, the interactive whiteboard's frequency of use does not reflect teachers' efficiency nor can it define one's quality of teaching.

Specifically, the objective of this study is to exemplify how technology embracer teachers integrate the interactive whiteboard on a day-to-day basis in their instructions through the documentation of their perspectives, pedagogical practices, and classroom management. The main research question that drives this study is: How do social, cultural, and historical practices impacts the activity around the interactive whiteboards? This question is answered using an instrumental case study, a versatile methodology in a way that it facilitates an in-depth understanding of a phenomenon within a real-life context, within which details of meaningful interactions and activities could be sought (Md. Khambari, 2015). Two school teachers at Vista Elementary who were identified as technology embracers by the school principal, are the participants of this study. They are Third Grade classroom teachers, Nicole Collins and Scott Millard. Data for this study are based on the interviews and observations with these teachers, fieldnotes of conversations with the school community, artifacts from around the school, and documents obtained legally from the school administrators.

3. Findings and Discussions

To best understand Vista Elementary as an activity system, we illustrate in vignettes of its historical, cultural, and social aspects to foreground the findings and discussions.

a. Background of Vista Elementary: the Historical, Cultural, and Social Aspects

The background of Vista Elementary can be understood from the historical, cultural, and social aspects. These aspects can be exclusive, complementary, and/or contradictory from one another; depending on the perspectives and situations of the school as an activity system.

i. The Historical Aspect

The community of Vista Elementary has a very strong foundation of supporting the use of technology in classrooms. It was built with a very distinct vision in mind, which is to embed technology in every classroom and every shared space in the building. When Vista first opened, every classroom was equipped with a telephone, a computer, a projector, and a white screen. The school gradually received more advanced gadgets such as DVD players, video projectors, integrated amplification systems, wireless infrared microphones, and wireless network accesses. This encouraged same grade level teachers to work together as a team to apply for grants so that they could get more gadgets and use them in their classrooms. Through these grants, the teachers then received interactive SMARTBoards, SMARTBoard Response Systems (iClickers), document cameras, Airliners, and iPads.

ii. The Cultural Aspect

The school principle, Olivia Kaufer, hired a strong team of teachers with a sound foundation of technology and teaching pedagogies that supports her vision. To ensure technology is utilized in every classroom, she carried out a very selective teacher hiring process with the aim to hire teachers and staff who are solid in their pedagogy and have the desire to grow on technology. The culture of the school was built with the aim of fostering inclusiveness among its community. Among others, a Parent Room was included in the design, and similar grade classrooms were clustered together in the same hallway, which are now called "pods" in practice. In each pod, there is an area for a teachers' pantry, two cubby spaces, a resource room for students with special needs, and an area allocated for the installation of 20 desktop computers. On the walls of the hallways and staircases, there were several posters that tell the code of conducts or "good behaviors" in prints. The students' published journals and artwork, or their aspiration as a community of Vista, or their programs. By the main office, a huge wall size calendar displayed the events and day to day happenings at the school.

iii. The Social Aspect

On a typical day, teachers, students, and visiting parents gather at the cafeteria for an assembly. Unlike any other schools in the district, the morning recess time in Vista is replaced with breakfast and assembly time. Every morning, teachers, students and visiting parents gather in the cafeteria for a morning meeting they call "Jumpstart". Students line up according to their classroom, with their lines separated by small orange traffic cones. Classroom teachers stand at the end of the line, counting their students or giving them signals to be quiet. School marshals, who are also the students, with other teachers and parents, surround the large group on the cafeteria floor. As the principal, Olivia would address the assembly and give morning messages like her hopes and expectations, event reminders, or ongoing and upcoming events. Besides that, the school community recites the pledge of allegiance unanimously before the flag of the United States daily, with their right hands placed on their hearts. When it comes to the school pledge known as CARES, they face each other, saying the pledge to their friends: "As a citizen of Vista, I will be **C**ooperative, **A**ssertive, **R**esponsible, **E**mpathy, and have **S**elf-control."

b. The Innovations and Practices Stemming from the Historical, Cultural, and Social Aspects

Having analyzed the data using the lenses of the Cultural Historical Activity Theory and the Theory of Diffusion of Innovations, we have come up with identifiers that have made Vista Elementary the community it is today. Such identifiers are their practices of community building, developing routines, and balancing act. However, this discussion will begin with the innovations diffused at Vista Elementary.

i. *The Innovations*

In this study, the two most obvious innovations introduced to Vista were CARES and the SMARTBoard technology. CARES is an innovation in the sense that it was a new rule in the form of *ideas* (Rogers, 2003) that the principal and her foundation team had invented prior to the opening of the school. The people who came to the school perceived CARES as a new and different culture. They perceived CARES as an innovative idea that created a culture for learning. They also regarded the installation of the SMARTBoard as having a similar impact on the learning culture as CARES. The parents whose children were transferred to Vista from the neighboring schools were deeply affected by CARES and the changes in the rules and regulations. It was something new and different.

An unusual trend in Vista that is typically not common in schools that were not built with technological innovations in mind was that there were no *late majority* or *laggard* teachers. There may have been some teachers who were in that category during the diffusion of the SMARTBoard technology, but at the time of this study, the adoption of both CARES and SMARTBoards had already been completed. Hence, they are all now the adopters of the SMARTBoard technology and CARES. This phenomenon arises from the teacher hiring process that the principal had conducted prior to the school's opening. The very stringent teacher selection process then had saved her time and effort from having those types of teachers who do not uphold Vista's mission. Figure 1 below shows a visual presentation of the types of innovation adopters in Vista Elementary.

When introducing and diffusing a new innovation, the *late majority* and *laggards* are the group of people that needs to be convinced somehow, or better yet, brought into the fold as members of a community. The newness of the Jumpstart program caused feelings of uncertainties among parents. In Vista's social system, these parents were identified as the *late majority* and *laggards*. Besides the newness aspect, their uncertainties and cautiousness of the Jumpstart and CARES may have been caused by a point of reference in the past or some unfavorable experiences (Rogers, 2003). Vista has initiated several programs to invite the parents in so that they could be more involved as a community and understands the innovations brought into the school. They carry out informational meetings as a *communication channel* to inform parents about their innovations. Olivia introduces the new practices that form the climate and culture of Vista and relates the rules to the common goals that Vista and parents share: to give the best education to their children. She also encourages parents by showing them ways of becoming part of Vista's community, starting with becoming more involved in their children's learning. In Vista, there is also a Parent Room, which we identify as a form of *communication channel*. It is a channel that serves as a place where parents can feel comfortable coming to the school. It indirectly draws parents to be around Vista and learn about its climate and culture through observations and participations in activities. Now that the parents have finally understand Vista's culture and see how the new rules could help achieve their shared goals, they have gradually accepted the new culture. Finally, the *social system* is put in place. This has made Vista all the stronger.

Another innovation that needs to be mentioned is the use of technology in Vista. The integration of desktop computers is not seen as a threat to the *late majority* and *laggards* as they have become ubiquitous in schools. In fact, it was welcomed by the community. The parents may have seen teachers from the previous schools use desktop computers. Moreover, most of these parents come from the middle class. Therefore, we may assume that owning a computer is not beyond their parents' affordability. As such, the children might already have a decent background of technology. The SMARTBoard technology arrives at the right *time* when the *social system* has mostly accepted and understood Vista's mission and vision. Besides, knowing that Vista is specifically built as a technology-based school to instill digital-literacy, the parents are more than willing to allow their children learn in a classroom that accommodates the most advanced technology in education. The SMARBoard technology is an innovative *tool* in the words of Cultural Historical Activity Theory and is categorized as *object* in the words of the Theory of Diffusions of Innovations.

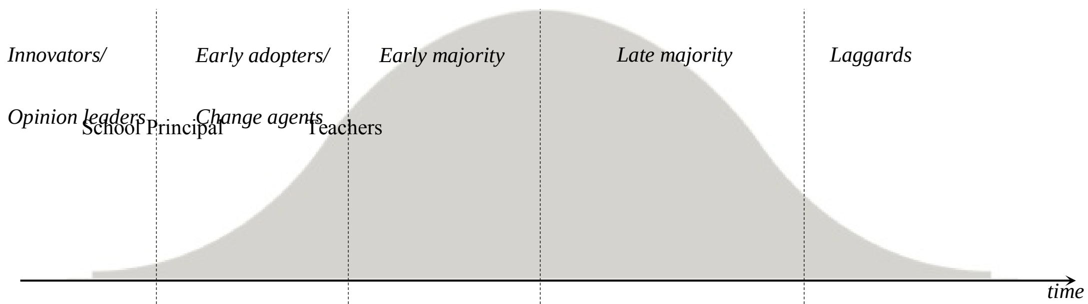

Figure 1. Type of adopters at Vista Elementary based on innovativeness (adapted from Rogers, 2003, p. 281).

An important point we want to emphasize in this study is that Vista Elementary and Scott and Nicole's classrooms are unique cases. Vista is a school built from the bottom-top, with a specific purpose and goal in mind. As such, the school may encounter less complex issues compared to the existing schools that try to introduce a new culture because the pre-existing social, cultural and historical practices have already been set in the school. In Vista's case, the culture is developed from the outset. Such a strategy has caused less resistance from the community. This analysis is unique to Vista Elementary, and may differ from other studies carried out by other scholars. In short, although Vista has the CARES philosophy and the SMARTBoards as the new innovation of *ideas* and *object*, without practices, these innovations will come to waste. In the next section, we discuss the themes that emerged after we analyzed the practices and pedagogy that make these innovations come to life. They are *community building*, *developing routines*, and *balancing act*.

i. *Community Building*

Vista's present community is shaped from solving issues and conflicts that they have encountered together through their journey. Well before the opening of Vista, Olivia had carried out a very stringent and selective teacher hiring process that looked for educators who have the experience and desire to grow with technology, and were child-centered in their approach in teaching and discipline, whom she depended upon a lot for transmitting the curriculum and non-curriculum agenda. Teachers play a very important role in bridging the gap between the school and the community. Together with the teachers, Olivia formulated the school culture that they wanted Vista to become in the future. The culture which is "the shared values, norms, symbols, language, object, and way of life that is passed on from one generation to the next," (Hammond & Cheney, 2009, n.p.) represents the approved norm and behavior that is accepted by the community of Vista.

In this study, Vista's efforts in shouldering the responsibility of bridging the gap between the school and the parents were evident. Such efforts include educating the parents by informing them of the school's culture and practices. They also invited parents to be in the school to volunteer, participate, or just observe their events. This strategy helped the parents to familiarize themselves with the educational system and how Vista operates (Grant & Ray, 2013). Gradually, Vista was able to transform the parents from outsiders to insiders and make them realize of the common goals they share. Several studies have emphasized the importance for the school leaders to bring parents into the school community and have advocated school-parent partnership models (Turnbull & Turnbull, 2001; Hornby, 2011; Auerbach, 2012; Hands, 2012). Afterall, parents are assumed as the stakeholders as they "invest" in their children to seek education from the school. By being responsive to their needs, schools and students' achievement can be improved. Some interesting strategies that we could learn from the case of Vista are through the *communication channels* they provided for the parents such as putting up a downloadable handbook for parents on their online website, carrying out informational meeting with parents, providing a designated space for parents in the school building, and opening up opportunities for them to be involved in the school. These instances reflect Vista's effort in fostering their relationship with the parents that has accelerated the rate of innovation's adoption (Rogers, 2003). As a result of their mutual understanding, their relationship grew stronger as a community as they continue to help each other. Hands (2012) notes such an effort as a school's way to "garner additional resources, social support, and educational experiences to supplement students' in-school learning opportunities" (p. 173). She also mentions that such partnership could promote students' achievement.

The school leaders must not necessarily be the one who takes the steps to bridge the gap with the parents. For their relationship to flourish, parents also need to learn to be more supportive to these efforts. Parents need to realize that they share the same goal with the school in terms of their children's knowledge seeking experience. Additionally, these findings imply that it is important for the parents to acknowledge the school's capacity in achieving their goals. When discussing school-community relationships, Grant and Ray (2013) suggest that parents are more supportive and respectful toward the teachers when they volunteer in schools. Olivia mentions that parents are becoming more aware of the educational issues and starting to understand the educational process. Through their participation in school activities, parents have realized their capacity and ability to contribute to their children's learning. Without parents' esteemed support, the goals might still be possible, but are harder to achieve. From the findings of this study, we have learned that supportive and active parents have driven Vista's development from a new school to a renowned school in its district. As suggested by Hornby (2010), the key in building and sustaining a good relationship between school leaders and parents lies in specific attitudes such as showing genuineness, respect, and empathy. Vista's effort of building a close-knit community is strengthened by the practice of *developing routines* among their citizens.

ii. Developing routines

The findings of this particular section reveal that routines in the two Third Grade teachers' classrooms are developed remarkably early in the school year. These routines are based on the CARES pledge. Developing routines seems to be the way that Scott and Nicole manage their classroom by engaging their students in repeated activities, giving verbal reinforcements, and coordinating schedules with their colleagues. They spent a substantial amount of time in the beginning of the school year to let their students know and learn of their expectations. Their management methods are in congruence with scholars who have emphasized the importance of articulating clear expectations, teaching procedures and rules, practicing routines and following them, could enhance positive behaviors among children (McKevitt & Braaksma, 2008; Wong & Wong, 2009; Prior, 2013).

In both the classrooms that we observed, practicing everyday routines resulted in consistency in their every day conducts. Such consistency helps Scott and Nicole and their students to be mentally and physically prepared as it creates a predictable environment (Spagnola & Fiese, 2007; Wong & Wong, 2009; Marzano, 2011; Prior, 2013), and students are better able to work independently with minimal reminders by the teachers. By having consistent routines, the teachers have noted that the authority in the classroom instruction has shifted – teachers' role became more facilitative instead of the traditional didactic, while students are more in-charge of their own learning. Undeniably, socialization has almost always occured in the every day classroom events. In fact, Hammond and Cheney (2009) imply that humans are subject to socialization throughout their lives. In the case of the two Third Grade classrooms, the routines and positive behavior that resulted from them being part of an overt socialization process (Biesta, 2010) practiced by Vista Elementary beyond the mandated curriculum. These routines not only furnished the students with the 21st Century skills, they have also lightened the administrative work that teachers have to do in their classrooms.

iii. Balancing act

As teachers, Scott and Nicole are tied to juggling several tasks and obligations as they carry out their duties. However, they have found a mechanism to strike a balance between their struggles, teaching philosophy, and pedagogy. The mechanisms are sharing responsibilities and enhancing collaboration colleages to reduce workload, selecting suitable tools to accommodate the varied needs of their students, and using a myriad of teaching modes to balance the classroom authority and enhance its dynamics. All these practices have forced them to think creatively and allow them to come up with a practical solution – by balancing the use of technological and non-technological tools in their teaching. Their wide set of tools, either physical or otherwise, represent a fresh perspective of looking at tools for teaching. It revokes the idea that technology must be the main tool and used all the time in teaching when it is placed in teachers' hands.

Although the literature that discussed about how the overuse and underuse of technology has triggered the debate between teacher-centered and student-centered instruction (Beauchamp, 2004; Miller, Glover, & Averis, 2005; Kelley, Underwood, & Potter et al., 2007; Kershner et al., 2010; Northcote et al., 2010), perhaps Scott and Nicole's mechanisms in balancing the use of technological and non-technological tools in their teaching approach could settle the issue once and for all. Realizing the affordances of other non-technological form of tools and resorting to using them when they are required in their teaching has helped Scott and Nicole find "what works" in their teaching.

iv. The Mix that Works for Vista Elementary

The following diagram shows the connections between the aforementioned practices and the two innovations in Vista Elementary.

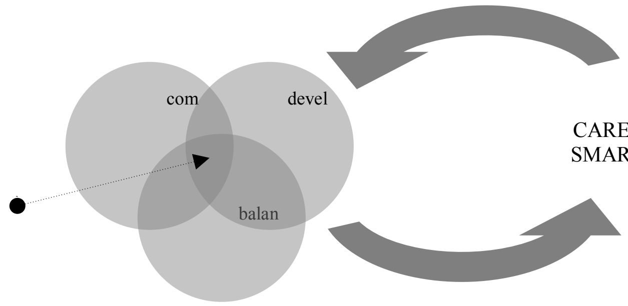

Diagram 1. The reciprocal relationship between the practices and the innovations.

This diagram shows the three practices as overlapping with each other. This is because they are interrelated and mostly complement each other. The heaviest overlapping area from the three practices represents Vista today as a community of practice. The right side of the diagram shows the two prominent innovations chosen to be analyzed in this study, which are CARES and the SMARTBoard technology. Their diffusion in Vista has triggered the community to adopt and adapt with them by engaging in *community building, developing routines,* and *balancing act.* Such practices may differ if that Vista was diffused with different innovations other than CARES and the SMARTBoard. From this study, we have identified a reciprocal relationship between innovations and practices. A close examination of the data reveals that they complement each other's existence. CARES and SMARTBoard have driven the practices and pedagogy, and the practices and pedagogy have brought these innovations to life.

4. Concluding Remarks

The findings seemed to paint a perfect picture of a perfect school which many of the Malaysian teacher longed for. Of course, it was easy for us to get impressed by the way Vista Elementary is managed especially when it is driven by a strong set of rules and equipped with the most advanced technology. But Rogers (2003) asserts that pro-innovation bias is one of the shortcomings of diffusion research whereby a researcher believes that an innovation is ideal and should be adopted by all members of a social system, and should not be re-invented or rejected. We took a step back to examine and re-examine them to detect any pro-innovation bias that might influence the analysis and writings of discussion. At every turn of this study, we found that Olivia, Scott, and Nicole often justified their school or classroom practices and activities in terms of preparing the students for the course of their school and future career. Through this, we found that the data of this study tells a story of a particular mix of qualification, socialization, and subjectification–the three functions of school suggested by Biesta (2010). He proposes that these three dimensions are what make education, and they do not necessarily have to be equal in propotion. As such, a different desirable and justifiable combination can be found at each school.

Within the notion of qualification, socialization, and subjectification, we have found that Vista has a particular mix of these dimensions that was necessary for their community. Biesta emphasizes that it is more about finding a combination or "mix" of these dimensions that is desirable and justifiable to a particular institution. Vista's particular mix was made of their core practices, which are *community building, developing routines,* and *balancing act*. Although these dimensions often lend themselves to each other, their equal presence is not necessarily required in schools. Similarly in Vista, their core practices are always interrelated and overlapped in most areas, hence complemented each other in many ways. The mix found in Vista Elementary explains how the school has become a close-knit and successful community through the combination of these practices. Through Biesta's notion of qualification, socialization, and subjectification, we learned that what we have seen was not Vista as a perfect school, but Vista as a school that has found its perfect mix and combination of these dimensions.

It is important to note that there is least one important caution that should be heeded. This study is limited to Vista Elementary in general and its two Third Grade classrooms in specific. Therefore, this particular combination of *community building, developing routines,* and *balancing act,* is unique to this particular case study. We suggest future researchers to look for different "mixes" that can be found in different schools. It would be interesting to find different combinations and mixes in different activity systems and learn whether these combinations are suitable to them. However, we would forewarn that if this type of study were to be replicated by other researchers or school leaders, they must be aware that the mix they will find in other schools may or may not be the same as the findings of this study. Furthermore, the specific mix that works for Vista cannot be replicated in another situation with the assumption that it will work as well as it has for Vista. This is because Vista is a unique case in the sense that they have CARES and the SMARTBoard technology, whose innovations have driven their core practices. Other parallel studies may have different innovations, social, cultural, and historical influences imposed on them. Hence, different combinations can be derived out of Biesta's dimensions of qualification, socialization, and subjectification.

The use of Cultural Historical Activity Theory and the Theory of Diffusion of Innovations, could help paint a picture of how the Malaysian schools are conducted. If schools were to enforce new technologies, we suggest that this framework to be used as the background for such initiatives. Having a thorough plan that counts many areas of an activity system could promote a happy school community, professional practices, and efficient use of technologies and innovations. This study has shown that there could be several possible antecedents that could have triggered their practices. In the case of Vista, their practices are driven by the diffusion of CARES and SMARTBoard as new innovations. Their practices also mirrored their acceptance and attitude toward the innovations. If CARES rules were not the same from what they are and the SMARTBoard were not integrated in the classroom, the teachers might have a different perspective towards technology. The close-knit community built through CARES in Vista has balanced out the questions of a classroom's mode of instruction. We find it important for us to once again acknowledge technologies as tools in mediating the relationship between teachers and students, and as catalysts in lessons (Miller et al., 2005).

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Enhancing Primary Students' Online Talks and Epistemic Beliefs through a Knowledge Building Community Approach

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Abstract: This paper aimed to investigate the effects of the knowledge building community (KBC) approach in enhancing primary students' online talks and their epistemic beliefs within the subject domain of Social Studies. Participants were four classes of Grade 3 students (N = 157) from a neighborhood primary school in Singapore. Two classes (i.e., experimental group) were taught with the KBC approach, while the other two (i.e., comparison group) with regular (ICT-integrated) approach. By using a within-subject design and Chi-square analysis, the experimental group students' online talks (e.g., questions and answers posted on a platform named Knowledge Forum) during the first three months and the last three months were compared. At the end of the intervention, both comparison and experimental groups responded to a five-point Likert scale on epistemic beliefs. Independent t-tests were conducted to examine the difference between the two groups in the three dimensions (i.e., *source, certainty,* and *development*) of epistemic beliefs. Results showed that the online talks of the experimental group shifted from *disputational talks* to *cumulative talks*, whereas no *exploratory talks* were observed. Compared to the comparison group, the experimental group generally demonstrated more sophisticated beliefs in the source and certainty of social studies knowledge. No significant differences were found in the *development* dimension. Findings and implications are also discussed.

Keywords: Knowledge building, knowledge forum, epistemological belief, social studies

1. Introduction

With the emergence of knowledge-based economy, the current understanding of learning and knowledge has been greatly challenged (Bereiter, 2002; MacDonald and Hursch, 2006).In a teacher-centered and test-driven classroom, especially in the Asia Pacific region (e.g., Hogan and Gopinathan, 2008; Law, Lee and Yuen, 2009; Liu and Fang, 2009), students are inclined to become passive knowledge receivers who may seldom actively share and discuss their own ideas during learning activities (Chai, Wong, Gao and Wang, 2011). As an illustration, students' classroom talk is mostly "disputational talk", which "is characterized by an unwillingness to take on the other person's point of view, and the consistent reassertion of one's own" (Mercer, 2000, p. 97). However, this type of talk seems to prevent students from further constructing knowledge and developing ideas with their peers (Deng, 2012). Besides, the traditional classroom may lead the students to *naïve* epistemic beliefs about the nature of knowledge, such as the source, certainty and development of knowledge, which associates with their learning approach and performance (Hofer, 1997; Phan, 2008).

Given the above issues, international educators and organizations have attempted to reform the current classroom practices by designing various learning environments and/or using different pedagogical approaches (e.g., Anderson, 2010; Deng, Chen, Chai and Qian, 2011; Mercer and Littleton, 2007; Scardamalia and Bereiter, 2006). In this paper, we attempted to enhance students' classroom talk and their epistemic beliefs through a knowledge building community (KBC) approach (Bereiter and Scardamalia, 2006). We hypothesize that the KBC approach provides more opportunities for students' co-construction and creation of knowledge, which may be conducive to their "deeper" classroom talk and more sophisticated epistemic beliefs. Relevant rationale is detailed in the following section.

2. Review of the Literature

2.1 Improving the Quality of Students' Classroom Talk

According to Mercer and his colleagues proposed, students' classroom talk can be generally classified as three categories: disputational talk, cumulative talk, and exploratory talk (e.g., Mercer, 1995; Mercer and Littleton, 2007). Unlike the *disputational talk* defined above, the *cumulative talk* "occurs when participants build a shared understanding and body of knowledge from the accumulation of uncritically agreed-upon pieces of knowledge" (Atwood, Turnbull and Carpendale, 2010, p. 366). Specifically, ideas or knowledge claims are justified mainly through agreement at a group level. By "exploratory talk", it generally refers classroom talk in which students engage critically but constructively in conversation about each other's ideas (e.g., Mercer, Dawes, Wegerif and Sams, 2004). Specifically, ideas are sought for joint consideration and challenge, and changes/revisions of ideas are evident if necessary (Mercer and Wegerif, 1999). As Mercer and Howe (2012) argue, disputational and cumulative talks are generally evident in the classrooms, whereas exploratory talks are rarely observed.

Several studies have focused on how to improve the quality of students' classroom talk through various interventions. These included the Thinking Together program (e.g., Mercer et al., 2004; Mercer and Wegerif, 1999), laboratory verification (e.g., Zohar and Nemet, 2002), scientific inquiry (e.g., Ford, 2008; Osborne, Erduran and Simon, 2004), and scaffolding for argumentation/reasoning (e.g., Deng, 2012; Martin and Hand, 2009; McNeill and Pimentel, 2010). In general, these studies consistently report positive findings that students' classroom talks became more constructive and/or critical (e.g., exploratory talk). A closer examination of these "successful" interventions reveals that they share the similarities in (at least implicitly) engaging students in the process of knowledge building/construction. This lends much support to the hypothesis of the current study that the KBC approach can enhance students' talk in the classroom. Besides, these intervention studies were mostly conducted within the subject domain of Science. Very few studies have investigated the development of students' talk especially in the Social Studies classroom, which constitutes a gap this paper aims to fill.

2.2 Facilitating the Changes in Primary Students' Epistemic Beliefs

The term "epistemic beliefs" generally refers to beliefs about the nature of knowledge and knowing (Hofer, 1997). As suggested by Conley, Pintrich, Vekiri and Harrison (2004), these beliefs include beliefs about the source of knowledge (e.g., from authority figures), certainty of knowledge (e.g., belief in a "right" answer), changing/development knowledge of knowledge (e.g., knowledge can change over time), and justification of knowledge (e.g., role of experiment)

Although many empirical studies (e.g., Price and Lee, 2013; Sahin, 2010) have explored how to change students' epistemic beliefs through various interventions, only a small number of them (e.g., Conley et al., 2004; Smith, Maclin, Houghton and Hennessey, 2000; Wu and Wu, 2011) have targeted the primary school students. For example, in the study of Smith et al, eighteen Grade 6 students were engaged in a constructivist-oriented curriculum (i.e., experimental group) that values students' own ideas, group collaboration, and personal reflection. Compared to other 27 students from the comparison group, the experimental group expressed more sophisticated epistemological stance toward science. Besides, using a pre-post-test design, Conley et al reported that a nine-week inquiry-based science unit was "partly" effective in changing Grade 5 students' epistemic beliefs. That is, students showed more informed beliefs about source and certainty of knowledge over time, but no significant changes were observed in their beliefs about development and justification of knowledge. Involving similar intervention used (5-week inquiry-based science activities), participant group (i.e., Grade 5 Taiwanese students), and research design (pre-post-test), Wu and Wu reported different finding that most students' epistemic beliefs remained naïve, "such that …experimental results are scientific knowledge, and there exists only one method to conduct an experiment" (p. 337). The inconsistency may be a function of duration of intervention, definition of epistemic beliefs, instrument used, and the cultural context.

At least two main gaps can be identified from the above studies. First, very few studies focused on the change in primary students' epistemic beliefs within the learning context of other non-Science subjects (e.g., Social Studies). The existing studies seem to mainly examine students' epistemology of science and/or beliefs about the nature and justification of scientific knowledge. Second, very few studies have explicitly engaged students in knowledge creation practices that may be more beneficial to the change in students' epistemic beliefs. Previous studies seem to rely on regular scientific inquiry activities to imitate scientists' research activity of creating scientific knowledge. Considering the domain-specificity of epistemic beliefs (Hofer, 1997) and the dearth of relevant studies, this study attempted to explore the effectiveness of the KBC approach in developing students' epistemic beliefs.

2.3 Potential Advantages of the Knowledge Building Community (KBC)

Grounded on the social constructivist framework, the KBC approach (Bereiter and Scardamalia, 2006) has become one of the pedagogical models that are highly referenced for the cultivation of knowledge builders/creators. As an idea-centered approach, it places much emphasis on the collaborative knowledge creation among students. To well support the use the KBC approach, an evolving knowledge co-creation platform called the Knowledge Forum (Scardamalia and Bereiter, 2006) have been developed. This platform allows students to articulate their ideas through customizable metacognitive prompts and to share their ideas (e.g., post notes like questions and answers) by using different multimedia. All online notes (or "talk" in this paper) are cognitive artefacts that can evolve if the student or others would like to further revise or refine them. In this sense, we hypothesize that the KBC approach (with the Knowledge Forum platform) may enable students to produce more exploratory (online) talks (see Mercer, 1995; Mercer and Littleton, 2007).

As evident in many empirical studies, the KBC approach seems to show great potential in facilitating changes in individuals' epistemic beliefs. For example, it helps not only promote changes in secondary students' epistemic beliefs about the authoritative nature of science (Goh, Chai and Tsai, 2013), but also develop student teachers' epistemic beliefs towards constructivist orientation (Hong and Lin, 2010). This is probably because the KBC approach creates rich opportunities for students to personally experience the epistemic practices, which may be more beneficial to the changes in how students perceive the nature of knowledge and knowing. Therefore, we hypothesize that the KBC approach may help change students' epistemic beliefs.

3. Methods

3.1 Participants

The participants were 157 Primary 3 students from four classes: Class 3B (*n* = 42), Class 3C (*n* = 36), Class 3F (*n* = 41), and Class 3G (*n* = 38). Classes 3B and 3F were selected as the experimental group (*n* = 83) taught by the KBC approach, while Classes 3C and 3G as the comparison group (*n* = 74). Among the 157 students, about 53% were girls. The four classes were taught by two Social Studies teachers, and each taught one comparison class and one experimental class.

3.2 Intervention

In the two experimental classes, students were provided some anchoring phenomenon related to the key ideas embedded in the Social Studies curriculum. They were given time to work on their initial ideas about the phenomenon and to conduct independent research (e.g., search information from Internet) to better understand the phenomenon. Meanwhile, they were encouraged to post their ideas (e.g., in the form of a knowledge claim or a question) on the platform of Knowledge Forum. Each student was also encouraged to refine/revise others' ideas by adding on new ideas or questions and/or to provide answers to others' questions if possible. The teachers acted mainly as a facilitator, s/he would provide necessary assistance for the students only when necessary. In the two comparison classes, the teacher guided the students to go through the contents in the textbook. The classroom discussions were usually initiated and led by the teacher, while students were inclined to provide answers for specific questions asked by the teacher. Video clips were sometimes used in the classroom. Overall, the intervention lasted for about 6 months.

3.3 Data Collection and Analysis

Two main data sources were collected for analysis in this study. The first source was experimental group students' online notes/talks, that is, the questions and answers they have posted. Based on Chin, Brown, and Bertram's (2002) classification of questions and answers, we employed the content analysis method to analyze students' online talks. Specifically, one researcher applied Chin et al.'s (2002) coding scheme (see Table 1) to code the data first. Another researcher then randomly selected 20% of the data and coded them with the same coding scheme. This yielded about 97% of inter-rater agreement. To examine the effectiveness of the KBC approach in enhancing students' online talks, Person's Chi-Square analysis was performed to test if any significant difference in question types and answer levels. Instead of using a pre-post-test approach, we divided the data into two parts (i.e., first three months and the last three months) and compared the category distributions accordingly.

Table 1: Coding scheme for analyzing students' online talks.

Type of talk	Categories	Descriptions
Questions	Basic information questions	• Yes/no questions • Basic text-based or encyclopedia questions
	Wonderment questions	• Why/how question • Question of comparison/contrast • Questions with multiple answers • Comprehension questions asking for clarification
Answers	Level 1	• Simple answer
	Level 2	• Answer with reasoning, summarization, clarification, or example
	Level 3	• Answer with reasoning supported with authoritative sources, comparison, or contrast
	Level 4	• Answer with reasoning supported with evaluation and interpretation of authoritative sources

The second data source was all students' responses to a five-point Likert-scale used to measure students' epistemic beliefs of Social Studies knowledge. The survey questionnaire was adapted from Conley et al.'s (2004) instrument with specifying the subject context (i.e., Social Studies). The "Justification of knowledge" dimension was not used in this study. This was mainly because this dimension focuses more on the role of scientific experiments in justifying knowledge, which may be unsuitable for the learning contexts of Social Studies. Besides, considering the participants were Primary 3 students, we did not intend to burden them with too many instrument items. As a result, the questionnaire consisted of three dimensions: *source of social studies knowledge* (e.g., "Only experts know for sure what is true in social studies"; 5 items), *certainty of social studies knowledge* (e.g., "All questions in social studies have one right answer"; 5 items), and *development of social studies knowledge* (e.g., "Ideas in social studies change over time"; 5 items).

To establish the construct validity, the survey data were factor analyzed (e.g., principal component analysis). As a result, three factors with eigenvalue larger than 1.0, each with 5 items, were identified as expected. They explained about 57% of the variance. The factor loadings ranged from .56 to .80 (>.50), which suggests that the instrument shows acceptable construct validity (Hair, Black, Babin and Anderson, 2010). Besides, the Cronbach's α coefficients of each dimension ranged from .69 to .87, which also indicates good reliability/internal consistency. Independent-tests were subsequently conducted to examine the difference between the comparison and experimental groups in the three dimensions of epistemic beliefs.

4. Results

4.1 Improvement in Students' Online Talks

Results of Chi-square analysis showed that significant differences were observed in students' question types ($\chi^2 = 8.45$, $p < 0.01$) and answer levels (($\chi^2 = 9.99$, $p < 0.01$)) between the first three months and the last three months. Specifically, during the last three months, students were more likely to ask "wonderment questions" that involve higher cognitive level as compared to the "basic information questions". Similarly, students' answer levels also shifted from Level 1 to Level 2 and Level 3. That is, students were more capable of providing answers with reasoning (supported by authoritative source, comparison, and contrast), summarization, clarification, or examples. From the perspective of Mercer and his colleagues (e.g., Mercer, 1995; Mercer and Littleton, 2007), students' online talk shifted from "disputational talk" to "cumulative talk". However, as shown in Table 2, students' answer level did not reach the highest level (Level 4) during the whole 6 months. As seen from Table 1, Level 4 requires students to reason with careful interpretation and critical evaluation of the authoritative sources they found. That is, it seems to demand more criticality and higher metacognitive level and it bears much resemblance with Mercer's (1995) *exploratory talk*. These seem to suggest that the KBC approach was *partly* effective in enhancing students' online talk.

Table 2: Distribution of students'' online talks.

Type of talk	Categories	Frequency - first 3 months	Frequency - last 3 months
Questions	Basic information questions	84 (57%)	68 (41%)
	Wonderment questions	63 (43%)	99 (59%)
Answers	Level 1	93 (94%)	287 (81%)
	Level 2	5 (5%)	57 (16%)
	Level 3	1 (1%)	12 (3%)
	Level 4	0 (0%)	0 (0%)

4.2 Differences between the Comparison and Experimental Groups in Epistemic Beliefs

Results of independent t-tests showed that significant differences were observed in *source* ($t = 3.58$, $p < .001$) and *certainty* ($t = 3.26$, $p = .001$) of social studies knowledge, but not in the *development* dimension ($t = .28$, $p = .78$). As inferred from Table 3, the experimental group was less likely to view social studies knowledge as handed down from authority figures, while the comparison group was more likely to believe that social studies questions have a right answer. That is, the experimental group expressed more sophisticated epistemic beliefs (i.e., constructivist-oriented) at the end of the intervention than the comparison group did. However, the two groups did not differ in the "development" dimension. This may be due partly to the "ceiling effect". This interpretation can be supported by the high mean scores and fairly low standard deviations of the two groups. Overall, these results indicate the advantage of the KBC approach in enhancing students' beliefs about the source and certainty of social studies knowledge.

Table 3: Comparison of epistemic beliefs between the comparison and control groups.

Dimension	Experimental Group (n = 83)		Comparison Group (n = 74)	
	M	SD	M	SD
Source	2.83	1.16	3.42	.91
Certainty	2.84	1.05	3.34	.86
Development	3.98	.76	3.95	.69

5. Conclusion and Discussion

5.1 Using the KBC Approach to Enhance Classroom Talk

In this study, we found that the KBC approach partly enhanced students' online talks (i.e., questions and answers posted), shifting from *disputational talk* to *cumulative talk*. However, no evidence showed that students were able to use *exploratory talk* during their learning tasks on the platform of Knowledge Forum. This finding is *partly* consistent with other studies that reported students' ability to produce exploratory talk after specific interventions (e.g., Deng, 2012; Mercer et al., 2004; Osborne et al., 2004). A possible reason why no exploratory talk was spotted in this study could be this type of talk is too challenging and demanding for young children who have been accustomed to the traditional learning environment (Driver, Newton, and Osborne, 2000; Mercer and Howe, 2012). Although they were encouraged to co-construct ideas together, students may end up working individually rather than talk to their peers. Another possible explanation could be students' considerable difficulty in argumentation/reasoning (e.g., Berland and Reiser, 2011; Chinn and Brewer, 1998). Therefore, to enable students to use more exploratory talk, teachers can attempt to teach argumentation skills (Zohar and Nemet, 2002) explicitly and/or provide in-situ prompts/scaffolds (Deng, 2012).

5.2 Using the KBC Approach to Enhance Epistemic Beliefs

We also found that the KBC approach was effective in enhancing students' beliefs about the source and certainty of social studies knowledge rather than the *development* dimension. This result generally parallels findings of other studies that constructivist-oriented classrooms allow students to develop more sophisticated epistemic beliefs (e.g., Conley et al., 2004; Smith et al., 2000). The experimental group's more constructivist beliefs can be due mostly to the KBC approach that underscores the value of students' various "folk" ideas. That is, they would rely less on authorities (e.g., teacher and textbook) and express more doubts about the certainty of social studies knowledge. Akin to Conley et al.'s study, the intervention seemed to be little beneficial to students' epistemic understanding about the development of social studies knowledge. Other than the "ceiling effect" issue (e.g., high mean scores and low standard deviations) discussed above, another explanation could be students were seldom engaged in argumentation and reflection. This interpretation can be supported by the above finding that no exploratory talks were evident. As Conley et al. argued, students may lack the opportunities to recognize and appreciate how ideas/knowledge may develop with the facilitation by critical argumentation and deep reflection. Therefore, future studies can take these two components into consideration when designing interventions for promoting students' epistemic beliefs.

5.3 Limitation of the study

A few limitations of this study should be noted. First, we adopted a quasi-experimental-post-test-only design to investigate the role of the KBC approach in enhancing students' epistemic beliefs. Since no pretest data were available in this study, we could not exclude the potential effect caused by pretest (i.e., two groups' epistemic beliefs prior to the intervention). For example, it is possible that the experimental group did showed less sophisticated beliefs about the development of social studies knowledge before the intervention, which would suggest different interpretation about the effectiveness of the KBC approach. Future research can address this issue by using more rigorous research design (e.g., pre-post-test and experimental design). Second, limited data sources were collected in this study, which may *bias* the findings reported above. Future studies can consider the use of other data sources (e.g., interviews, observation, and reflective journals) for the triangulation purpose (e.g., Deng, 2012).

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Ark of Inquiry: Responsible Research and Innovation through Computer-Based Inquiry Learning

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Abstract: Ark of Inquiry is a learning platform that uses a computer-based inquiry learning approach to raise youth awareness of Responsible Research and Innovation (RRI). It is developed in the context of a large-scale European project (http://www.arkofinquiry.eu) and provides young European citizens (7–18-year-olds) with a pool of engaging inquiry activities. Computer-based inquiry learning has been found effective in numerous studies. At the same time, several EU policy documents emphasize the need to increase society's active involvement in knowledge creation and scientific discussions. Therefore, RRI is a key term in the current policy of the European Commission. RRI is a transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view on the acceptability, sustainability and societal desirability of the innovation process. In the Ark of Inquiry project, we have developed a pedagogy that helps to link RRI to computer-based inquiry learning. In the current theoretical paper, we introduce this approach and explain how it has been implemented in the Ark of Inquiry project.

Keywords: inquiry learning, Responsible Research and Innovation, computers, science education

1. Introduction

According to various reports, young people are losing interest in science and less frequently regard science as their future career (e.g., Rocard et al., 2007). To ensure Europe's long-term capacity to innovate and conduct high-quality research, science education needs to become more engaging. It has been widely shown that inquiry-based science education (IBSE) increases learners' interest in science. Use of computers in IBSE further motivates young people and can support teachers in evaluating their learners' progress through learning analytics – the collection and analysis of data for adapting the next learning activities to the needs of (individual or groups of) learners. Another possibility of making science more engaging is to provide meaningful contexts for doing science. Therefore, the overall aim of the Ark of Inquiry project is to create a "new science classroom" that provides authentic opportunities for doing science. In the Ark of Inquiry project, a web-based platform is developed through which inquiry activities are made available for schools across Europe. Teachers in twelve countries across Europe are trained to help them implement the platform in their primary and secondary schools.

In recent years, Responsible Research and Innovation (RRI) has been an important focus in the European Commission to render science more meaningful for young citizens (Regulation (EU) No 1291/2013, 2013). Several large-scale projects have been financed to achieve a better understanding of what RRI is and how it could be realized (e.g., http://www.rri-tools.eu). Likewise, the Ark of Inquiry project seeks to promote RRI awareness and skills. However, the definition and pedagogies of RRI have not been developed in depth yet (Stahl, McBride, Wakunuma and Flick, 2014). The aim of this paper is to show how the Ark of Inquiry project defines RRI and relates it to computer-based IBSE.

2. Inquiry learning

Inquiry learning is an educational approach of discovering knowledge through formulating and testing hypotheses by conducting experiments and/or making observations (Pedaste, Mäeots, Leijen and Sarapuu, 2012). Active and self-directive participation of learners is central (e.g., Wilhelm and Beishuizen, 2003). Inquiry learning is usually divided into phases of scientific thinking that together make up the inquiry cycle. A variety of inquiry cycles can be found in the literature (e.g., Bybee et al., 2006; White and Frederiksen, 2000). A systematic literature review conducted by Pedaste et al. (2015) identified the core features of inquiry cycles, resulting in an inquiry cycle that combines the strengths of all existing inquiry learning frameworks and comprises five major phases. In the Orientation phase, curiosity about a topic is stimulated, resulting in a problem statement. In the Conceptualization phase, research questions and/or hypotheses are stated. In the Investigation phase, empirical data is gathered and processed to resolve the research questions or hypotheses by exploration or more structured experimentation, leading to the Data Interpretation sub-phase. In the Conclusion phase, research findings are reported. Finally, in the Discussion phase, the outcomes of the inquiry are communicated and the inquiry (sub)processes evaluated.

3. Responsible Research and Innovation

"Responsible Research and Innovation" (RRI) is fundamentally an attempt to re-imagine research and innovation and redefine the relationship between the social sciences, humanities, and technosciences (cf. Felt 2014; Levidow and Neubauer, 2014). Current research on RRI evolved from the definition provided by René von Schomberg (2011), who defined RRI as "a transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view on the (ethical) acceptability, sustainability and societal desirability of the innovation process and its marketable products (in order to allow a proper embedding of scientific and technological advances in our society)" (p.9). In recent years, several other authors have further contributed to the conceptual development of RRI and its applications (e.g., Owen et al., 2012; Stahl, 2013; Stilgoe, Owen and Macnaghten, 2013).

Promoting RRI awareness is a key factor in the Ark of Inquiry project. In the project, RRI is defined as "the attitude and ability to reflect on, communicate and discuss processes and outcomes of inquiry in terms of its relevance, consequences and ethics for oneself, others and society". Three main RRI actions are present in this definition: reflection, communication, and discussion. The act of reflection is dedicated to developing the attitude and ability to *individually think through* the relevance, consequences and ethics of inquiry. The act of communication refers to the attitude and ability to *present and explain* the relevance, consequences and ethics of inquiry to an audience. Finally, the act of discussion refers to the attitude and ability to further *question and discuss* the relevance, consequences and ethics of the processes and outcomes of inquiry with an audience.

RRI awareness is promoted through several means in the project. First, a Framework of Inquiry Proficiency and an Evaluation System were developed that enable teachers and learners to assess their skillfulness in doing scientific inquiry; RRI aspects (reflecting, presenting, and discussing) are included in the Discussion phase of the framework. Second, an Award System was developed which is particularly aimed at promoting RRI awareness and skillfulness. Third, support is provided to teachers for promoting RRI awareness in the existing inquiry activities.

4. Ark of Inquiry pedagogy and platform

In the Ark of Inquiry project, we have developed a pedagogy that helps to link RRI to computer-based inquiry learning. A Framework of Inquiry Proficiency, an Evaluation System and a related Award

System as well as Pedagogical Scenarios for supporting teachers have been created. The framework and supporting systems have been integrated into an online learning platform in which existing inquiry activities are collected and offered to learners across Europe for the purpose of learning science and learning to do science.

4.1 Inquiry proficiency levels

The Ark of Inquiry project seeks to challenge learners to increase their inquiry proficiency. For this purpose, a Framework of Inquiry Proficiency was developed that helps to categorize inquiry activities and determine learners' inquiry capabilities. Three levels are distinguished between in the framework: A (novice), B (basic), and C (advanced). The levels categorize inquiry activities according to how they challenge a learner to exhibit increasingly complex inquiry behavior defined across three dimensions: problem-solving type, learner autonomy, and learner awareness of RRI. In the framework, all dimensions are linked to the five phases of the inquiry cycle (Table 1).

In the first dimension characterizing inquiry proficiency, inquiry activities are divided into two types: well-defined or ill-defined problems (Robertson, 2001). A well-defined problem has a clear path to reaching a solution, and the solution itself has been thoroughly established as a scientific fact. An ill-defined problem does not suggest an obvious path to a solution, and a 'correct' solution is not necessarily prescribed beforehand. Increased proficiency according to this first dimension moves from well-defined to ill-defined problems.

Degree of learner autonomy is the second dimension. In case of novices, inquiry is initiated and led by the teacher and/or by the materials so that learners become familiar with the method of scientific inquiry. As learners progress, the teacher guides the inquiry process less and less and the learner moves from structured to guided inquiry and finally to open inquiry (cf. Colburn, 2000). The progression is associated with self-regulated learning, where learners themselves increasingly take control of the learning process.

Learner awareness of RRI is the third dimension. In this dimension, inquiry activities gradually expand the amount and type of interaction learners have with other learners and/or stakeholders in order to explore and include different perspectives. For example, basic inquiry activities take place within the school setting involving only their teacher and peers, but progression in inquiry requires gradually expanding the scope of societal stakeholders a learner interacts with, for instance, through work visits on off-school premises or social media platforms. A developed sense of RRI allows a learner to communicate, explain and discuss the relevance and consequences of research and research findings to people and society.

Table 1. Framework of Inquiry Proficiency

INQUIRY PHASE	INQUIRY PROFICIENCY LEVEL		
	A (novice)	B (basic)	C (advanced)
ORIENTATION	Learners are introduced to a problem within a well-defined problem space.	Learners are introduced to a problem in a semi-structured problem space.	Learners identify a suitable problem in an open-ended problem space.
CONCEPTUA-LIZATION	Learners are led to common questions and/or hypotheses that will be studied in the investigation.	Learners formulate questions and/or hypotheses through guidance.	Learners explore and formulate meaningful questions and hypotheses.
INVESTIGATION	Learners collect and analyze data according to prescribed procedures and fixed instruments.	Learners collect and analyze data in semi-structured steps and formats.	Learners operationalize procedures and formats through which they collect and analyze data.
CONCLUSION	Learners reach an understanding of fixed conclusions.	Learners reach conclusions through (semi-)structured procedures.	Learners reach conclusions and explain the process.
DISCUSSION	Learners present in fixed formats to teachers and/or peers.	Learners present and communicate in semi-structured formats to teachers and/or peers.	Learners present and discuss at appropriate times and in applicable formats with diverse stakeholders.

4.2 Evaluation and awardance of inquiry proficiency and RRI awareness

The function of the Evaluation System in the Ark of Inquiry is twofold. First, it monitors the progress learners make in doing inquiry across three levels. Across those levels, learners become better in the so-called transformative inquiry skills, such as formulating hypotheses, collecting data, and interpreting data to reach evidence-based conclusions (Pedaste and Sarapuu, 2014). Second, the Evaluation System evaluates scientific inquiry and RRI awareness by assessing regulative (metacognitive) skills such as planning, monitoring and evaluating the inquiry process (de Jong and Njoo, 1992). Next, the three principles of the Evaluation System and the evaluation forms that spring from them are described.

The first principle is personalized learning, defined as an emerging pedagogy that takes differences between learners as a starting point to tailor education to their needs. Personalized learning aims at solving some structural problems in the educational system that are often associated with standardized learning settings, such as low effectiveness and success rates, low motivations, and underestimation of talents (e.g., Robinson, 2009). Following from this principle, the Evaluation System emphasizes formative assessment and uses a format for formative dialogue to reflect on the inquiry activity, the learner's performance, and the next challenge.

The second principle is self-regulation, defined as 'a systematic process of human behaviour that involves setting personal goals and steering behaviour toward their achievement' (Zeidner, Boekaerts and Pintrich, 2000, p. 751). Self-regulation is about giving control to the learner and is claimed to be beneficial for a learner's sense of autonomy, motivation and, subsequently, learning outcomes (Ryan and Deci, 2000). Proceeding from this principle, the Evaluation System uses self-report. In the self-report, learners write down what they have been doing, what they have learned and which questions they have after finishing the inquiry activity.

The third principle is becoming part of a community of learning, defined as a group of learners that share a learning purpose and meet (ir)regularly either live or through a platform to share and support each other (see Wenger, 1998). The Ark of Inquiry will be used by thousands of learners, thus creating a sense of becoming part of a community of learners. Based on this principle, the Evaluation System uses peer feedback on inquiry processes and products.

The Evaluation System sets the stage for structured and formative reflection on the process and outcomes of scientific inquiry. Learners collect inquiry products, learner reports, formative assessments and peer feedback in a personal portfolio. This portfolio presents an overview of a learner's progress as well as collects proof for passing summative level tests. On top of that, an Award System is embedded in the Ark of Inquiry that explicitly promotes and celebrates RRI activities and products. Learners who explore the relevance, consequences and ethics of scientific inquiry collect their RRI products in their portfolio and can get nominated and awarded by their teachers and/or peers. Awards include a star and diploma for outstanding individual reflection and presentations to small audiences and subsequently a bronze, silver and gold medal for excellent large-public debates on the RRI aspects of research. The collected awards become part of a learner's portfolio.

4.3 Pedagogical scenarios

In the Ark of Inquiry project, pedagogical scenarios were designed to help teachers implement, adapt and reuse inquiry activities in their classrooms. The need for the scenarios stems from the fact that in the Ark of Inquiry, existing inquiry activities are collected which, for instance, do not always contain all inquiry phases or include RRI aspects. The scenarios help teachers re-design the existing activities so that they better fit the Framework of Inquiry Proficiency, relate to RRI goals, and improve the exchange of activities across countries and educational contexts. Six pedagogical scenarios have been developed so far.

The first scenario introduces the inquiry model of the Ark of Inquiry and, in particular, its inquiry cycle and shows how other inquiry models used by teachers can be linked to the inquiry cycle used in the Ark of Inquiry. The second scenario is for changing the difficulty level of a particular inquiry activity. For instance, the teacher can either reduce or increase the structure and scaffolding, thus giving more or less initiative to learners. The third scenario is for improving the existing inquiry activities by adding missing phases. The fourth scenario aims to support attracting more women to science and science careers. Girls' negative views and low self-efficacy in science are often associated with characteristics of the learning environment that do not motivate and engage girls (e.g., Kim and Lim, 2013). The scenario helps teachers provide activities which connect to contexts that are more engaging for girls and supports the presence of female role models in or around the activities. The fifth scenario is meant for overcoming language dependency issues by showing teachers that the language dependency of activities widely varies and does not need to be an obstacle (for instance, in visually oriented learning environments) or could even turn into an advantage when combined with foreign language learning.

In the Ark of Inquiry project, special attention is paid to enhancing the RRI awareness of learners. Therefore, the sixth pedagogical scenario focuses on linking the existing inquiry activities with the RRI approach to scientific inquiry. Because the inquiry activities used in the Ark of Inquiry platform already exist, they do not always explicitly incorporate RRI or the RRI aspects could be elaborated on or made more explicit. For that purpose, teachers need to be able to recognize the RRI aspects in the existing activities and should be supported in adding or elaborating on an RRI aspect in the existing activities (e.g., by giving examples of RRI assignments, public debates or videos). Moreover, teachers should be guided in adapting RRI aspects so that they fit their classroom pedagogies.

4.4 *The Ark of Inquiry platform*

Within the Ark of Inquiry platform, the inquiry activities are presented as a library of activities, allowing potential users to scroll through the list of activities, search for activities using a search function or select an activity based on keywords. In addition, teachers can suggest or assign activities to learners based on levels of proficiency. All activities included in the platform are in line with the pedagogical framework of the Ark of Inquiry. The information (i.e. metadata) on each activity that will be available to the users includes the following: title of the activity, description, location (web-based or physical location), domain(s), topic(s), language(s), overall proficiency level of the activity, inquiry phases covered, age range, learning time, materials needed, and evidence on the success of the activity.

The initial version of the Ark of Inquiry platform contains a total of 68 activities. These can be accessed through the platform and implemented, adapted and reused worldwide in classrooms, at home and in science centers and museums. The repository of activities represents a good coverage of the central components of the project and provides a fruitful baseline for a small-scale pilot.

5. Conclusion

In conclusion, we can say that the Ark of Inquiry project aims at finding a new pedagogy to link inquiry learning with RRI in the context of computer-based education. Teachers are a key factor in reaching the goals of the project. Therefore, our efforts in the near future focus on supporting teachers in starting to use the Ark of Inquiry in two ways. First, teachers will be provided with web-based materials helping them orient to inquiry learning in general and RRI in particular. Through the web-based materials, teachers get to learn the Framework of Inquiry Proficiency and the Evaluation System that are at the core of the Ark of Inquiry project. The web-based materials aim at helping teachers to *adopt* the Ark of Inquiry. Second, teachers are invited to take part in teacher training sessions to learn to use the Ark of Inquiry in their classrooms. The teacher training comprises (1) inquiry learning in general, (2) the Ark of Inquiry pedagogy (Framework of Inquiry Proficiency, Evaluation System and Award System), and (3) adaptation of the Ark of Inquiry activities (pedagogical scenarios). The teacher training aims at helping teachers successfully *implement* the Ark of Inquiry in their own classrooms. In the long run, the Ark of Inquiry project seeks to equip teachers with the necessary skills and knowledge in order for them to become designers of classrooms in which young people can practice inquiry learning and scientific reasoning as well as become responsible citizens who are able to take into account the relevance, consequences and ethical issues related to scientific discovery and innovations for themselves, others and society. More information can be found on the project website http://www.arkofinquiry.eu/.

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Effects of Using Online Resources by Undergraduate Students for Self-Directed Learning of English Speaking

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Abstract: This qualitative study aimed to investigate (1) what and how students used online resources to improve their speaking abilities and (2) whether those online resources affected their speaking fluency. For case students were third-year English major at Khon Kaen University. Three sets of data included pre and post-tests, a questionnaire and a semi-structured interview. Data were analyzed and presented by using frequencies. The findings were firstly, proficient case students used Ryan Higa's channel on YouTube and online movies web site to practice speaking. They repeated after the conversation of the speakers from movies. Total hours from both students are 80 hours. In addition, one of then used online dictionary on website to find the new words for 8 hours within 2 months. Secondly, results from one of low English proficient students used YouTube to sing English songs with sub-title for practice. She has spent for 32 hours. Moreover, she also used online dictionary website for correcting her pronunciation problems (32 hours). One of them used "talkenglish.com" for practice speaking by reading the passage out loud for 2.40 hours within 2 months. Thirdly, the findings from pre and post-test were found that all students can reduce the filled pauses and dysfluencies after using the online resources within 2 months. The highest score student, Pang, did the longest runs as 140 words per minute after used online resources less mistakes. However, Pla from the proficient group is the highest progression from this study. Her speeches were increased 15 words, however; Pang increased only 7 words. Therefore, the proficient case students have advanced ways to learn a language by using online resources and they also spent more hours than another group.

Key Words: Online resources, learning, self-directed learning, english speaking, accuracy, fluency in speaking

1. Introduction

Language learning is not easy to learn. Wiriya (2012) found that in order to facilitate the learners to learn English autonomously and effectively by using Self-Access Language Learning center with teacher's control is successful. Likewise, Lamp and Rienders (2008) mentioned that even though students take their responsibility to learn, they cannot direct and learn lonely without teacher's direction. Therefore, learning outside classroom may promote students' motivation in order to be active learners and to facilitate students' affection in language learning. It will be a factor that can motivate a student to learn things effectively and actively. Moreover, he or she may take more responsibility and participation (Sheerin, 1997). There are many ways to learn English outside classroom such as going to Self-Access Learning Center (SALC) or they can access or using the online resources including accessing through the Internet at home. Rukietgumjorn, et. al., (1998) found that Students can design their own pace to reach the goal as a commitment because they can meet their different needs, different goals and the different level of English proficiency. Chongpensuklert (2011) found that four keys intrinsic motivation that Thai students at International College in Suan Sunandha Rajabath University promoted their speaking outside the classroom such as studying abroad, gaining a higher degree of education, surviving in overseas, getting a better job. Therefore, it is similar to the self-directed learning process, learners can start with identifying their learning interests, setting their learning objectives, searching for learning materials, using the learning strategies to learn, and measuring the progress. It is a strategic approach for pedagogical study. Using online resources may be a possible way that students can achieve their objectives in language learning as well. This study aims to find out the students use online resources for improving their speaking and to study the fluency effects of using online resources from the students. It is more challenging to understand more about the effect of students' using the online resources for self-directed learning in which way and how. It may lead the researcher to see the way for developing the students' speaking performance, especially in speaking fluency in the near future. The next section will be described about reviewing the literature.

2. Literature Review

The scope of this chapter will be explained more as followings:

2.1 Speaking Ability

Speaking is a productive skill. Harmer (1998) stated that speaking skill is the productive skill. The speakers plan to produce speech before saying. Fulcher (2003) mentioned that speaking is the verbal use of language to communicate with others. It can be much more that, the learners need the knowledge to produce speech and learn it over and over again. The speaker needs to concentrate on accuracy and fluency. To teach speaking is not easy to do. Harmer (1998) claimed that good students need to step over the trouble when you speak discontinuously. The assessment of the speaking ability is very difficult because the teacher needs to have the high experience to give marks. Marking will be always given within 4 criteria such as fluency and coherence, lexical resource, grammatical range, and accuracy. In this study will focus on speaking fluency.

2.2 Fluency in Speaking

There are numerous definitions of fluency in speaking according to the characteristic of speakers' speech. "Fluency" refers to the speakers' proficiency which can be described features as followings: Lehtonen et. al. (1977) cited that fluency in speaking refers to the advanced learners in foreign language learning. They can produce the target language without unconfident and pauses, how long in sentences, wrong grammatical and pronounce, and speed (Kopnen, 1995; Freed, 1995; Freed, So and Lazar; 2003, Ellis and Barkhuizen, 2009). In this study, the researcher tries to analyze the temporal aspect such as speech rate, speech pause relationships, and frequency of dysfluency markers such as hesitations, repetitions, and self-corrections. The fluent speaker refers to the one who can use fewer pauses and hesitations in speech with the explanation below:

- Speech Rate: The speech rate of it is calculated by dividing the total number of the words produced in a given speech sample by amount of time (includes pause time), however; the rate of speech will be calculated on the number of the words without repetition within minute (word/minutes). For example, I would like to to go to Starbuck. 7 words (7 divided by 60 seconds = 0.11 w/m)
- Frequency of *unfilled* pauses: it will be counted on silent pauses longer than 0.4 seconds in the duration per minutes (excludes filler).
- Frequency *of* filled pauses: it will be counted on filler sounds, draws, sound stretches or the filler L1 words such as like, or, okay, and yeah (includes filler).

- Length of speed runs: it will be calculated on the number of words produced between pauses as the longest fluent speech run. It is not containing any silent or filled dysfluencies (e.g. um, ah).
- Frequency of repairs: it will be calculated by counting the repaired words produced.
- Repetitions: it is calculated by the number of repetitive words produced per minute.

2.3 Self-Directed Learning Definition

Self-directed learning is derived from adult education. This approach is described in terms of types of learners and their roles for becoming self-directed learners. There are many concepts from many educators as follows: Knowles (1975) defined that self-directed learning is a particular way to direct learners' learning with encouragement or discouragement. Dickinson (1987) defined self-directed learning as the attitude towards learning individually; he or she is prepared to take responsibility for his or her own learning. A self-directed learner is the one who has responsibility for the management of his or her own learning for goal setting, monitoring their development of the course, assessing their performance, and taking an active role in learning. Brookfield (1995) mentioned that self-directed learning emphasis on the mechanism of adult learners direct their own learning such as setting the objectives of their learning, find the suitable resources, choose their learning processes to use and assess their development.

2.4 Online Resources

Technology is important for our daily life. Likewise, using computer plays an important role in language learning and teaching. Levy (1997) defined that Computer-Assisted Language Learning (CALL) is using the benefit of the computer in language learning and teaching. It includes the Interactive tutorial program, websites, electronics communication tools and linguistics aids. Students are motivated to learn; for example, using the internet to learn to speak. Students can choose their own preferences in practicing speaking using online resources including websites, applications or software in other gadgets. It may encourage them to map their interests with the way they want to learn individually. Moreover, learning English outside classroom online resources (e.g., web or software) supports students to achieve their learning objectives. It has a potential for resource access any time, any place, any path, or any pace (Hiemstra, 2009).

3. Research Questions

1. What online resources do students use to practice English speaking ability?
2. How do students use online resources?
3. To what extent do online resources affect students' speaking fluency?

4. Research Methodology

4.1 Participants

There were 4 participants in this pilot study. They were third-year English major, studying in the course of English Conversation and Discussion at Khon Kaen University. The criteria for choosing this group of students, the researcher considered with the sum of 2 speaking task scores and the midterm test scores. They also held on the floor in a Midterm examination from a random topic. The highest group had 2 students such as Pla and Pang. The lowest score had 2 students such as Kae and Chompu. The researcher used the alias in order to avoid the information in this study.

4.2 Method

The students were assigned to speak with the persuasive topics which were prepared by the teacher in order to avoid the unrelated topics. The students picked up from the teacher preparation. The researcher collected the data, decoded and transcribed from two videos. Time one home video recording has 4 minutes length and time 2 has 5 minutes length from the same topic and uploaded on Facebook. From time 1 and time 2, the duration was approximately 2 months.

5. Data Collection and Data Analysis

(1) Oral Fluency Measurement Coding Scheme: The students were given the persuasive topics in time one (pre-test)and time two (post-test)which are the same area, however; they are not exactly the same test (parallel test). (2) Questionnaires: Rating scales and with open-ended questions. (3) Interview: The questions were clarified from the answers of the participants and the further information of questionnaires.

Even though the two tasks took 4 or 5 minutes, in this study the researcher analyzed only a minute in oral performance which the researcher considered that the students felt more confident in within 60 seconds because this pilot study will be limited in time-consuming. The data from the task performance (time 1 and time 2) were decoded and transcribed. Other sets of data from questioners and the interviews were described in a report.

6. Results

From table 1, the progression can be seen from time 2 of every group. The students will reduce the filled pauses and dysfluencies. The more they can produce the language, the more we can see the fluency of language produced. From Pang, she did the longest runs and less mistakes. She had the high fluency in oral performance in this group. On the other hand, Kae had the same score in a mean. It meant that she had no progression on fluency. From the table 2, we can see the frequency use of online resources that the proficient students and the activities that they used to improve their speaking abilities. They chose video clips from YouTube and movies to practice speaking. They repeated after the conversation of the speakers from movies. Total hours from both students are 80 hours. In addition, Pang has spent for 8 hours within 2 months. She used online dictionary on website to find the new words. The table 3, we can see the students' self-reflection of the use of the online resources that the low proficient students used. It also has been shown about that the web-site to improve their speaking skill, it can be seen the results from one of low English proficient students used online resources for practice speaking by reading the passage out loud for 2.40 hours within 2 months. Chompu used YouTube to sing English songs with sub-title for practice. She has spent for 32 hours. Moreover, she also used online dictionary website for correcting her pronunciation problems (32 hours).

Table 1: Raw scores of pre-test and post-test oral performance between high speaking score students and lower speaking score students in KKU (within one minute)

Speech Measurement Items	High Speaking Score Ss (N =2)			
	Pre	Post	Pre	Post
	Pang	Pang	Pla	Pla
Speech Rate:	133w/m =2.21	140w/m =2.33	127w/m =2.11	142 w/m =2.31
Frequency of unfilled pauses	3	3	4	3
Frequency of filled pauses	4	3	3	3
Length of speed runs	28	31	24	26
Frequency of repairs	1	1	1	1
Repetitions	0	0	0	0
Speech Measurement Items	Lower Speaking Score Ss (N =2)			
	Pre	Post	Pre	Post
	Kae	Kae	Choompu	Choompu
Speech Rate:	91 w/m =1.51	94w/m =1.53	108w/m =1.66	113w/m =1.88
Frequency of unfilled pauses	12	9	5	5
Frequency of filled pauses	4	3	3	2
Length of speed runs	14	16	22	24
Frequency of repairs	2	2	0	1
Repetitions	4	3	1	0

Table 2: The use of online resources (Higher Speaking Score Students)

The name of the student/The name of online resources	How to practice	How long/ day	How many time/week	How many hours	What have you learnt from the web?
Pla / Ryan Higa's channel on YouTube	-Try to listen and try to repeat (without sub-title).	1 hour/ day	7times /week	60	I have learnt speaking in any situations
Pang 1/ http://www.itvmovie.eu/	-Try to understand what people said -Try to repeat (with and without sub-title)	2-3 hr/day	1time /week	20	I have learnt the way people speak natural.
Pang 2/ http://www.ldoceonline.com/	-Find new words	1/day	5times /week	8	I have learnt new word

Table 3: The use of online resources (Lower Speaking Score Students)

The name of the student/The name of online resources	How to practice	How long/ day	How many time/week	How many hours	What have you learnt from the web?
Chompu 1/ http://www.talkenglish.comom/	Read the suggestion about speaking and follow ex. Read the passage out loud	20 mins	1 time /week	2.40	I get a tips to speak well
Chompu 2/ https://www.youtube.com/watch?v=h8Hgp150Enoom/watch?v=h8Hgp150Eno	Try to practice by sing along English song with sub-title	1 hour	4 times/ week	32	Get more vocabulary and pronunciation.
Kae/ http://th.w3dictionary.org/index.php?q=say	Find out the meaning of the vocab for doing homework and try to pronounce	1hour	4-5 times /week	32	I got new vocab, its meaning, and how to pronounce it correctly.

7. Conclusion

This case study found that the proficient case students had more difficult ways to practice their speaking ability. Speaking fluency development by using online resources is the choice that can match learners' satisfaction with activities. Although students need or do not need someone who can facilitate them for the achievement, responsibility is also needed for self-directed learning. We can see from the evidence of the duration that all students used. The proficient students spent more time to practice speaking.

8. Discussion

Motivation is a key term of self-directed learning (Dickinson, 1987). Likewise, Mat Daud, Abdual Rahman and Samsudin (2013) found that online self-directed learning on students' motivation can have a positive impact on the enhancement of students' motivation. It means that there is an increasing in the level of students' motivation after implementing this approach. Rafiee, Pazhakh and Gorjian (2014) claimed that self-directed learning ability of Iran students increases in speaking that means they also have high motivation in learning. To compare with this study, some case participants have high motivation, we can see from the activities that they did (repeat after the conversation), however; they need the activity which is providing speaking assessment and receiving feedback. They also can start to write their plan and progression on the paper (a learner contract). It can remind them to know what they have learned and see their weak points.

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The Digital learning environments to promote information literacy in higher education: Designing and Instruction framework

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Abstract: People in the 21st century live in a technology and media-suffused environment, media and information literacy is an important prerequisite for fostering equitable access to information and knowledge and promoting free, independent and pluralistic media and information systems. The purpose of this research is to synthesize theoretical framework and designing framework of the digital learning environments that promote information literacy in primary school. The developmental research: Phase I: Product and tools research (Richey and Klein, 2007) was employed in this study. Several methods used were document analysis and survey. The procedures are as follows: (1) Examining and analyzing principles and theories, (2) Synthesizing the theoretical framework of the digital learning environments which promote information literacy in primary school, and (3) Synthesizing the designing framework of the digital learning environments which promote information literacy in primary school. The results revealed that this model consisted of nine elements as follows: (1) Problem base and learning task, (2) Learning resource, (3) Information Operations Centre, (4) Coaching, (5) Scaffolding, (6) Collaboration.

Keywords: Learning environments, information literacy, 21st Century skill, higher education

1. Introduction

Information literacy is important owing to the amount of information that is available in contemporary society. Simply being exposed to a great deal of information will not make people informed citizens; they need to learn how to use this information effectively, ACRL (2000). Data Smog refers to the idea that too much information can create a barrier in our lives. Especially students and the society require a special skill to handle this fast increasing information, in order to use their educational and economical purposes more effectively. Information literacy is considered as the solution for the data smog (ACRL, 2006). Information literacy allows us to cope with the data smog, by equipping us with the necessary skills to recognize when we need information, where to locate it, and how to use it effectively and efficiently. Consequently it will help decision-making and productivity that is beneficial to the society.

Due to the information explosion and data smog all students and the society face many difficulties to locate, evaluate, use, and communicate information. Due to the expansion of Internet services we receive a lot of information that is not evaluated, unlike the printed sources. Hence the authenticity, validity, and reliability of this information is in doubt. Student centered, inquiry based, problem solving, and critical thinking proactive learning environment with the help of information literacy skills, will develop deep learners in the society. Furthermore, information skills are vital to the success in education, occupation, and day-to-day communication of all citizens. In the twenty- first century, lifelong learning has become one of the main themes in the higher education sector. Therefore the students need to be educated with regard to the abilities and skills of how to learn, or learning to learn, by developing the aspects of reasoning and critical thinking. Information literacy skills will help students to achieve this target in a broader sense, in student centered learning. Traditionally, we assume that the students will gain information literacy skills automatically by themselves. But it is not. In fact, information literacy skills need to be inculcated among the students, by the teachers and librarians.

Learning mainly focuses on achieving knowledge, skills and attitudes, associated with particular subject areas. Irrespective of the disciplinary stream, each and every student should be able to access, use and communicate information in an innovative manner. The Information literacy curriculum plays a major role in order to cultivate these skills among the university and school students. The library professionals with the help of academic and administrative staff can implement the curriculum.

2. The Purpose of This Research

To synthesize the theoretical and designing framework of the digital learning environments enhancing the information literacy in higher education.

3. Methodology

3.1 Research Design

The developmental research Type I: Product and tools research (Richey and Klein, 2007) was employed in this study. Several methods were used such as document analysis, survey, and case study.

3.2 Research Instruments

The instruments used of in this study were 2 kinds as following details:

1) The document examination and analysis recording form. The scope of document analysis regarding with Constructivist theories, information literacy framework, and web based learning theory.

2) The expert review for evaluation of the designing framework. The framework of this instrument consists of 3 major issues which are: Learning content, Instructional design, and Web-Based learning environments.

3.3 Data Collection and Analysis

1) Synthesis of theoretical framework of the digital learning environments learning environment to enhance information literacy. The data were collected by analyzing principle, theories related research of the Constructivist theories, Cognitive constructivist theory, Information literacy framework, Web-Based learning environment theory and Technological theory.

2) Synthesis of designing framework: The above theoretical framework was taken into this process. The underlined theories such as, Cognitive theories, Problem solving transfer, Cognitive constructivist, Social constructivist, and the Constructivist learning

4. Information Literacy in Higher Education: Definitional Issue

Information literate in higher education researchers will demonstrate an awareness of how they gather, use, manage, synthesize and create information and data in an ethical manner and will have the information skills to do so effectively.

CILIP have defined information literacy in higher education as “Information literacy knows when and why you need information, where to find it, and how to evaluate, use and communicate it in an ethical manner.” They have also created more in depth guidance on the skills required to be information literate. The Society of College, National and University Libraries (SCONUL) developed the Seven Pillars of Information Literacy model in 1999. It was designed to be a practical working model that would help develop ideas amongst practitioners and generate discussion. It was updated in 2004 and again in 2012. SCONUL define Information Literacy as: “Information literate people will demonstrate an awareness of how they gather, use, manage, synthesize and create information and data in an ethical manner and will have the information skills to do so effectively."

The Association of College & Research Libraries (ACRL) defines information literacy as: "the set of skills needed to find, retrieve, analyze, and use information." The ACRL has created a set of standards that outline in detail the skill set needed to be information literate. The website also provides guidance on collaboration, curriculum design and pedagogy. The Australian and New Zealand Institute for Information Literacy (ANZIIL) have developed an information literacy framework that outlines what makes information literate citizen. The Illinois Mathematics and Science Academy define "Digital Information Fluency (DIF) as the ability to find, evaluate and use digital information effectively, efficiently and ethically."

Conclusion of information literacy in higher education is can be used to examine critically knowledge and understandings. Through the research process, students can revise their understandings, perceive weaknesses in information, and make better sense of their world. People in the 21st century live in a technology and media-suffused environment, marked by various characteristics, including:

1) *Access and Evaluate Information:* (1) Access information efficiently (time) and effectively (sources); (2) Evaluate information critically and competently
2) *Use and Manage Information:* (1) Use information accurately and creatively for the issue or problem at hand; (2) Manage the flow of information from a wide variety of sources; and (3) Apply a fundamental understanding of the ethical/legal issues surrounding the access and use of information.

5. The digital learning environments

5.1 The digital learning environments base on constructivist theory

A framework provides a basis for designing instruction. Sometimes it is referred as philosophy or the theory behind a specific design. Three schools of thought have been widely used and explored to provide guidance for instructional practice: behaviorism, cognitive psychology and constructivism (Villalba and Romiszowski 2001). However of the three, constructivism has been identified as the most suitable one for online learning environments (Hung, 2001; Oliver, 1999; Hung and Nichani, 2001). Constructivist learning environments, Lebav (1993) suggests, should have the following minimum requirements:

- Provision of the experience of the knowledge construction process;
- Provision of experience in and appreciation of multiple perspectives;
- Creation of learning tasks which are relevant and authentic;
- Encouragement of ownership and voice in the learning process;
- Encouragement of the development of multiple modes of representation; and
- Encouragement of self-awareness of the knowledge construction process.

The constructivist-learning paradigm transforms the 'teacher-directed learning' to 'student-directed learning'. As such it holds the following premises (French et al, 1999):

- Objectives are written with student collaboration based on the learner's need;
- All the learners are unique and bring their own social understanding to learning context;
- Problems are solved when they have personal relevance to learning;
- Knowledge is individually and socially constructed; and
- Learning can only be measured through direct observation and dialogue.

While web enables to transform constructivist tasks to be used in online learning (Table 1), the design framework (Mishra, 2002) for the digital learning environments is an eclectic one where the three learning theories and their basic instructional approaches have been used. Figure 1 depicts the design framework used in the digital learning environments.

5.2 The Digital Open Learning Environments: Foundations, Methods, and Models

Salomon (1991) describes a learning environment (LE) as a system consisting of interrelated components that jointly affect learning in interaction with (but separate from) relevant individual and cultural differences. He suggests that when technology is introduced to the LE, the changes in the individual will depend on the changes distributed over the whole learning environment.

Hannafin (1999) describes a theory for situations where divergent thinking and multiple perspectives are valued over a single "correct" perspective. It is appropriate for heuristics-based learning and for exploring fuzzy, ill-defined, and ill-structured problems.

Some of the values upon which this theory is based include: (1) Personal inquiry and divergent thinking and multiple perspectives, (2) Self-directed learning and learner autonomy with metacognitive support, (3) Mediating learning through individual experience and personal theories, (4) Hands-on, concrete experiences involving realistic, relevant problems, and (5) Providing tools and resources to aid the learner's efforts at learning.

These are the major methods this theory offers: (1) Enabling contexts (to establish the perspectives taken in the environment), (2) Resources (to provide the domain of available information sources), (3) Tools (to provide the basic means for manipulating information), and (4) Scaffolds (to guide and support learning efforts)

While this theory does offer some guidelines (conditions under which different methods should be used), much of it is presented here as a taxonomy of methods, where the practitioner needs to figure out when to use each.

6. Research results

The research found that the theoretical framework consisted of 4 crucial bases as follows:

6.1 The Theoretical Framework of the Digital Learning Environments to Information Literacy in Higher Education

The theoretical framework consist of 4 precious bases which compose of: (1) psychological learning base: constructivist theory and framework of information literacy in higher education, (2) pedagogical base: web based learning environment and constructivist learning model--OLEs model, CLEs model, and SOI model, (3) technological base: web based which helps to enhance information literacy, and (4) contextual instruction base: Thailand higher education. These all of 4 bases are analyzed, and synthesized the relationships between each of them show in Figure 1.

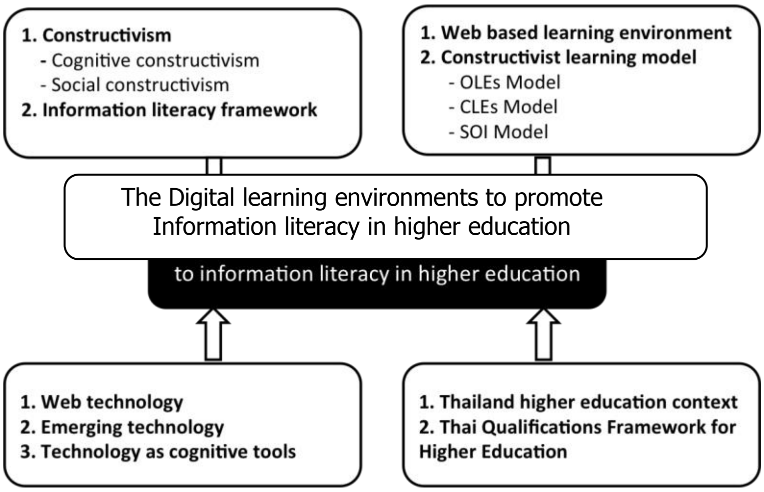

Figure 1. The theoretical framework of the digital learning environments to information literacy in higher education.

6.2 Designing Framework for the Digital Learning Environments to Promote Information Literacy in Higher Education

The theoretical framework that was used as foundation in synthesizing the designing framework of the digital learning environments to promote information literacy in higher education. It is found 5 crucial bases for enhance information literacy as follows:

1) Cognitive structure and information literacy activate: It is illustrated the relationship between the underlined theories as follows: cognitive constructivist, OLEs Model, information literacy and the components of innovation which used Problem base.

2) Support for equilibrium of cognitive structure and information literacy: It is illustrated the relationship between the underlined theories as follows: cognitive constructivism, SOI Model, and the components of the digital learning environments Learning Resource.

3) Enhance for information literacy: It is illustrated the relationship between the underlined theories as follows: cognitive constructivism, CLEs Model and the components of the digital learning environments which called Information Operations Centre.

4) Promote and support equilibrium: It is illustrated the relationship between the underlined theories as follows: cognitive constructivism, CLEs Model, OLEs Model and the components of the digital learning environments which Scaffolding, Collaboration, and Coaching.

7. Discussion and Conclusion

The frameworks of the digital learning environments to promote information literacy in higher education consist of 4 aspects: (1) psychological learning base, (2) pedagogical base, (3) technological base, and (4) contextual instruction base. As for this study the result illustrates the designing framework of the digital learning environments to promote information literacy in higher education consist of 4 process: (1) activate cognitive conflict and information literacy, (2) support for adjusting cognitive conflict and problem solving transfer, (3) support for problem solving transfer, and (4) promote and support equilibrium. According to the synthesis of the designing framework base on theoretical framework that is applying theories into practices. The five components in designing the digital learning environments to promote information literacy in higher education are as following details: (1) Problem base and learning task, (2) Learning resource, (3) Information Operations Centre, (4) Coaching, (5) Scaffolding, (6) Collaboration.

There consistent with Shaharuddin et al.(2012), Chaijaroen et al.(2008), Lesley-Jane et al.(2012), Kanjug (2012) and Samat (2012). The results of this study, design elements of the learning environment that promotes student cognitive skill. That there is a theoretical basis.(1) the basic psychology of learning, including constructivist theory ,cognitive theory (2) basic science instruction focusing on learning environment designed along constructivist and cognitive skills and information literacy theory (3) fundamental of media symbol systems (4) based technology such as learning with web-based learning environment and (5) based on this principle into context such as graduate desirable features, guidelines for teaching and the essence of the analysis and design courses.

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Effect of Social Media Learning Environments (SLME) on Learners' Expertise Mental Model in Computer Programming Subject for High School Students

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Abstract: With the ease of use and linking various knowledge resources, social media technologies have been widely used for educational area and societies to promote lifelong learning. Consequently, this paper presents the design social media learning environments for enhancing mental model in computer programming course. The target group consisted of 40 high school students. The research design was Pre-experimental with One Shot Case Study. For qualitative data, they were analyzed by using an in-depth interview and students' answering responsibility while they were studying by protocol analysis. The research findings showed that the students were able to construct expert mental model representing understanding as: (1) ability to explain various stories or incidents, (2) ability to change the rules and processes into problem solving, and (3) ability to express the association of fact and studied rules with different situations. Besides, it was found that the students could be able to organize the categories of constructed mental model as well.

Keywords: cognitive process, learning technology, social media, mental model

1. Introduction

In recent years, computers and communication technologies have been playing a crucial role in human daily lives. Because human need information to make decision. Communication with convenience and speed are more effectively in human lifestyle. In the UK, studies from Internet Information Research (IIR), Social Science Research Network, Center for Genetic Engineering and Biotechnology, and National Electronics and Computer Technology showed that there were 23,846,315 Internet users. In 2013, the Office of electronic transactions reported the behavior of Internet users such as student interacting with e-mail and officer interacting with electronic transactions. In Thailand, there is likely increasing in using Internet. Obviously, the computers and communication technologies are more vital to human life. With the rapid development of communicative technology and information in making the transition into the era of globalization and the impact of changes in the country, as well as other countries around the world in the 21st century, the world economy towards the economy, knowledge based economy, the use of knowledge and innovation is a major factor in the development and production of more capital and labor. Such that gaining knowledge may be influenced by Social Media. In particular, a popular medium for marketing communication has been promoted. And online marketing activities in many forms such as Facebook, You tube, and twitter. In this paper, "Media" refers to materials or tools used for communication, "Social" refers to a society in the context of social media. Social sharing means in society in which it may or share content on social interaction

In other hands, the findings of instructional design model enhancing knowledge construction as mental model which was the students' mental representation would be changed and constructed throughout the time. Specifically, if the students' mental representation was the mental model using for explaining the stories or real world sensed by them. This model also be able to explain the changing between an object or incident affecting the changes of other objects or incidents. The students' characteristics and specific domain of knowledge would affect the construction of mental model (Mayer, 1996). The researchers suggested that when the mental model was stimulated while knowledge was constructing, the students would be able to associate the relationship between knowledge units of different topics in the brain as called complex schema (Dreyfus and Dreyfus, 1986). As a result, the students were able to solve complex problems efficiently. According to Mayer's (1996) study, it was suggested that the mental model is constructed by students. It means that the students understand and learn in the things by themselves. In summary, if the students were able to construct mental model, it would show complete understanding which is major outcome of knowledge management. However, the students' mental model development sometimes would not be able to occur immediately, especially, in the content need complex skills or phenomena to solve. Such that it is difficult to occur or adjust mental model. In this vein, teachers may provide learning environment by stimulating the construction and improvement of mental model as well as support the students in developing good mental model.

Based on above concerns, the social media environment was special designed for enhancing expertise mental model. That is the integration of social network and learning method was proposed by extending previous study (Kanjug, 2008) and focusing on developing mental model with following conceptual idea: (1) stimulating the mental model; (2) supporting the creation of mental models; (3) promoting division of expertise mental model; (4) promoting and supporting the creation of mental model. Because the learning and teaching programming focusing on remembering algorithm code was caused students with menthol model. Such that the students might not be expertise in applying the knowledge to design and develop programs. It would be better if the students are encouraged the mental model by using the social media in the topic.

2. Methods

2.1 Research design

To examine the leaner's mental model leaning with social media learning environments enhancing mental model (SLME), there were 40 high school students participating in this study. This study was pre-experimental design as one shot case study. Therefore, after experiencing in the SLME, the students were interviewed to respond their mental model.

2.2 The Construction and Development of Social Media Learning Environments (SLME) Enhancing Mental Model

The SMLE was designed and developed as following details (Figure 1): (1) examine and analyzed principles, theories and research related to social media and mental model of computer programming topic; (2) synthesize theoretical framework of learning environments enhancing expert mental model consisting of 5 foundations such as psychological base, pedagogies base, technologies base, and contextual base; and (3) create designing framework of learning environments enhancing expert mental model.

Figure 1. The designing of social media learning environments to enhance learners' expertise mental model in computer programming subject for high school students

3. Research results

According to the interview questions, we found that the students were able to construct expert mental model by understanding the computer programming topic as follows:

- It was representative of understanding different topics or incidents explaining as model which could be seen from the statement of interview as *"because when we try to understand, we construct the map and hide it such as C language structure and condition"*
- For understanding, there were explanation of changes from the things one understood to other things by being able to change rules and processes to problem solving one facing immediately such as that *"it was not a long time, after reading a little bit, it was known that what kind of knowledge would be used such as the situation in the analyzed condition that the specified algorithm, which algorithm would be applied for write program."*
- The ability to explain with reasons showing expression which was not only rationale and theories. But, there was an association between facts and studied rules with different facing situations.

According to the findings, we found that the students constructed expert mental model. It might be due to the design of learning environments with having factors for enhancing the development of expert mental model. Specifically, the problem situations with multi task levels enhancing development of expert mental model and the scenario model from real incidents were provided. The students had to make their decision and manage with specified situations and contexts. For that situation, the related information technology had to be presented as well as considered together with the context so that it could be basic information for making decision by students. Moreover, the conditions of techniques or strategies under limited time to be chosen by the students had to be specified as expert type based on Dreyfus and Dreyfus's (1986) expert development approach as well as Resources of designed knowledge by transforming the knowledge content into conceptual models explaining those contents as the cause-effect model by the Figure or graphic. As a result, the students could be able to more easily and efficiently construct their mental model (Mayer, 2003). In addition, it was a decrease of cognitive load in integrating the students' information technology of working memory while they were working. In this situation, the expert type would be developed. Consequently, cognitive resource could be quickly retrieved as an automatic. It could be seen from interviewing information that *"The resources constructed as concept map would develop easy understanding and retrieving that model immediately."* Moreover, the similar case which was the presentation of experience in daily life which could be suddenly associated by the students in their daily life. Therefore, expert mental model was supported because the proposed environment constructed the students' understanding as meaningful structure for themselves in pattern of facing situations. When the students were faced with problems, the incidents immediately retrieved or adjusted for use. It was supported by Jonassen's (2000) who suggested that the understanding of each problem was like a stimulation of experience relating that problem and constructing mental model of problem. In case of the students had a little experience, the expert would not have characteristics as Cho, Lee and Jonassen's (2011) statement. If there was a design allowing students in constructing various kinds of experience. The similar case would be important tool as the interviewing statement that: *In case of similar case, it would help to think for solving problems quickly because when we entered it, we could adjust to apply with the problem situation immediately since there was a guideline we could apply it suddenly."* There was a Center of expert development with cognitive training with experts or Apprenticeship. In case of the students training to be as expert based on Dreyfus and Dreyfus's (1986) approach, learning and perception were quickly developed. When facing situations, one could be able to make decision and express very efficiently and automatically (occurring by nature). The center would present the problem solving model, decision making model, and strategies used by the experts in designing instructional design. The researcher transcribed the mental model of designing through the performance of experts as national instructors in various learning substance groups which the students understood and could retrieve immediately while they were facing different incidents. For the proposed environmental design, it would be different from general teaching which focused on transferring the content. Thus, the students would memorize only the presented information technology which was not their understanding constructed by themselves. As a result, they could not be able to apply in their daily life. Besides, the above research studies, it was found, in this study, that the students could be able to organize the constructed mental model group as well as the statement that *"Yes, it was like channel dividing each topic and there was map in it."* According to all of above findings, the efficiency of learning environments enhancing expert mental model could be confirmed that it could very well improve mental model development.

4. Conclusions

The results revealed that the learner can construct expert mental model. It is mental representation of knowledge which the learner constructed. Three aspects of expert mental model were found as following aspects: (1) the mental model which the learner constructed was representation of objects, situation or even in whatever the model describes; (2) the mental model illustrated how changes in one object effect changes in another that is the learner can transform from rules and procedure into problem solving action immediately; and (3) the learner can explain the casual relation of the situation not only exploitation of theory and principle but also connecting between fact and rule with encountering situations. In summary, the proposed learning environment could promote mental model experts. There are elements that help promote mental model experts. Since the design of the problems with many of the characteristics of experts to learn the 5 levels novice, advanced beginner, competence, proficiency, and expert and a training center for professional help develop the intellectual and professional. Suggested strategies could use to make decisions. Mental models proposed in the design of teaching professionals. Such that the students could learn how to think about the design and function that occur while instructional design experts. Moreover, training to increase the level of experts from Novice to expertise allowed the students to experience access problems. That can be taken as a reference. The experiences related to them. And design information in Knowledge Bank are extremely effective in helping learners build mental models easily. However, the study is only preliminary findings, which will be used to build and develop the learners to complete and bring to trial the students in the real world.

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The Development of Rich Chemistry Multimedia Learning Environment Model to Foster Scientific Thinking: Validation Phase

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Abstract: The purpose of this research was to examine the internal and the external validation of the rich chemistry multimedia learning environments model to foster scientific thinking. The target group for the internal validation consisted of 9 expert reviewers, 1 teacher teaching chemistry in grade 10 and 30 students in grade 10 from Piboonrukpittaya school. The developmental research phase II: model validation was employed in this study. The results were revealed as follows; firstly, for the internal validation, it was found that the model design was consistent with underlined theories based on Instruction Design theories (ID Theories). Secondly, for the external validation, it exposed that the students learning with model have high levels of scientific thinking and achievements. The average scores of scientific thinking test and achievements test were 73.92 % over the 70 percent threshold and 75.67% over the 70 percent threshold respectively. The students' opinions toward the rich chemistry multimedia learning environments model to foster scientific thinking were appropriate in all aspects and could enhance students' scientific thinking.

Keywords: Instructional design, multimedia learning environment, scientific thinking, constructivist learning environment, chemistry education

1. Introduction

The rapid developments of information technology and telecommunications in Thailand and around the world have struggle the changes. The flows of culture across the world and the social network have been happening by utilizing both economic and learning. Thai society is the outcome of a knowledge-based society. The amount of information has increased tremendously. Knowledge is constantly changing. The human needs to learn continuously throughout life. The students themselves must have the skills to seek knowledge and knowledge construction at all times which is consistent with the National Education to be given the learning process for learners to practice thinking and encounter situations. In particular, science education focused on human development followed by the development of scientific thinking. Student can think to inquire, make critical thinking, and make a decision by using a variety of information and evidences to review (Office of Education Council, 2005). Therefore, to encourage the students to construct the knowledge that inquires knowledge, students then use scientific thinking processes. The Cognitive process in solving problems is to think logically for the problems in situations in which the scientific inquiry is as to include scientific analysis and a summary of the justifications. This leads to an understanding and concepts of the science learners (Kuhn, Amsel and O'Loughlin, 1988; Indrani, 1995; Boo and Toh, 1998; Dunbar, 1999; Li & Klahr, 2006; Kuhn, 2004 & Zimmerman, 2007). However, the development of scientific thinking to students in schools is learning, most students focus on content rather than on recognition of the students thinking. In addition, students lack of problems solving ability in everyday life and not able to develop the inquiry idea for knowledge and critical thinking (Kaewdee, 2005).

Learning how to handle students to construct knowledge and promote thinking in people which mentioned above is concerning the philosophy of constructivist learning. The students must act with enthusiasm and construct their knowledge by themselves. Based on the theories of philosopher; Dewey (1891), Piaget (1985), Vygotsky (1962), and Glasersfeld (1995); students understand and learn by themselves. And they create knowledge through interaction within the provided environments. Learning how to learn is about the way how we come to know. It is consistent with the epistemology about how humans learn, and believe that knowledge can be changed. Students must construct the knowledge and understanding actively and focus on the development of meaningful learning and understanding (Kowtrakul, 2005). Jean Piaget stated that students construct knowledge by having cognitive equilibrium in their cognitive structure. If they are activated by a problem and confront cognitive conflict evoking or disequilibrium, students then try to restructure the cognitive structure to equilibrium via modification of intellectual structure. And Vygotsky believed that students learn from social and cultural context by emphasizing in cognitive development that occured when students interact with environment in society. Regards Zone of Proximal Development, it is the potential of cognitive development that may lead to restrictions on the development. If students are lower than the Zone of Proximal Development. They need assistance which is called Scaffolding, also the support from the teacher (Chaijareon, 2005).

To support the above mentioned towards the cognitive process, the characteristics of the media are needed. The media attribution and symbol system influence the cognitive process; especially multimedia that can represent text, visual, animation and audio as hypertext, hyperlink and hypermedia to support knowledge construction, meaningful learning, and thinking ability as well as to promote an inquiry for knowledge efficiently. In addition, learning with multimedia on network also provide opportunities for students to learn by interaction, share cognition, correct misconception, enhance scientific thinking and communication with the cognitive tools that include a variety of symbol systems (Kozma, 1991; Jonassen,2004; Khun,2004; Chaijaroen,2006; Gumlunlert, 2011). This can be supported by the study of media attribution and symbol system that can help enhancing cognitive process such as cognitive skills, sharing cognition, knowledge constructing and thinking ability as cognitive tools (Kozma, 1991; Fraser, 1998; Chaijaroen, 2006.)

The reasons mentioned above, this study recognize the importance of science learning environment design. The researcher applied the scientific thinking, constructivist theory and the multimedia attribution and symbols system used, synthesizing them as the framework for designing the rich chemistry multimedia learning environments model to foster scientific thinking. The finding may help to promote the scientific thinking and knowledge construction to the students.

2. Method

The target groups used in the internal validation and external validation are as follows: the target group for the internal validation consisted of 9 experts, 3 content experts, 3 the model design experts, 3 media experts in order to evaluate the rich chemistry multimedia learning environments model to foster scientific thinking. Moreover, the target group for external validation consisted of 30 students who studying chemistry during the first semester of 2011 academic year.

The instruments for collecting data of internal validation of the rich chemistry multimedia learning environments model to foster scientific thinking consisted of 3 evaluation forms as follows: the evaluation form for content, the evaluation form for instructional design, and the evaluation form for media design. Moreover, the instruments for collecting data of external validation of the rich chemistry multimedia learning environments model to foster scientific thinking were: (1) the interview form used for examining of scientific thinking using open-ended questions based on 4 aspects of scientific thinking: Inquiry, Analysis, Inference, and Argument. (Kuhn, 2004); (2) the scientific thinking test; (3) the achievement tests for the students on the topic of chemical reaction; and (4) the opinionnaire of students towards the rich chemistry multimedia learning environments model to foster scientific thinking (Khan, 1997; Hanafin, 1999; Chaijaroen et al., 2007).

To collect and analysis data, the internal validation was the examination of the design and development of model in order to confirm the quality of the models by experts in various fields as following: (1) the content experts; (2) the media experts; and (3) the model design experts. The data were collected and analyzed by using interpretation, analytic descriptive and summarization. Moreover, the external validation of the model was to study the impact of utilization of the model in 4 aspects as following: (1) The students' scientific thinking were collected by in-depth interview based on Kuhn (2004): inquiry, analysis, inference, and argument; (2) The students' learning achievements were collected by the achievement tests for the students on the topic of chemical reaction; (3) The relationship between the students' scientific thinking and the students' achievements were collected by the scientific thinking test and the achievement tests for the students on the topic of chemical reaction and was analyzed by using Pearson product moment correlation coefficient (r) (Howell, 2007); and (4) The students' opinions toward the rich chemistry multimedia learning environments model to foster scientific thinking were collected by opinionnaire and analyzed by using the interpretation, analytic descriptive and summarization.

3. The Research Results

3.1 The results of this study can be summarized as follows:

The result of the internal validation examination of the model showed that the designing of the rich chemistry multimedia learning environments model to foster scientific thinking which was appropriate and congruent with the underlined theories and principles. Learning theories used in this research are Cognitive constructivism based on Piaget (1975), Social constructivist based on Vygotsky (1962), scientific thinking based on Kuhn (2004). Based on above mentioned theories the designing framework of the rich chemistry multimedia learning environments model to foster scientific thinking was synthesized. The designing framework consisted of 4 crucial bases: 1) activating cognitive structure 2) supporting cognitive equilibrium 3) fostering and developing scientific thinking 4) supporting knowledge construction and scientific thinking (Saman and Chaijaroen, 2012). The results showed that, for activating cognitive structure, it illustrated the relationship between the underlined theories and the component as follows: cognitive constructivism, CLEs model (Jonassen, 2004; Lambros, 2004). The design of the component of which was called Problem base focused on authentic chemical problems in daily life, real world problems, and contextualizing problems. This may help activating cognitive structure of the students. The relationship between the underlined theories and the components of the model was shown in Figure 1.

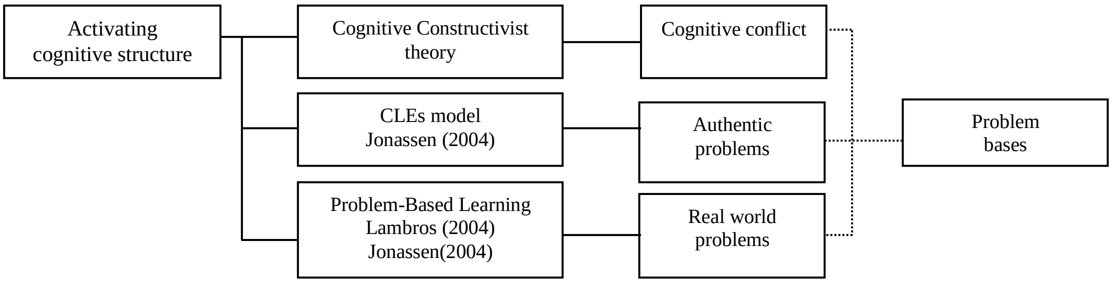

Figure 1. The relationship between the underlined theories and the activating cognitive structure

For supporting for cognitive equilibrium, it was illustrated the relationship between the underlined theories and the component as follows: cognitive theories, multimedia learning principles of Mayer (2005), SOI model (Mayer, 1996). Designing of the component of which was called (1) Learning resources. It focused on how the students process the information effectively. This can help the students understand easily; (2) the other component is Collaboration. The underlined theories used was the collaborative learning of Honebein (1996) Brewer (2006) and Palloff and Pratt (2005). It focused on the collaborative problem solving, sharing cognition and multiple perspectives and preventing misconception of the students. The relationship between the underlined theories and component was shown in Figure 2.

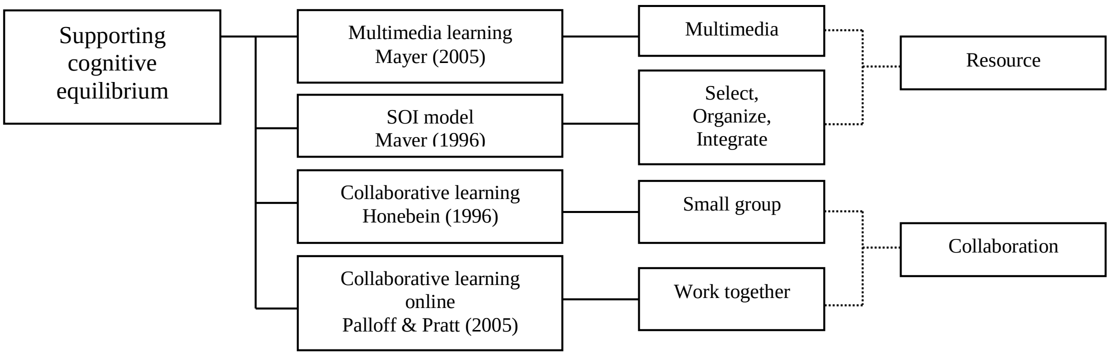

Figure 2. The relationship between the underlined theories and the components of the model

For fostering and developing scientific thinking, it illustrated the relationship between the underlined theories and the components as follows: the scientific thinking of Kuhn (2004) which consisted of (1) inquiry; (2) analysis; (3) inference; (4) argument. The design of the component was called (1) scientific thinking lab. It focused on fostering and developing scientific thinking. This could help the students to foster the ability to think scientifically. The relationship between the underlined theories and components of the model were shown in Figure 3.

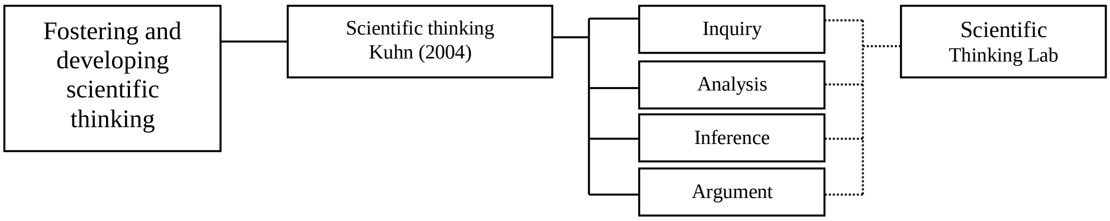

Figure 3. The relationship between the underlined theories and developing scientific thinking

For supporting knowledge construction and scientific thinking, it illustrated the relationship between the underlined theories and the components, as follows: social constructivist theory (Vygotsky,1962), CLEs model (Jonassen, 2004). They focused on the Zone of proximal development to support students in resolving conflicts and reaching a balance, or equilibrium. From these theories were designed scaffolding, coaching and related cases. Social constructivist (Vygotsky, 1962), Scientific language (Madsen, 1970) and scientific thinking (Kuhn, 2004). They focused on scientific language, which is different from the language of daily life; students should be surrounded by scientific language. From these theories a scientific language room was designed. Social constructivism (Vygotsky, 1962), Scientific community (Wandersman, 2003) and Scientific thinking (Kuhn, 2004). They focused on providing opportunities for students to learn science in the science classroom by talking, writing, and sharing. From these theories were designed a scientific community, a science museum (Fujitani, Mitsuishi & Makihara, 2002) that focuses on providing ideas of scientists and scientific discoveries to evoke thinking. From this theory was designed a science museum, the design of the components of which are (1) related cases; (2) scaffoldings, including metacognitive scaffolding, strategic scaffolding, conceptual scaffolding and procedural scaffolding; (3) coaching; (4) a scientific language room; (5) a scientific community; and (6) a science museum. The relationship between the underlined theories and components is shown in Figure 4.

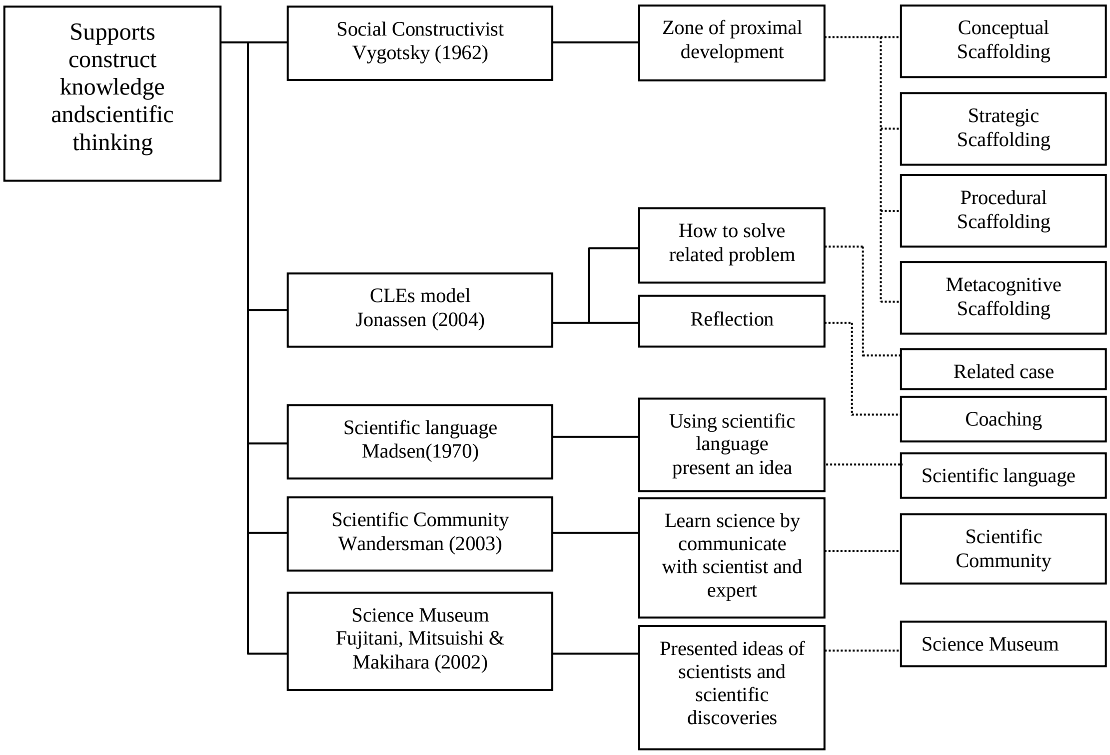

Figure 4. The relationship between the underlined theories supporting of knowledge construction and scientific thinking

In addition, the results of the external validation of the rich chemistry multimedia learning environments model to foster scientific thinking showed that, for the students' scientific thinking, the scientific thinking on inquiry, analysis, inference, and argument, helped to foster students for learning chemical reaction at high level.

The average scores of scientific thinking test was 73.92 %. It was higher than the specified criterion as 70%. Moreover, it was found that the students' scientific thinking has four aspects: inquiry, analysis, inference, and argument. For the achievement of the students, it was found that the average scores are 75.67 %. It was higher than the specified criterion as 70%. The opinions of the students toward the rich chemistry multimedia learning environments model to foster scientific thinking, show that: it was appropriate in all aspects as following details: 1) Content was up to date, clear, accurate and beneficial for them to inquiry; 2) The web-based design: the consistency of the navigation structure design helped the learners to access information easily and not make confusing; the students can access the network environment as a similar structure; and 3) The model design: the design problem was to encourage students to learn. The elements that encourage students to find answers or knowledge used to solve the problem.

4. Conclusion and Discussion

The results of the internal and the external validation were revealed as follows. For the internal validation, the model had been examined by 9 experts and it was found that the model design was consistent with underlined theories based on Instructional Design theories (ID theories). For the external validation, it was found that students learning with model had high level score in students' scientific thinking. The average scores was 73.92 %. It was higher than the specified criterion as 70%. and the standard deviation was 2.03. For the students' opinions to the rich chemistry multimedia learning environments model to foster scientific thinking, found that appropriated in all aspects and the model could foster learners' scientific thinking. These findings were consistent with the study of Chaijaroen, et al. (2008); Chaijaroen, Kanjug and Samat (2012); Saman, et al. (2011); Puangtong, and Chaijaroen (2014). In addition, it is also consistent with Monica W. Tracy (2009) studied on the design and development for the multiple intelligences. The above mentioned findings of the internal validation and the external validation of the model may cause from the Instructional design using ID theory. Theories used here were Scientific thinking based on Kuhn (2004), learning theories: Cognitive constructivist based on Piaget (1975) and Social constructivist based on Vygotsky (1962), cognitive theories, media theory and media symbol system. Those theories could enhance the student's scientific thinking. Based on the theories used as foundation in the design of the model, this led to enhancing the student's scientific thinking. In addition, the specialized designer might result in the internal validation of the model. Since she specialized in chemistry for more than 10 years and she had the educational background. Moreover she is studying in Doctor of Philosophy Program in Educational Technology focusing on Instruction design especially ID Theory. Consequently, this may help in designing the components of the model congruent with those underlined principles and theories. This might result in the internal validation of the model. It could be supported by the above mentioned experts' examination and evaluation of the rich chemistry multimedia learning environments model to foster scientific thinking. This might affect the impact of the utilization of the model to enhance the student's scientific thinking both in test scores and scientific thinking scores.

The various finding of this study could suggest that the model could be illustrated both the internal and external validation. This might result in the constructivist learning environments model enhancing scientific thinking that illustrated by the learners' scientific test scores and achievement test scores.

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Effect of Gender Difference on Students' Perceptions toward Instruction Technology in Problem-Based Gamming Environment

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Abstract: Educational game combines gameplay characteristics with learning content, not just for fun. It can be used to support learning that refers to the use of digital technology to promote learning performance and experience through game-based activity. Currently, several researchers mentioned that digital game-based learning could promote students' interest and enhance students' motivations and learning outcomes by appropriately visualizing abstract ideas. This study aims to investigate the correlation between gender difference and student's perception toward instruction technology in problem-based gamming. The participants in this study involved with the tenth-grade students totally 106 students. The results showed that males and females had the same perceived ease of use, perceived enjoyment, and perceived satisfaction toward instruction technology in problem-based gamming. In contrast, males and females had difference among perceived learning, perceived flow, and perceived playfulness toward instruction technology in problem-based gamming. Overall, the results revealed that females had better perceptions toward instruction technology in problem-based gamming than males had.

Keywords: Perceptions, Educational digital game, Gender, individual difference

1. Introduction

Currently, science and technology has been continued development and that has a role and influence daily life. Technology has been used widely in learning environment, especially in science education (Nieto and Carbonell, 2012). Technology can also enable new ways of education to deliver knowledge directly from teachers to students and the learning can take place anywhere and anytime. Recently, there are many technologies to supported inquiry-based science learning environments such as WISE, Co-Lab, Island and Inquiry (Sun et al., 2013). The instructions that teachers implement have been changed by conducting the new learning paradigm and innovative educational tools.

In a present, technologies have been used to support learning science. With the benefit of computers and technology in science education community, the contemporary technology-based approach has been used to enhance students' conceptual understanding (Srisawasdi and Kroothkeaw, 2014). Rieber (1996) describes video games-as-microworlds having intrinsically motivating features to offer high potential for learners to engage and persist in the embodied learning activities. Video games are encouraging students to act as self-regulated learners participating in a learning activity and they are thereby better able to monitor and evaluate their own learning. This is in contrast to other types of e-learning, such as web-based instructions or simulations, which offer a direct link to the subject matter or content and therefore encounter the challenge of engaging unmotivated students (Cheng et al., 2014)

Digital games or computer games are programs or software that was created for entertainment purpose (Rollings and Adams, 2003). Recently, digital games have been becoming popular and integral part of our society, especially children or younger generation who like to play game as a favorite activity. To apply the game to educational system, teachers and educators have attempted to find the new ways of teaching by adding educational purpose into the games which is called educational games or serious games, this approach namely game-based learning (Tang, Hanneghan and Rhalibi, 2009). Educational games combine gameplay characteristics with learning content is not just for fun, it can be used to support learning by appropriately visualizing abstract ideas and key principles of given topics in game environment to support active and authentic learning, and provide concrete and direct experience to evoke students' motivations and facilitate their understanding (Cheng et al., 2014). In addition, educational games have a positive impact on learning outcomes (Echeverría et al., 2011; Giannakos, 2013). Learning by using the educational digital game-based learning, learners can learn lessons of subject matter by playing the game, might learn higher level thinking skills and improve their problem-solving ability by immersing themselves in the games. With educational games, students' experience in the embedded learning activities is a series of problem-solving processes. Students constantly have to use newly acquired knowledge and skills to overcome subsequent challenges. Several researchers revealed that it might be much easier for students to apply knowledge gained from the games to solve real-life problems (Cheng et al., 2014). Huang (2012) indicated that learners have more confident in learning after playing with educational game. In an addition, using game in education increased students' perceived learning, enjoyment and flow of learning experience (Barzilai and Blau, 2014). Similary, Cheng et al. (2014) indicated that students who learned through playing educational game generally had a positive learning experience and increased their perceived useful, easy, appealing, playful, and satisfying.

Human immunology, which is one topic in biology course, is difficult to learning due to its complexity and much information. The immune system is crucial to living organisms, yet it is inherently complicated and extremely difficult to understand, as immune processes involve cellular and molecular interactions among a variety of cell types and antigens (Kelly et al, 2007). The regulation of human immunological defense is a physiological process that intertwines both humoral and cellular interactions among a variety of cell types and antigens. The students often feel confused and have difficulties in learning this subject (Kelly et al., 2007). Moreover, the processes, microscopic and connections among different lines of human immunological defense are much more abstract than any of the other biology topics, and students usually do not have sufficient prior knowledge when they first encounter the topic (Cheng and Chen, 2009). However, in biology class, there is few studies investigated influence of educational game on students' perceptions.

Consequently, the researchers created an educational problem-based gamming on biology concept of human immunology and this pilot study was to investigate correlation between gender differences and students' perceptions toward instruction technology in problem-based gamming.

2. Literature Review

2.1 Educational Digital Game

The new media and digital technology industries and digital gaming immerse several environments. Digital game include of dazzling and sophisticated image and sound, be parallel textual communication. Player get engagement which is both pleasurable and challenging. The educational digital game keep players immersed in digital worlds, knowledge and information become increasingly accessible outside confines of formal education (Castell, Jenson and Taylor, 2007). Moreover, in the educational games, students' experience embedded learning activities is a series of problem-solving processes. The students constantly have to use newly acquired knowledge and skills to overcome subsequent challenges. It was found that it might be much easier for students to apply knowledge gained from the games to solve real-life problems, as games often offer a virtual environment with realistic situations wherein students can practice over and over without cost or penalty (Cheng et al., 2014). Currently, educators employed digital game by adding content of subject matter or information for education purpose. Several research presented empirical evidence that the education digital games have positive effect on student learning. It could improve not only learning achievement but also learning attitude and motivation to learn (Sung and Hwang, 2013).

In the past, game produce only for entertainment but recently educational researchers have attempted to adapt games for learning called educational games or serious game (Cheng et al., 2014). The games that compose of challenge, control, curiosity and fantasy can motivate persistence and enjoyment (Toro-Troconis and Partridge, 2010). The educators have developed games for three goals including: (i) students can learn from playing the game; (ii) the component of game can support learning; and (iii) students have motivation to learn when they learning by playing the game (McNamara, Jackson, and Graesser, 2010). Game-based learning is a kind of constructivist-based active learning. Based on the learning research, Watson, Mong and Harris (2011) found that using game in classroom made a shift of teaching from teacher-centered learning environment to student-centered learning environment.

2.2 Gender difference and Educational Digital Game

In the past decade, several researchers studied the interaction between educational computer game and gender differences. For example, Agosto (2004) found that both females and males at the preschool age showed the same enthusiasm in computer games. Papastergiou (2009) found that there were no gender differences in terms of science achievement of high school students when using computer game. They also showed better performance than those who did not use computer game. In contrast, Gee (2007) and Unlusoy et al. (2010) revealed that males show more interest in digital games than females. Therefore, among various human factors, gender difference plays an important role when playing digital game affecting learning performance (Paraskeva et al., 2010).

2.3 Students' Perceptions

2.3.1 Perceived Learning

Perceived learning relates to a retrospective evaluation of the learning experience and can be defined as a set of beliefs and feelings one has regarding the learning that has occurred (Caspi and Blau, 2011). The perceived learning is about the new information was obtained and person can get the new understanding, subjective evaluation of learning by learners themselves. Researchers mentioned that perceived learning is connected to emotion as flow, enjoyable , and satisfaction (Chu and Hwang, 2010). Regarding in context of educational computer game, when learners are immersed in game-based learning environment, they can judge themselves in the learning process and quality of how to get the knowledge from game, so game can help learned and practiced (Giannakos, 2013).

2.3.2 Perceived ease of use

Perceived ease of use, refers to the degree to which a person believes that using a particular system would be free of effort. The definition of ease that freedom from difficulty or great effort. All else being equal, we claim, an application perceived to be easier to use than another is more likely to be accepted by users (Davis, 1989).

2.3.3 Flow

Flow is a state of deep concentration in which thoughts, intentions, feelings, and all of the senses are focused on the same goal. The experience of flow would happen when person who take part in challenge situations or activities that need skills. Flow depends on a chance to concentrate, an immediate feedback, a sense of control, and a clarify goal (Barzilai and Blau, 2014). As such, if learners concentrate with the learning experience of educational computer game, the flow of learning would occur during playing the game (Meesuk and Srisawasdi, 2014).

2.3.4 Perceived Playfulness

Characterizing playfulness is difficult, because laymen and researchers use the term ‘‘play’’ in several ways. The trait of playfulness may be treated as a motivational characteristic. Individuals who ranked high in playfulness demonstrate better performance and higher affective response to computer training tasks. But playfulness may instead be defined as a situational characteristic of the interaction between an individual and a situation. (Lin et al., 2005)

2.3.5 Enjoyment

Enjoyment is the condition of having and using technology, e.g. educational computer game that is good or pleasant. The enjoyment of player is a key goal, related with an easy to use of game and enjoyment was found to have valuable in explaining objective to use applications (Giannakos, 2013). When learners which act as players of game fail to pass the game task, they would get disappointment and attempt to replay again. As such, the enjoyment can help reduce worry to learn and feel more confident when learners success. Accordingly, if the educational computer game can enjoy learners, then they would like to learn more and think positive to the subject (Meesuk and Srisawasdi, 2014)

2.3.6 Satisfaction

Satisfaction is the individual awareness of how well a learning environment supports academic success (Lo, 2010). It is relevant to instructional method that learners can think and learn, so their satisfaction can help to get how academic success. At the moment to learn with educational computer game, if it gets positive response from learners that means they reach to positive learning experience with also. In an addition, satisfaction can yield positive of learning performance and can improve learning outcome (Giannakos, 2013).

3. Method

3.1 Participants

This research was conducted to explore the effect of gender on perceptions toward instruction technology in problem-based gamming by using a survey research. The 106 students (37 males and 69 females) who are studying in ten grade, age ranging from 14 to 16 years old and study was carried out in the second semester of year 2015 in a local public school at the northeastern region of Thailand were recruited in this study.

3.2 Learning Materials

In this study, the design of the game, called “Immunology Game”, was related to content of adhesive humane immunology. That designed to comprise three missions of playing, each of mission provides problem situation to students. The Immunology Game is the first mission was created in style of shooting game. The goal of this educational game is to facilitate student getting the definition external defense mechanism as shown in Figure 1-3.

When the student starts the game she or he encounter with problem situation in the first mission. The problem is the girl children playing computer together with eating cookies as a result antigens or pathogens through to the body as shown in Figure 1.

Student is receive scaffolding for decision by he or she can see basic information of each pathogens that include name, picture, toxin and weakness before into game play. Then he or she into game play, in this part in which they have to fight pathogens that enter the body by choosing to use ammunition to destroy pathogens as shown in Figure 2.

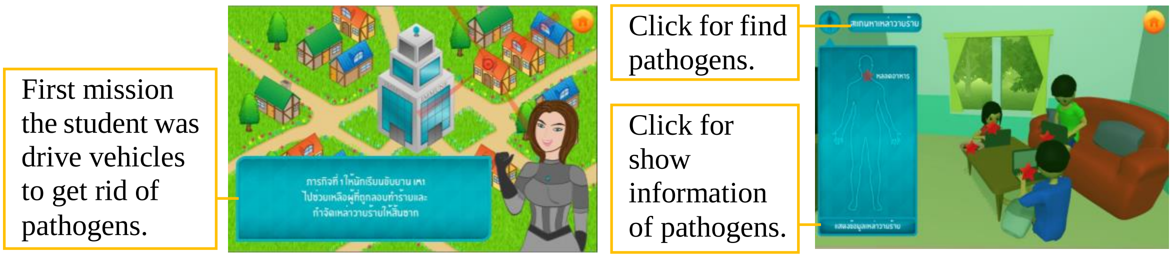

Figure 1. Shows home screen of first mission in the game (left) and first problem situation in first mission (right).

Student is receive scaffolding for decision by he or she can see basic information of each pathogens that include name, picture, toxin and weakness befor into game play. Then he or she into game play, in this part in which they have to fight pathogens that enter the body by choosing to use ammunition to destroy pathogens as shown in Figure 2.

Figure 2. Basic information each type of pathogens (left) and home screen of game play (right).

Finally, If student perform mission incomplete as a result, he or she is diseased or illness. On the other hand, student perform mission complete as a result, he or she is happy life as shown in Figure 3.

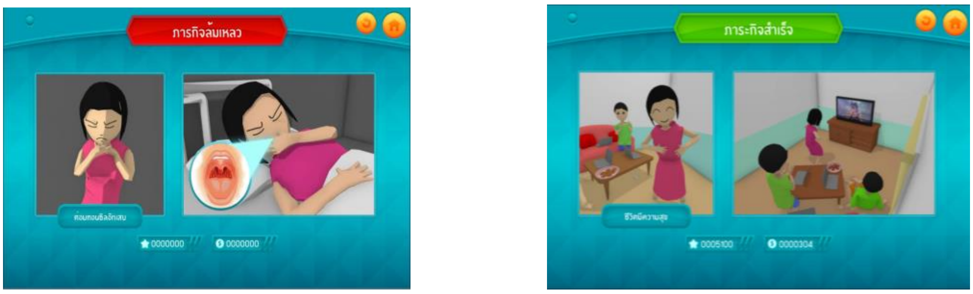

Figure 3. Student perform mission incomplete (left) and perform mission complete (right).

3.3 Research Instrument

3.3.1 Student's Perception

To study students' perception of the educational computer game, we adapted the questionnaire with 6 subscales consisting of perceived learning (PL) (three items), perceived ease of use (PEU) (two items), Flow (F) (three items), perceived playfulness (PP) (three items), perceived enjoyment (PE) (two items) and perceived satisfaction (PS) (five items) (Cheng, 2014; Barzilai and Blau, 2014), developed in Thai by Pinatuwong and Srisawasdi (2014). All of these 5-point Likert scale (1-strongly disagree; 2-disagree; 3-neutral; 4-agree; 5-strongly agree). For overall items have a very good reliability, see Table 1

3.4 Data Collection and Analysis

The intervention class consists of 106 students. The participants were exposed to play The Immunity Game for 20 minutes. After finishing the game, the students' perceptions were examined by the same questionnaire for 10 minutes. To examine correlation between genders and post perceptions on each subscale, MANOVA in SPSS was used.

Table 1: Scale and sample items of the perception questionnaire

Dimension	Items
perceived learning (PL)	The games increase my learning efficiency. The game will help me understand the things I learned.
Perceived ease of use (PEU)	The games are easy to use. Using the games to complete course related tasks are easy.
Perceived flow (PF)	I was very involved in the game. When I played I did not think of anything else.
Perceived playfulness (PP)	It is interesting to use games. I was totally immersed in the game.
Perceived enjoyment (PE)	I had fun playing the game for learning science. I feel relaxed to use games for learning science.
Perceived satisfaction (PS)	I like to learn new skills by using games. I would like to know if the innovative approach can be applied to other courses to improve my learning performance.

4. Results and Discussion

4.1 Investigating the Gender Gap on Students' Perceptions

In order to investigate the influence of gender on students' perceptions toward problem-based gaming (PBG), MANOVA test was used in this study as shown in Table 2.

Table 2: MANOVA results for correlation between genders difference and students' perception

Dimension	Gender	N	Mean	S.D.	F	Sig.	η^2
Perceived learning (PL)	Males	37	9.595	2.409	8.069	.005*	0.072
	Females	69	10.957	2.323			
Perceived ease of use (PEU)	Males	37	6.649	1.876	1.461	.230	0.014
	Females	69	7.043	1.419			
Perceived flow (PF)	Males	37	9.243	2.241	18.214	.000*	0.149
	Females	69	11.043	1.974			
Perceived playfulness (PP)	Males	37	10.378	2.564	5.857	.017*	0.053
	Females	69	11.551	2.272			
Perceived enjoyment (PE)	Males	37	6.784	1.858	2.178	.143	0.021
	Females	69	7.377	2.030			
Perceived satisfaction (PS)	Males	37	18.027	4.160	3.888	.051	0.036
	Females	69	19.623	3.870			

* $p < .05$

Considering Table 2, the results of participant (37 males, 69 Females) for MANOVA from genders' effect for perception toward instruction technology in problem-based gamming, six subscales score consists of PE, PEU, PF, PPF, PE and PS were used. The results showed that there were three dimension of students' perception non correlation significant ($p > .05$) between genders consist PEU, PE and PS. The statistic MANOVA indicated that effect of gender on students' perception for PEU ($F = 1.461$, partial $\eta^2 = 0.072$), PF ($F = 18.214$, partial $\eta^2 = 0.014$) and PS ($F = 3.888$, partial $\eta^2 = 0.036$). The results suggested that both males and females were the same Perceived ease of use, Perceived enjoyment and Perceived satisfaction toward instruction technology in problem-based gamming. In contrast, there were three dimension of students' perception correlation significant ($p < .05$) consist PL, PF and PP. The statistic MANOVA indicated that effect of gender for students' perception on PL ($F = 8.069$, partial $\eta^2 = 0.072$), PF ($F = 2.178$, partial $\eta^2 = 0.149$) and PP ($F = 5.857$, partial $\eta^2 = 0.036$). In addition to comparison graph between mean value and dimensions can simplified for understanding as shown in Figure 4.

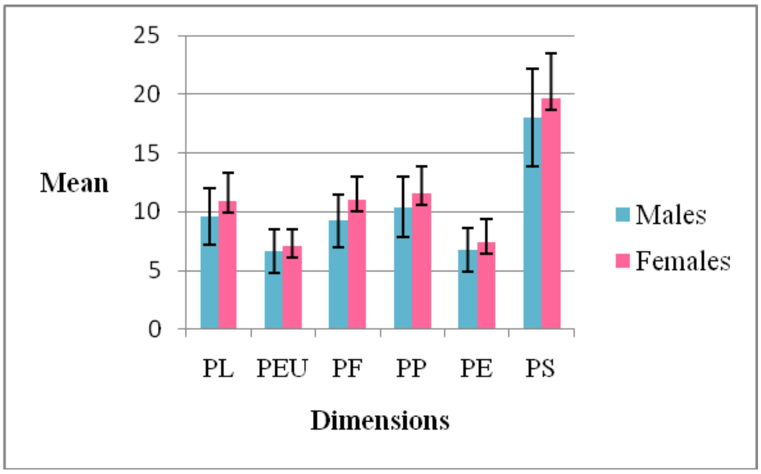

Figure 4. Compare genders difference of mean students' perception of each dimension.

The results suggested that males and females ware different in Perceived learning, Perceived flow, and Perceived playfulness toward instruction technology in problem-based gamming. Students' perception of each dimensions total 6 dimensions showed that female had better means perception than male perception as shown in Table 2.

5. Discussion and Conclusion

This study reported the impacts of students' perception toward instruction technology in problem-based gamming with gender difference. It was found that gender affect to student's perceptions including PL, PF and PP. While, genders non affects to student's perceptions including PEU, PE and PS. Although Gee (2007) and Unlusoy, et al. (2010) revealed that males are more likely to use digital game on learning than females. The main findings of this study showed that females had better perception than males with in the developed instruction technology in problem-based gamming.

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Using Social Media-based Cooperative Learning to Enhance Pre-Service Teachers' Computer Multimedia Instruction Performance

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Abstract: This research is to study the cooperative learning on Facebook that is a popular social community in Thailand. Several studies have found that participants are willing to share personal information and to learn how to do things on Facebook. There is integrated to learning approach so that to enhance students' learning in the development of computer multimedia instruction course that is special topic for pre-service teachers. The 31 students in experimental group learned on social network site as a cooperative learning, while the 28 students in the control group learned with traditional face-to-face classroom. The results of this research illustrated that the learning achievements of students in the experimental group were significantly better than students in the control group. In addition, these findings indicate that the students in experimental group not only have positive attitude, but also have high level of satisfactory.

Keywords: Facebook, computer multimedia instruction, cooperative learning, pre-service teachers

1. Introduction

Today, Facebook has become a popular social network in the world and continues to increase (Hayes, van Stolk-Cooke and Muench, 2015). Especially, in education area, many educators have attempted to implement Facebook in the educational context. They have found that it is not only possible to easily send, receive and share information, but also to facilitate communication, interaction and cooperation with different people, companies and organizations in different parts of the world using various modalities such as writing, pictures, video or link sharing, voice or video chat (Bowman and Akcaoglu, 2014; Korfiatis, Zicari and Lytras, 2015; Li, Chen and Popiel, 2015) and supporting on argumentative learning in Facebook (Tsovaltzi, Judele, Puhl and Weinberger, 2015). Several studies have presented using Facebook to promote students' learning in many countries. For example, Chang and Lee (2013) presented the trust in such facilitators in the Facebook community influenced the development of students in the writing of business plans in order to model in Taiwan. Milošević, Živković, Arsić and Manasijević (2015) used SEM methodology (Structural Equation Modelling) to examine the attitude of students towards Facebook as virtual classroom, through consideration of its acceptability level students in Serbian. Ainin, Naqshbandi, Moghavvemi and Jaafar (2015) presented the impact of Facebook usage on students' academic performance of Malaysian university students in Malaysia. Akbari, Pilot and Robert-Jan Simons (2015) presented Facebook group learning a foreign language in terms of autonomy with SDT theory for the Iranian Ph.D. students. In addition, many studies have explored the importance of Facebook usage. Peters, Winschiers-Theophilus and Mennecke (2015) presented the cultural influence of engaging social network of undergraduate students in the United States and Namibia. Abbas and Mesch (2015) investigated the role of variations in the cultural values and attitudes of young people and their association with the motivations for using Facebook of students in the private and public Arab high schools in Israel. Nam (2014) presented the effects of trust and constructive controversy on student achievement and attitude in online cooperative learning environments. Several studies have investigated a variety of factors affecting use of social networking sites such as life satisfaction influence the intention (Oliveira and Huertas, 2015) or gender effects and cooperation styles (Korfiatis et al., 2015).

In this study, we proposed new learning approach to enhance students' learning in the development of computer multimedia instruction course, which is the part of special topic of pre-service teachers. The objective of this course is to motivate the students to develop multimedia instruction in groups. Therefore, we focused on the process of cooperative learning to enhance students' learning because the cooperative learning is an approach to groupwork that minimizes the occurrence of those unpleasant situations and maximizes the learning and satisfaction that result from working on a high-performance team. Cooperative learning refers to work done by members of team producing a product, creating a project, or the design of a product under conditions that satisfy five criteria: (1) positive interdependence, (2) individual accountability, (3) face-to face interaction for at least part of the work, (4) appropriate use of interpersonal skills, and (5) regular self-assessment of team functioning as shown in Table 1 (Felder and Brent, 2007).

Table 1. Cooperative learning frame work (Felder and Brent, 2007)

Cooperative Learning Elements	Applying to Facebook Activities
Positive interdependence	The group members shared individual information for group on Facebook. They are obliged to rely on one another to achieve the goal. If any team members fail to do their part, everyone suffers consequences.
Individual accountability	Three or four students in a group are held accountable for doing their share of the work and for mastery of all of the material to be learned.
Face-to-face promotive interaction	The group members discussed and exchange idea about assignment via Facebook. Although some of the group work may be parcelled out and done individually, some must be done interactively, with group members providing one another with feedback, challenging reasoning and conclusions, and perhaps most importantly, teaching and encouraging one another.
Appropriate use of collaborative skills	The group members are encouraged and helped to develop and practice trust-building, leadership, decision-making, communication, and conflict management skills.
Group processing	The group members set group goals, periodically assess what they are doing well as a team, and identify changes they will make to function more effectively for preparing the presentation.

Consequently, in this study, we used the Facebook in order to support students' learning with the process of cooperation on the social network. The experimental design was conducted with university students who learned the development of computer multimedia instruction course to investigate the following research questions:

1. How can we explain the differences between a traditional group and a Facebook cooperative learning group?
2. What are students' attitudes towards Facebook cooperative learning?

2. Methodology

2.1 Participants

In this study, we recruited 59 students who were the pre-service teachers in vocational education of the university in central of Thailand. Participants were divided into two groups consisting of 31 students in experimental group learned with cooperative learning via social network site, while the 28 students in the control group learned with traditional face-to-face group in the classroom.

2.2 Procedure

Prior to the experiment, the students in both groups took the pre-test. After that, the students in experimental group participated a group on the Facebook, then they were separated into 7 teams by topic of individual interest. The group members learned contents of the development of computer multimedia instruction course while instructor gave the guidelines appropriate for the condition to which they had been assigned, everyone in the group was received the different task for project construction consisting of the searching information, design the instruction, animating media, selecting sound effect within cooperated by discussion on Facebook (as shown in Figure 1) while the students in control group learned regular content and group discussion in the classroom. Both groups were conducted over a period of approximately 14 weeks. After that, they took the post-test and interviewed. While students are learning, a teacher's role is to facilitate a Facebook collaborative group to reach the topic's goal.

Figure 1. Illustrative examples of learning activities on Facebook

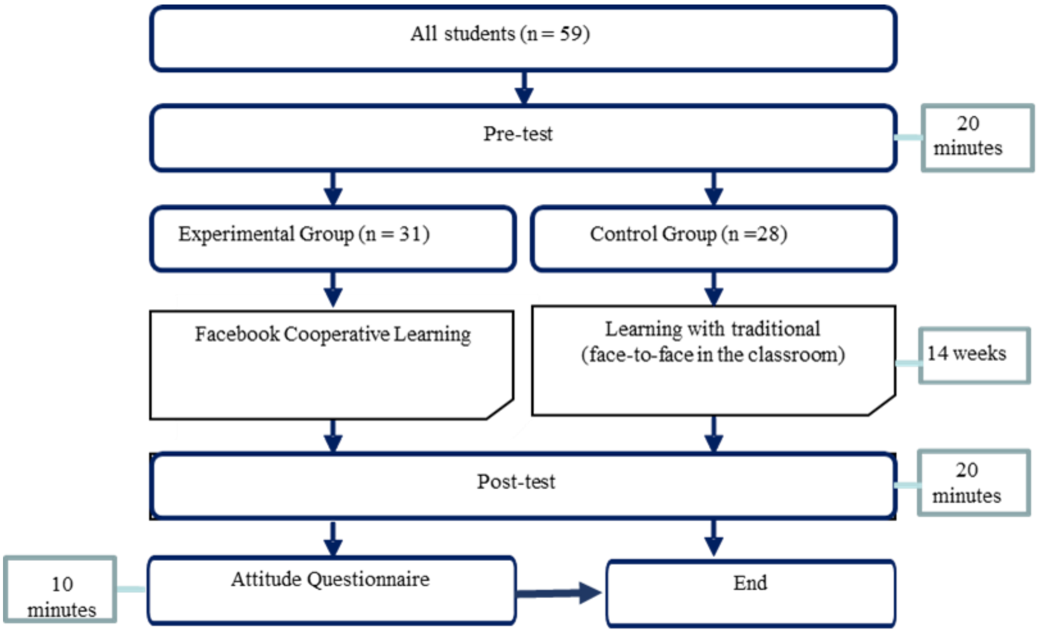

Figure 2. Experiment procedure

3. Research Results

In this study, the pre-test and post-test questionnaire consisted of 20 multiple-choice items. The KR-20 value shows that the reliability of this test was 0.74, indicating that it is reliable. Table 2 shows the *t*-test results of the mean scores and standard deviations of the pre-test scores of students in experimental group (EG) was 11.03, (SD = 2.01), and control group CG was 11.10, (SD = 1.90) respectively. It is found that the test scores of the EG and CG did not significantly differ with t = 2.000 and p value > 0.05, indicating that the two groups of students had equivalent prior knowledge.

Groups	N	Mean (S.D)	*T*-value	*P*-value
EG	31	11.03 (2.01)	2.000	.880
CG	29	11.10 (1.90)		

Table 2. T-test results of the conceptual pre-test for the two groups of students

Table 3 shows that the EG achieved significantly better performance than the CG with t =2.001 and p value < 0.05, implying that the learning achievement of the EG was greater than that of the CG. We have found that two groups of students had equivalent prior knowledge before participating in the learning activity. After finishing the learning activity, the post-test scores of experimental group was 23.57, (SD = 2.42), and control group was 20.90, (SD = 2.98), respectively.

Table 3. T-test results of the conceptual post-test for the two groups of students

Groups	N	Mean (S.D)	*T*-value	*P*-value
EG	31	23.57 (2.42)	2.001	.000*
CG	29	20.90 (2.98)		

* $p < .05$

The questionnaire was administered to investigate the students' satisfaction after participating in the learning activities on Facebook. There was employed a 5-point Likert scale ranging from 1 "strongly disagree" to 5 "strongly agree". This questionnaire consisted of ten items divided into four dimensions. The result (as shown in Table 4) show that the students strongly agree in all dimensions: behavioral intention (M=4.85, SD=0.35), perceived satisfaction (M=4.81, SD=0.40), interactive learning activities (M=4.77, SD=0.41) and perceived usefulness: (M=4.74, SD=0.44).

Table 4. The students' satisfaction Cooperate learning on Facebook

Questionnaire items	Mean	SD	Remark
Perceived satisfaction:	***4.81***	***0.40***	***strongly agree***
1. I am satisfied with using cooperative learning on Facebook as a learning assisted tool.	4.81	0.40	strongly agree
2. I am satisfied learning Facebook functions.	4.70	0.44	strongly agree
3. I am satisfied with the learning contents in cooperative learning on Facebook.	4.87	0.34	strongly agree
Interactive learning activities:	***4.77***	***0.42***	***strongly agree***
1. I would like to share my contents in using cooperative learning on Facebook experience.	4.71	0.45	strongly agree
2. I believe using cooperative learning on Facebook can assist teacher-student-student interaction.	4.84	0.37	strongly agree
Behavioral intention:	***4.85***	***0.35***	***strongly agree***
1. I intend to use cooperative learning on Facebook to assist my learning.	4.81	0.40	strongly agree
2. I intend to use Cooperative learning on Facebook as an autonomous learning tool.	4.90	0.30	strongly agree
Perceived usefulness:	***4.74***	***0.44***	***strongly agree***
1. I believe using cooperative learning on Facebook is a useful learning tool.	4.71	0.45	strongly agree
2. I believe the contents in cooperative learning on Facebook are useful.	4.77	0.42	strongly agree

Moreover, when we asked the participating students to report their own attitudes toward the Facebook cooperative leaning, we found that they had positive attitude as follows:

Students A: *"I like learning on Facebook because I can send my work and group work anytime and we can easily discuss our topic".*
Students B*: "Easy to connect with my friends and my teacher, only post on Facebook then someone had an answer or idea".*
Students C: *"It's convenient to support our requirement such as we want to discuss in my team or exchange idea or share information".*
Students D: *"Facebook is part of my team work, it is the way to learning together in my team".*

4. Conclusion

This paper presented the results of the proposed approach that students in the development of computer multimedia instruction course saw the use of Facebook as a positive. To evaluate the performance of this online cooperative learning, 31 pre-service teachers were recruited to participate in this study. We found that the online cooperative learning could help students' learning achievement and they had positive attitude toward learning in this online cooperative learning environment. Likewise, Ainin et al. (2015) accepted influences Facebook usage on students' academic performance In addition, Chang and Lee (2013) investigated Facebook community influences the development of students.

The success of this study, we summarized that it is an important role in enhancing the effectiveness of the online cooperative learning with using Facebook.

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Inquiry-based Learning with Augmented Reality Mobile Application to Enhance Scientific Conceptual Understanding: TheFruitAR

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Abstract: Scientific inquiry has been considered to be a process to constructing scientific knowledge. With students' misconception of Types of Fruits and Their Flowers, we developed an augmented reality mobile application and its accompanying booklet, TheFruitAR. The purpose of this development was to enhance scientific conceptual understanding on such topic guided by inquiry learning approach. This could help facilitate their learning in a more meaningful way by interacting with interactive multimedia materials and learning activities on mobile. In order to evaluate the effectiveness of TheFruitAR, a comparative experiment was conducted with upper elementary school graders in Thailand. The findings showed that students who learned with our proposed development could outperform than those who learned with the conventional approach, indicating that TheFruitAR could enhance students' conceptual understanding. Moreover, students also revealed positive attitudes towards learning on TheFruitAR, indicating that it motivates students to inquire knowledge.

Keywords: Mobile learning, Augmented Reality, Scientific Inquiry

1. Rationale and Motivation

Science has been playing a vital role in the world. The process of learning science makes learners themselves solve the problems, which is known as scientific literacy (Abd-El-Khalick, 1997). One way to develop scientific literacy is to teach science as inquiry. Inquiry-based learning provides students with opportunities to reflect on, question, and analyze the enormous amount of digital, print, and media information that characterize the complex technological society (National Research Council, 2000).

Types of fruits is one important concept in science subject describing how different kinds of fruits related to different kinds of flowers. Most students hold great amount of misconception on this learning topic because they usually learned this topic passively in the classroom only supplemented by conventional e-learning materials, in which students cannot actively inquire the conceptual understanding by interacting with the materials; such that they could not make a relationship between fruits and their flowers.

According to the advantages of Augmented Reality (AR) that can combine virtual object and physical object in real time, using AR technology could help students to solve this problem because they can interact and see the relationship of flowers and fruits simultaneously (Dunleavy, Dede and Mitchell, 2009).

Therefore, we developed an AR application on mobile to enhance students' conceptual understanding on the relationship of flowers and fruits (hereinafter called TheFruitAR), accompanying with the learning booklet designed to support their scientific inquiry learning. Moreover, this study attempted to evaluate the effectiveness of the proposed development by investigating following research questions:

1) Do students who learned with the proposed development have better scientific conceptual understanding than those who learned with the conventional approach?

2) How are the learning attitudes of students towards the proposed development?

2. Related Studies

2.1 Augmented Reality in Science Learning

Augmented Reality (AR) is a technology combining real world and virtual world together which exactly overlays physical objects in real time (Yuen, S., 2011). There are many fields beneficial for using AR technology such as entertainment, medicine, and education (Klopfer & Squire, 2008).

In science education, AR was adopted to enhance learning activities and motivation in various applications (Kerawalla, Luckin, Selijefot and Woolard, 2006). For example, Institute for the Promotion of Science and Technology (IPST) in Thailand developed a 3D AR geology textbook which enhance students to see the relationships, differences and functions between the earth and geological characteristic. Moreover, AR games have been developed in order to assist players inquiring science concepts with fun (Yuen, S., 2011); while AR technology have also been used as tools in discovery based science learning.

Although AR applications on science learning have been developed and studied in different aspects, there are a limited number of studies concerning on using AR to promote scientific inquiry (Zhou, Duh and Billinghurst, 2008).

2.2 Scientific Inquiry

Science inquiry has been defined as the process of constructing science concepts and patterns, and creating meaning about an idea to explain them (Bybee, 2000). This approach has been highly advocated to be implemented in many levels of teaching science; it allows students to inquire about the phenomenon of the nature of science through five essential features of science inquiry which are 1) engaged by instructors or posing their scientifically-oriented questions, 2) determining what constitutes evidence and gather it to provided evidence, 3) formulating explanations after summarizing evidence, 4) linking the explanations to scientific knowledge, and 5) forming reasonable and logical arguments to communicate (National Research Council, 2000).

There are many educational researches studying the effectiveness of science inquiry used for science teaching strategies. Inquiry-based laboratory work is an effective mode of learning to improve and enhance students' understanding (Lord & Orkwiszewski, 2006), reading ability and learning environment and promoting higher order thinking skills (Madhuri, 2012).

According to the implications of scientific inquiry, it has been considered and agreed to be an effective strategy to teach and learn science (Cuevas, Lee, Hart and Deaktor, 2005). It could help learner to inquire and construct knowledge by themselves and support learner to understand the scientific relationship between fruit and flower that help them to avoid the misconception (Crawford, 2007).

3. Development of AR Learning Package on Types of Fruits and Their Flowers

Fruit is one part of flowering plant which mostly derives from ovary of flower. Fruit contains one or more seeds with some accessory tissues. There are three kinds of fruits which can be distinguished by their types of flowers as follows. (1) Simple fruit is developed from both single flower and compound flower that one flower has only one ovary. (2) Aggregate fruit is developed from single flower that has multiple independent ovaries, and (3) Multiple fruits are developed from a cluster of flowers; each flower produces its fruits which later joining together.

However, most students hold great amount of misconception since they could not figure out the types of fruits and relate them with their flowers. Therefore, we developed an AR learning package to enhance scientific conceptual understanding based on guided inquiry approach. This package bundled with the designed booklet and developed mobile application, which was designed to be used in the science classroom with the content of ‘Types of Fruits and Their Flowers.’

3.1 Guided-Inquiry Learning Booklet for TheFruitAR

The main purpose of the booklet was to provide necessary information with guided-inquiry learning approach, as shown in Figure 1. The information provided in this booklet was structured as follows: 1) Providing open-ended question: to ask student if he/she already understood the topic, 2) Providing necessary theory/concept: to present key information in order to construct the conceptual understanding in the learning activity, and 3) Providing learning procedure: to show AR trigger images for learning activities on mobile application.

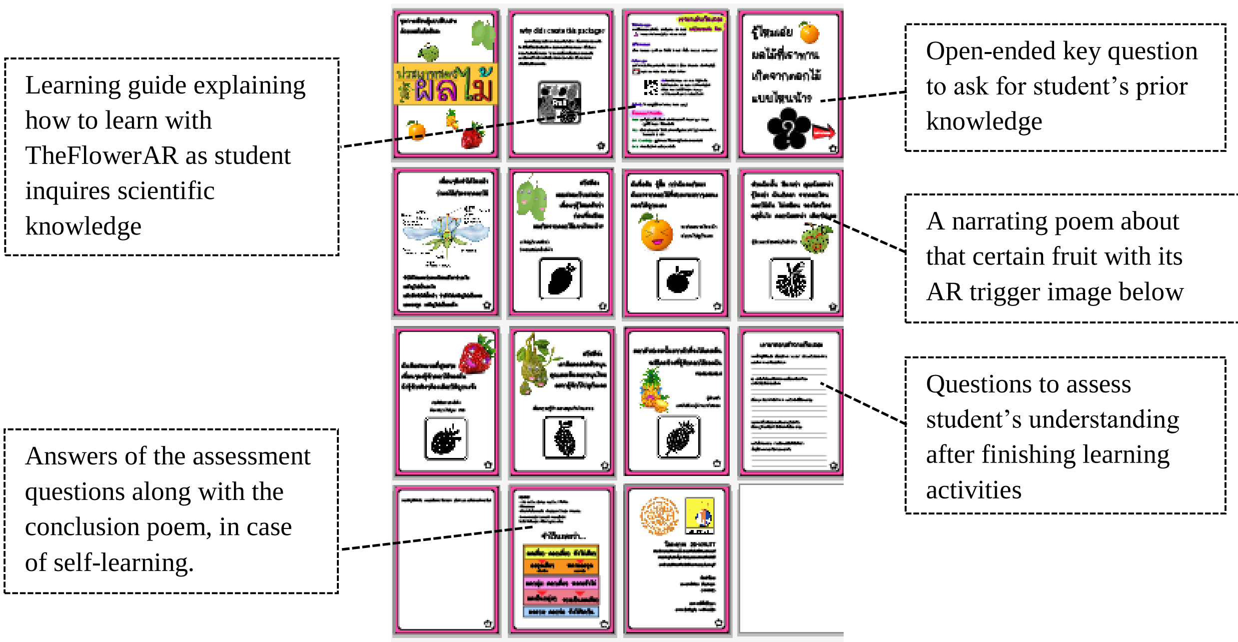

Figure 1. Page Layout of Guided-Inquiry Learning Booklet for TheFruitAR

In the later steps of analysis and discussion, these are not provided; instead, we guided students to work in group to analyze what they have learned with the questions, followed by urging them to make a conclusion statement of the learning content.

3.2 Augmented Reality Mobile Application (TheFruitAR)

To provide more interesting learning experience to the students, we developed the AR application to use in the third step of the guided inquiry procedure. AR application was developed with a free account of Aurasma software.

Once the student opens the AR application and capture to any trigger image on the booklet, he/she is entering to the interactive mobile learning activity. As shown in Figure 2, the student will first be prompted to select a corresponding flower to its fruit, a direct feedback is then given with the sound to let student know if he/she correctly or incorrectly understood.

Figure 2. Learning Activity in AR Application

If answered incorrectly, the meaningful feedback is given, followed by presenting the interactive multimedia video presenting its type of fruit by considering the characteristic along with its flower. In the meantime, student could actively learn the subjects by swiping force and back and by zooming in and out to any misunderstood parts. Here, the student will enjoy learning and have inquired more conceptual understanding at his/her learning pace. Once the student finished learning, he/she will be re-prompted to answer the question again. With this mechanism, it could ensure a student if he/she has reached the certain required conceptual understanding level of the subjects.

4. Experimental Design

In order to investigate the effectiveness of TheFruitAR, an experiment was conducted with 2 classes of 83 upper elementary school graders in central Thailand who were taught by the same teacher.

One class of students learned with our proposed TheFruitAR called experimental group, while another class learned with the conventional e-learning approach, mainly video learning material on computer, called control group. The group selection was done by a draw by representatives of 2 classes. Both groups started with the pretest for 10 minutes. After that each group of students participated in their selected learning approach for 30 minutes. Finally, both groups tool the parallel posttest; moreover, the experimental group took additional learning attitude questionnaire.

The pretest and posttest, each comprised of 12 multiple-choice items with a total score of 12, were collaboratively designed by 3 experienced teachers to investigate the scientific conceptual understanding; while the attitude questionnaire was adopted from Chu, Hwang, Tsai and Tseng (2010). Cronbach's alpha of pre and post tests, and of the questionnaire were 0.86 and 0.82, respectively.

5. Experimental Results

5.1 Scientific Conceptual Understanding

To test the effectiveness of the proposed TheFruitAR, all students took the same conceptual pretest. It was found that the mean ± standard deviation of the control group was 5.30 ± 1.58 and of the experimental group was 5.25 ± 1.39, showing that there was no difference between two groups before the experiment (t = 0.295, p = 0.371).

After the control group learned with the conventional e-learning approach while the experimental group learned with TheFruitAR, all students took the same posttest to investigate the scientific conceptual understanding. As shown in Table 1, an independent t-test was performed by including 2 different learning strategies as independent variable, the result showed that the posttest score of those who learned with TheFruitAR was significantly higher than those who learned with the conventional e-learning strategy (t = 2.135, p = 0.008). Therefore, it could be implied that learning with TheFruitAR helped students gain more conceptual understanding.

Table 1: Students' posttest scores between control and experimental groups.

Independent variable	N	Mean	SD	*t*	*p*
Learning with conventional e-learning (Control group)	43	8.15	2.35	2.135	0.008*
Learning with TheFruitAR (Experimental group)	40	9.92	2.64		

$^{*}p<0.05$

5.2 Learning Attitudes towards TheFruitAR

To investigate how students in the experimental group perceived TheFruitAR, they took a learning attitude questionnaire to express their satisfaction, as shown in Table 2. The descriptive statistics were analyzed from the 5-Likert scale measures ranging from 5 for "Highest satisfaction" and 1 for "Lowest satisfaction."

It was found that students revealed high satisfaction on most attitudinal measures; moreover, they found booklet could help their learning on TheFruitAR more meaningful, while the mobile AR application could help motivate their learning to inquire more conceptual understanding, as they rated high satisfaction.

Table 2: Student's satisfaction attitude towards TheFruitAR

Measures	Mean	SD	Satisfaction
1. TheFruitAR makes my learning more interesting.	4.34	0.75	High
2. Interactivity helps me inquire more understanding.	4.27	0.86	High
3. With the guide provided on booklet, my learning is meaningful.	4.68	0.74	Highest
4. Feedback helps me improve learning.	4.36	0.78	High
5. Interactive multimedia on TheFruitAR motivates me to learn.	4.71	0.68	Highest
6. I like to learn with TheFruitAR.	4.43	0.74	High
7. I would recommend TheFruitAR to my friends.	4.33	0.65	High

6. Conclusion and Discussion

This study attempted to enhance students' scientific conceptual understanding on Types of Fruits and Their Flowers via our proposed AR learning package, TheFlowerAR. Students were guided to follow the inquiry learning strategy on the booklet while learning process, students enjoyed learning by interact with the application and were prompted with interactive multimedia learning materials, questions and feedback to help their learning more effective and interactive. Based on the comparative experimental study, we found that the proposed TheFlowerAR could enhance their conceptual understanding and gained positive attitude.

This finding is aligned with other studies. For example, learning on mobile could enable them to inquire the conceptual understanding by interacting with the prompts and questions (Parsons, Ryu and

Cranshaw, 2007), and AR could make learning activities more meaningful and interesting (Kaufmann & Schmalstieg, 2003). In addition, students could interact with the virtual object in the real environment simultaneously on their mobile devices.

As this application developed during the pilot phase, it was studied to be a supplementary aid to facilitate and motivate students' scientific inquiry; however, there are limitations which could be further enhanced. For example, the learning activity could adjust to fit student's learning situation. Teacher could keep tracking students' learning progress by having students' learning logs stored and analyzed. In addition, the findings of this study could not generalize to other different subject if the nature of that content is different.

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Combining Context-aware Ubiquitous Learning and Computer Simulation: A Lesson Learned in Elementary Science Education

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Abstract: Context-aware ubiquitous learning has been recognized as an innovative mobile learning approach that enables students to directly interact with real-world natural phenomena with supports from digital technology. To enhance visualization of the phenomena, computer simulation could be used to simplify the real world using visual representation. These approaches could be used to motivate science-based learning and facilitate inquiry-based learning process in elementary school science. As such, the mobile "Answer Me" application has been created as a cloud-based instructional system to facilitate context-aware ubiquitous learning in science. In this study, the Answer Me was used to facilitate students' investigation of scientific phenomena of sound. To enhance their comprehension about sound wave, a computer simulation, developed by Physics Education Technology research group, was employed to visualize unobservable phenomena of sound. Both technologies were combined to promote science learning experience regarding predict-observe-explain learning process. Moreover, to evaluate its impact on science learning in elementary school, 54 fifth-grade students were recruited to interact with the app and simulation through POE learning activities. They were examined conceptual understanding about sound and science motivation both before and after the intervention. The results showed that students improved their conceptual understanding about sound and the proposed approach had a positive impact on students' science motivation of learning science by the combined learning experience.

Keywords: Blended environment, ubiquitous technology, simulation, science learning, primary education

1. Introduction

Recent development in information and communication technology (ICT) have influenced on teaching practice and learning process in 21st century community. Today, computer and wireless network technologies have greatly affected the delivery of learning and capacitated people to convenient. Minami, Morikawa, and Aoyama (2004) stated that mobile devices, such as tablet PC, PDA, and smart phone, has transformed learning modes from e-learning to m-learning. Mobile technology provides opportunities to support science learning both inside and outside classroom, and the technology provides learning opportunity to anyone, anywhere, and anytime (Nasaro and Srisawasdi, 2014). Consequently, the government of Thailand has been concerned the important of mobile technology that affects educational process and improvement of quality of education.

In 2014, Thailand government has initiated One Tablet Per Child (OTPC) project by administering the OTPC tablet (tablet PC) devices for schools nationwide with the aim for improving quality of education in basic education level. As such, this project initially included some free applications to support learning in the various forms and the government has funded a project to support the development of applications for learning and encourages independent developers by handling the contest application for students. However, the application was developed largely remained focused on the lesson around, which is not different from reading a book.

Due to the abovementioned reason, this study invested an effort to find the way of using national OTPC tablet for students' learning in science. With mobile technology of the tablet, the learning environment can go with the student to outdoor, the laboratory, and other beyond. As such, a combination of ubiquitous learning (u-learning) and computer simulation has been selected by the researchers. This study brings the principle of context-aware u-learning that was designed to provide students authentic science learning in real context. This may be an effective way to enhance construction of conceptual understanding in science for students. In additions, computer-simulated technology were selected to use for facilitating the science teaching and learning through visualizing objects, processes, and interact dynamics models of natural phenomenon, that are normally beyond the user' control in the natural world (Pinatuwong and Srisawasdi, 2014). Kelton et al. (2003) cited in Loagnam (2009), mentioned that the simulation is a compilation of the various methods used to simulate real-life situations or behavior of the system onto a computer by using a computer software program to support science learning of natural phenomena. From these reasons, the researchers produced the combination and emphasized investigation of effects of the combination on elementary school students' conceptual understanding and science motivation.

2. Literature Review

2.1 Context-aware Ubiquitous Learning

Recent progress in wireless and sensor technologies has led to a new development of learning environments, called context-aware ubiquitous learning environment, which is able to sense the situation of learners and provide adaptive supports based on radio-frequency identification (RFID), wireless network, embedded handheld device, and database technologies. (Hwang, Tsai and Yang, 2008). In the past decade, researchers have been widely conducted research concerning mobile and ubiquitous learning and reported the effectiveness of adopting mobile and ubiquitous learning approach in various learning contexts (Hwang and Wong, 2014). Jones and Jo (2004) stated that the concept of adjustment teaching with ubiquitous technology has the potential to revolutionize education, and reduce the physical limits of traditional learning by applied learning to computer at anywhere. Moreover, this innovative practice in the field of education can be realized in the form of individual and learning style of each student as well. (Junqi, Yumei and Zhibin, 2010).

2.2 Computer Simulation

Computer simulations represent the real world by using a computer program. Simulations can be a valuable tool in the science classroom. They can exemplify scientific concepts and situations, thereby allowing students to explore the nature of things. Computer simulations rely heavily on visual representations of the phenomena they model. Currently, computer simulations are powerful tools which can make unobservable phenomena being visible representation and could support students' conceptual learning in science. Regarding the use of computer simulation, learners can formulate hypotheses about the simulated environment and test these hypotheses by changing parameters in the simulation and observing the way in which the simulation responds to these changes (Lee, Plass and Homer, 2006). Concurrent with the progressive development in science education community, contemporary technology-based approaches to science learning offers computer simulations with ample opportunities for students' inquiry-related learning environments in science (Srisawasdi and Panjaburee, 2015). Researches indicated that computer simulation can facilitate student reducing alternative conceptions, and improving conceptual understanding of science concepts (Srisawasdi and Kroothkeaw, 2014; Srisawasdi and Sornkhatha, 2014; Suits and Srisawasdi, 2013).

2.3 Inquiry-based Learning with Predict-Observe-Explain (POE) strategy

Inquiry-based learning is an important form of learning process in science-based education, as seen from the goals of the national science curriculum in many countries around the world, even in Thailand. The inquiry-based learning is one of the primary pedagogy in science learning based on the investigation of scientific questions or problems. (Kuhn, Black, Kesselman and Kaplan, 2000). By the process of investigation and collection of science data, inquiry activities provide a valuable context for learners to acquire, clarify, and apply an understanding of science concepts. (Edelson, Gordin and Pea, 1999). Basically, the learning process of inquiry often begins with an assessment by the teacher of the pre-existing knowledge, understanding and awareness of the learners, and then leads the learners to ask questions when curiosity is provoked by exposure to authentic experiences. After that, learners make discoveries in the search for new understanding upon which they construct meaning and build further connections to understand the world in a way that is unique to them. Predict-Observe-Explain (POE) strategy is an inquiry-based pedagogy and it shows great potential for increasing students' understanding of scientific knowledge and their engagement in science. (Nasaro and Srisawasdi, 2014). This kind of instructional settings may provide a powerful learning environment for students where they have opportunities to construct scientific conceptual understanding that is durable over time. (de Jong, 2005). In addition, researcher reported that incorporation of POE strategy into ubiquitous learning environment affected students' self-efficacy and perceived ease of use in science learning activity. (Nasaro and Srisawasdi, 2014).

3. Method

3.1 Study Participants

The 54 fifth-grade students were divided into a control group (N = 30) and an experimental group (N = 24) in a local public school at the northeastern region of Thailand participated in this study. They came from the same class and ages between 10-12 years old. They have informal experience with the use of OTPC tablet in school but they have no experience in using the Answer Me app before.

3.2 Learning Materials and Activity

To implement the integration of context-aware ubiquitous learning experience and computer simulation in this study, a cloud-based application, named “Answer Me”, has been created by the cooperation between science educators and computer engineering at Khon Kaen University. The Answer Me app was installed into wireless OTPC tablets. The app is a ubiquitous-based learning application that allows using for submitting questions or learning tasks by teacher and collecting students' answers and responses via wireless communication, with its built-in visualization and cloud computing features. This app supports high-resolution touch screen feature of tablet which makes it easy and intuitive to read question and to giving answer, as illustrated in Figure 1.

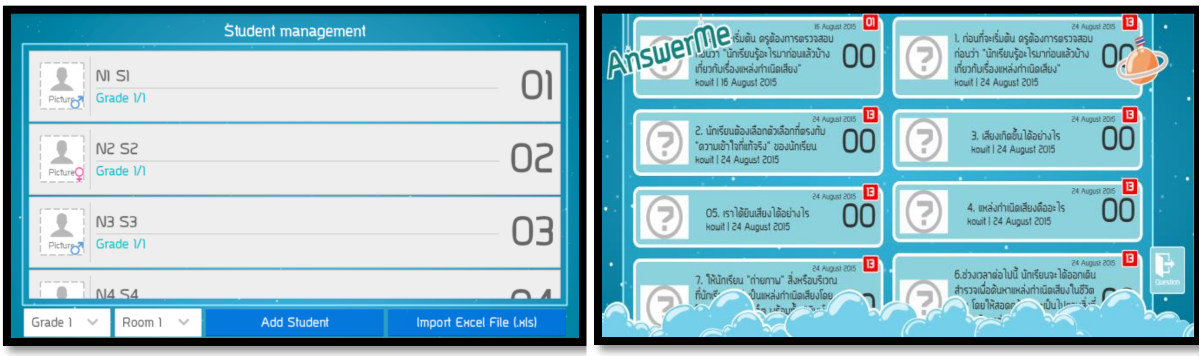

Figure 1. Examples of the Answer Me app’s screen user interface: Teacher (Left) and student (Right) interface

Based on the app, students can submit their answers or responses back to teacher immediately from anyplace, which connected the wireless internet. Figure 2 displays an illustration of using the Answer Me app for context-aware u-learning experience. To enhance students’ understanding of science concepts on sound, a number of computer simulation obtained from Physics Education Technology (PhET) research group were utilized as visual aid of unobservable phenomena in the class, after completing the ubiquitous learning experience. In an addition, the POE strategy was used as an intervention for their learning activity across four main concepts, including source of sound and its propagation, pitch, tone, and noise pollution.

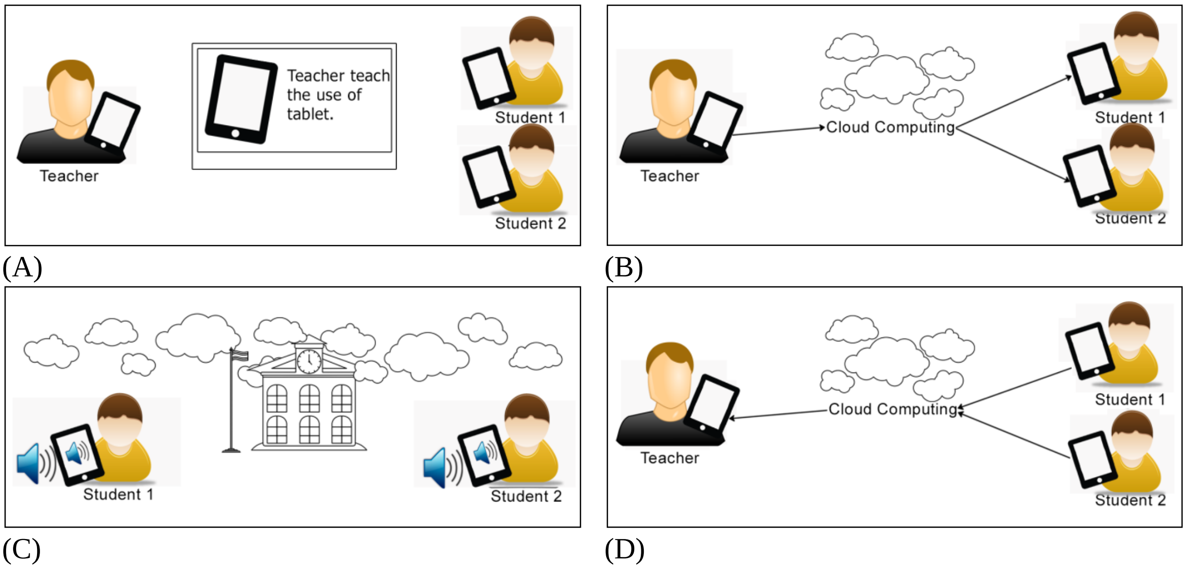

Figure 2. An illustration of u-learning environment by the Answer Me app

For the learning activity, teacher, first of all, introduced students how to use the Answer Me app on OTPC tablet in classroom as seen in Figure 2 (A). Teacher then sent a sample question to students as a demo. Students were assigned to submit their responses to teacher via the cloud-based application. After, teacher sent a series of conceptual questions to students (see Figure 2(B)), and student must find the answers in field, school, or home (see Figure 2(C)). After students found the answers, they sent their answers through the Answer Me's cloud services. Lastly, teacher marked scores for all students as seen in Figure 2(D). According to the proposed pedagogy, Figure 3 displays an example of students' learning scenario through the combination of ubiquitous learning environment and computer simulation.

Figure 3. An illustration of ubiquitous learning activity, outside classroom, by the Answer Me app (Left) and computer simulation in classroom (Right)

3.3 Instruments

To examine the students' conceptual understanding of sound wave, five open-ended conceptual questions were administered to them both pre-test and post-test. In these questions, they were assigned to drawing the sound wave phenomena and explaining their understanding on the sound wave. Draw-A-Sound instrument focuses on four main science concepts consisting (i) source of sound (ii) pitch (iii) tone (iv) noise pollution was used for the evaluation, and its maximum score was 15 points. To probe how much students can learn from each learning activity, POE work sheets were used to measure their conceptual progression along the intervention and their learning performance based on the worksheet were evaluated with the maximum score of 10 points each activity.

3.4 Data collection and Analysis

Figure 4 shows the procedure of the implementation of the learning activity. Before the learning activity, the students took the pre-test of scientific understanding and science motivation. For implementing the ubiquitous learning lesson, they were provided four ubiquitous experiences following POE learning strategy that their learning tasks were encouraged with open-ended inquiry questions and then precede the prediction, observation, and explanation, respectively. After completing all of ubiquitous learning experience, the students were administered the conceptual test again as the post-test. Finally, the science motivation questionnaire was provided to them for evaluating their view towards the ubiquitous learning experience. Figure 4 displays the procedures of the experiment and data collection in this study.

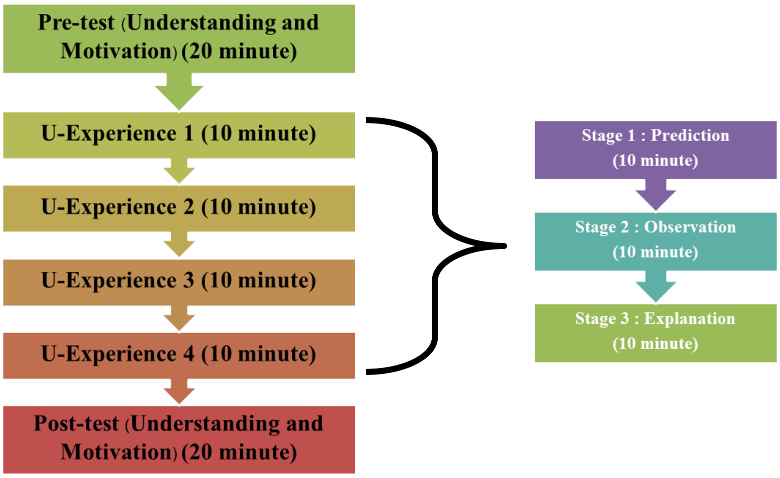

Figure 4. Diagram of experiment design.

To analyze students' conceptual understanding, an item-specific rubric scoring consistent with key concepts of sound wave was used to evaluate conceptual quality of students' understanding. Paired t-test was used to compare a significant difference between pre-test and post-test scores. For evaluating students' science motivation, arithmetic mean and standard deviation were used to describe how do they perceived the ubiquitous learning experience. Moreover, non-parametric statistics of Wilcoxon signed-rank test and Mann-Whitney U test were used to compare the significant change of science motivation.

4. Results and Discussion

In order to explore effects of the context-aware ubiquitous learning experience incorporated computer simulation following POE teaching sequence for science learning of sound wave, Table 1 shows the results on students' conceptual understanding comparing pre-test and post-test scores within group.

Table 1: Statistical results of paired t-test on students' scientific understanding scores of experimental group and control group

Intervention		N	Mean(S.D.)	*t*	*p*
Integrated teaching method of context-aware u-learning and simulation in POE-based inquiry process (Experimental group)	Pre-test Post-test	24 24	1.91(1.44) 12.24(2.41)	16.22	0.000*
Traditional teaching method (Control group)	Pre-test Post-test	30 30	1.37(1.19) 2.50(1.78)	3.26	.003*

*$p < 0.01$

The results show that students' conceptual understanding in experimental group on sound delivered by an integration of context-aware u-learning and computer simulation in POE-based inquiry have significantly increased from pretest to posttest (t = 16.22, p < 0.01), students' conceptual understanding on sound delivered by Traditional teaching have insignificantly increased from pre-test to post-test (t = 3.26, p > 0.01), as seen in Table 1.

According to the abovementioned results, this indicated that the integration of context-aware u-learning, using the Answer Me app., and computer simulation in POE-based inquiry can enhance students' conceptual understanding on sound.

Table 2: Statistical results on nonparametric of the students' science motivation

Scale	Group	Pre - questionnaire	Post - questionnaire	Wilcoxon signed-rank test		Mann-Whitney U Test	
		Mean(SD)	Mean(SD)	z-score	*p*	z-score	*p*
Intrinsic Motivation	EG	18.29(3.62)	18.92(3.32)	-.309	.378	-.279	.390
	CG	18.73(4.19)	18.80(2.89)	-.076	.469		
Career Motivation	EG	16.96(3.56)	18.58(3.92)	-1.727	.042*	-1.642	.510
	CG	18.70(3.81)	18.27(3.52)	-.554	.290		
Self-determination	EG	16.08(4.67)	18.33(3.70)	-2.216	.018*	-1.667	.047*
	CG	18.57(4.07)	18.20(3.43)	-.575	.283		
Self-Efficacy	EG	17.29(4.10)	18.58(4.32)	-1.025	.152	-.925	.177
	CG	17.93(4.19)	17.63(3.11)	-.441	.340		
Grade Motivation	EG	17.29(3.47)	18.88(3.80)	-1.652	.049*	-.595	.276
	CG	18.17(3.66)	18.80(3.30)	-.833	.202		

*$p < 0.01$

The Shapiro-Wilk test of data normality was checked and it showed that the data were not normally distributed, with p-value less than 0.05. Consequently, this study conducted in the nonparametric test (Demircioglu, Ayas and Demircioglu, 2005). The results of statistical analysis using nonparametric Wilcoxon signed-rank test of students in each experimental and control group before and after intervention could examine students' science motivation. The result showed that there was significant mean difference within experimental group in three scales consisted of self-determination (Z (n=24) = -2.216; p <0.05), career motivation (Z (n=24) = -1.727; p <0.05), and grade motivation (Z (n=24) = -1.652; p <0.05). From the results, it indicated that students in experimental group learning with integrated u-learning and simulation in POE-based inquiry improved their science motivation in self-determination, career motivation and grade motivation that's because of this intervention; students interacted with real world learning and precipitated that how importance of science related their daily life (Kamtoom and Srisawasdi, 2015). However, there was no significant mean difference in all scales within control group that studied in the conventional class as shown in Table 2.

Moreover, the results of statistical analysis using nonparametric Mann-Whitney U test of students in both experimental and control group before and after intervention found that there was significant mean difference between two groups from pre-questionnaire and post- questionnaire in the scale of self-determination (Z(n=54) = -1.667; p<0.05), but other scales were found not significantly difference as shown in Table 2.

5. Limitation of the Study

In this research, it should be noted that the students who participated in this study were selected by the researcher. The ratio of females to males was unequal and the number of participants involved was relatively small (N = 24). Therefore, these factors could pose a threat to the results generated from the paired t-test analysis.

6. Conclusions

In this study, the "Answer Me" app was created as an effective instructional tool to facilitate the context-aware ubiquitous learning experience. The results found that only the u-learning experience cannot enhance students' conceptual understanding about sound, especially at the unobservable level of sound phenomena. However, an integration of the u-learning experience and computer simulation in POE-based inquiry can help students to comprehend conceptual understanding about sound both observable and unobservable level of phenomena. After interacting with the intervention, students gain better understanding about sound and they can learn the sound concepts greater than a half of completed scores. In addition, the integrated u-learning and simulation in POE-based inquiry can promote students' career motivation, grade motivation and self-determination. As such, we believed that the proposed approach had a positive impact on students' science learning in promoting their scientific understanding. Last but not least, the Answer Me app. could be used to facilitate students' inquiry-based learning in science effectively.

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The Effect of Pedagogy-embedded Digital Game in Primary Science Education: A Comparison of Students' Understanding of Vitamin

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Abstract: Recently, effective instructional interventions are needed to enable primary school student to increase conceptual understanding in science. To archive the mentioned, well-designed instructional materials regarding appropriate pedagogy is an important platform for students' learning in primary school science. In this study, an educational digital game regarding fruit and vegetable consumptions, particularly called "The Fruit Eater", has been pedagogically designed concerning problem-based learning strategy and then collaboratively created in android application platform, under the cooperation by computer engineering, science educator, and in-service science teacher at Khon Kaen University, in order to transforming traditional learning environment into constructivist-based learning environment. To investigate the effect of the intervention, a study has been conducted with 104 primary school students, classifying into three different groups, in order to verify the value of the game app. The results showed that the game demonstrated good performance (as compared to regular traditional (problem-based) instruction, and problem-oriented game-based inquiry learning) concerning the gain of conceptual understanding of vitamins, and health benefits of fruits and vegetables, even though the pedagogy-embedded digital game was used independently by students for learning. To this end, this study concluded that the use of pedagogy-embedded digital game could facilitate students' development of scientific understanding as well as teacher-centered instruction, and well-designed digital game regarding appropriate pedagogy might be a key factor associated to this effect in science learning.

Keywords: Problem-based learning, pedagogy, digital game, science learning, primary education

1. Introduction

In the 21st century, tools for acquiring knowledge are more important than content knowledge. The advancement of technology has made the students to find their own knowledge from various sources and whenever they want, and make a transformative change from the traditional classroom. The growth of educational games in the last years has largely impacted learning procedures (Shin, Sutherland, Norris, and Soloway, 2012; Virvou, Katsionis and Manos, 2005). Researchers mentioned that educational games have enhanced the value of instruction (Meesuk and Srisawasdi, 2014: Nantakeaw and Srisawasdi, 2014). In additions, educational computer games embrace the characteristics of the new pedagogy in terms of providing authentic and increasing learners' autonomy. For examples, Tüzün et al. (2009) reported that educational computer game can used as learning tool to support students learning and increase their learning motivation while making the learning fun. This is consistent with Dorji, Panjaburee and Srisawasdi (2015) who reported that game-based inquiry learning approach can enhance students' learning in physics better than the traditional teaching approach.

In recent decades, the integration of digital games as learning tools has been studied at the primary, secondary, and college levels, and they has been applied in different disciplines, such as mathematics (Lee and Chen, 2009), history (Watson et al., 2011), biology (Annetta et al., 2009;

Kanyapasit and Srisawasdi, 2014; Lokayuth and Srisawasdi), chemistry (Meesuk and Srisawasdi, 2014: Nantakeaw and Srisawasdi, 2014), physics (Dorji, Panjaburee and Srisawasdi, 2015a, 2015b), and social sciences (Cuenca and Martin, 2010), to effectively achieve various educational goals. Regarding the fostering of learning by digital game, the digital games have colorful pictures and sounds that are interesting to make players happy, enjoy and be challenged. During the process of learning a challenge and hence the incentives encourage the learning of students (Nelson, Erlandson and Denham, 2011). In additions, the digital games allow players to interact in the game world, and players will gain knowledge and skills in education beyond school books (Castell, Jenson and Taylor, 2007).

In context of Thai science education, digital game-based learning is not a famous pedagogy in school science. It is sometimes, though rarely, used in the classroom setting to promote 21st century skills. However, the use of computer games has continually increased in educational settings in Thailand because the educational game transformed pedagogical strategies about learning and teaching (van Eck, 2006). In 2012, Thai government distributed tablet PCs to public school around the country by a project called One Tablet Per Child (OTPC). A challenge for researchers and educators around the country is how to make usefulness for the OTPC tablets in teaching and learning. We are a team who are thinking about development of digital game in OTPC tablets for Thai learners. In this study, we are developing “The Fruit Eater” game and it is implemented into the OTPC tablets in a primary school. "The Fruit Eater" has been created in android app platform with the aim to enhance construction of scientific knowledge and induce behavioral change in fruits and vegetable consumptions for primary school students. The purpose of this study was to use a pedagogy-embedded serious game in teaching to facilitate the construction of scientific understanding about vitamins and benefits of fruits and vegetable through game playing.

2. Literature Review

2.1 Educational Digital Games

With the rapid improvement of technology, video game play has become popular entertainment. Due to the features of video games, such as excellent interaction and attractive entertainment, most of today’s children have the experience of playing video games. As such, educational researchers, developers, and innovators trend to consider the probabilities of using video games in education (Griffiths, 2002; Squire, 2008).

Digital games have sophisticated and dazzling images and sound, and bring players’ enjoyment and challenge. The educational digital games keep players immersed in the game world because animations, sounds, and sophisticated graphics of games offer players an immersive environment in where they might ignore changes and forget everything at their surroundings; moreover, they might feel like they are the leading role of the game, and therefore put their whole concentration, thoughts, and even emotions into the game (Hsu and Cheng, 2014). Players may get knowledge, information, and skill in context of non-formal education (Castell, Jenson and Taylor, 2007). Researchers mentioned that the educational games could provide positive effectiveness on students both cognitive and affective domains of learning. Resulted on this, students get positive learning attitude and create learning curve in the meantime (Giannakos, 2013).

2.2 Digital Game-based Learning (DGBL)

Games consist of challenge, control, curiosity and fantasy, which can be created persistence and enjoyment (Toro-Troconis and Partridge, 2010). According to its features, educational researchers and developers have developed games for teaching and learning in three goals included: (i) students can learn from playing the game; (ii) the component of game can be supported the learning’s ability; and (iii) students have motivate to learn via playing the game (McNamara, Jackson and Graesser, 2010). Digital game-based learning (DGBL) is an instructional method that incorporates educational content or learning principles into video games with the goal of engaging learners. Applications of digital game-based learning draw upon the constructivist theory of education. Regarding to the important of

DGBL, researchers developed effective pedagogy to implement the game into classroom. For instances, Meesuk and Srisawasdi (2014) reported that the use of digital game following student-associated game-based open inquiry (SAGOI) pedagogy can increase students' chemistry understanding, by revising inaccurate conception in chemistry, and promote their motivation to learn chemistry. Nantakeaw and Srisawasdi (2014) reported that students' science attitude did not correlate with motivation toward digital game-based learning, and their conceptual understanding, mental model, and science motivation have been increased after interacting with collaborative game-based learning.

2.3 Problem-based Learning (PBL)

There are many different types of learning environments that are based on constructivist theories. One of the best exemplars of a constructivist learning theory based environments is ones called problem-based learning (PBL). PBL promotes students' confidence in their problem solving skills and strives to make them self-directed learners. These skills can put PBL students at an advantage in future courses and in their careers. Savery and Duffy (1995) considers PBL environments to have the three primary underlying constructivist propositions: (i) understanding is in our interactions with the environment, as posited by cognitive constructivists, (ii) cognitive conflict is the stimulus for learning and determines the organization and nature of what is learned, as posited by cognitive constructivists, and (iii) knowledge evolves through social negotiation and by the evaluation of the viability of one's understanding, as posited by social constructivists. According to the PBL environments, it promotes activation of prior learning, self-directed learning, and motivation (Barrows, 1996; Barzak et al., 2002).

Currently, design of educational computer games with the constraint that all game play activity embedded within the game be aligned with the instructional objectives has been suggested by educators and developers (DeCastell and Jenson, 2003; Shelton, 2007). The game uses simulated scenarios that are representative of the real-world situation, and the activity itself is useful for progression toward and designed around a learning goal. As such, the use of problematic scenario may engineer students learning to balance authenticity with alignment to the educational task and objectives. Therefore, educational games may benefit a great deal from incorporating the traits of PBL, and the combination of educational games and PBL may help bridge the gap between the enticements of a commercial game designed purely for entertainment and an educational game that holds no allure for learners (Walker and Shelton, 2008)

3. Research Question

In this study, we developed an educational digital game that intends to facilitate students' intuitive understanding of vitamins. The purpose of the game was to examine the effects of different instructional settings, namely traditional (problem-based) instruction, pedagogy-embedded digital game, and problem-oriented game-based inquiry learning, on students' conceptual learning scores. This study conducts an experiment to answer the research question: How do students in the individual mode with pedagogy-embedded digital game and in the collaborative mode with problem-oriented game-based inquiry learning differ from students who experienced traditional instruction of problem-based learning with respect to acquiring scientific understanding?

4. Methods

4.1 Study Participants

A total of 104 student-respondents aged ranging from 10 to 15 years old in a local public school at the northeastern region of Thailand were recruited in this study. Two classes were assigned to be the experimental groups and one the control group. The first experimental group (EG#1, N = 39) interacted with the pedagogy-embedded digital game, and the second experimental group (EG#2, N = 32) participated with problem-oriented game-based inquiry learning, and the control group (CG, N = 33) was exposed to traditional (problem-based) instruction.

4.2 Instruments

A series of conceptual question were created regarding scientific knowledge about vitamins, types and the benefits of fruits and vegetables by the researchers. There were ten items, and five items were matching test items and another five items were open-ended items. For the test, the maximum score is 15 points. The question items were content validated by a science educator and two science teachers.

4.3 Learning Material

In this study, we designed and developed a digital game-based learning environment, called "Fruit Eater" that emphasizes the promotion of fruits and vegetables consumptions and promote students' scientific understanding of vitamins and types and the benefits of fruits and vegetables in two versions. For the first version, we did not embed the problematic scenarios into the game while the problematic scenarios and a series of QR code card game has been developed and embedded into the second version. For both versions, the entertainment goal of the game is to get the highest score by controlling a monster to consume appropriate fruits and vegetables. The educational goals of the game were (1) to understand the effects of necessary and unnecessary foods and drinks, (2) to understand the types of vitamins, (3) to describe the benefits of fruits and vegetables, and (4) to understand the impact of not eating fruits and vegetable. The examples of activities embedded in the game are illustrated in Figure 1 and 2.

Figure 1. Screen shot of the main interface: player can select one of three monsters (Left) and player can select mode of playing controller (Right)

Figure 2. Screen shot of the gameplay: player can control the selected monster to eat fruit and vegetable (Left) and the amount of fruit and vegetable consumed will be displayed (Right)

To promote the players' enjoyment and flow of learning experience, we designed and developed a series of QR code digital card being the vitamin card for improving the players' challenge and their understandings about types and the benefits of fruits and vegetables consumptions. Figure 3 displays the QR code digital card and scientific information obtained from the card.

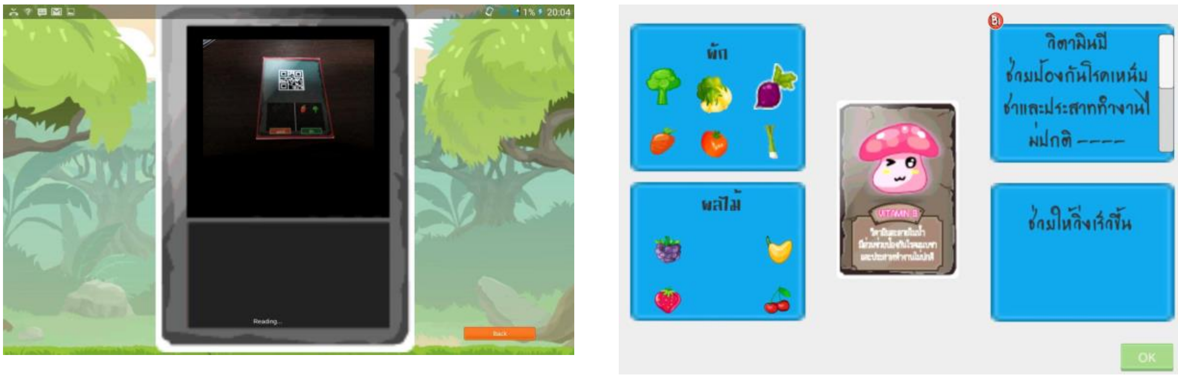

Figure 3. Screen shots of the QR card: QR code digital card displayed on the OTPC tablet screen (Left) and scientific information about type of fruit and vegetable, name of vitamin, and its benefit (Right)

4.4 Data Collection and Analysis

All three groups were examined for conceptual understanding by using the ten question items for 30 min, both pretest and posttest. They were also given an orientation to the learning activity and familiarized with the Fruit Eater game during 20 min after the pretest. The students in each group undertook the intervention for 200 minutes within two weeks. For answering the research question, one-way analysis of covariance (ANCOVA) was used to compare the scores of the three groups in terms of conceptual understanding among the experimental and control groups. Paired t-tests were also used to examine difference in the scientific understanding scores for each group, before and after instructional intervention.

5. Results and Discussions

To reduce the threats of sample error, one-way ANCOVA was utilized to test the main effects for the experiment groups and the control group on scientific understanding, controlling the effects of prior conception. The dependent variable, covariates, and independent variable were posttest measurement of scientific understanding, pretest measurement of scientific understanding, and teaching condition, respectively. Before the ANCOVA was done, the homogeneity test within groups regression coefficient was executed, and the result suggested that the homogeneity test has not reached statistical significance. It means that there is no significant difference in variances among the three groups. Therefore, the ANCOVA could be done. Table 1 reports the result of the ANCOVA analysis.

Table 1: ANCOVA results the experimental groups and the control group on conceptual understanding scores

Source	Type III sum of squares	df	Mean squares	*F*	Sig.	Partial η2	Observed power (a)
Group	2.388	2	1.194	.262	.770	.108	1.000
Error	459.249	100	4.562				

$R2 = .108$ (adjusted $R2 = .081$)
* $p < .05$; ** $p < .01$: ***$p < .001$

The result of the ANCOVA indicates that there is a no statistically significant difference ($F(2,100) = .262$, $p = .770$) between the experimental groups and the control group after the intervention as shown in Table 1. After eliminating the influence of covariance (pretest), the CG group had an adjusted mean of 8.42 (SD = .38) EG#1 group had an adjusted mean of 8.08 (SE = .41); and the EG#2 group had an adjusted mean of 8.56 (SE = .41), for the posttest measure of conceptual understanding. That means, students who participated in the problem-oriented game-based inquiry learning group outperformed others; and students in the traditional instruction group were better than the pedagogy-embedded digital game group. In other words, after the instruction, the students in the individual mode with pedagogy-embedded digital game can learn as well as students in the collaborative mode with problem-oriented game-based inquiry learning and in traditional instruction.

To determine where the differences among the teaching methods were, Bonfferoni's Post Hoc Test was employed to test for significance. All tests were conducted using the adjusted means, controlling for any differences in prior conception. Table 2 reports the result of the Bonfferoni's pairwise comparisons.

Table 2 : Bonferroni Post Hoc Test results by teaching condition

Group	(J) Group	Mean difference (I-J)	Sig.
CG	EG#1	.330	.585
	EG#2	-.133	.805
EG#1	CG	-.330	.585
	EG#2	-.463	.477
EG#2	CG	-.133	.805
	EG#1	.463	.477

* $p < .05$; ** $p < .01$; *** $p < .001$

The evidence from Table 2 indicated that students in the individual mode with pedagogy-embedded digital game did not significantly differ than students in the collaborative mode with problem-oriented game-based inquiry learning and students who experienced traditional instruction of problem-based learning with respect to acquiring scientific understanding. In addition, Table 3 reports the results of the paired t-test between pretest and posttest for all groups.

Table 3 : Descriptive statistics and paired t-test on the pretest and posttest for the experimental groups and the control group

Group	Pretest Mean (SD)	Posttest Mean (SD)	*t*	*p*
CG	5.06 (1.54)	8.12 (1.64)	-7.000	$.000^{***}$
EG#1	7.87 (2.18)	8.73 (2.36)	-2.559	$.015^{**}$
EG#2	4.44 (1.58)	8.03 (2.54)	-8.009	$.000^{***}$

* $p < .05$; ** $p < .01$; *** $p < .001$

The results from Table 3 indicated that there is a statistically significant difference between pretest and posttest for the CG group (t = -7.000, p = .000) EG#1 group (t = -2.559, p = .015), and EG#2 group (t = -8.009, p = .000). It indicated a significant difference in students' scientific understanding change over time in for all three groups. This finding is consistent with Dorji, Panjaburee, and Srisawasdi (2015a, 2015b) and Giannakos (2013) that the enactment of digital game-based learning could complement the inquiry-based learning process in order to develop collective conceptual understanding of the scientific phenomena.

In overall conclusion, these results suggest that the use of pedagogy-embedded digital game is beneficial for students' scientific conceptual learning as well as the problem-oriented game-based inquiry learning and traditional instruction.

6. Conclusions

This study reported impacts of pedagogy-embedded digital game and problem-oriented game-based inquiry learning on students' scientific understanding of vitamins, comparing with traditional instruction. The findings revealed that students' development of scientific understanding of vitamins, and types and benefits of fruits and vegetable consumption in the individual mode with pedagogy-embedded digital game did not differ than students in the collaborative mode with problem-oriented game-based inquiry learning and students who experienced traditional instruction of problem-based learning. That means, the pedagogy-embedded digital game called Fruit Eater demonstrated good performance (as compared to regular traditional (problem-based) instruction, and problem-oriented game-based inquiry learning) concerning the gain of scientific understanding. The finding of this study implied that well-designed digital game regarding appropriate pedagogy, i.e. problem-based learning, might be a key factor associated to this effect in science learning.

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Evaluation of Secondary School Students' Perceptions toward Combination of Digital Learning Technology for Physics Learning

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Abstract: With rapid growth of digital learning, researchers revealed that the digital technologies for teaching and learning could promote students' interest, motivations, attitudes, and enhance conceptual learning outcome. According to this evidence, an educational computer game and a computer simulation were chosen as important digital learning technology in physics learning in this study. Moreover, perceptions of perceived learning, perceived ease of use, perceived playfulness, enjoyment, perceived satisfaction, and flow were chosen as important factors in learning physics with gender differences through the physics lesson. Fifty-one students in Northeast region of Thailand were recruited to interact with the digital learning technology to investigate the effect of perception toward science lesson. Before participating in the learning activities, a Likert-scale perception was administered to the students as a pre-test. After finishing the learning activities, the Likert-scale perception was administered to the students as a post-test. The results indicated that females and males increased their perceptions on perceived learning, perceived ease of use, perceived playfulness, enjoyment, perceived satisfaction, and flow after interacting with digital learning technology; moreover, females showed positive perception more than males.

Keywords: Educational computer game, computer simulation, gender differences, perceptions, science education

1. Introduction

In the past decade, the researchers revealed that the important digital learning technologies in improving quality of education and preparing new generation to have skills in 21st century society were educational computer game (Dorji, Panjaburee and Srisawasdi, 2015; Hwang, Chui and Chen, 2015; Moreno-Ger, Burgos, Martínez-Ortiz, Sierra and Fernández-Manjón 2008; Lee and Chen, 2009) and computer simulation (de Jong and van Joolingen 1998; Rutten et al. 2012; Srisawasdi and Panjaburee, 2015; Vreman-de Olde et al. 2013). Those researchers concluded in the same way that the students improved their learning performance and experience, and attitudes through learning activity with such digital learning technologies.

In the previous studies, researchers revealed that digital game-based learning could promote students' interest, motivation, attitude, and enhance conceptual learning outcome and explained how digital game support students' motivations and learning achievement (Giannakos, 2013; Lokayut and Srisawasdi, 2014; Nantakaew and Srisawasdi, 2014). Interestingly, the experimental results showed that the inquiry-based educational computer game significantly improved the students' learning achievement on energy consumption as well as their awareness on electric energy conservation (Dorji, Panjaburee, and Srisawasdi, 2015). In an addition, using computer game in education reported that it increased students' perceptions regarding learning, flow, and enjoyment in the game (Barzilai and Blau, 2014; Huang and Johnson, 2008; Hwang, Sung, 2012; Hwang, Sung, Hung, Huang and Tsai, 2012; Liu and Chen, 2010). Not only the educational computer game could promote learning performance and motivation but also the computer simulation has been growing in supporting learning, especially, in discovery learning (Egenfeldt-Nielsen, 2005; Michael and Chen, 2006).

Computer simulations which contain visualization and features for representing an authentic system or phenomenon and they have a number of features has been recognized as an effective tool for teaching and learning method in science (Blake and Scanlon 2007; Wellington 2004). As such, computer simulation can help students to engage productively in physical sciences lessons and are referenced as appropriate tools for promote students engagement (Khan, 2011). Insummary, the computer simulations can be effective instructional practices in promoting science content knowledge, developing process skills, and facilitating conceptual change and flexibility, safety, and efficiency deserve attention (Smetana and Bell, 2012) and promoting students' perceptions of learning (Kamtoom, Srisawasdi, 2014).

Since, scientific knowledge is abstract and often complex to learn. Both educational computer games and computer simulations could cope that abstraction and improve learning performance and promote perceptions. However, learning perception through the learning environment with integration of the education computer game and computer simulation has not addressed yet. Moreover, the successful usage of those digital learning technologies depends on the features, the learning strategies, and human factors. Among various human factors, gender difference play an important role in learning using digital learning (Paraskeva, Mysirlaki and Papagianni, 2010). In summary, the perceptions of each gender toward the learning environment with integration of the education computer game and computer simulation has not investigated yet. Based on these concerns, this study aims to cope in this uninvestigated area.

2. The Combination of Educational Computer Game and Computer Simulation

For the purpose of this study we used an educational computer named energy consumption and conservation game (Dorji, Panjaburee and Srisawasdi, 2015) and computer simulation named circuit construction kit of PhET. Figure 1 shows the collaborative learning environment of the students interacting with the computer game and computer simulation. The students are divided into teams of two people for one computer. Starting from the interaction with the computer simulation and the last computer games.

Figure. 1 Illustrative of classroom learning activity through digital technology
By simulations (Left) and computer game (Right)

Figure 2 shows an example of computer simulation representing the equation form of Ohm's law related to a simple circuit. The students can adjust the voltage and resistance, and see the current change according to Ohm's law.

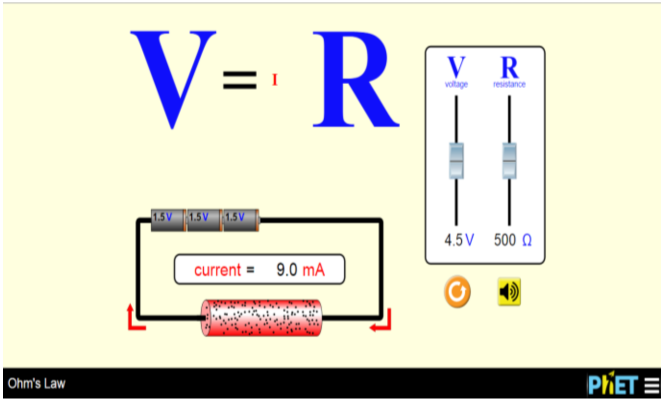

Figure. 2 Illustrative of Ohm's Law simulation (obtained from PhET) for computer-simulated interaction

In addition, Figure 3 shows an example of computer games part which lets the students to solve cases to find out the factors for energy consumption by our daily household electrical appliances in game case 1: identify the factors for energy consumption-factor 1 and game case 2: identify the factors for energy consumption-factor 2.

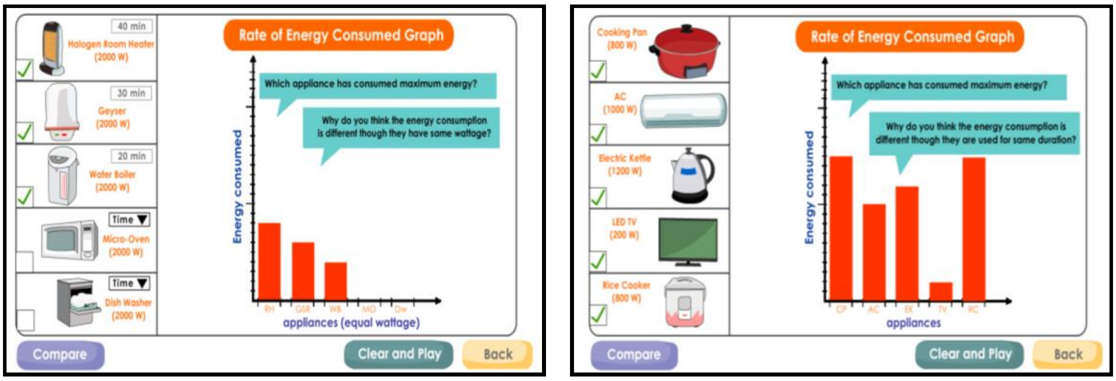

Figure. 3 Illustrative Explore energy consumption factors in electrical appliance by using "energy detective game" by Game case 1: Finding the first factor (Left) and Game case 2: Finding the second factor (Right)

3. Method

3.1 Participants and Research Instruments

The participants in this study were seven-grade students (13-14 years old) in Thailand. A 21-item Likert-scale questionnaire was developed to use to collect data in this study for examining gender difference among perceived learning (4 items), enjoyment (3 items) perceived flow (4 items) obtained from Barzilai and Blau (2014), and perceived playfulness (3 items), perceived ease of use (3 items), and perceived satisfaction (4 items) obtained from Cheng (2014). To develop a Thai version of the questionnaire, the original English version was translated identically in Thai language. Two experts were recruited to identify communication validity of the items. On each item, respondents were assigned to rate how much the respondent agree with into five scale, from 1-strongly disagree to 5-strongly agree.

3.2 Data Collection and Analysis

Students were investigated perceptions by using the 5-point Likert-scale perception questionnaire before experiencing the simulation and the game intervention for 10 minutes as pre-test. Both learning environments, students participated to interact with them for 40 minutes. After the instruction, students were administered by the same questionnaire again as post-test. The statistical data techniques selected for analyzing students' perceptions was repeated-measures MANOVA in SPSS 22.0.

4. Results and Discussion

The results for the repeated-measures MANOVA was conducted to determine students' perceptions scores. The assumption of homogeneity of variance-covariance was tested with Box's M Test which was not significant and indicated that homogeneity of variance-covariance was fulfilled (p = 0.088). The results for the repeated-measures MANOVA indicated significant main effect for gender (Wilks' lambda = 0.671, $F_{(6, 44)} = 3.599$, $p = .005$, $\eta^2 = 0.329$) and time (Wilks' lambda = 0.504, $F_{(6, 44)} = 7.205$, $p = .000$, $\eta^2 = 0.496$). Also, there was significant interaction effect between gender and time (Wilks' lambda = 0.753, $F_{(6, 44)} = 2.411$, $p = .042$, $\eta^2 = 0.247$). Thus, these results indicated there was significant interaction effect between females and males, significant interaction effect time and indicated that the students had increased their positive perception towards through the proposed digital technologies. Univariate analyses of variances (ANOVA) on each subscale were conducted as follow-up tests to the one-way MANOVA. The results of the univariate test for time are summarized in Table 1.

Table 1: The students' subscale means of perceptions by time and univariate MANOVA

Subscales	Tests		$F_{(6, 44)}$	Sig.	η^2
	Pre-test Mean (SD)	**Post-test** Mean (SD)			
Perceived learning (PL)	11.20 (1.93)	14.04 (2.72)	33.343	.000**	0.405
Perceived ease of use (EU)	8.78 (2.17)	9.76 (2.41)	6.123	.017*	0.111
Perceived playfulness (PP)	9.12 (2.14)	10.14 (2.33)	30.513	.000**	0.384
Enjoyment (EJ)	9.69 (2.21)	10.73 (2.19)	4.656	.036*	0.087
Perceived satisfaction (PS)	12.94 (2.93)	14.90 (2.50)	6.850	.012*	0.123
Flow (FL)	10.31 (2.64)	12.88 (2.27)	15.123	.000**	0.236

$^{*}p < 0.05$, $^{**}p < 0.001$

Moreover, Figure 4 illustrates a graphical data showing the pre-test and the post-test of six perception dimensions. The trend of the graph indicates that there is a positive perceptions in learning to participate the digital technologies from the pre-test and post-test.

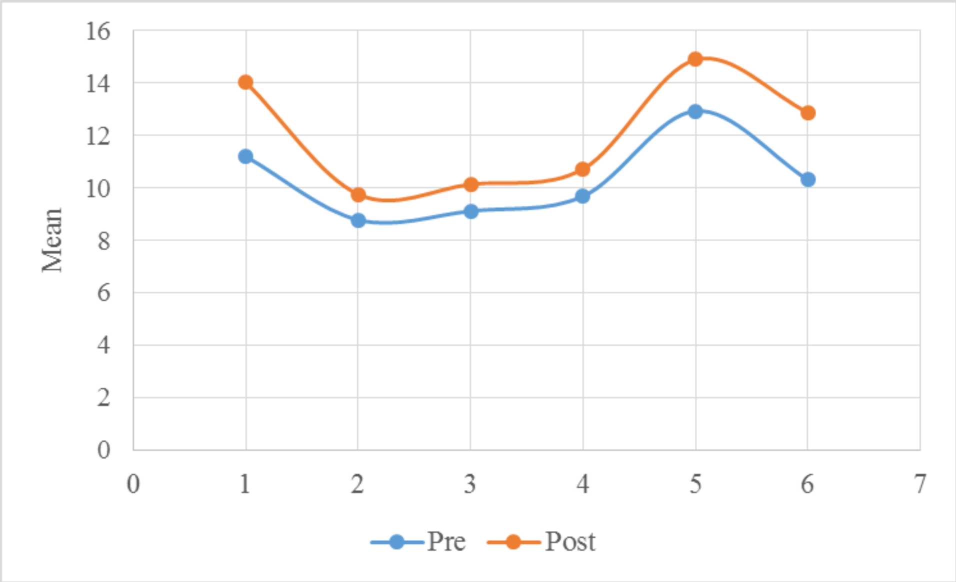

Figure. 4 Compare mean score between pre- and post-questionnaire of five scales of six perception dimension

These results consistent with findings that the computer game can improve the students' conceptual understanding progression and enjoyment and intention to use with the game for males and females (Panjaburee, Dorji and Srisawasdi, 2014). In an addition, it confirms with previous studies (Lokayui and Srisawasdi, 2014) that game could enhance students' perceptions. And it confirms with previous studies (Buyai and Srisawasdi, 2014) that computer simulation could be used to promote students' physics learning experience in which the perception of student increased. The computer game and the computer simulation are digital technology to promote perceptions of students for both females and males meaning that they makes both female and male student had playfulness and content interest.

5. Conclusions

This study reported impacts of learning environment combining with the educational computer game and computer simulation on female and male students' perceptions. The findings revealed that gender difference has effect on students' perceptions towards learning of science through learning environment combining with the educational computer game and computer simulation. As such, it is clear that both females and males increase their on perceived learning, perceived ease of use, perceived playfulness, enjoyment, perceived satisfaction, and flow after interacting with the learning environment in physics course. The results from this study could lead us to conclude that the learning environment combining with the educational computer game and computer simulation can be an alternative way for promoting science learning and female and male students' perceptions in school.

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Students' 21st Century Skills Development in Technology-rich Learning Environment: A Study towards Analyzing Teachers' Lesson Plans in Chinese Primary Schools

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Abstract: More attention is paid in students' 21st century skills development in China. This paper presented the cultivation of 21st century skills in Chinese primary schools by analyzing 20 lesson plans in technology-rich environment. The paper found teachers focus more on learning and innovation skills and lack aware of information, media and technology skills. In 1:1 technological environment students had more opportunities to develop 21st century skills than non 1:1 environment. There were also some differences between subjects.

Keywords: 21st century skills; lesson plan analysis; technology-rich learning environment; Chinese primary education;

1. Introduction

In the new age, many organizations such as the Organization for Economic Cooperation and Development, The National Research Council, and the Partnership For 21st Century skills have proposed the standards of 21st century skills. Some researchers compared them and proposed that standards given by P21 (Partnership For 21st Century skills) is much more comprehensive than others (Zhou, Zhang& Zhang, 2015). Even some details of frameworks are different, advanced thinking and learning skills for 21st century such as critical thinking, problem solving, and creation are primarily focused. In China, with the social development and education reform process, more attention are paid in the cultivation of 21st century skills rather than just focus on the assessment of basic knowledge. Niu(2012) pointed out that P21 framework is also the most connectible one with the requirement of New Course Reform Standards issued by Chinese government.

Charalambidis (2014) proposed that in order to provide to the students significant 21st century skills, a pleiade of ICT tools is needed such as an efficient infrastructure (internet access, multi-touch LCD interactive boards, tablets and so on) as well as the proper educational content. Many researches also advocates for accessing technology like Skype, blog, GPS(Global Positioning System) for incorporating 21st century skills into academic content(Walser,2008; Knobel and Wilber,2009; Sprenger,2009). Zurita, Baloian, Hasbun(2015)designed a blended learning environment enhanced undergraduate students' meaningful learning practicing 21st century skills and found a positive development. In the technology-rich environment, K-12 schools should take advantage of e-learning for the development of 21st century skills (Kong, Chan, Griffin, et.al, 2014).The Chinese government also invested a large amount of money in the construction of technology-rich learning environment in schools for students' comprehensive development in the past five years.

Learning By Design approach that can help teachers develop a flexible and situated understanding of technology (J. Koehler & Mishra, 2005). Also, with the benefits acknowledged of Teachers as Designers (TaD), more research is needed to understand how teacher involvement in design impacts the quality of the artifacts created, their implementation, and ultimately, students learning(Kali, Kenny & Sagy,2012).In order to know more about the cultivation of 21st century skills in technology-rich environment in Chinese primary schools, lesson plans could be an effective way. Lesson plan provides the researcher information about a larger unit of teaching than observation (Jacobs, Martin & Otieno, 2008).

There are some researches of 21st century skills by analyzing teacher's lesson plans. Forty-three graduate students in a university-based teacher training program were asked to incorporate at least one 21st century skill into each of their lesson plans. In the created 167 lessons, 46 times of the 21st century themes were addressed, and 218 times for the Learning and innovation skill, 81 for the Information, media and technology skill and 45 for the Life and career skills. Forty-five lesson plans from the Ohio Resource Center database were randomly selected and analyzed to determine which P21 skills have been integrated into each lesson. 21st century themes were only addressed six times and Learning and Innovation skills were included most frequently similarly to the pre-service teachers (Gut,2010). Niu (2012) has focused on the cultivation of 21st skills by analyzing lesson plans in the 1:1 tablet-computer environment in Shanghai and tried to give some guidance and advices for teachers in class activities designs.

The study chooses 20 lesson plans from in-service teachers in Futian district of Shenzhen City to analyze their pedagogical designs. Shenzhen is a developed city in China with an early start of e-Learning so these samples represent a better level of technology and curriculum integration. Therefore, the research aims to analyze the current situation of 21st century skills cultivation from in-service teachers' lesson plans by descriptive statistics and compare differences in 1:1 and non 1:1 learning environment and diverse subjects.

2. Methods and procedure

2.1 Samples

The 20 lesson plans are full samples from a competition named *Creative Lesson Plans in Technology-rich classroom.* All the lesson plans were implemented in the class. Six Chinese lesson plans, two math lessons, two English lessons, five Science lessons, and five Art lessons are included. All of the teachers have training experience of technology-enhanced instructional design. The technology environment is different in each school and detailed information can be seen in Table1. Classes equipped with intelligent terminal like tablet computer, computer, and mobile phone for each student can be defined as 1:1 learning environment. While the others are defined as non 1:1 learning environment.

Table1: Technological learning environments of the samples

	Hardware	Frequency	Software	Frequency
Non 1:1 environment	Computer +projector (for teacher-used only)	3	PowerPoint Only	2
			Micro class video	1
	Interactive Whiteboard	4	Interactive Response System & Interactive Courseware	4
1:1 environment	1:1 Desktop PCs	7	Cognitive tools*	10
	1:1 Tablet computer	5	Tablet Course Management	3
	1:1 Smart phone	1	Cognitive tools	1

** Software like Concept map that facilitated learners' cognitive process*

3.2 Instrumentation

As it mentioned above, the P21 framework (clarified detailedly by Trilling and Fadel,2009 *in 21st century skills: Learning for life in our times*) was chosen as the grounding one and there are little changes for the following considerations: (1) divide the sub-skills of "Critical thinking and problem-solving" into two sub-skills separately, because in some lesson designs they may not appeared at the same time (2) delete the sub-skills of "Initiative and self-direction", which is not easy to extract from lesson plans (3) add the sub-skills of "Application of knowledge in life", which is thought to be very important as kind of Life and Career skills.

By analyzing the lesson plans, the study found that some of the cultivation of 21st century skills are obvious to see in the "instructional objectives" like "promote students' abilities of communication and collaboration by group work", while some are implicit like "ask students to use mobile phones to test the noise level" (can be seen as the skill of ICT literacy). Then we give detailed descriptions and examples as guidelines in Table2.

Table2: The description of 21st century skills analysis framework

	Sub-skills	Descriptions	Examples
Learning and innovation skills	Critical thinking	Reason effectively; Use systems thinking; Reflect critically	Teacher asks the question " Do you think robot must be similar with real person? Why?"
	Problem-solving	Make judgments and decisions; Solve different kinds of non-familiar problems in both conventional and innovative ways	Students need to solve different kinds of problems in inquiry activities
	Communication and collaboration	Communicate clearly; Collaborate with others willingly and responsibly	Students are divided into different groups to finish tasks
	Creation and innovation	Creative thinking and working with others; Implement innovations	Students propose their ideas for creation and make them into real product like robots
Information, media and technology skills	Information literacy	Access and evaluate information efficiently and effectively; Use and manage information	Students search and evaluate information on the internet
	Media literacy	Analyze media and create media products	Students need to choose proper kinds of media to show the project work
	ICT literacy	Apply technology effectively	Students use mobile apps to test the noise level
Life and career skills	Application of knowledge in life	Connect and use knowledge in real life	Students observe and take photos of the spot in life before learning "spot"
	Flexibility and Adaptability	Adapt to change and be flexible	Students write papers in different roles
	Social and Cross-cultural Interaction	Interact effectively with others; Work effectively in diverse teams	Students interview people from community and government
	Productivity and Accountability	Manage projects and produce results;	Students design and optimize questionnaires for research activities;
	Leadership and Responsibility	Guide and lead others; Be responsible to others	Students choose one leader of each group and take relevant responsibilities

3.3 Coding

According to the standards above, two graduated students with experience of teaching guidance in technology-rich environment and coding works are as the coders in the research. The rule is that once the coders see the cultivation of sub-skills in lesson designs they remark 1 times and repeated sub-skills in the same lesson plan is not included. Jaccard Similarity Coefficient (JSC) was computed as a measure of inter-rater reliability and the areas of disagreement were discussed and rectified. In JSC test all the items are more than 0.7, which imply the coding has a good reliability.

4. Results

4.1 Overview

As shown in table 3, in all the 20 lesson plans there were 104 times of sub-skills can be remarked. Learning and innovation skills were identified most frequently (55times), particularly the creation and innovation skill. The fewest were Information, media and technology skills with 22 times. It can also be seen that there's lack of attention on the sub-skill of Social and cross-cultural communication as well as Production and accountability skill.

Table 3: The result of teachers' cultivation of 21st Century Skills in the 20 lesson plans

21st Century Skills	Frequency	Percentage

Learning and innovation skills	Critical thinking	11	52.9%
	Problem-solving	15	
	Communication and collaboration	13	
	Creation and innovation	16	
Information, media and technology skills	Information literacy	8	21.1%
	Media literacy	4	
	ICT literacy	10	
Life and career skills	Application of knowledge in life	17	26%
	Flexibility and Adaptability	5	
	Social and Cross-cultural communication	1	
	Production and Accountability	1	
	Leadership and Responsibility	3	

4.2 Comparison of different technological environment

There's difference in the cultivation of 21st century skills between two different environments as Figure 1 presented. In the 1:1 digital classroom, there are more opportunities for students to develop 21st century skills not only in the quantity, but also in a wide range. Abilities such as information literacy, media literacy, leadership and responsibility, social and cross-cultural skills could not be found in non 1:1 environment lesson designs. However, skills of critical thinking, application of knowledge in real life, non 1:1 environment outweigh the 1:1 environment. (The number is the average frequency of item in each environment)

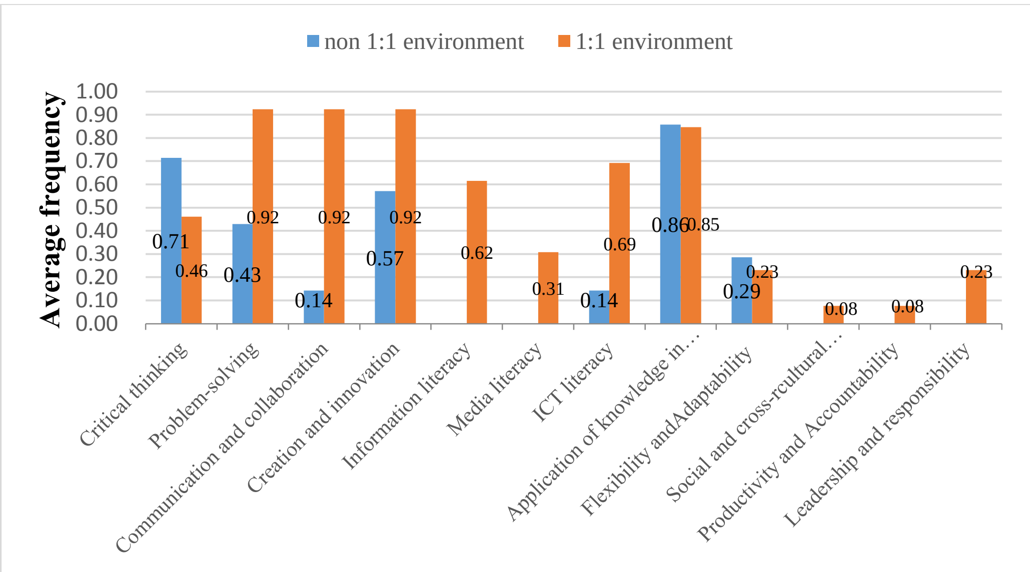

Figure.1 Comparison of 21st century skills in 1:1 and non 1:1 environment

4.3 Analysis on high-quality lesson plans

Seven lesson plans, which win the first and second prize in this competition were chosen as representations of high-quality samples. The scoring standards of this contest include design philosophy (10%), instruction content (30%), class activities (30%), assessment (20%) and innovation (10%). Student-centered learning design with comprehensive ablity-based assessment, usage of new ICT tools or creatively integration of technology ,which lead to meaningful learning were well accepted and encouraged. All the works were reviewed by one professional teacher and one experienced postgraduate in university. There's also a discussion on works with divergence and one doctor and two postgraduates were invited to make a final consensus. These samples were student-centered class and teacher encouraged students to engage learning by project-based learning, inquiry learning and so on.

There are two main characteristics in the cultivation of 21st century skills of these high-quality ones. Firstly, the average skill frequency is higher, which is 6.14 (43/7=6.14), comparing with the average frequency in all samples which is 5.2(104/20=5.2). Moreover, Table 4 shows the number of sub-skills in each plan and it can be seen that among these seven plans, six of them covered all the three aspects of skills, which means that the teachers focused more on the comprehensive development of students.

Table 4: Frequency of 21st century skills in the high-quality lesson plans

	Learning and innovation skills	Information, media and technology skills	Life and career skills
No.1	2	0	2
No.2	4	1	2
No.3	3	1	1
No.4	3	3	3
No.5	3	2	2
No.6	2	2	2
No.7	3	1	1

4.4 21st century skills in different subjects

Five subjects were classified into three kinds of courses: Chinese and English as Language courses(8 lesson plans) ; Math and Science as Science courses(7 lesson plans) ; and art courses(5 lesson plans) . Figure 2 demonstrates a difference of 21st century skills in different kinds of subjects (the number represents the average times). It can be seen that science and art courses contributes more to the cultivation of Learning and innovation skills and Information, media and technology skills than language courses.

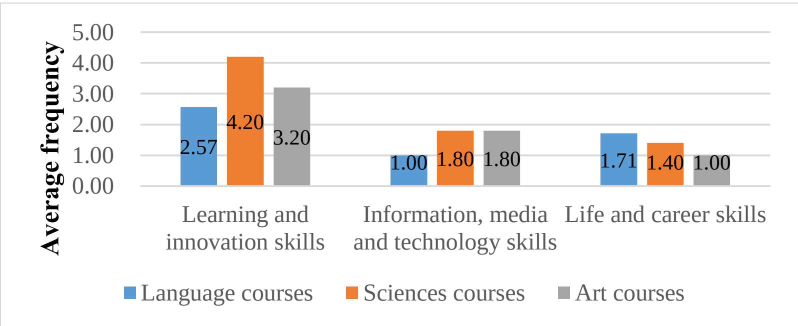

Figure2. Comparison of of 21st century skills in different subjects

5. *Conclusion and discussion*

The research focused on the overview and comparison between different technological environment, quality and subjects of cultivation of 21st century skills in primary education from teachers' lesson plans. There're also observation in teachers' design skills and technology pedagogical and content knowledge (TPACK).

Similarly with research of Gut (2010), Learning and innovation skill takes the largest proportion, while the other two is lack of attention. And this is a little different with research by Niu(2012)finding that Information, media and technology skill is the highest. The probable reason is that in the environment of 1:1 tablet computer classrooms, each student own a device and more opportunities are provided for promoting Information, media and technology skills. In this analysis, the study also found that in non 1:1 environment, teacher seldom ask students to use the technology in the classroom or at home so they have little chances developing this kind of skills, which remind teachers raising the awareness on this.

Even the quantity and range of 21st century skill development is better in 1:1 learning environment, we should realize that it's the teachers' design, not technology, is the critical factor. In some classrooms there are one computer only but many heuristic questions and activities helping students to construct their knowledge can be found in the lesson plans, thus the skills frequency is very high, such as critical thinking and application of knowledge in life. Also, in the high-quality lesson plans, teachers adopt the student-centered pedagogical methods with using technology in a constructive way. For example, in a science lesson, a mobile application of smart phone named Baidu

Map with the function of GPS were used for students to learn the knowledge of maps, and to explore the surroundings in their real life. Teachers adopted constructive alignment with ability-based goal, well designed learning activity and assessment criteria in a rich, authentic and practical context for technology-enhanced active learning and also promote their professional development.

Comparing with science and art courses, language course teachers need to pay more attention in the cultivation of 21st century skills. Social and intercultural communication is low for just appearing once, which gave a potential space for language teaching. Cutshall (2009) suggests the use asynchronous communication methods like Skype and Web sites that provide global connections to enhance the teaching and learning of foreign languages and such interactions provide support for developing global awareness, and social and cross-cultural interaction, in addition to communication and collaboration skills.

By analyzing the plans, we found that teachers tended to use the technology proficiently learned in the training program before, which shows the importance of supporting of TaD in technology enhanced learning environment. Teachers' perception of TPACK development throughout ICT lesson design could be complex thus the variations among different groups of teachers need to be better understood (Kho& Chai, 2013). For this group, comparing with technology pedagogical knowledge (TPK), more attention should be paid in the improvement of technology content knowledge (TCK).

This is a pilot study and it has many limitations. The amount of lesson plans is small and it’s better to make a more precise analysis integrating the class observation, students’ and teachers’ perceptions in each item. In the future, the framework of the scale will be improved and the larger samples will be used for analysis.

Acknowledgements

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Experimental Evaluation of Error-Based Simulation for Dynamics Problems in Science Class at Junior High School

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Abstract: In order to solve mechanics problems, force finding on the objects of the problem is an indispensable step. Also, this step is often difficult for beginners. Therefore, there are several researches proposed supporting method for learners in this step. Error-Based Simulation (EBS) is one of the support methods. In this research, we have experimentally evaluated EBS for a dynamics problems which an object has a velocity at a junior high school. As a result, we have confirmed that EBS is promising method to support force finding correctly.

Keywords: Error-Based Simulation, Physics, Mechanics, Force, Visualization

1. Introduction

One of the most difficult steps in solving of mechanics problem is the step of force finding on the targeting objects. Therefore, examinations and support methods for this step are important research issues in mechanics education (Clement, J. (1982), Clement, J. (1993), Tao, P.-K., & Gunstone, R., F. (1999)). For this step, learners need to correlate force with motion, but this correlation is not easy.
Error-Based Simulation (EBS) is a promising method to support a learner to correlate force with motion (Hirashima, T., Horiguchi, T., Kashihara, A. & Toyoda, J. (1998), Horiguchi, T., Imai, I., Toumoto, T., & Hirashima, T. (2014)). EBS is a mechanical behavior simulation reflecting the forces that a leaner find in a problem. If any incorrect force is included, EBS generates incorrect behavior reflecting them. By observing the incorrect behavior, it is expected that the learner correlate force with motion, also detects his/her mistake and correct it. The Effectiveness of EBS has already been confirmed at static problems. In this research, we have experimentally evaluated EBS for dynamic problems.

2. Error-Based Simulation

Error-Based Simulation (EBS) is a mechanics behavior simulation which reflects learners' error about force in a mechanics problem. EBS shows strange behavior of objects, and visualizes error as difference between wrong behavior and normal simulation. In this section, we will illustrate about EBS system.

2.1 EBS System

In this research, we implemented EBS system for dynamics problems on Android tablet. Figure 1 shows user interface of our system. Screen of the system consists of problem sentence (upper stage), some buttons (middle stage), and drawing area (bottom stage).

Drawing of force, and showing of EBS are done on drawing area. On drawing of the force, learners draw force they think acting on target objects as arrow by flicking. Then, motions of objects are simulated based on this drawing by touch for “Done” button. It is supposed that learners detect and correct own error by observation for this simulation because correct motion is known for them.

The motion simulation for learning of mechanics was tried in previous study (Tao, P.-K., & Gunstone, R., F. (1999)), but it could treat possible motion. On the other hand, EBS can accept impossible motion which based on learners’ mistakes.

For example, figure 1 shows the problem about the forces act on the person who skating on the ice without friction with uniform motion. In this problem, many learners draw the force direction of motion. For that drawing, the parson is accelerated in EBS.

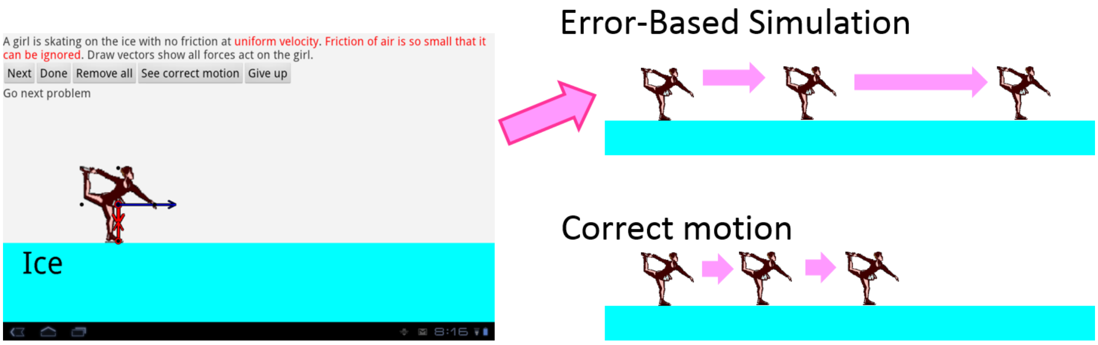

Figure 1. System Interface

2.2 Problems in this Practice

In this section, problems implemented in our system are explained. In this research, practice about dynamics problems is main target. On elementary mechanics, these three kinds of motion are treated: (1) linear uniform motion without force of motion direction, (2) linear uniform motion with balanced forces of motion direction, (3) motion with acceleration.

In this research, we implemented these three “basic problem” corresponding to above three kinds: (A) a person who skating on the ice without friction, (B) a person who dropping at constant velocity by parachute, (C) a ball thrown up vertically. Also, we implemented these three “application problem” corresponding to above three kinds: (D) a space ship moving linearly at constant velocity in cosmic space, (E) an object pushed at constant velocity on horizontal plane with friction, (F) a ball thrown up on the angle. These problems are more difficult than basic problems in that there are more forces and these motions are more complex. Also, we prepared these three problems which used in previous study (Horiguchi, T., Imai, I., Toumoto, T., & Hirashima, T. (2014)) because statics problems must have been studied before dynamics problems: (a) a block rest on horizontal plane, (b) aligned two blocks pushed toward wall, (c) piled two blocks rest on horizontal plane. From here, we call above nine problems “learned problems”. These problems are shown in figure 2.

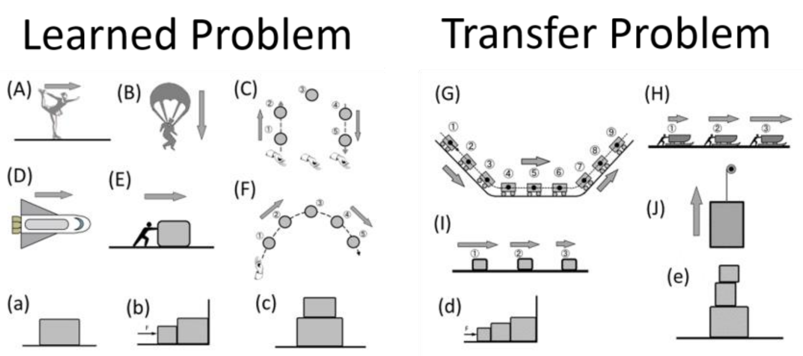

Figure 2. Used Problem

3. Practical Use

In this research, EBS system explained above was used practically. In this section, this use is explained.

3.1 Plan for Practical Use

In our research, practical use of EBS system for ninth grade was conducted to evaluate its effect. This use consists of these contents: pre-test (25min), 1st practice in same week of pre-test (static problems: 45min), 2nd practice in next week (dynamics problems: 45min), post-test in same week of 2nd practice (30min), and delayed-test after a month (30min).

3.2 Practice Method of Each Group

In this practical use, we set up three conditions and assigned a class to each group: EBS exercise group (35 students), EBS class group (33 students), Normal class group (37 students).
For EBS exercise group, we gave tablet PC each learner, and they practiced EBS system on it. While this practice at dynamics problems, basic problems (above (A) to (C)) were target to solve because students could solve about three problems in same hours at previous research (Horiguchi, T., Imai, I., Toumoto, T., & Hirashima, T. (2014)). Also, learners who solved basic problems were allowed to try application problems (above (D) to (F)). While this practice at statics problems, problem (a) to (c) were target to solve. After the practice, teacher showed only correct drawing of force.
For EBS class group, we gave tablet PC each learner, and they attended a class with EBS system. In this practice, we tried to treat problems as many as possible because this class was new initiative. As a result, we could treat all nine learned problems on EBS system.
For Normal class group, three basic dynamics problems ((A) to (C)) which shown the correct drawing at EBS exercise group, and all three statics problem ((a) to (c)) were treated to compare with EBS exercise group. In the class, learners drew the forces on the figure on the handout, and teacher explained correct drawing as if general class. After that, student drew the force again as brush up.

3.3 Evaluation Test

In this practical use, we conducted written test of force to evaluate the effect.
In pre-test, we used problem (A) to (F) and problem (a) to (c) above, and test was done for 25 minutes. In post-test, we used nine problems on pre-test, and additional four dynamics problems and two statics problems which not used at practice. So, total fifteen problems were used at post-test for 30 minutes. Added four dynamics problems: (G) a truck moving on slope and horizontal plane without friction, (H) a sled which being pushed and accelerating on ice without friction, (I) a box decelerating on horizontal plane with friction, (J) an elevator which being lifted up at a constant speed. Added two statics problems: (d) aligned three blocks pushed toward wall (e) piled three blocks rest on horizontal plane. From here, we call above six additional problems “transfer problem” (figure 2).
Delayed-test was conducted after a month of post-test, also used problems and time are same as post-test. Result of these tests are explained at next section.

4. Results of Evaluation Test

In this section, the result and analysis for three test above are explained. In this research, we analyzed the number of correct answer (we call this number “point” from here). Also, the correct answer of problem (D) is no force, but we could not distinguish it from non-respondent. Therefore, we eliminated this problem on this analysis. From this, the maximum point was 5.

4.1 Result of Dynamics Problems

Here, the result and analysis of dynamics problems are explained. Because the exercise with EBS system is voluntarily, learners' ability may affect it. From this, we divided students along point of dynamics problems of pre-test. Learners whose point had been one or over was divided into high understanding learner and another was low understanding learner because average point was 0.543.

4.1.1 High Understanding Learner

In this time, ten learners of EBS exercise group were fallen into high understanding learners, and nine of them drew correct answer on three application problems in addition to three basic problems on EBS system. Also, 12 of EBS class group were fallen into high understanding learners, and all of them drew correct answer for all three basic problems and three application problems on EBS system. Also, 15 of Normal class group fallen into high understanding learners, and all of them drew correct answer of three basic problems in the end of class.
In learned problem, there was no significant difference between each group (Figure 3, Table 1).
In transfer problem, there was marginally significant difference just between EBS exercise group and Normal class group ($p = 0.0560 < 0.10$) at delayed-test (Figure 3, Table 2).

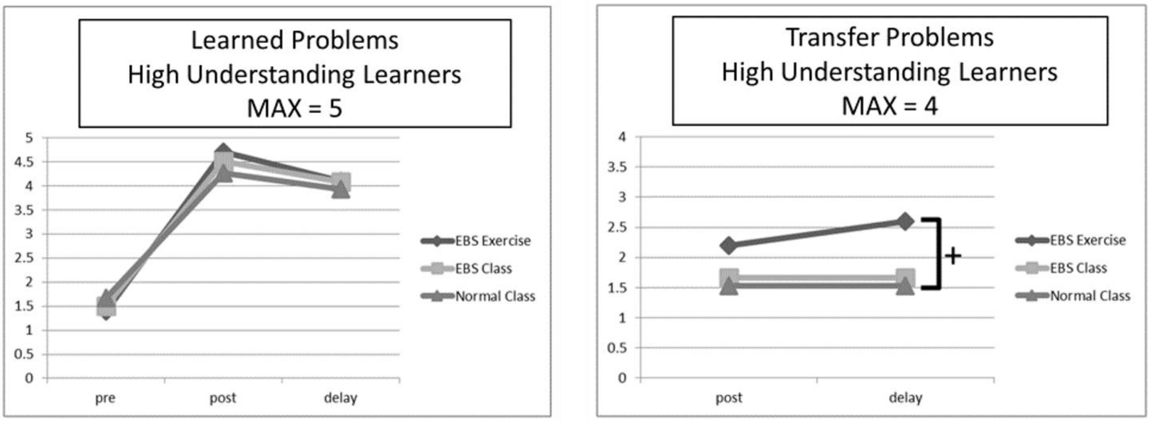

Figure 3. Result: High Understanding Learners

Table 1: Points at Test of High Understanding Learners for Learned Problems.

Learned Problems	Pre-Test	Post-Test	Delayed-Test
EBS exercise group	mean = 1.400 SD = 0.490	mean = 4.700 SD = 0.640	mean = 4.100 SD = 1.446
EBS class group	mean = 1.500 SD = 0.645	mean = 4.500 SD = 0.645	mean = 4.083 SD = 0.862
Normal class group	mean = 1.667 SD = 1.193	mean = 4.267 SD = 0.929	mean = 3.933 SD = 1.236

Table 2: Points at Test of High Understanding Learners for Transfer Problems.

Transfer Problems	Post-Test	Delayed-Test
EBS exercise group	mean 2.200 SD = 1.166	mean = 2.600 SD = 1.497
EBS class group	mean = 1.667 SD = 1.374	mean = 1.667 SD = 1.312
Normal class group	mean = 1.533 SD = 1.147	mean = 1.533 SD = 1.258

4.1.2 Low Understanding Group

In this time, 25 learners of EBS exercise group were fallen into low understanding learners, and 20 of them drew correct answer on three application problems in addition to three basic three problems on

EBS system. Also, 21 of EBS class group were fallen into low understanding learners, and 20 of them drew correct answer on three basic problems and three application problems on EBS system. Also, 22 of Normal class group are fallen into low understanding learners, and all of them drew correct answer of three basic problems in the end of class.
In learning problems, there was significant difference between Normal class group and EBS exercise group ($p = 0.0000276 < 0.05$), also between EBS class group and EBS exercise group ($p = 0.00344 < 0.05$) at delayed test at delayed-test (Figure 4, Table 3).
In transfer problem, there was significant difference just between EBS class group and EBS exercise group ($p = 0.0483 < 0.05$) at delayed-test (Figure 4, Table 4).

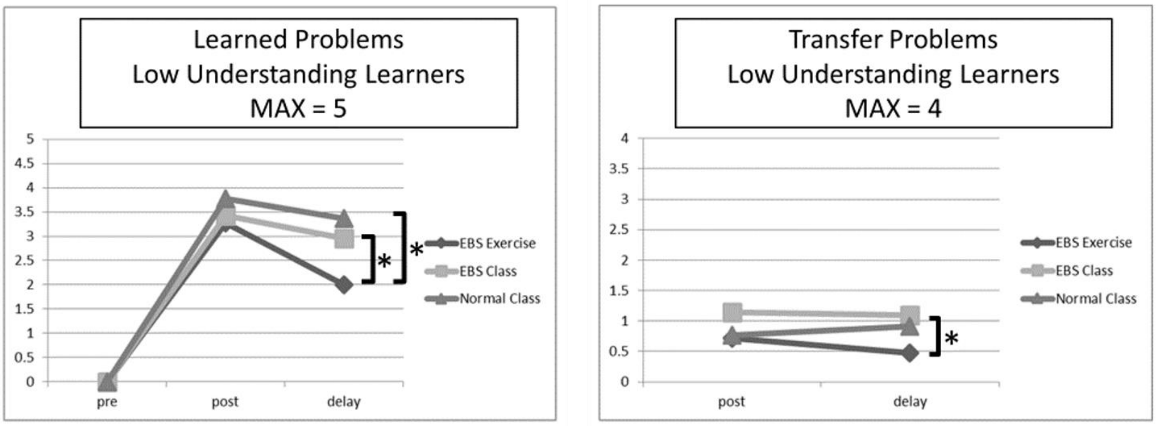

Figure 4. Result: Low Understanding Learners, Learned Problems

Table 3: Points at Test of Low Understanding Learners for Learned Problems.

Learned Problems	Pre-Test	Post-Test	Delayed-Test
EBS exercise group	mean = 0.000 SD = 0.000	mean = 3.280 SD = 1.217	mean = 2.000 SD = 1.549
EBS class group	mean = 0.000 SD = 0.000	mean = 3.429 SD = 1.466	mean = 2.952 SD = 1.618
Normal class group	mean = 0.000 SD = 0.000	mean = 3.773 SD = 0.794	mean = 3.364 SD = 0.932

Table 2: Points at Test of Low Understanding Learners for Transfer Problems.

Transfer Problems	Post-Test	Delayed-Test
EBS exercise group	mean = 0.720 SD = 0.960	mean = 0.480 SD = 0.806
EBS class group	mean = 1.143 SD = 1.166	mean = 1.095 SD = 1.231
Normal class group	mean = 0.773 SD = 0.794	mean = 0.909 SD = 1.124

4.1.3 Consideration

In high understanding learner, there was no difference between each group in learned problem in this practical use. That was indicated that students of EBS exercise group understood at the same level as other two groups in spite of exercise only with EBS system. In transfer problem, there was significant difference between EBS exercise group and Normal class group at delayed-test.
In low understanding learners, there was no significant difference between each group in post-test, but point of EBS exercise group was lower significantly than others at delayed-test in learned problem. Also, in transfer problem, the point of EBS class was higher significantly than EBS exercise group at delayed-test. These results are different from high understanding learners' one.

It is needed for EBS exercise to detect and correct own errors based on feedback from EBS system because the system does not show the answer directly. Briefly, it can be said that EBS exercise encourages "Self-regulated Learning" (Schunk, D., H., & Zimmerman, B., J. (1998), Zimmerman, B., J., & Schunk, D., H. (2001)) that need to think about own answer, which is effective but demands high capacity for learners. This can be calculated as the reason of the result of this use.
From these results, it was indicated that EBS has positive effect on high understanding learners, also has negative effect on low understanding student than normal practice. Also, it was indicated that the negative effect can be cleared by blending of EBS and normal class, but this blending can clear positive effect too. From these indications, blending of EBS and normal class is important question.

4.2 Result at Static Problems

In this practical use, we conducted practice of statics problems before dynamics one. On it, the trend of result similar to dynamics problems' one was seen. From this result, practice with EBS system only can achieve positive effect, but also can achieve negative effect, same as case of dynamics problems.

5. Conclusions

In this research, we are trying to evaluate the effectiveness of EBS system which has been used in statics problems in dynamics problems. In this paper, we reported about the design of EBS system for dynamics problems, and about its practical use.
In this practical use, it was confirmed that EBS exercise is effective for the learners with high understanding, but it is not appropriate for low understanding learners. For these low understanding learners, the method that use EBS as educational material in class was effective, but this method was as effective as normal class for learners with high understanding. From these result, it was indicated that if the learners correlate force with another element of motion is depending on prior understanding.
As future work, support for learner who don't get effect from EBS enough like seen in this use. As one of concrete methods, using of additional feedback to encourage understanding with EBS can be thought. Also, examination the types of learner who get effect from EBS by more large scale experiment. As more developmental agenda, learning support that focuses on Motion Implies Force (MIF) misconception (Clement, J. (1982)) on dynamics problem is important.

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Exploring Student Difficulties in Divide and Conquer Skill with a Mapping Tool

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Abstract: Divide and conquer is an essential thinking skill for engineering undergraduates to have in order to solve engineering estimation problems. However, there exist no teaching-learning tools and strategies for divide and conquer skill for engineering estimation. In this paper, we report on the design of a mapping tool to improve students' divide and conquer skill while solving engineering estimation problems. We evaluated the tool to identify student difficulties in doing divide and conquer while using the tool. We identified several categories of difficulties which will be used to design appropriate scaffolds to support improvement of students' divide and conquer skill for engineering estimation

Keywords: divide and conquer, engineering estimation, mapping tool, external representations

1. Introduction

Consider this problem: "A toy manufacturer has designed a laptop for kids which helps them spell and read and is touch sensitive. Estimate how many AA batteries will be needed to run it for 5 hours at a stretch." Engineers must regularly make estimates like these in the workplace for purposes such as sanity check of results, to establish the feasibility of a design and to eliminate candidate design solutions (Shakerin, 2006; Adolphy et al, 2009). Thus estimation is an important skill for engineering undergraduates to have (Linder, 1999).

One of the key and initial skills practiced by professional engineers in solving problems such as estimation is breaking down large problems into smaller problems in order to make them tractable (Paritosh & Forbus, 2004). Thus breaking down large problems into small problems or divide and conquer is an essential thinking skill of engineering estimation. Divide and Conquer helps in approaching physical quantities that initially seem hard to estimate (Mahajan, 2014). For instance, it is difficult to estimate the energy consumption of a household in a month directly; however breaking down the energy consumption as the sum of energy consumed by all the appliances in a household makes the problem tractable. Thus divide and conquer is needed for many types of estimation problems and is applied repeatedly until one reaches quantities that can be directly estimated.

However the skill of divide and conquer for estimation is not taught in engineering classrooms (Adolphy et al, 2009). Therefore, it is important to develop teaching-learning tools and strategies that explicitly address the development of this skill among engineering undergraduates. In order to help students learn this skill, we propose a mapping tool that helps solvers create tree representations of divide and conquer (Mahajan, 2014). The tool has the provision of creating different kinds of maps such as concept maps and argument maps by adding different types of nodes and links, in addition to divide and conquer trees. We conjecture that using the mapping tool to create trees and maps while doing divide and conquer of estimation problems, will facilitate the doing and learning of divide and conquer skill for engineering estimation. The purpose of the study reported in this paper is to identify the particular difficulties which students face while doing divide and conquer of estimation problems using the mapping tool, so that we can design appropriate scaffolds in the mapping tool to overcome the difficulties.

We followed design based research (Reeves, 2006) to design and evaluate the teaching-learning tool. In the first iteration, we adapted an open-source mapping software called Compendium to create our mapping tool and evaluated it to identify student difficulties in doing divide and conquer of estimation problems while using our tool. Our research question was, “What difficulties do solvers encounter in divide and conquer skill for estimation while using the mapping tool?”

We conducted a lab study wherein engineering undergraduates worked with our tool to do divide and conquer for three estimation problems. We recorded all student questions and researcher responses, screen captures of students’ interactions with the tool and solver created artefacts. Using content analysis of the transcript of student-researcher interaction we identified categories and degrees of difficulties students faced. Our next step will be to translate these difficulties into suitable scaffolds to support student learning of divide and conquer skill.

2. Related Work

The design of the mapping tool is based on the theories of distributed and embodied cognition (Hollan et al, 2000) which argue that cognition emerges from an ongoing interaction between internal resources such as attention, memory and imagination and external resources such as the objects and artefacts in the surrounding environment. External representations facilitate this interaction as they allow processing which is difficult and often impossible in the mind (Kirsh, 2010).

The skill of divide and conquer for estimation includes the following sub-skills (Mahajan, 2014),

1. Identifying information about problem context, conceptual relations among quantities, structural knowledge about objects in the problem and the working of the systems in the problem.
2. Integrating all the above and selecting information and knowledge relevant for estimation.
3. Decomposing the quantity to be estimated as a sum or product of other sub-quantities.
4. Evaluating whether these sub-quantities are simpler to estimate.
5. Choosing a particular breakdown among many possible ones which makes the estimation process easier and more reliable.

Thus, divide and conquer for estimation requires imagination of the problem context, structures of objects, behaviors of systems and qualitative relations among the quantities involved. Research has shown that epistemic actions (Kirsh & Maglio, 1994) performed on external representations during task performance make this imagination more reliable and memory & time efficient. Therefore external representations are required for performing divide and conquer for estimation.

Knowledge representation such as schematic diagrams have been shown to improve performance in problem solving (Hegarty and Kozhevnikov, 1999; Martin and Schwartz, 2009). From a learning point of view, research in scientific inquiry shows that knowledge representations such as models, explanations and argument maps support students’ inquiry and their learning of the skill of scientific inquiry (Quintana et al, 2004; Toth et al, 2002). Similarly, in ill-structured problem solving, the use of concept mapping (Stoyanov & Kommers, 2006; Hwang et al, 2014) and dual mapping (Wang et al, 2013) have been shown to improve problem solving learning and performance. In all these interventions students construct representations, such as argument maps, of the knowledge required for the task and are scaffolded in this process. Research has also shown that hierarchical knowledge structures, such as sub-goals, support problem solving performance and learning (Catrambone, 1998). This has been exploited to improve learning of problem solving in computer-based tutors (Koedinger, 2006) by including features to make the sub-goal structure explicit.

For divide and conquer of engineering estimation a representation showing the breakdown of the physical quantity to be estimated into sub-quantities is required. A tree is an appropriate representation of this breakdown as it depicts the hierarchy inherent in breaking down a problem into sub-problems. Further, the tree diagram serves as an external representation that can be used for restructuring the problem, which would otherwise have to be done in imagination (Kirsh & Maglio, 1994). Mahajan (2014) also recommends creating divide and conquer trees for the physical quantity to be estimated as it is a way of capturing the analysis with a single diagram. However, the strategies described in Mahajan (2014) to breakdown the physical quantity to be estimated are at a broad level and assume learner facility with concepts, which may not be true. So learners will need conceptual and estimation specific epistemic scaffolds (Quintana et al, 2004) to do the breakdown.

In this work, we flesh out the recommendations of Mahajan (2014) for creating divide and conquer trees with theoretical inputs from the cognitive and learning sciences to design a mapping tool that facilitates the doing and learning of divide and conquer skill for engineering estimation.

3. Design of the Mapping tool

We have chosen design-based research (Reeves, 2006) as our approach towards design of the mapping tool as it will require cycles of evaluation and solution refinement followed by producing design principles. Figure 1 describes how we applied design-based research in iteration 1. The last stage of mapping student difficulties to scaffolds will be done based on the results of this study.

The broad conjecture guiding the design of our tool is that creating external representations like the divide and conquer tree (Figure 2) will improve students' performance in the skill of divide and conquer. Therefore, the basic feature required in the tool is the ability to create a tree with a central node denoting the quantity to be estimated (say, mass of air) and nodes branching out from it, each node representing a quantity (say, volume and density) such that mass of air = volume x density. Similarly, there are nodes branching out from the volume node such that volume = length x breadth x height. However, divide and conquer skill for estimation includes several sub-skills (defined in section 2) which require additional actions and external representations from the learner. For instance, the sub-skills 1 & 2 require representations such as equations, graphs and schematics. Therefore a complete list of features required in the tool that will support performing divide and conquer are listed in Table 1.

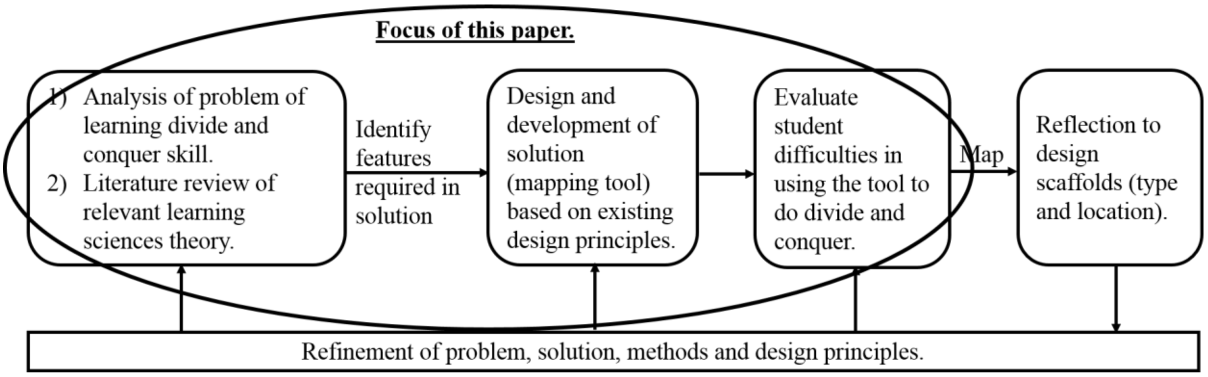

Figure 1. Iteration 1 of design-based research approach to design of mapping tool

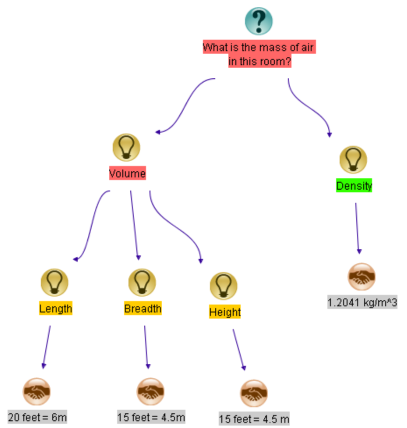

Figure 2. An example of a divide and conquer tree created in Compendium

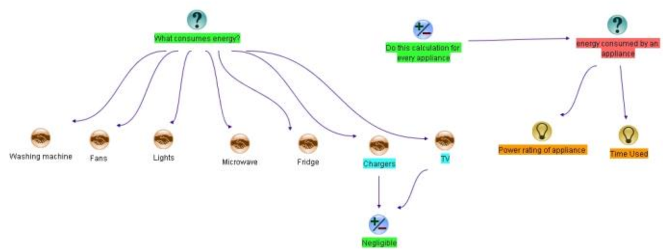

Figure 3. An example of a knowledge map created in Compendium

In the current iteration, we used an available open source knowledge mapping software called Compendium (http://compendiuminstitute.net/) to design the mapping tool. Compendium is a software that visually represents thoughts, ideas, issues and arguments (nodes), and the connections (links) between these. It has different types of nodes and links to represent different types of ideas and connections. Compendium was chosen among several available open source software like IHMC CMAP tools, yEd, FreeMind, etc. because it had the maximum number of features needed in our design.

The mapping tool was created by repurposing some of the available features in Compendium for divide and conquer of estimation problems as shown in Table 1.

Table 1: Features required in the mapping tool.

Feature Required	Available in Compendium?
Ability to create a divide and conquer tree.	Yes
Ability to construct knowledge maps for problem analysis (example in Figure 3).	Yes
Ability to zoom into a particular idea and explore it in depth by creating idea-specific argument and analysis maps (example in Figure 3).	Yes (using the map node)
Ability to move nodes around anywhere on the screen.	Yes
Ability to create different tree structures for sum and product breakdowns.	Yes (using different types of nodes for sums and products)
Ability to provide arguments for chosen breakdown at each level of the tree.	Yes (using argument node)
Ability to color nodes to indicate confidence level in quantities and arguments	Yes
Ability to link different types of knowledge such as information about problem context, conceptual relations among quantities, structural knowledge about objects and the working of the systems with appropriate representations; for example, equations for conceptual relations and diagrams for structural knowledge.	No (use pen and paper)
Scaffolds for doing and learning (Quintana et al, 2004; Ge & Land, 2004) at appropriate points	No (provided by researcher)

4. Evaluation

4.1 Experimental Procedure

To evaluate the first iteration of our mapping tool we performed a lab study with six engineering students (convenience sampling) from the freshman and sophomore years of engineering. These students had the prior knowledge required for the estimation problems we presented. The procedure involved the following steps:

1. Watching an introductory video about divide and conquer, divide and conquer trees and the mapping tool (6 minutes).
2. Watching a video detailing how to use the mapping tool for doing divide and conquer and an example of divide and conquer tree construction for an estimation problem (15 minutes).
3. Individual divide and conquer of three estimation problems using the mapping tool (open ended). An example problem is, "What is the output power of the human heart?"

The students were allowed to watch the videos as many times as they wished, including while solving the problems. They were also given a set of instructions summarizing the two videos. Students used pen and paper to perform steps in the divide and conquer which the tool didn't have provision for as described in Table 1. If students' encountered difficulties while solving problems they asked the researcher who provided them scaffolds regarding how to proceed.

In pilot studies, we observed that even graduate students were unable to proceed in the absence of scaffolds. As a result, we could not get a complete picture of all student difficulties. Therefore scaffolds were provided as just-in-time-and-scope prompts to allow students to proceed. The initial scaffolds were reflective (Ge & Land, 2004), such as "To draw this tree I need to know...". Subsequently, if students were still unable to proceed, the scaffolds became elaborative such as, "How are energy and power related?"

We audio recorded all questions asked by students and researcher responses, captured the on-screen interaction (using CamStudio) of students with the tool, saved the final maps produced in the tool and any rough paper students' used.

4.2 Data Analysis

The audio recordings were transcribed and analyzed using content analysis with grounded codes. First the transcript of four students was coded; the initial codes were categorized into the “Category of difficulty” and “Degree of difficulty”. Next these categories were used to code the transcript of the remaining two students. The codes and categories were revised by constant comparison until a final list of categories emerged. The final maps, screen captures and rough sheets were used while analyzing the audio recordings in order to identify the context of some of the questions that students asked.

5. Results

The categories and degrees of difficulties identified are shown in Table 2. The frequencies are not reported as we are interested in identifying all the possible difficulties that students encounter and providing scaffolds for those. There were three categories of difficulties, those emerging because of the nature of the mapping tool, those related to any of the five sub-skills of divide and conquer and those specifically arising in the process of solving estimation problems. The nature of the mapping tool led to usability issues such as underuse of map node to do problem analysis, using incorrect types of nodes and links and difficulties with the node colors. Related to divide and conquer skill students had difficulties in a) understanding and applying engineering concepts, principles & units and facts, structures & behaviors needed in the problem (sub-skill 1 & 2), b) breaking down the physical quantity into sub-quantities (sub-skill 3) and c) evaluating and choosing a breakdown (sub-skills 4 and 5). The estimation specific difficulties were making assumptions, quantity estimation, argumentation and assessing facts & numerical values. Finally the ill-structured nature of estimation makes it difficult for students to start the problem, proceed when stuck and identify problem requirements.

Table 2: Categories and Degrees of Difficulties.

Category of difficulty	**Sub-category of Difficulty**	**Degree of Difficulty**
Mapping tool	Map node; Color codes; Types of nodes; "-1" link; Argument node; General	Underused; Incorrectly used; Use not understood
Divide and Conquer Skill	Problem context-specific knowledge (sub-skills 1 & 2): Facts; Structures (Spatial); Behaviors	Unknown; Partially known; Incorrect; Unsure
	Prior engineering knowledge (sub-skills 1 & 2): Concepts and Principles	Misunderstood; Partially understood; Not understood; Unsure
	Prior engineering knowledge (sub-skills 1 & 2): Formulas	Inappropriate Application; Incorrect identification
	Prior engineering knowledge (sub-skills 1 & 2): Units	Incorrect
	Breakdown of physical quantity (sub-skill 3)	Incorrect breakdown; Incomplete breakdown; Tree structure not understood
	Evaluate and choose (divide and conquer sub-skills 4 & 5)	Inability to do
Estimation problem related	Assumptions	Inability to recognize; Partially justified; Unjustified; Inability to judge validity; Unable to make
	Quantity estimation	Inability to do
	Argumentation	Unable to write; Unable to judge
	Assessing facts & numerical values	Specificity (for look up); Reasonableness; Relative significance; Standardness; Relevance
	Ill-structuredness of problem	Inability to deal with low information; Inability to start solving; Inability to proceed when stuck; Inability to identify requirements; Inability to reason; Inability to relate; Incorrect identification of problem requirements
	Terminology	Causes misunderstanding; Unable to articulate

6. Conclusions and Future Work

From this study we identified usability issues in the tool that will need to be modified in iteration 2 of the design. Further we learned that the problem context-specific knowledge needs to be provided to students to enable them to begin divide and conquer. Finally we identified specific aspects of estimation problems and divide and conquer skill which students need scaffolds for such as making assumptions and breaking down physical quantities. We will design appropriate scaffolds to overcome these difficulties; for example "elaborative prompts" to get students to articulate their assumptions and providing a tree template to kick-start the breakdown process.

An interesting finding was that even though we had ensured that students had learned the concepts and principles necessary to solve the problems, students have difficulties in understanding and applying prior conceptual knowledge. There are two ways to manage this difficulty; either we can target our tool to advanced engineering students (juniors and seniors) or we can incorporate conceptual knowledge as a scaffold in our learning tool. For our next iteration, we propose to do the former as we do not want the emphasis of this tool to shift from learning divide and conquer skill to learning engineering principles. In future iterations we will incorporate conceptual knowledge in the tool and evaluate the difference between beginning and advanced engineering students in learning divide and conquer skill. We will also try to identify whether students difficulties with the tool are related to their difficulties with divide and conquer skill for estimation problems, i.e., whether they are unable to or underuse certain features of the tool because of their difficulty with divide and conquer skill and/or their inability to think and reason about estimation problems.

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A Game to Improve Hypothetico-Deductive Reasoning Skill in undergraduates

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Abstract: In this paper we describe sequence of steps taken during the different phases of design based research (DBR) while developing murder mystery game intended to teach hypothetico-deductive reasoning (HDR). Murder mystery game is a collection of sequential activities which aims at solving mystery. The underlying principle behind different activities is to teach HDR. In the first phase of DBR students were assessed through questions in three different context i.e. murder mystery, determining genotype of a pea plant and crashing Firefox. Difficulties faced by students during HDR were identified by analysis of results of first phase and inputs from literature. This fed into next phase of designing an intervention. In the next phase students' interacted with the intervention. Feedback from students through analysis of survey after interaction with intervention gives an insight into a number of user interface issues which is to be addressed in the next cycle of DBR.

Keywords: Hypothetico-deductive reasoning, design based research, murder mystery

1. Introduction

Hypothetico-deductive reasoning (HDR) is important for understanding the underlying reason behind any phenomenon. It is shown to be required in understanding of various phenomena related to science and technology (Lawson, 2000; Bao, 2009). This skill is important for designing experiments in a scientific research study. Even 21st century skills aim at developing HDR in the context of problem-solving abilities. Researchers have pointed out various difficulties faced by students during HDR. Various teaching strategies (project based learning and inquiry based learning) and technology-enabled learning (TEL) environment (WISE) (Slotta, 2002) have focused on helping the students to overcome the difficulties and improving this reasoning skill.

Many studies focus on teaching this reasoning skill to school children and few studies focus on teaching HDR to undergraduates. The affordances that a game can provide in teaching this to undergraduates are also not completely explored. We analyzed the literature related to the difficulties in teaching-learning of HDR and did a pen and paper study with students. On the basis of these we identified the features to be included in a TEL environment that would help students in overcoming the difficulties. We intend to evaluate our design of the game with respect to the following specific research questions:

1. What are the difficulties faced by undergraduate students while doing HDR?
2. What are the characteristics of web based browser game which focuses on improvement of HDR skill?

We performed a pilot study with the developed game and identified the technical and user interface (UI) changes to be made in the game. We consider this as the first cycle of DBR process.

2. Related Work

2.1 *Hypothetico-deductive reasoning (HDR)*

HDR is a series of reasoning steps followed during scientific inquiry (Lawson, 2004). These steps are formation of testable hypotheses, designing a feasible experiment to test this hypothesis, comparison of results (predicted and observed) and forming conclusion. Without sufficient chunking of the information, constructing arguments in working memory and deriving conclusions is difficult (Lawson, 2003). In order to help students to overcome these difficulties different teaching strategies and TEL environments have been developed. Many TEL environments focus on improvement of scientific reasoning skill in general but don’t focus on HDR explicitly. Researchers have pointed out various difficulties faced by students during HDR. Some of them are difficulty in hypothesis formation, predicting result, drawing conclusions and connecting back to existing theory (De Jong and Van Jollingen, 1998). So suggestions have been made for the improvement and transfer of this skill (Adey and Shayer, 1994; Chen and Klahr, 1999).

2.2 Existing environments for teaching-learning of HDR

Various teaching-learning strategies like project based learning and inquiry learning focus on developing scientific reasoning which can be in the form of blended learning environment. Also TEL environments like WISE and Inquiry island (Slotta, 2002; Eslinger, 2008) focus on development of scientific reasoning. Within different steps of these environments, scientific reasoning pattern is required but they are not made explicit. Mostly these TEL environments are created in the context where subject knowledge is more important than reasoning pattern. Another example of TEL environment is Geniverse, which is a web based software developed by concord consortium to teach concepts of genetics to high school biology students. It improves scientific reasoning in a game like environment.

2.3 Game-based learning of HDR

At present this reasoning skill is taught by various classroom teaching strategies and different TEL environments. One of them is through computer supported learning environment which has been developed to promote effectiveness in learning among students (Li and Lim, 2008). Also educational games have been shown to be effective in increasing learning motivation and problem-solving skills among students (Moreno-Ger, Burgos, Martínez-Ortiz, Sierra, and Fernandez-Manjon, 2008).These games can provide situated meaningful learning environment along with gaming activity(Hwang, Sung, Hung, Huang, and Tsai, 2012).Both authenticity and learning by doing can affect problem solving abilities among students (Kiili,2007). An interactive educational game is found to be effective in increasing students’ motivation (Inal and Cagiltay, 2007).

2.4 Design considerations of TEL environments for teaching-learning of HDR

Many studies talk about the features to be included in the TEL environments or games which aim to reduce the difficulty of carrying out HDR reasoning. In order to help students to overcome the difficulty of tracking everything in working memory, some support to organize evidences and claims, for example an editable notebook should be present (Furberg, 2010). Researchers have argued that recognition of patterns of argument is needed by the students (Lawson, 2004) and scaffolding in the form of explicit prompts will help students to structure their argument. It is shown that students can be guided by features like text accompanied with illustrations and multiple choice selections (Furberg, 2010).

By analyzing the difficulties of learning HDR and the affordances of technology which will help students in dealing with the difficulties, we have designed a web browser based single player game. Since this reasoning skill is required across the domain, we focus on creating an educational game which aims at developing this skill among students. The game is in the form of a murder mystery which is then transferred to the context of biology and computer science. Any student can play this murder mystery game despite being from different educational background. We have adopted DBR approach to design this game.

3. Methodology

DBR is a methodology used to develop theories not just about teaching-learning process but also about the design of the means to support that process (Cobb, diSessa 2003). We have used DBR methodology according to the steps proposed by Reeves (Reeves, 2006). It consists of steps like analysis of practical problem by researchers and practitioners, development of solutions with a theoretical framework, evaluation and testing of solutions, documentation and reflection to produce “design principle” and finally refinement of problems, solutions and methods by revisiting individual steps. Figure 1 shows our adapted version of DBR methodology.

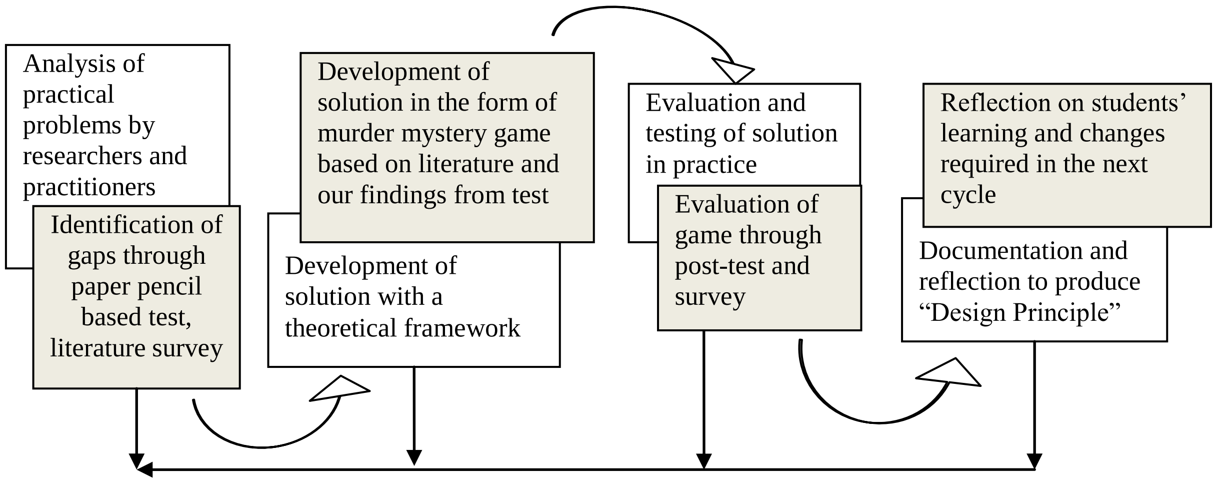

Figure 1: Steps in DBR Methodology (adapted from Reeves, 2006)

3.1 Problem analysis

In order to get a first-hand experience of what the students are able to do without any intervention, we did a study on pen and paper with 29 students in three phases.

Phase 1: The students were given questions related to three domains: a) General: Murder Mystery, b) Technical: Troubleshooting a browser (Crashing Firefox) and c) Biology: Determine the genotypes of plants after crossing. They were asked to find out the answers and support their findings with data.

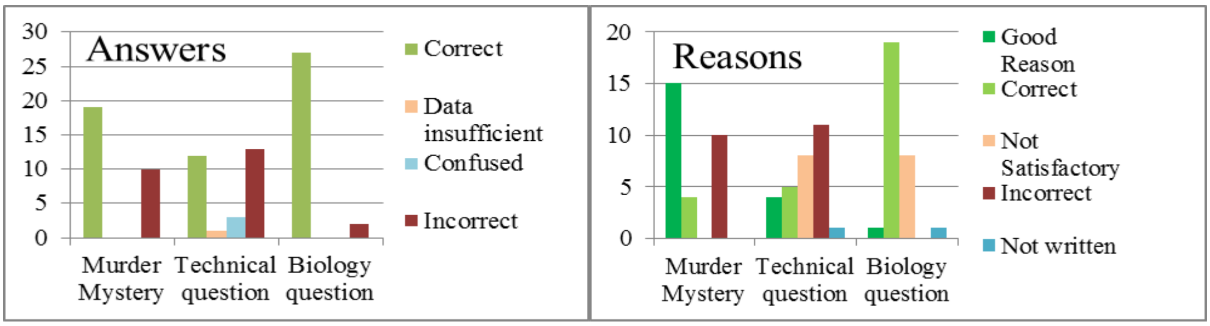

Fig 2: Students responses in phase 1 of problem analysis

Rubrics used for this evaluation is given below:

- Good reason: Provided all the required evidences and correct logical argument
- Correct: Provided all the evidences but no logical argument OR Logical argument but some evidences missing
- Not satisfactory: Some evidences missing and logical argument missing
- Incorrect: No relevant evidences and logical arguments

Analysis of students' responses in Fig 2 shows that most of the students are successful in answering murder mystery with good reasons. In case of technical question, half of them were unable to answer the question correctly. But most of them couldn't give good reasons for questions related to general computer usage and biology. In some of the answers the students seems confused.

Phase 2: In the next phase, they were given a list of hypotheses and facts related to technical and biology question. They had to distinguish between hypotheses and facts. From the second phase, we found that, while solving the technical question, none of the students were able to distinguish between all hypotheses from the facts in technical question - 14 of them identified 3 out of 4 hypotheses and 13 of them identified 2 hypotheses. Their responses in genotype problem too were similar where only 2 out of 29 were able to distinguish all the 6 hypotheses from facts. The other 27 students could identify 3 out of 6 hypotheses. However, 22 out of 29 students identified the facts correctly in technical question and only 5 out of 29 students identified the facts correctly in the genotype question.

Phase 3: In the third phase, they were given the following template:

Because _______________ and ________________ we can conclude that the murderer is ___________.

Because _________________ and _______________ we can conclude that the Firefox was crashing.
Because ____________ and _________we can conclude that the genotype of pea plant is __________.
This was meant to act as a prompt in order to provide answers with reasons or evidences. We analyzed the answer sheets and got the following result shown in Fig 3.

Fig 3: Students responses in phase 3 of problem analysis

Here we observe that few students, who gave 'not satisfactory' reasons in first phase for the technical question, gave correct/good reason in third phase. However, giving the template didn't seem to help much in case of students who gave incorrect reasons in the first phase. In murder mystery and biology domain, the reasons of the students didn't change after giving the template. By analyzing at these results and related literature, we included some features in the game. These are given in Table 1.

3.2 Design and development of the game

This is a web browser based game. The initial screen explains what are hypothesis, prediction, observation and conclusion by giving an example. Then in the next screen the player is given the role of a detective under training. The detective has to go to the murder scene and help an officer with the investigation. Accordingly, we have four steps in the game:

1. Investigation: In this step, the detective interrogates everyone related to the murder say, the victim's employee. The detective also tries to get more information from the investigating officer present in the scene. The player has to click on the pictures of each character to listen to their story. This is assumed to reduce the cognitive load on part of the students because there is an inherent chunking going on. The information obtained by the detective will be automatically stored in a notebook as and when the detective listens to each 'character' in the scene. This notebook can be used in subsequent steps when the detective needs this information.

2. Look for evidence: After collecting information from characters in the investigation screen, the detective moves ahead to look for evidences. For example the detective has to click on a coffee mug to check if it contains anybody's fingerprint. Images of possible evidences are shown and the player has to decide and select the important evidences within a given number of chances to get points.

3. Synthesize: After listening to all the versions of the story and finding out the required evidences, the detective comes to his desk with a set of hypotheses and facts. The next job is to sort these out: The player has to distinguish between facts and hypotheses. A link is given to the initial screen so that they can refer to the definitions of hypotheses etc. Now with all the hypotheses in front of the detective, he/she has to find the ones which are supported by data i.e., he/she have to find which of the hypotheses can be true. Initially, if the detective clicks on a fact, then he/she will get a response that it is a fact. When the detective clicks on a hypothesis, he/she is trained by showing what can be the prediction and observation and conclusion for that hypothesis. This scaffolding is removed in later stages of the game.

4. Conclude: In the next screen the detective has to predict what would happen if this hypothesis is true and then give the required observations to check if the prediction is true or not. Then conclude whether the hypothesis in consideration is accepted or rejected. There are explicit prompts at this stage which asks the detective to enter predictions and observations needed to test the hypothesis considered. This was added to familiarize students with the argument pattern. After the detective has considered all the hypotheses and analyzed which ones are supported by the available evidences, he/she has to conclude who is the murderer.

Difficulties faced by the students	Evidences for the difficulties		Features included in the game to help students overcome the difficulties
	Literature	Our findings from problem analysis	
Students find it hard to parse large amount of text at once	Lawson, 2003	Students said that reading long text is frustrating and demotivating.	Characters - Dividing the complete text as dialogues by different characters forms the first level of chunking.
			Each mystery is divided into different steps of investigation.
Students are not able to refer to different parts of the text when needed	Furberg, 2010		Notebook - no need to go back and forth, reduces memory load
Students find it hard to connect related parts from large amount of text at once.	Lawson, 2003	Students failed to support their claims with correct evidences.	Evidences- Evidences are included as a separate step where students already know the context and are searching only for the evidences
Students find it difficult to present their argument logically	Lawson, 2000; Lawson, 2004	Many students found the correct answer but struggled to support it with correct argumentation	Scaffolding in the form of how to write prediction and observation for a hypothesis
			Explicit prompts for writing predictions, observations and conclusions
Students find it less motivating while reading only text	Lawson, 2003		Points - motivating gaming element

Table 1: Design considerations for the game

Here the player has to fill the following template and then conclude:
Because ______________ and ____________ we can conclude that the murderer is _____________.
The blanks are in the form of a drop down box where the players have to select a hypothesis supported by evidence and then type in the prediction and observation required to test that hypothesis.

3.3 Evaluation

After the intervention students were given a post-test consisting of three problems related to murder mystery, problem related to genotype identification and computer science in the same sequence and format as in pre-test, except that post-test was online. They had to write prediction, observation and conclusion explicitly within a box which pop up when they select any hypothesis. After attempting the questions they had to fill a feedback form which included two open ended questions. Questions in the feedback form were about features of tool which was useful and challenging. Then some of the students were interviewed in a focus interview regarding usefulness of the tool.

Answers of three questions was analyzed and compared with the rubric created. Feedback of students was analyzed. 11 out of 29 students were able to answer all three questions after their interaction with intervention. Most of the students were not specific in writing prediction and observation. Remaining students were not able to solve murder mystery. 8 out of 29 students filled the feedback form.

3.4 Reflections

Based on participants' feedback and their performance in post-test, we inferred some changes to be made in the next cycle of DBR. We observed that some changes are needed as mentioned in Table 2.

4. Conclusion

Considering that hypothetico-deductive reasoning (HDR) is important even in higher education and lifelong education, we designed and developed a game based on solving murder mysteries to teach HDR. Addition of gaming elements have helped in increasing the motivation of the students but there are many changes required to the game as observed from the first cycle of a design based research

(DBR) study. We propose to implement these changes in the second cycle of DBR and evaluate the effectiveness of the game design for teaching-learning of HDR.

Inferences (learning and UI issue)	Changes in next cycle
Boring to read just text	Audio and video format to be included
Confusion in hypothesis and prediction	More scaffolding related to hypotheses testing by prediction and observation
Clicked next without writing prediction and observation	Writing prediction and observation will be made mandatory
Same action (Click on image) to know more about an evidence and to select it as the important evidence	Separate actions for these two tasks
From experts' suggestions	Editable notebook

Table 2: Inferences and changes needed

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Monitoring Gender Participation with Augmented Reality represented Chemistry Phenomena and Promoting Critical Thinking

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Abstract: Currently, augmented reality (AR) is considered as cognitive tool having ability for pedagogical applications to add a part of lack experiment when the phenomenon cannot be imitated in reality. This study aims to investigate effect of AR in chemistry learning regarding gender and design how to use AR for promoting students' critical thinking. In this pilot study, 90 eleventh-grade students in northeastern region of Thailand were recruited to participate with a series of AR represented chemistry phenomena. They were measured perception toward AR technology as pretest and posttest by 21-item perception questionnaire. The results founded that the perception of females and males toward mobile augmented reality (AR) was detected that there was no significant difference between genders in fostering their perceptions to learn chemistry with mobile AR. Both males and females have positive perceptions in chemistry learning experience of acid-based interaction with mobile AR. This evidence implied that learning chemistry with AR could make science more approachable and meaningful for student. As such, the researchers present a proposed instructional strategy of chemistry learning with AR through model-based inquiry process for promoting students' conceptual understanding in chemistry and critical thinking. We believed that the AR-oriented model-based inquiry learning environment could improve the way student learning of chemistry and engage them to criticize and think about natural phenomena meaningfully.

Keywords: Augmented reality, gender, critical thinking, model-based inquiry, chemistry

1. Introduction

In the 21th century, technology was fast changed in the world, and it has become commonplace in advancing the practice of science education because of their ability of go to be change in ways of learning (Srisawasdi, 2012). In case of Thailand, the use of technology-enhanced learning is becoming more popular and increasing in research and development for school science (e.g. Meesuk & Srisawasdi, 2014; Srisawasdi & Panjaburee, 2015; Kamtoom & Srisawasdi, 2014; Piraksa & Srisawasdi, 2014). However, there was no study on the use of augmented reality (AR) in education in Thailand before.

Nowadays, the applications of AR technology have been increasingly gaining attention by researcher, educators, developers, and teachers. AR technology allows users to see a physical space with virtual elements (or information) superimposed on it in real time, and it was developed for several applications in education. Several AR studies in education have indicated the enhancement of students' motivation for learning with the AR technology (e.g., Di Serio et al., 2013; Martín-Gutiérrez and Contero, 2011), and the benefits of AR in learning effectiveness were also reported by researchers. The results of previous researches mainly showed learners' positive attitudes toward AR, whereas AR is participate in the potential for pedagogical applications (Johnson et al, 2011). According to the abovementioned, the aim of this study was to investigate effect of applying AR technology in chemistry learning of acid-base interaction.

2. Literature Review

Augmented reality (AR) refers to technologies that dynamically blend real-world environments and context-based digital information (Sommerauer & Muller, 2014). Recent advances in mobile technologies (esp., smartphones and tablets with built-in cameras, GPS and internet access) made AR applications available for educational system. Several researchers have examined the affordances and constraints of AR for teaching and learning. Today's mobile AR applications leverage science-based education and allow both teachers and students to interact with the combined environment of real- and virtual world for getting better understanding of natural phenomena. The previous result showed its effectiveness in promoting significant learning and it was indeed helpful in promoting learner motivation and willingness to learn from AR system for library instruction was developed (Chen & Tsai, 2012). Fonseca et al. (2014) stated that AR on mobile devices presented an opportunity to visualize different stages of a constructive process, in order to develop understanding of the process and to investigate the relationship among the usability of the tool, students' participation, academic performance after using AR. The results indicated that the use of AR in mobile device could increase motivation of learning and academic achievement, and they both are highly correlated each other. This paper presents the result on gender difference of a pilot study to answer the question: Do the gender differences of secondary school students impact chemistry learning in context of using AR technology?

3. The Pilot Study and Methods

In this study, the researches aim to explore the effect of gender difference on perception toward mobile AR application for chemistry learning of acid-base. The researcher expected that the findings will provide us informative data that can use to design the learning process of model-based inquiry (MBI) with AR for enhancing students' scientific conceptual understanding and critical thinking skills. The participants of this pilot study were 90 eleventh-grade students, including 30 males and 60 females, in a public school in northeastern region of Thailand. They were aged ranging from 16 to 17 years old. All of them have basic skills in using information and communication technology for learning, and they have fundamental skills in using mobiles devices.

In this study, the researchers have constructed a series of mobile AR in acid-base topic as learning material for chemistry education, as illustrates in Figure 1.

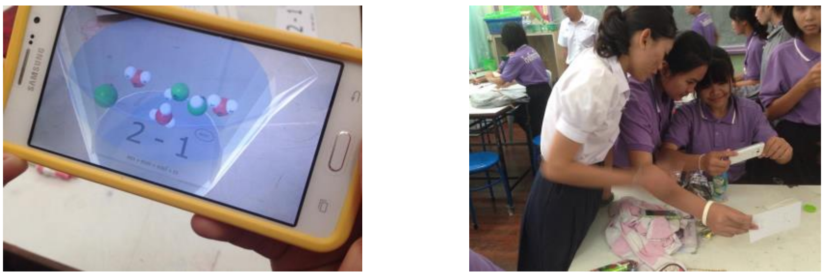

Figure 1. The acid-base augmented reality (AR) of a strong acid as shown on displays. (Left) Students explored learning activity with augmented reality (AR). (Right)

The mobile AR of acid-base has been designed to promote students' understanding of chemical phenomena regarding macro-, micro-, and symbolic representation in chemistry. The AR used in this pilot study contains a particular AR application, two markers that printed with the numbers 2–1, and an exploratory learning activity using mobile device has been created by the researchers. The mobile AR of acid-based contains a numbers of specific substances in a composition of atoms, such as the composition of hydrogen and oxygen atoms representing water molecules. To examine influence of gender gap, a 21-item perception questionnaire was used to measure students' perception toward mobile AR. The items of questionnaire were classified into six subscales: perceived learning (PL), perceived ease of use (PEU), Flow (F), perceived playfulness (PP), enjoyment (E) and satisfaction (S) (Tao, Cheng, & Sun, 2009), developed in Thai version by Meesuk & Srisawasdi (2014). The students were administered the questionnaire, as posttest, for 15 minutes at the end of the exploratory activity.

Based on the obtained data, multivariate analysis of variance)MANOVA(was used to analyze the impact of gender difference on their perception toward mobile AR application for chemistry learning of acid-base.

4. Results and Discussion

The result of statistical analysis of MANOVA shows that there was no significant difference among gender on students' perception toward the mobile AR application in chemistry learning. In details, there was no statistically significant difference for PL, F)1,88(= .748, p = .389; PEU, F)1,88(= 1.830, p = .180; F, F)1,88(= 1.811, p = .182; PPF, F)1,88(= 2.190, p = .142; PE, F)6,83(= 3.176, p = .078; and PS, F)6,83(= .081 , p = .776. The results of this study indicated that there was no significant difference between genders in fostering their perceptions to learn chemistry with mobile AR application. In additions, the finding indicated that both male and female secondary school students have positive perceptions in chemistry learning experience of acid-based interaction with the mobile AR. This is consistent with Plant et al. (2009) and Srisawasdi (2015) that exposures students to technology-enhanced inquiry learning modules did not contribute to any significant gender disparity and both genders improved motivations to learn science after participating in the learning module.

In this study, this evidence of students' perception toward mobile AR application for chemistry learning of acid-base interaction implied that learning chemistry with AR could make science more approachable and meaningful for student. With the aim to promote students' critical thinking skills to learn science, researchers have proposed a design of instructional strategy that may reduce the gender gap and increase students' critical thinking skills in chemistry learning.

5. A Proposed Instructional Strategy of Model-based Inquiry with Mobile AR for Promoting Critical Thinking Skill in Chemistry Learning

Model-based inquiry (MBI) is based on the generating, testing and revising of scientific models. This kind of inquiry-based learning process is different to typical school science investigations. This kind of minds-on inquiry activity is critical to enhance students' learning of scientific knowledge and insight into how scientists work (Abrahams and Millar, 2009). In the MBI classroom, mobile AR will be used to help students visualizing scientific model of invisible chemistry phenomena of acid-base interaction, and inquiry learning process contributes to developing critical thinking skills (Maria T.Oliver-Hoyo, 2003). In the model-based inquiry with mobile AR, scientific model was illustrated as representation that simplifies a system by focusing on key highlights to predict and explain scientific phenomena. The target of modeling includes four elements as student construct models, use models to predict phenomena, compare and evaluate the ability of different models to predict new phenomena, and modify models to explanatory and predictive power (Schwarz, 2009). To promote critical thinking skills, the mobile AR application could enhance acquisition of accurate scientific models and support student comparing and evaluating the different or alternative models and then facilitate them to reconstructing their own models of target natural phenomena. By the way, the researcher hypothesized that the AR-oriented model-based inquiry learning environment could improve the way student learning of chemistry and engages them to criticize and think about acid-base phenomena meaningfully. In the AR-oriented model-based inquiry learning, teacher will give a series of conceptual questions that describe a target chemistry phenomena associated acid-base interaction at the beginning of the class. In the pre-stage of MBI with mobile AR, initial model of the target chemistry phenomenon will be created by students. Next, students will be allowed to interact with mobile AR of acid-based phenomena and then they will be encouraged to share their own model of the chemistry phenomena against other models. After that, they will monitor the initial model and then revise the model being accurate scientific model. In the post-stage MBI, students will present the data and experiment results to others, and synthesis main idea to summarize and answer for the phenomena while teacher will add the complete information of the chemistry phenomena.

5.1 An Example of AR-oriented Model-based Inquiry Learning for Promoting Critical Thinking in Chemistry

In the AR-oriented model-based inquiry learning, teacher will give a series of conceptual questions that describe a target chemistry phenomena associated acid-base interaction at the beginning of the class. In the pre-stage of MBI with mobile AR, initial model of the target chemistry phenomenon will be created by students. Next, students will be allowed to interact with mobile AR of acid-based phenomena and then they will be encouraged to share their own model of the chemistry phenomena against other model

Table 1: An example of Modeling Base Inquiry with Augmented reality (AR).

MBI process	Description of learning process	Illustration
1. Anchoring phenomena	At the beginning of the lesson, teacher will give a series of conceptual questions and introduces the target chemistry phenomenon. Then, students will analyze the phenomenon that may necessitate using a model to figure it out. This is the analysis process of critical thinking.	
2. Construct a model	According to the phenomenon, students will be assigned to create their initial explanatory model of the phenomenon by drawing an image or forming a hypothesis. This is the disposition process of critical thinking.	
3. Empirically test the model	Students will investigate the chemistry phenomenon by interacting with mobile AR integrated with refutation text for visualizing what would happen in molecular level of the phenomenon. This is the interpretation and analysis process of critical thinking.	
4. Test the model against other ideas	Students will be assigned to test their existing model of understanding by presenting and discussing with peers, and sharing ideas for improving the initial model. This is the evaluation process of critical thinking.	
5. Revise the model	Students will be assigned to edit and revise their initial model to fit new empirical evidence and compare both models, initial and revised model, by themselves. Finally, they have to construct a consensus model of the target chemistry phenomenon. This is the evaluation and inference process of critical thinking.	
6. Use the model to predict or explain	At the end of the lesson, teacher will give them another challenge chemistry phenomenon for the whole class. Students will be assigned to use their revised model of understanding to predict and explain what would happen to the phenomenon both observable and molecular level. This is the explanation process of critical thinking.	

After that, they will monitor the initial model and then revise the model being accurate scientific model. In the post-stage MBI, students will present the data and experimental results to others, and then summarize and answer and draw a conclusion for the chemistry phenomena, while teacher will add necessary information of the chemistry phenomena. Table 1 presents the proposed learning process of AR-oriented model-based inquiry learning in chemistry.

5.2 An Example of Refutation Text for Promoting Critical Thinking in Chemistry

Refutation text is a text structure that stimulates readers' misconceptions. The structure of refutation text contains three components: (1) a commonly clasp misconception; (2) a clear refutation of that misconception with an emphasis on scientific explanation; and (3) a cue that alerts the reader to the occasion of another conception (Tippett, 2010). For promoting students' critical thinking in chemistry, the mobile AR will be used to visualize scientific model and explanation of the chemistry phenomena for supporting and opposing the misconception of students. Previous research revealed that the use of refutation text can facilitate conceptual growth and produce the change of misconception among students (Mason & Gava, 2007). An illustration of refutation text integrated with mobile AR is presented in Figure 2.

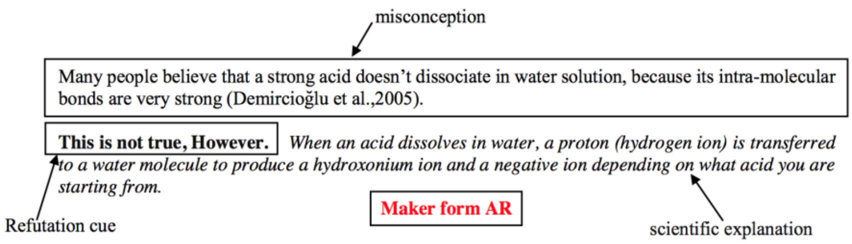

Figure 2. An example of refutation text integrated with mobile AR

5.3 Measuring Students' Critical Thinking

A main goal in chemistry education is fostering students' critical thinking skills. Ennis (2003) stated that the high demand for critical thinking assessment can be bind to the propagation of critical thinking as a goal at all levels of education. To evaluate students' critical thinking in the future study, a rubric-scored instrument developed by Saxton et al. (2012) will be used to measure their critical thinking. The instrument by Saxton et al. (2012) is Critical Thinking Analytic Rubric (CTAR) that included six categories: interpretation, analysis, evaluation, inference, explanation, and disposition. Students will be assigned to complete worksheet for each lesson and then the CTAR will be used to analyze their critical thinking during chemistry learning. The researchers hypothesize that students' critical thinking may be promoted by the pedagogy of model-based inquiry learning with refutation text integrated AR.

6. The Future Study

As the instructional design of AR-oriented model-based inquiry learning in chemistry, the results of this pilot study will be applied to design a series of learning activity for implementing with secondary school students in northeastern region of Thailand. In further study, the combination MBI pedagogy and mobile augmented-reality (AR) technology will be used to leverage students' conceptual understanding, induce cognitive mechanism of conceptual change, and also promote critical thinking skills. For the promotion of critical thinking, a series of fundamental cognitive process including interpretation, analysis, evaluation, inference, explanation, and disposition (Saxton et al., 2012) will be used to investigate students' critical thinking in chemistry learning of acid-base. The study participants comprise of two groups, a control group and an experimental group. In the future study, the experimental group will received AR-oriented model-based inquiry learning while the control group will received regular inquiry learning. The research hypothesis is that the AR-oriented model-based inquiry learning environment could improve students' conceptual understanding, induce cognitive mechanism of conceptual change, and promote critical thinking better than regular inquiry learning.

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Design of TEL environment to develop Multiple Representation thinking skill

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Abstract: Multiple Representation thinking skill is one of the important skills for problem solving in Engineering domain. In this paper, we describe learning activities to develop multiple representation thinking skill in TEL environment. We proposed the learning activities like Decision Making Task Questions, Simulative Manipulation, and Guided Constructor in TEL environment to develop multiple representation skill. We conducted a post-test quasi-experiment to test the effectiveness of the learning activities developed. Quantitative results indicated that the activities are useful and that the mean ranks for the experimental group are significantly ($p<0.001$) higher than control group. The pedagogical framework is emerged from the steps followed to design the learning activities for MR.

Keywords: Multiple Representations, sub competencies, metacognitive processes

1. Introduction

Engineering students should be prepared to demonstrate pan-domain thinking skills (Mishra, Koehler & Hendrickson, 2011) such as problem estimation, problem posing, modeling, system thinking, and design thinking along with content knowledge. Thinking skills are cognitive processes that human beings apply for sense-making and problem-solving (Beyer, 1988). Multiple representations thinking skill is one of the important skills which are recommended for problem solving. Students should be able to mentally represent the constituents of problems to solve problem successfully (Jonassen, 2000). Multiple representation skill is defined as the ability of learners to encode appropriate information based on domain from given representations, select or construct appropriate representations for given problem and identify link between two representations (Ainsworth, 2006). Even though multiple representation skills are important students are not able to demonstrate these skills while solving the problems. Learners find it difficult to prepare these representations, they cannot identify similarity and discrepancies in representations and they cannot translate between different representations (Ainsworth, 2006)

In recent years, researchers have addressed the problem of teaching multiple representation thinking skills by developing technology enhanced learning environments by utilizing the affordances of modern information and communication technologies (ICT). They developed simulation based learning environments to teach multiple representation skill. Simulation based learning environments are designed to support learner to make correct relation between different representations (Ploetzner, et.al, 2009). Dynamically linked representations (van der Meij and de Jong, 2006) are designed to help students to relate different representations. These learning environments are mainly available at K-12 level and for science education. The learning environments to teach multiple representation thinking skills are not reported at tertiary level especially for engineering education.

The research goal of our paper is identification of learning activities in technology based learning environment to develop multiple representation skill among engineering graduates. In this paper we report the design and evaluation process of learning activities for multiple representation thinking skill. We designed learning activities for an Electronics Circuits course, which is part of all four-year undergraduate engineering programs in Mumbai University, India. Content for this study is selected from topic of BJT applications.

2. Process to design learning activities for multiple representation thinking skill

2.1 Identification of instructional strategies to develop MR

The first step of design process was to identify measurable learning outcomes (backward design-Wiggins & McTighe, 2005). We characterized multiple representation thinking skill in terms of measurable competency and then operationalized MR competency into measurable units. These measurable units are referred as 'sub-competencies' (Mavinkurve &Murthy, 2012). Sub-competencies are identified through content analysis of experts' problem solutions. Multiple representation competency is operationalized into the following sub-competencies: Students should be able to 1) construct valid representations for given problem (MR1); 2) Identify consistency between the representations (MR2); 3) apply representations to solve problem (MR3).

The next step of design process was to decide the learning activities to help learner to attain these sub-competencies. In order to attain these sub competencies learner should be able to carry out the set of processes (Ainsworth, 2006). We identified these processes by applying qualitative content analysis method. We analyzed expert (N=5) problem solutions to know the processes to be performed to attain the sub competency. The problem given to expert is "*1mV signal is applied to the amplifier to get 1V output. The frequency range of signal is 100Hz to 100KHz.Draw suitable circuit, waveforms, using circuit calculate values of circuit components.*"

We first coded the steps of problem solving based on actions taken by experts. For example, the statement "Draw a circuit of two stage BJT-FET amplifier for given application" falls under MR1 sub-competency and decision is taken for identification of appropriate representation. The code assigned to this action is 'Decide representations'. When these codes are examined it was found that some of the actions can be categorized under common heading. For each sub-competency of MR such types of actions were frequently seen. Common actions were clubbed together into category. It was found that for "MR1-construct valid representation" valid representations need to be identified and then drawn correctly. In order to achieve this desired outcome decision need to be taken based on conceptual understanding. Similarly for MR2-"Consistency between two representations" link between two representations should be decided based on concepts. Students will be able to decide connectivity between the representations based on their conceptual understanding. Both these actions require decision making in different conditions. For both these sub competencies decision task was clubbed into decision making category.

We found that for each category emerged from content analysis a regulation of thinking process is required. Monitoring and regulation of thought processes to ensure effective and consistent learning process is referred as metacognition (Schwartz, 2009). Hence we defined these categories as metacognitive processes (Biswas et.al, 2013). For sub competency of 'MR1-construction of valid representation', we found that experts apply decision making and they construct accurate representations. Metacognitive process of decision making and drawing consistent constructions is required for sub competency of MR1. For 'MR2- identification of consistency between representation 'expert decide the common and supporting points between the representations. This is decision making process. They establish link between the two representations based on domain knowledge. This metacognitive process is referred as complementary thinking (Ainsworth, 2006). For sub competency of 'MR3-Application of representations to solve problem', decide part of representation useful in problem solving and implement the solution process based on selected representation. This need decision making as well as concept integration. The main metacognitive processes identified from experts' solutions to attain MR are decision making, concept integration, construction of representation and complementary thinking.

Decision making involves an iterative series of divergent-convergent thinking in which students need to generate many options based on the set of information available, evaluate them based on domain knowledge expertise (Gresch, 2012). Concept integration process expects learner to select appropriate pieces of information based on domain knowledge (Chen et.al, 2011). Complementary thinking metacognition process (Ainsworth, 2006) expects learners to create referential connections between the corresponding elements to construct coherent knowledge structures (Seufert, 2003). For example in circuit problems students should be able to create connections between the components values and waveform parameters which will help them to understand function of circuits or application of given circuit. Drawing of consistent construction metacognitive process expects learners to select correct elements, arrange these elements or connect these elements to make meaningful constructions (Zacks & Tversky, 1999).

Our goal is that the learning activities should be able to trigger these metacognitive processes by incorporating appropriate instructional strategies (Zimmerman, 2007). We reviewed research work on learning science principles and instructional strategies to find the recommended strategies for each metacognitive process. Decision making can be triggered using series of deep reasoning questions (Aurisicchio et al., 2007) as well as providing options for selection. Decision making process can be triggered using formative assessment in which series of deep reasoning questions were developed at decision step and feedback provided to guide learner for self-monitoring to aid decision process (Mavinkurve & Murthy, 2014). Concept integration is triggered by providing guided experimentation opportunity to learners (Mavinkurve &Murthy, 2014). Dyna-linked multiple representations (concurrent changes over time) with guided questions help learner to make connections between two representation (Van der Meij and de Jong, 2006) to develop complementary thinking process. Learner generated drawing (Van Meter & Garner, 2005) is recommended strategy for helping learners to construct representations. In this strategy learners are provided with key elements of constructions and guided questions are provided to connect the key elements for developing appropriate constructions.

2.2 Learning activities based on instructional strategies of MR

The instructional strategies identified in previous section are implemented through learning activities of TEL environment. In order to realize the instructional strategies within the TEL environment, we use instructional scaffolding (Bull et.al,1999) as a base to design the learning activities. Instructional scaffolding is two-way interaction between the learner and the learning environment in such a way that the learner is actively engaged in the learning activities. Interactivity design principles (Mayer, 2009) are applied while designing learning activities to ensure two way process of instructional scaffolding.

We created learning activity implementing formative assessment for decision making using guided activity principle and feedback principle. Learning activity that implement the formative assessment strategy is referred as *Decision Making Task Questions (DMTQ)*. DMTQ is a conceptual question in which various choices are given to students to include all plausible decisions related to the question. For each choice, feedback is designed considering feedback principles of effective feedback. Feedback works as prompt in decision making process which guides students to reasoning of wrong answers and pointer to correct answer. We designed *Simulative Manipulations* as a learning activity in TEL environment to provide experimentation opportunity to students. We created Simulative Manipulation using guided activity principle. In Simulative Manipulation, students are allowed to select different parameters and changes are shown as graphs or waveforms. Feedback is provided in the form of text or question prompt.

Table 1: Steps to develop learning activities for MR competency

Sub competency	Expert actions	Metacognitive processes	Theoretical Basis		Interactivity Design principles (to operationalize strategy to TEL environments)	Learning activities
			Learning science principles	Instructional Strategies		
MR1-Construct representations-	Apply concepts for decision making	Decision Making	Planning, monitoring and evaluation Self-regulations	Formative assessment question and feedback	Guided activity	DMTQ

We used feedback principle to design feedback of Simulative Manipulation (SM). SM essentially included simulations of graphs or waveforms based on various input values. Theses simulations are dynamically linked followed by guided question to help learner to make links between the corresponding constituents of representation. We created 'Guided Constructor' learning activity to implement strategy of learner generated drawing .In this activity the key elements of constructions are provided as tool box. This tool box guides the learner for selection in construction process. Learners are guided through the conceptual questions and feedback for connection of key elements. Formative assessment strategy helps learners for verification of accuracy of final connections. Table 1 shows the steps of development of learning activities for MR1 sub competency.

3. Learning material for analog electronics to develop MR

We selected concept of BJT operating regions and its application as switch. Fig. 2 shows an example of a DMTQ learning activity which directs user to decide the relevant representation for given problem.

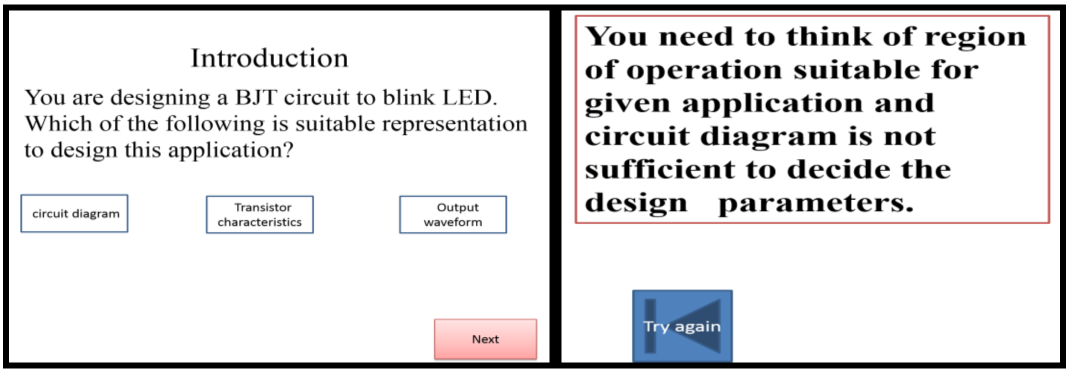
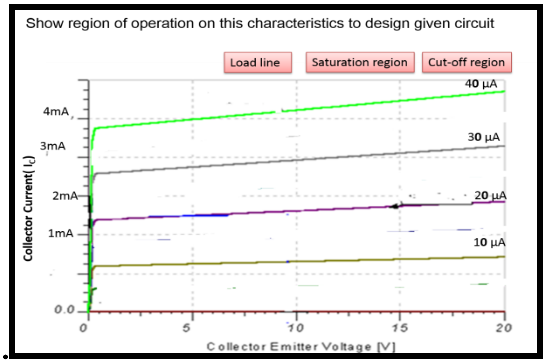


Fig 2. DMTQ *learning* activity for Multiple Representation

Guided constructor activity contains the tool box of key elements such as load line, saturation region, cut-off region as shown in fig 3. Guided questions are provided to help learner to use these key elements to draw constructions and mark relevant labels of construction.

Fig 4 represents simulative manipulation learning activity in which we showed two representations such as circuit diagram and load line characteristics. When learner will vary values of resistor (RB) he/she will be able to see changes in load line characteristics and switching conditions of LED.



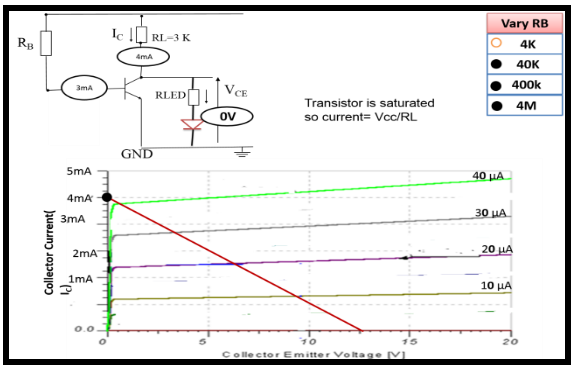


Fig 3. Guided Constructor Fig.4.Simulative Manipulation

4. Learning effectiveness testing to develop MR

4.1 Methodology

We conducted a two group post-test quasi-experiment to test the effectiveness of the Learning activities developed for MR thinking skill.

Sample: Our sample consisted of students from 2nd year Electronics engineering (N=53). Students had some familiarity with the content in the visualization, as they had learnt it in the theory course on the same topic. They were also familiar with using ICT materials.

Procedure: Students were randomly assigned to two groups. The experimental group consisted of 27 participants and the control group had 26 participants. The equivalence between the two groups was tested on basis of their previous semester's grades and no significant difference was found between them ($t=0.14$, $p=0.44$). Two sets instructional materials on the same topic were developed. This experiment is conducted in teacher driven mode i.e. teacher used learning material to teach the topic of BJT application as switch. For experimental group teacher used TEL based instructional material to explain concept of transistor switching. Instructor showed DMTQ and asked students to write their answers and then showed feedback for each selected answer. In control group PPT slides with same diagrams, concepts are applied. But students were not given questions instead instructor explained them which is correct representation why is it a appropriate representation etc. Students in both groups were taught by same teacher for 30 minutes, after which they attempted the post-test. The test was based on application of transistor as switch but the application was for development of digital test signal was given in post-test.
Instrument: To assess the development of students' multiple representation competency (and sub-competencies) we used assessment rubrics, which had a 4-point scale: 0-Missing, 1- Inadequate, 2-Reasonable but needs improvement, 3-Good. Each rubric item corresponded to one sub-competency (MR 1-3).For e.g. In order to assess MR1 the target performance level was described as constructions are valid as per problem requirement and all primary and secondary details are present in the constructions. These rubrics were validated prior to the experiment. Inter-rater reliability testing was found to give 94% agreement between 3 instructors.

4.2 Results

The scores on the post-test are ordinal data; hence we used a Mann-Whitney U-test for analysis. The mean ranks for each sub-competency for the two groups are shown in Table 2. The results show that the mean ranks for the experimental group are significantly ($p<0.001$) higher in each sub-competency. We inferred that learning activities proposed in our study helped learner to develop MR competency for topic of BJT application

Table 2: Comparison of experimental group and control group MR sub-competency scores

Sub competency	**Group**	**N**	**Mean score**	**Mean Rank**	**z**	**p**
MR1	Control	26	0.88	17.04	4.59	<0.01
	Expt	27	1.85	36.59		
MR2	Control	26	0.26	16.52	4.83	<0.01
	Expt	27	1.51	37.09		
MR3	Control	26	0.26	17.79	4.25	<0.01
	Expt	27	1.25	35.87		

5. Conclusion and future work

We focus on teaching of multiple representation competency through TEL based learning environments. In this work we characterized MR into measurable competency which is further operationalized into sub-competencies. We developed learning activities of TEL based system to trigger essential metacognitive processes required to attain MR sub competencies. We proposed the learning activities like Decision Making Task Questions (DMTQ), Simulative Manipulation(SM), and Guided Constructor (GC) in TEL environment to develop MR. In this paper we started with sub competencies of MR and identified the metacognitive processes applied by experts to attain sub competencies. We then reviewed literature on learning science principles to find the learning strategies to trigger these metacognitive processes. We then implemented these strategies into learning environment using Interactivity Design principles.

A pedagogical framework is emerged from the steps we followed to develop learning activities of MR. We tested these activities in instructor driven mode; it is required to study effectiveness of these activities in self-learning TEL environment. Quantitative result indicated that the activities are useful but how they help learner in MR development process need to be investigated. We plan to conduct student's problem solving interviews once they learn through our system and will find the correlation between the learning activities designed by us with development of MR thinking skill.

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Exploratory Factor Analysis for the Survey of Epistemic Beliefs for Discipline-Based Knowledge Creation

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Abstract: The study of personal epistemology has been very much confined to the dimensions of nature of knowledge and nature of knowing. Given the technology driven knowledge society that we face today, it is necessary to cultivate knowledge creators among 21[st] century learners. This study proposed to study personal epistemology from the perspective of knowledge creation. A new questionnaire the survey university students epistemic beliefs for discipline-based knowledge creation was crated. Through exploratory factor analysis and internal consistency analysis, the survey was found to possess construct validity and good reliability. This new questionnaire can be the basis for a range of new studies on personal epistemology.

Keywords: Epistemological beliefs, exploratory factor analysis, discipline-based

1. Introduction

Research in personal epistemological beliefs investigates one's belief about the nature of knowledge and knowing. This field of study within the broader context in educational psychology was initiated by Perry's (1970) investigation of Harvard male students' stage like progression in their epistemological beliefs. The students were interpreted to develop through four major stages which are progressively the dualist, multiplist, relativist and committed relativist. The nature of knowledge was correspondingly seen as progressing from either right or wrong to the stage where there are legitimate multiple views; subsequently to a stage of all claims are relative and thus there isn't absolute right/wrong; and finally to committing to a personally held conviction about knowledge without having absolute objective proof. These qualitative interpretations have been further strengthened by later researchers (for example, Belenky et al., 1986; King & Kitchener, 1994).

Building on these earlier work, Schommer (1990) initiate the quantitative approach of researching personal epistemology. She created the first epistemological belief questionnaire and discovered that students' epistemological beliefs are associated with their reading comprehension. The dimensions of epistemological beliefs in the questionnaire were beliefs about the Certainty of knowledge (i.e. whether knowledge changes over time), Simplicity of knowledge (knowledge as isolated bits to integrated concepts), Source of knowledge (whether knowledge are from experts and authority or from within oneself through observation and reason), Quick knowledge (learning as happening quickly or not at all) and Fixedness of knowledge acquisition (learning ability as fixed at birth to life-long improvement) (see also Schommer-Aikens, 2002). The inclusion of quick knowledge and fixed learning ability has been questioned as they are dimensions of learning beliefs rather than epistemological beliefs (Hofer & Pintrich, 1997). Nonetheless, Schommer inspires many researchers to develop quantitative questionnaire (see for example Chan & Elliott, 2004; Schraw, Bendixen & Dunkle, 2002). Subsequent quantitative studies reveal more influences of epistemological beliefs on constructs associated with internet-based learning and self-regulated learning (Stromoso & Braten, 2010); students' learning approaches and academic achievement (Cano, 2005); students' performance on resolving controversial issues (Mason & Boscolo, 2004) and learning targeted at creating conceptual change among students (Qian & Alvermann,1995). Generally, sophisticated epistemological beliefs that see knowledge as uncertain and knowing rely much on personal sense making are associated with good learning practices such as deep approach to learning.

The interest to study Asian students' epistemology emerged around the turn of the century with Chan and Elliott (2004) creating a questionnaire based on Asian context. Earlier attempts using Schommer's questionnaire have raised many questions about its construct validity for the Asian learners (see Wong & Chai, 2010). Recent research includes Chai, Deng, Wong and Qian's (2010) study of China undergraduates' general epistemological beliefs and their scientific epistemological beliefs. These authors surface that the undergraduates' epistemological beliefs are associated with the disciplines they are studying. Undergraduates from discipline associated with the hard sciences are more likely to adopt an objectivist epistemological stance while their counterparts from the social sciences or humanities are more inclined towards relativist stance.

An important gap in current research on personal epistemology that has been surfaced is the lack of inclusion of wider consideration of knowledge itself. Wong and Chai (2010) pointed out that current research in personal epistemology seems to be confined to the traditional the Greek word *episteme,* which is equivalent to our current understanding of scientific knowledge. They argue that *episteme* in early Greek literature are commonly contrasted with *techne* or art/craft and *poiesis* or making/inventing/transforming. Thus, they suggested that a more adequate grasp of epistemology today might have to incorporate elements of *techne* and *poiesis*. Their suggestion seems to correspond with Cross's (2007) proposed realms of knowledge as Sciences, Humanities and Design. Tsai, Chai, Wong, Hong and Tan (2013) has also proposed that it is important to foster design epistemology among today's learners as they consider design-oriented epistemological outlook as critical for the 21st century knowledge society. The key challenge posed by the 21st century knowledge society on education is to cultivate workers in the knowledge society capable of creating usable knowledge leveraging on the meaningful use of technology, and not just knowledge that are governed by academic interests concerning the "truth" (Bereiter, 2002). In this light, current research on personal epistemology is apparently in need of means to assess students' epistemology that are associated with their view of creating knowledge rather than acquiring knowledge. In other words, current quantitative research of personal epistemology seems to be confined to understanding knowledge as scientific knowledge and the dimensions of epistemology studied are about certainty of knowledge and source of knowledge. This paper adopts a radically different stance to the study of personal epistemology that sees knowledge as dynamic creation of *episteme, techne and poiesis.* In this sense, knowledge is definitely uncertain and created by self (likely in the context of communities of practice), through the employment of different disciplines and transdisciplinary methodology. This study is an initial attempt by the authors to create an instrument to investigate if the learners in the 21st century are able to discern the various knowledge creation traditions they have been exposed to through broad base education.

2. Method

2.1 Participants

Participants (N=250) comprised of university students from three universities in Taiwan. The students were from a diverse range of background including account, business management, education, engineering and social sciences. There were 110 male students. There were 87, 47, 48, 30 year 1 to year 4 undergraduate students respectively and 38 postgraduate students.

2.2 Materials

An 18-item questionnaire was designed by the authors who were trained in different majors, namely literature, science and technology. Three dimensions of discipline-based epistemological beliefs were studied including scientific knowledge creation (SKC), artistic knowledge creation (AKC), design oriented knowledge creation (DKC), with six items in each factor. The authors brainstormed and discussed their discipline-based knowledge creation practices and formulated items that represent the practices. The 18 items were then subjected to review by a philosopher and an education professor before being pilot tested with an initial group of (N=20) university students for item clarity. Each item required respondents to indicate via a 7-point Likert scale the degree to which they found they are agreeable (1 = Strongly disagree to 7 = Strongly agree).

3. Results

3.1 Exploratory Factor Analysis

Principal Axis Factoring with Varimax rotation of the data extracted three factors of 14 items with factor loading of .50 and above (Please see Table 1). Kaiser-Meyer-Olkin measure of sampling adequacy was .88 and Bartlett's test of sphericity was significant (χ^2 (91) = 1258.12, $p < .001$). The total variance explained was 58.1%. The overall internal consistency of the all 14 items was 0.87. Individual factor Cronbach Alphas were 0.72 (SKC) , 0.79 (DKC) and 0.83 (DKC). Two items from SKC and DKC were removed due to insufficient factor loading. The mean scores and standard deviations of the 3 factors were M=5.32 (SD=.88), M=5.75 (SD=.79), 5.82(SD=.72) for AKC, DKC and DKC respectively.

Table 1: Exploratory Factor Analysis

	AKC	DKC	SKC
A3 Artistic creation requires professional experiences to represent social cultural phenomenon	.786		
A4 Artists express deep human experiences through creative thinking	.754		
A2 Artists create artifacts that can awake deep aesthetic experience among its audiences.	.711		
A1 Artistic thinking is focused on transforming subjective experiences into the art forms that can create empathic experiences.	.650		
A5 The knowledge quest for the arts is associated with inquiry about social cultural phenomenon	.650		
A6 Artists give meaning to the artifacts through innovative use of medium	.603		
D5 the designer's thought are focused on finding corresponding solutions for the problem.		.805	
D4 Designers approach the problems they are concerned with from various angle to find possible improvements.		.742	
D6 Designers seek to create meaningful solutions to complex real world problems.		.663	

D3 Designers usually produces many ideas to explore possibilities.		.649	
S1 Scientists develop explanation of natural phenomenon through analytical thinking.			.789
S3 The methodology of scientific research is reliance on certain degree of objectivism.			.703
S2 The creation of scientific knowledge is dependent on experiments.			.673
S5 Scientists construct theory to explain causal relationship.			.590
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization. a. Rotation converged in 5 iterations.			

Discussion

The main goal of this paper was to design an instrument that can be used to explore college students' epistemic beliefs concerning knowledge creation from three generic disciplines, namely, natural science, human science, and design science based on Cross (2007) and Tsai et al (2013) proposal. The results support that the newly design instrument possesses adequate construct validity and reliability for future studies in personal epistemology. The newly designed instrument offers a useful measure for assessing students' disposition for knowledge creation rather than being confined to earlier instrument that measured the certainty of knowledge and source of knowledge (see Schommer, 1990; Chan & Elliott, 2004; Chai et al., 2010). The new instrument may help to provide some possible explanations concerning how students with different majors see and work with knowledge in a very different fashion. It may also be used to assess how students understand different forms of knowledge creation. The mean scores obtained for this study indicate that students seem to understand the scientific ways of knowledge creation more than they understand the design-oriented knowledge creation and artistic ways of knowledge creation. Follow up qualitative studies is necessary to unpack the results.

As we are entering into a knowledge society that highly values collaborative knowledge creation supported by advancement in technology, there is also a corresponding demand for universities to educate and cultivate more creative knowledge workers with competencies to address 21st-century societal, economical, and environmental problems. To this end, it is essential for educators to have a clear understand of students' epistemological beliefs and dispositions so as to better help them develop their creative potentials for identifying and solving future problems. The questionnaire designed in this study serves as a useful tool in helping us understand the different epistemic views students from different disciplines may possess. The design of this instrument also has implications for educators' designing more innovative pedagogy which targets to help foster creative 21st-century competencies among students' with different disciplined backgrounds. It may be used to assess pre-and-post intervention changes in epistemic beliefs among the students and also cross sectional studies to map out the development of students' epistemic beliefs in knowledge creation. Future studies will further validate this instrument using a larger pool of participants for sustained improvement.

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The Relationship between Senior High School Students' robotics and 21st century learning

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Abstract: The main purpose of this study investigates the relationship of 21st century learning for senior high school students in robotics learning. There are 28 sophomores in senior high school as the participants to attend the study. The questionnaire is the way to investigate the 21st century learning, which includes 5C (collaborative learning, critical thinking, meaningful use of information and communications technology (ICT), problem solving, self-efficacy), the robotics learning self-efficacy, and the learning beliefs. There are two goals in this study. Goals find the differences between the collaborative learning and cooperate learning, which affects students' self-efficacy and 21st century learning in robotics learning.

Keywords: Robotics learning, 21st century learning, collaborative learning, robotics learning self-efficacy

1. Introduction

1.1 Robotics Learning

Robotics Learning is a complicated integration to many individual courses, such as electronics, electrics, machinery and computing element (Hiroyuki, 1999). Seung Han Kimand & Wook Jeon (2006) indicates the robotics learning is valued practicing tool in mathematics and engineering, since the learning engages in diversity contents.

Comparing to other technologies, many researchers found that the robotics learning can help student connect with the real world when they learn the courses (G. Loewen et al., 2011). Robot is not only a toy, but also a tool for learning (EZF Liu, 2010). Around the decades, robots apply for various curricular, such as language program, mathematics, and cooperative learning (W.I. McWhorter & B.C. O'Connor, 2009). In addition, robots can create a pleasure and meaningfulness for students to experience the learning, so the robotics learning is a crucial trend in the next generation for technology education.

1.2 Self-efficacy

According to the social cognitive theory, psychologist Bandura (1977) defined self-efficacy is one's belief in one's ability who will success in a situation, increases the confidence to achieve the goals, and affects one's thinking and mood (Bandura, 1994). The self-efficacy insists four main elements to develop (Bandura, 1997). Firstly, the mastery experience is from passed succeed or failure experience. Secondly, the vicarious experience: persuading self as others can solve same problem, and improving self-efficacy. Thirdly, the verbal persuasion: persuasive language can make self to believe one's ability and succeed achievement. Lastly, the physiological and effective states: one involves into a specific situation. Physiological and effective states will evaluate self-efficacy.

In engineering education, self-efficacy has been proofed a crucial reason in learning motivation (Ponton. M et al., 2001). Consistently, the study will discuss the robotics learning has different self-efficacy in different groups.

1.3 21st century learning

In 2012, National Research Council of the National Academics of Science aimed the learning essential definition of 21st century learning. The robotics education is the theme of this study. Collaborative learning, critical thinking, creative thinking, problem solving, and meaningful use of ICT are the key factors in this study. The 21st century learning emphasized learning activities as problem-based learning (PBL). The theme of learning and the design of learning environment should integrate into learners' daily life. It will help learner solve problems in real life. Learners can also understand the theme of learning deeply. It will lead learners to solve problems through collecting information, knowledge exploration, interpersonal interaction.

1.3.1 Collaborative Learning

Slavin (1985) indicates that collaborative learning is a structural and systematic teaching strategy. In collaborative learning, teachers assign students who have different skills, gender, and ethnic background into different groups. Through group learning, sharing, peering suggestions and undoubtedly, students can engage in the structural teaching, discuss in the groups, and gain award from teacher. The result of collaborative learning is efficiency than traditional learning (Tsay & Brasy, 2010).

In teaching of collaborative learning, each group includes more than three students to achieve the learning goal. Each student must engage in and work together, and teacher plays a role as a counselor or a promoter (Akinbobola, 2009).

1.3.2 Critical Thinking

Critical thinking is a high level of learning. It advocates the objective collection to find out the evidence, and generalizes the conclusion. Through the conclusion, students should contribute the reasonable reflections for solving problems. From the research of critical thinking, when teachers teach student for evaluating information from internet, teacher should enhance students' critical thinking, and should notice students that they must be cautiously for evaluating information and seeking reasonable explanation. In addition, teacher can quote information from webpages, and students can criticize and make comments for the assignment (Elder, 2002). The instructional theory of critical thinking should involve with the situated learning and learning factors for approaching the practical thinking model, and establishing the critical teaching and the learning theory correspondingly (Paul & Elder,2002).

1.3.3 Creative Thinking

Teachers must pay attention on students' way of thinking and thinking process to teach. Through the teaching strategy, teacher should provide some ideas or ways for students to brainstorm, and listen to each students' distributed thinking for producing creative learning and performance (Feldhusen, 1980). Furthermore, Bahlke(1980) indicates that teachers not only teach for knowledge and solving problems, but they must go through the teaching to enhance students' creativity, since it will help students in the future.

1.3.4 Problem Solving

When facing to the problem, students will go through the solving problem method to solve problem. From the process of solving problem, students can develop a new concept for realizing the problem. When students understand the answer, it can enhance their previous experience knowledge. Ramelli (2012) represents that the solving problem integrates the learning process. Therefore, teachers should prepare some questions of solving problem for each curriculum. Students will gain some abilities of solving problem when they engage in problems.

1.3.5 Meaningful use of ICT

Information and communications technology (ICT) has the text and the image to assist teaching and learning, and the meaningful use includes diverse learning style and teaching technique (Mayer, 2001). In the globalization and information technology era, the informational and communications technology integrates to teaching universally. An appropriated media for teaching will enhance professional development, and enrich teaching contents. In previous research, using the media for teaching can increase learners' learning efficiency (OECD, 2011).

1.4 Collaborative Learning & Cooperate Learning

The concept of collaboration and cooperation are always confused. Both of the concepts define more than two students as a team to achieve the goal, but these two concepts have different interaction. Tu (2004) had been compared the characteristics of these two concepts. Tu found that the cooperate learning is more flexible than collaborative learning, since the cooperate learning is advanced in a team for developing a high level of thinking skill, and promote one another ability for gaining knowledge and learning. On the other hand, the cooperated learning encourages to think out of the based knowledge box. The cooperated learning uses different level to think about the problems, and the knowledge learning sets on the social constructivist model. Since the cooperated learning is teamwork, so some enterprises consider that the cooperated can be practical apply, and also the collaborative learning becomes the trend of teaching gradually. Srinivas (2004) had been defined that the cooperated learning is a way for teaching and learning, since it involves in a group of students who solve problem together, and complete a mission, or create a production. In the research of educational practice, the characteristics of the cooperated learning can intensify the group discussion and creativity.

Tu, C. H. (2004) represents the main points distinguishing collaboration and cooperation:

Collaboration

- Applying the small-group activities as strategies to develop higher-order thinking skills and enhance individual abilities to master knowledge.
- Encouraging the laissez-faire approach for higher-level, less-foundational knowledge content.
- Assuming that knowledge is socially constructed.
- Is applied in colleges.

Cooperation

- Encouraging an explorer approach but in a more structures manner for the foundational knowledge typified in gateway instruction.
- Assuming knowledge is constructed socially, but the methodology of choice is for foundational knowledge.
- Is applied in primary school.

Palloff & Pratt(2005) think if the cooperated activities include entity and virtual, it will promote the reflection of development and critical thinking, and work on knowledge and meaningfulness. The cooperated transforms as a learning course.

1.5 Research Question

- Investigating that the groups of cooperated learning and the collaborated learning. Will it causes the performance of self-efficacy in robotics learning? What are the differences?
- In robotics learning, investigates the groups of cooperated learning and the collaborated learning. Will it causes the difference between the cooperated and collaboration in 21st century learning?

2. Method

2.1 Participants

All participants were invited to complete the two main instruments that aims at robotics learning in self-efficacy and 21st century learning. In Taiwan, male students are more than female students in polytechnic background. Thus, this study has 25 males, 3 female.

2.2 Learning Beliefs

The main purpose of the learning beliefs investigated that the beliefs of learning for students. The scale separated into two aspects, which are constructivists and traditional? The explanation and example are shown as below:

- Constructivists: students can learn by himself or herself. Teachers will help, when students need help.
  Example: learning means students have opportunities to investigate, discuss, and express one's thinking.
- Traditional: Only accept teacher to lead the way of learning.
  Example: learning means students remember teachers have been done with teaching.

Each aspect includes six to seven questions. The scale uses Likert 5 points table 1-5. 1 represents as strongly disagree, and the 5 represents as strongly agree.

2.3 Assessing Participants' Robotics Learning Self-efficacy

The main purpose of robotics learning self-efficacy investigated how students confidence in robotics learning. Scale includes six aspects, which are conceptual understanding, practical work, everyday application, higher-order cognitive skills, social communication, and self-efficacy. The explanation and example are shown as below:

- Conceptual understanding：Measuring students' confidence in their ability to understand the definitions of robotics concepts, laws, and theories.

Example: I can be able to use an appropriated way to solve robotics problem.

- Practical work：evaluating students' confidence in their ability to accomplish robotics activities including skills in both cognitive and psychomotor domain.

Example: I know how to use instruments and materials to build up a robotics practice

- Everyday application：addressing students' confidence in their ability to apply robotics concepts and skills to everyday events.

Example: I can learn the knowledge of robot, and connect to the robot report from media.

- Higher-order cognitive skills：assessing students' confidence in their ability to employ a robotics approach such as robotics inquiry skills, problem solving, critical thinking and other higher-order cognitive skills.

Example: When I have problem in robot, I will think directly, and then produce the way to solve.

- Social Communication：evaluating students' confidence in their ability about how well they can communicate or discuss with others.

Example: I feel free to communicate and discuss with classmates about the content of robot.

- Self-efficacy：evaluate high school students' self-efficacy in learning robotics.

Example: I understand what I learn from robotics course definitely.

Each aspect includes five to night questions. The scale uses Likert 5 points table 1-5. 1 represents as extremely no confidence, and the 5 represents as strongly confidence.

2.4 21st century learning

The purpose of 21st century learning is in order to recognize how students use the key learning ability on robotics learning activities. In this study, the scale of 21st century learning includes five aspects, which are collaborative learning, critical thinking, creative thinking, problem solving, and meaningful use of ICT. The explanation and example are shown as below:

- Collaborative learning: assigning students into groups to discuss, and work together for solving the mission of robotics learning.

Example: When processing the robotics learning, I will work with classmates to complete the mission willingly.

- Critical thinking: students can assess robotics information accurately, and determine what the next step is.

Example: When processing the robotics learning, I will think my learning of robotics is correct or not.

- Creative thinking: students produce different thinking, and brainstorm to build up a robot.

Example: When processing the robotics learning, I can think many new methods to solve the practical problems in robotics.

- Problem solving: When receive problems on robotics course, students will think ways to solve problems.

Example: When processing the robotics learning, I will investigate what the reasons initiate the practical problem in robotics.

- Meaningful use of ICT: Students will use many media materials to record in robotics course.

Example: When processing the robotics learning, I will use computer to record what I learn from robotics course.

Each aspect includes six questions. The scale uses Likert 5 points table 1-5. 1 represents as strongly disagree, and the 5 represents as strongly agree.

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Comparison of students' perceptions of small group discussion in online and face-to-face environments

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Abstract: The aim of this study is to understand students' experiences in online and face-to-face discussion and compare their perceptions towards these two environments. Students from two undergraduate classes (n=208) were surveyed by questionnaires and 30 students were interviewed. The analyses centered around five major aspects – learning, affection, reading and writing skills, critical thinking skills, and efficacy. The results show that the student perceived more positively towards face-to-face discussion than online discussion in all but the reading and writing aspect. The interview data revealed the advantages and disadvantages of each discussion method.

Keywords: online asynchronous discussion, face-to-face discussion, perceptions towards discussion, undergraduate

1. Introduction

Group discussion and small group collaboration has become one of the most common activities in higher education. With support of the Internet and computer technologies, group discussion can be administrated online in conjunction with face-to-face teaching (e.g., Zhan, et al., 2011). There are reported advantages and disadvantages of online asynchronous discussion. For instance, online discussion promoted active learning or self-regulated learning, and it encouraged critical thinking and collaborative knowledge construction (S. W.-Y. Lee & Tsai, 2011a; Vighnarajah, Luan, & Bakar, 2009; Wang & Woo, 2007; Yeh, 2010). However, as online asynchronous discussion become increasingly popular, few studies made direct comparison of students' perceptions and experience between online and face-to-face discussion. Therefore, the purposes of this study are as follow:

- To validate a questionnaire for measuring students' perceptions of online and face-to-face discussion.
- By surveying and interviewing students, to investigate which method of discussion that the students preferred and why.

2. Methods

In this study, we surveyed undergraduate students from two general education courses in the same university in Taiwan. Those two courses were chosen because they used similar class design – using online and face-to-face discussions extensively in addition to the lecture. Additionally, the two courses shared similar subject area, about biology and society. The questionnaire was revised from the Perception of Online Asynchronous Discussion (POAD) questionnaire (Lee, 2013). The original questionnaire includes five aspects, namely, Cognition, Affection, was further divided into two sections – the online discussion section and the face-to-face discussion section. A total of 208 students completed the questionnaires. Because of the addition of the face-to-face section of the questionnaire, exploratory factor analyses and reliability analyses were conducted to validate the questionnaire. Paired-t statistics were conducted to compare the results for the online and face-to-face discussion for each aspect. In addition to questionnaire data, 30 students (15 students from each class) were interviewed at the end of the semester. The purpose of the interview was to further elicit students' perception and experience with both online and face-to-face discussion in order to find confirming and disconfirming evidence for the questionnaire results. Here are the questions we asked for the online discussion. "What is your perceived purpose of online discussion?" "How do you participate in online discussion?" "How do you prepare to participate in the online discussion?" "What kind of attitude did you have towards online discussion when you were taking the class?" "Do you think online discussion is helpful to your learning? If so in which aspect?" "When you compare your experience with online and face-to-face discussion, which one was more helpful to you?" The same questions were repeated for understanding the face-to-face discussion.

3. Results

3.1 Validity and reliability of the questionnaire

For both the online questionnaire and the face-to-face questionnaire, the results of factor analysis showed five factors corresponding to the five aspects in the original design of the questionnaire (Lee, 2013). Item 7 resulted in a factor loading below .40 therefore it was deleted. The final version of the questionnaire consists of 16 items accounting for 69.948% of the variance for the online questionnaire and 76.672% of the variance for the face-to-face questionnaire. The reliability (Conbrach alpha) of individual constructs range from .630 to .892 for the online section and range from .616 to .929 for the face-to-face section. The results show that the questionnaire, including both sections, has good validity and reliability

Table1. Validity and reliability of the PAOD questionnaire.

Item		Online	Face-to-face
Cognition	1	.711	.848
	2	.644	.830
	3	.782	.839
	4	.850	.842
	5	.820	.805
	6	.562	.693
	α	**.892**	**.929**
Affection	8	.615	.570
	9	.751	.885
	10	.811	.778
	α	**.681**	**.716**
Reading &Writing	11	.656	.894
	12	.859	.908
	α	**.630**	**.616**
Critical Thinking	13	.895	.847
	14	.851	.824
	α	**.860**	**.865**
Efficacy	15	.732	.653
	16	.828	.847
	17	.778	.807
	α	**.733**	**.780**
Total	***α***	**.718**	**.777**

3.2 Comparison between online and face-to-face discussion

The results of paired t-test statistics show that statistically significant differences exist between students' perceptions of online discussion and face-to-face discussion in all five aspects. It appears that students perceived that the face-to-face discussion was better than the online discussion in terms of Cognition ($t = -7.902$, $p < .001$), Critical Thinking Skill ($t = -4.249$, $p < .001$) and Efficacy ($t = -10.142$, $p < .001$). The Affection aspect includes reversed items that describe students' negative emotions towards learning. Therefore, the results indicate that students perceived more negatively towards online discussion than face-to-face discussion ($t = 5.954$, $p < .001$). Among the five aspects, students only perceived more highly of online than face-to-face discussion in terms of gaining reading and writing skills ($t = 2.519$, $p < .05$).

During students' interview, we also asked students which method of discussion they preferred overall. Among the 30 students, 18 students answered that they either enjoy participating in face-to-face discussion or feel face-to-face discussion more helpful. Five students preferred online discussion and seven students perceived both methods of discussion were equally good. This result is consistent with the questionnaire findings.

3.3 Qualitative findings in terms of the five aspects of discussion

3.3.1 Learning aspect

Some students indicated that through face-to-face interactions during the discussion, they gained more insights into the discussion topics and understood the topics more deeply. Other students' immediate responses contributed to the efficiency of learning during face-to-face discussion while the low response rate during online discussion made learning less efficient. Also, students mentioned that they had more preparation prior to the small group discussion in the face-to-face sessions (n=8). Nevertheless, students mentioned that both online and face-to-face discussion helped them to gain new knowledge, to see multiple perspectives, and to discuss some value of life. For online discussion, some students (n=6) perceived learning autonomy.

3.3.2 Affection

Both online and face-to-face learning environments were described as interesting and enjoyable. During face-to-face discussion, students (n=10) felt particularly positive towards the opportunities of getting to know other students. During online discussion, on the other hand, students felt more courageous to voice their opinions and felt less restricted by time and location.

3.3.3 Skills

As mentioned by students during the interviews, both online and face-to-face discussion seemed to promote skills for analyzing and synthesizing information and also promote critical thinking skills. Due to the design of the online and face-to-face discussion, students tended to engage in rebuttal or argumentation with other students. The major differences between online and face-to-face discussion can be found in the training of oral representation skills and the in-depth reflection. The small group assignments during face-to-face discussion required students to represent orally, therefore, some students (n=9) mentioned that their oral representation skills improved after the semester. A few students (n=5), however, felt difficult to express their opinions through writing.

3.3.4 Efficacy

In the questionnaire, we asked students' efficacy in terms of satisfaction with their own learning, satisfaction with the peer's performance, and satisfaction with faculty's facilitation. The interview data mostly emphasize satisfaction and dissatisfaction with their classmates. Not only during online discussion, but also during face-to-face discussion, the students felt inspired by other people's ideas emerging in the discussion. However, three students found that face-to-face discussion not only creates positive experiences but also contributed to negative learning experience if the team members did not cooperate well.

3.3.4 Overall preference

When we asked students which method of discussion they prefer, the majority of the students who chose face-to-face discussion focused on the benefits of immediate and quick responses. Although less students preferred online discussion, they appreciated the fact that they can reflect upon the information on the Internet while participating in asynchronous discussion.

4. Implication and Discussion

Although past studies have reported some advantages and disadvantages of online and face-to-face discussion, few studies made direct comparison of the students' experiences with their online and face-to-face discussion. Despite online discussion has become the mainstream of collaborative learning, while students were given the opportunity to participate face-to-face, they may still prefer the latter one. Low and slow response rates and the lack of social interactions remain the issues of online discussion. Some interesting aspects about discussion such as "seeing multiple perspectives," "discussing value," or "feeling inspired by others" were not originally in the survey but were revealed during interview. This can be essential new findings for revising the questionnaire in the future.

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Research on the Normal Students' Professional Development in Self -organized Learning Environment-Taking the Project of "New Class" as the Case Study

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Abstract: Taking the project of "New Class" as the case study, this paper explores the practices of teachers' professional development based on the theory of "Self Organized Learning Environments".This project aims to improve the normal students' professional development by applying the ideas and methods of HCD of IDEO designed by the global design company, and organizes teaching activities design workshops which involved the normal university teachers in experiencing the education value of "students-centered teaching" and the experience teaching methods. This study focuses on the teachers' personal professional development from the perspectives of the autonomy of teacher development and the practices of teachers' professional development.

Keywords: Teachers' professional development; cultivation of normal university students; self organized learning environment

Introduction

In the context of the information age, knowledge and skills are developing rapidly.Teachers not only need to continue to move forward in the depth direction of professional education and teaching, but also requires them to interdisciplinary, extending the breadth of interdisciplinary subject knowledge. This put forward higher requirements to the teachers' teaching ability. Today,if teacher can make an outstanding contribution to education and equal with the social elite with people coming, enjoy the same status and reputation.They must be full-time teachers and their teaching level education should be more comparable with physician education(International Encyclopedia of Education,1990)(Chen-shijian,2007). The key to the success of education reform in teachers, they are the education reform practitioners and innovators. normal university students are the first pre-drilled to teaching skills practice, and that is Teaching Skills Upgrading the most important "exercise."

Teaching skills means "teaching teachers to use the existing theoretical knowledge, solid, complex behavior of the system by teaching practice and formation.It is based on the theory of teaching which includes, in accordance with a certain way for repeated practice or primary teaching skills due to mimic the formation, but also in teaching based on the theory and practice for repeatedly formed, reaching the level of automation of advanced teaching skills, namely teaching skills.Teaching skills are essential teacher education and teaching skills, it made good teaching effectiveness, innovation of teaching, has a positive effect. "

Above all, experts and scholars from the focus on the theoretical research of teacher's professional development, gradually pay attention to the practice of teacher's professional development,self-organizing and diversity, and pay more attention to the teacher in a relatively free and colleagues under the environment of mutual teaching practice efficiency and actual efficiency. Teacher's professional development from the past is only the government and schools to participate in to a third party public welfare organization intervention and evaluation of undergraduate teaching development.

2. Research Questions

Because of the most practice time is organized for the students in their sixth and seventh semester by school, the students are eager to exercise their teacher’s skills early, on one hand, many normal college students think it’s more and more sooner for the recruitment department to find their teachers, the earlier you contact with the primary and secondary school teachers and go into the teaching practical field, the more conducive to the normal students master the teaching skills and have the opportunity to find a suitable job; on the other hand, the training of normal students' teaching skills is a long-term, continuous improvement and optimization process, not overnight "temper". Therefore, the students have an urgent need to establish the self-organized team in normal university, contact with teaching practical field and advance the teaching skills’ training. So, how do the normal students and teachers form a self-organized team? How to develop the teaching skills’ training in the self-organized learning environment (SOLE)? These above two questions are the focus of this article.

The new class project is a teacher self-organized community, through the cooperation of teachers, normal students, the social people who pay attention to education to carry out a variety of workshops and teaching salon, to help teachers improve teaching skills, to solve the problems encountered in teaching, etc. The "new class" program mainly helps the students to develop the teachers' professional quality and mainly focuses on the cultivation of students' teaching practice skill, teaching design and teaching innovation. In this paper, we use the concept of Thinking IDEO which is the world famous design Domain Company and the Human Central Design method to carry out the teaching activity design based on children as the center by the solution of experience teaching workshop.

3. The Self-organized Model of the Normal Students' Teacher Professional Development

3.1 Self-organized Learning Environment Theory

In 2013, the TED Prize winner Dr.Sugata Mitra brings us the innovation concept of learning for children, self-organized learning environment (self-organized learning environments, referred to as the "SOLE"). SOLE is designed to help educators and parents to encourage their children to explore the problem, and they use the natural curiosity to take part in the children's oriented learning(Sugata Mitra,2013). (1) SOLE is an important role in guiding children to think about problems and give them space to think, and it also includes let children know how to ask questions. (2) SOLE consists of several key elements: self-organization, curious, interesting, social, cooperative, peer interest driven, adult encouragement and appreciation are the “catalyst". (3) Four ways of supporting the SOLE activity: first of all, the four children and one computer form a group; second, a whiteboard or blackboard is needed to record the inquiry; third, paper and pen for recording notes, easy to end sharing after SOLE; finally, provide a written chest card with their name or other which is easy to identify the helper role, let the children feel funny. (4) SOLE activity process is divided into three steps. First, the problem is raised; second, carry out the investigation; third, review the reflection(Sugata Mitra,2013). Students can self-organize to form a good learning environment, so, the teacher can also carry out the growth workshops in this self-organized environment, and to improve the teachers' professional ability and quality.

3.2.Teaching Skills of Normal Students Practice the Self-organized Structure

The practice for self-organzation of the teaching skills of the normal students is a kind of loose and mutual cooperation mode which is based on familiar with each other by the teacher, the normal student and concerned about education. Under this kind of informal organization, the teacher is mainly based on the interest and the need to participate in the activities. The new class organization structure is divided into three layers: the core team members, the primary and secondary school teachers and the normal students. The core team, with the help of the external think tank, decided to organize the development direction and concrete actions of the teachers. Teachers and normal students formed the group by voluntary pair, through in-service teachers guide the future teachers, pass on their experience to them,and help students about their professional development of teachers. The self-organized model can be formed, and it comes from the needs of both teachers and students. The normal students' needs are that entering the real classroom, participating in the real teaching environment, and contacting children closely to exercise their own teaching ability, to observe the in-service teachers about how to have class, but also hope to be able to accumulate teaching ability, to help them to get better jobs; the teacher's needs is that teachers can work with the normal students to carry out class management, teaching design, class preparation, etc. The self-organized community of the new class satisfys the needs of normal students and teachers, which is the value of the new class. In-service teachers and the normal students formed the mentoring relationship which can move towards to both internal and external school cooperation, stressed the need to learn and practice. The purpose of cognitive apprenticeship is making the students to adapt the real practice by those significant industry teacher-student way or similar activity and social interaction(Gu Linyuan&Wang Jie,2013).

4. the practice case of the normal students' teaching skills in self-organizatied learning environment

The preparation scheme of the student teachers' professional development's self-organization is the experiential teaching workshops which mainly is according to a point of knowledge or a problem, through group collective wisdom and collective action, forming concrete teaching plan, and then inviting teachers to participate in lessons and trial lecture of feedback, the teaching take the design to the real classroom. The research and development experience of self-organization is divided into four steps: participate in IDEO design workshop, research the experience teaching workshop, the internal testing and improvement workshop, and the external application and assessment workshop, shown in Figure 1.

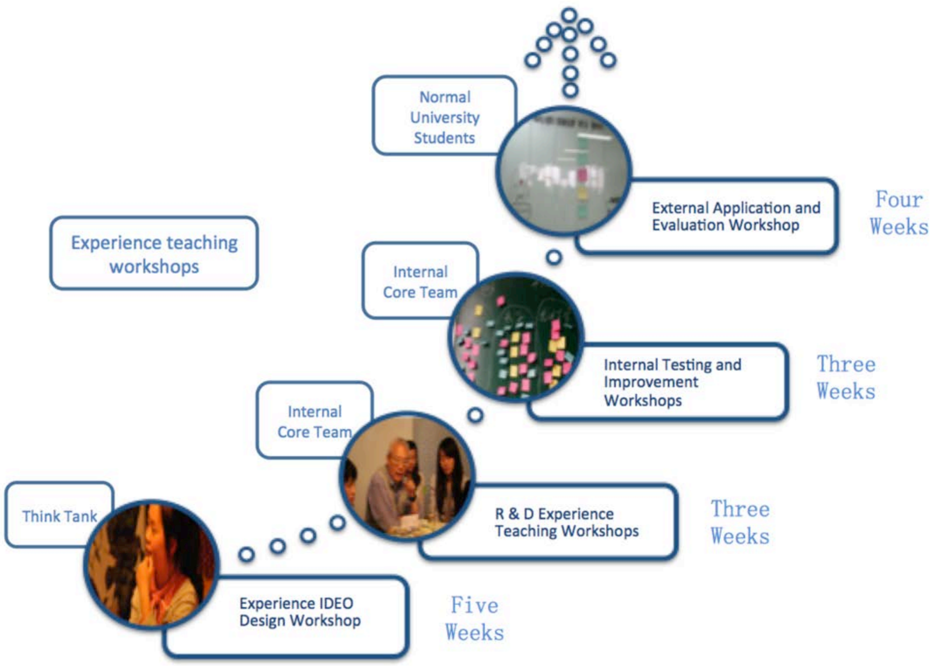

Figure 1. experiential teaching workshop three-dimensional diagram.

4.1. experience HCD design workshop

When participate the global famous design company IDEO's HCD creation workshops, a new class project team and ThoughtWorks company and the Chengdu Super Love education technology company learn a global open course which is human centered design for social innovation course(IDEO ,2015). Adopts the idea and method of “human central design” (short for HCD), and tries to use innovation way to solve the social problems. Throughout the whole course process are studied throughout the material of the network community, Google+, and the combination of off line group practice. The whole activity consists of five workshops, 5 weeks, include: the overview, the creation, the creation of the prototype, and the test piece. Specific content is: to determine social innovation challenges, to collect innovative ideas, to contact the user to carry out social investigation, the team develop brainstorming, to determine 1 to 2 solutions, to conduct user investigation to form a preliminary solution, and finally to test and modify. Weekly workshops choose a fixed place and time, and download and reading and leading manual, select a leader to lead team members to carry out the next workshop and help people prepared the workshop materials in advance at very week, and review the previous weekly workshop. Specific strategies include the notes, design thinking, social investigation, brainstorming, empathy, experiential teaching methods, etc. The core of the HCD workshop is standing the user's perspective, to help him to solve specific problems that he encountered. In the HCD global open course(IDEO ,2015).

4.2.Developing experience teaching workshop

In the research process, we first translated HCD five workshops(human centered design for social innovation course materials), from the perspective of teaching and learning create again, according to the "learner centered" teaching design concept, to meet the needs of normal college students' professional development, to design teaching programs, and then test it. The IDEO design workshop is reformed and polished; it is more suitable for the development of education and teaching. Reconstruction of experiential teaching workshop still have five steps: experience design thinking, determine the teaching challenges, convergence teaching creativity, design teaching program and test it. Through the short period, continuous iteration of the found problem and small steps in the development of the way, continue to test and modify and improve the experience teaching workshop.

4.3. the internal testing and improvement of the workshop

Testing the experiential teaching workshop which is researched before in the internal team, including 5 to 6 teachers and juniors at the department of Science Education in normal college, continue testing and iteration, and form a more perfect, suitable teaching workshop for the normal college students. The internal team of the new class has done three tests of challenges, "how to help 3 to 6 grade children to have more activities of environmental protection very week?", " how to help the 4 to 6 grade children to avoid unintentional injuries?" , " how to help 5 grade students understand the living environment of the earthworm through experiments?". To design a specific solution for the above 3 teaching challenges, and carried on the 3 round of testing, improved 3 editions of the teaching design plan. We find that there are 2 key problems in the concrete practice of the workshop: the positive and initiative of the students in the survey are not strong and lack of the ability of teaching design. For the already exists problems, the team give the active guidance to the normal students who participate in the workshop, and reduce a survey. In view of the weak design capability, we provide a series of design salon and design practice activities to help designer to improve and make up for the deficiencies in this area.

4.4. external application and assessment workshop

After 3 rounds of iterative and polished the experiential teaching workshop is relatively perfect. It began to spread and apply in several primary and middle school teachers in Chengdu, and to evaluate the effect of the application of young teachers and college students. Refer to the practical effect of the case "how to help 4-6 Grade children to avoid accidental injury?”. After the assessment, and then it will be modified and improved.

5. the practical effect of teaching skills of the normal students

In this way, we can meet the needs of teachers and the normal students, especially for the growth of normal students. This way can be evaluated in several ways, the participants' survey, teaching activity design case and network learning community. Through survey interviews, teaching activity design case and network learning community knowledge management data and other research data and marital, the use of "triangle mutual evidence method" is to ensure the reliability and validity of this study. In short, the combination of quantitative and natural research, from the medium and micro dimensions, is to promote the development of research.

5.1 the feedback of the participants’ experience

The normal students through participating in experiential teaching workshop get the opportunity for self-growth, the 74% participants considered their teaching activity design ability have a large promote after participate in experiential teaching workshop. We have a more scientific evaluation of the effect of the implementation of the project through the feedback from the students of 2010 grade and grade 2011 whose majors are science education. Wang Li think, “The new class project has brought a wide range of teachers and school internship opportunities for me, let me diversified know about the possible of the classroom teaching design”. Zhou Dan believes that "when the business friends of the new class critic and lead us, they give us sharp thought, let us clearly know what we don't know". Li Shuangjun, Chengdu Zongbei primary school science education teacher ,issued a feeling, "The new class builds a platform for learning and communication for us and the normal school students, the normal students are very lucky with such a good platform to communicate and grow with a good and experienced teachers, and for 12 years’ experience, my experience told me that the new class can make normal students walk less curving road which need themselves to explore own. "

5.2. teaching design case

By the new class team to design experience teaching workshop cases how to help 4-6 Grade children to avoid accidental injury?", "how to help grade 3 children have more environmentally activities every day? ". We mainly through peer mutual aid to carry out 5 field experience teaching workshop. The first workshop is from the activities named "you write I draw", to understand the design thinking. Then by the way of noting, writing on the note with the issues which they think most 3 concerned, and then expressing their views. Team divided the notes into five categories: natural class, English class, team building, the universe and human, we found that the most concerned issue is "wild escape", so the field of escape theme is formed to the teaching challenges that is "how to help children in grade 4 to 6 to avoid accidental injury?" through collective wisdom. Second workshops are brainstorming: on this subject ' what we know ', ' what we do not know '. Then, through the "I know" are posted by notes; "I want to know" are listed, brainstorm and classify the content. The new class team find experts, teachers, students, parents, etc. from the side and the network in this area to form suitable problems which are understood by the investigation object, in order to facilitate the investigation and get the real answers.

5.3. the knowledge construction of teachers' community

The new class and many schools are cooperated to carry out the teaching and research activities, and to establish partnerships with primary school attached to Sichuan University and Sichuan Normal University, Tongzi Lin primary school, to improve their teaching skills, and carry out platform application research. Teachers in the new class platform application mainly interact by the teacher community, and the normal students elicit the topic by asking questions, in the process of Tower.im discussion, there are 112 participants to discuss 411 topics. Topics focus on four categories: experiential teaching workshop, newclass.org platform development, teaching activities and seminars and teaching cases. The teachers, the normal students, public welfare organizations and other groups are formed a joint force to promote the application of the platform through the online and offline ways, and a large number of teaching cases based on the application of teaching platform are came out. As so far, the newclass.org platform has set up 150 high-quality teaching cases, the number of participated teachers is more than 50, the number of students reached 100 people or more. Offline activities carried out a total of four workshops, four open classes and two teachers Sharon.

6. conclusion

In this paper, we study the growth pattern of the teachers and student self-organization in the New Class, which is a combination of online and offline learning style. but it is also the product of social development for a certain stage. In this paper, the following conclusions are obtained: firstly, to meet the needs of the personal growth of the normal students and teachers is the prerequisite for the existence and development of self-organized community, and it is also the inner driving force of teacher development. Secondly, one of the contradictions in the process of self-organization is how to solve the problem of loose state and efficient cooperation. The research focus on the teaching research by different professional background and subject teachers; this study tries to find out the way to promote the professional development of teachers by combination of the public organizations, schools and teachers, especially in the structure of personnel, it makes a bold practice to try; finally, in the sustainable development level of the teachers' workshop, it is still needed to deeply study the driving and incentive mechanism.

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A Survey on Learners' Technology Acceptance Toward Virtual Self-organized Community

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Abstract: The Virtual Self-organized Community (VSC) has been paid enough attention in educational research, While few study investigate the contributing factors driving undergraduates' technology acceptance to VSC in the perspective of outsider learning environment. This research sampling 65 English majors explored their attitudes toward using WeChat or/and QQ in English study. The results showed that usefulness of WeChat and classmate's support are two significant variables accounting for this technology acceptance. Meanwhile, teacher's support is an acceptable but relative weak contributing factor. To our surprise, the ease of usage and self efficacy have no significant relationship with learners' technology acceptance towards virtual self-organized community. Furthermore, the academic and practical implications of this study are discussed.

Key Words: virtual communities, self-organized, technology acceptance

1. Introduction

Virtual self-organized communities (VSC) with their characters of anonymity, non-authority, decentralization, and diversification (such as tencent QQ and Wechat), are regarded as either extension of real society or independent social system. VSC, allowing each member to express their ideas spontaneously and freely in more convenient and low-cost way, play a significant role in education society, since knowledge sharing is a major goal of taking part in community activities of members (Shih et al, 2006). Virtual self-organized communities foster learners' capability of analyzing, solving the problem as well as ability of innovation thinking in whole learning process. Learners in the virtual community are progressing rapidly and cultivating the collaborative spirit to achieve common development through continuous learning. Therefore, some scholars appeal to colleges to extend the coverage of study in virtual self-organized communities.

Although many research about learners' technology acceptance in virtual communities were investigated in the perspective of usefulness and ease of use, rare studies considered the contributing factors from the perspective of learning environment, such as teachers and classmates' supports. Besides, learners' own perception about their self efficacy is seldom considered, when learners study in VSC. the current research aims to investigate the comprehensive contributing factor of technology acceptance in virtual self-organized communities, which might have a positive effect on extension of technology acceptance theory and reform of informal education.

2. Research background and hypotheses

The appearance and development of VSC came from mass application of internet, which has provided a new circumstance for researching about formation and effect of social rules in an empirical way. It could be not only regarded as a technical phenomenon constructed by network and software technology, but also a social phenomenon constituted by communication and interaction between different people (Hesse, 1995). In view of organization behavior, virtual self-organized communities are social technical systems interactively constituted by organized system and information technology system (Qiu & Tian, 2006), which meet the demands of communication, interaction and cooperation with others who have similar interests, hobbies, experience and recognition in network space by support of information technology. On one hand, this method of communication is simple, fast and convenient; On the other hand, it is unstable and fragile (Li, 2006).

The system self-organized theory has provided solid theoretical basis for virtual social system. Knowledge exchange comes from social exchange, which should be attributed to social attraction. Since, psychological factor plays an important role in virtual community studying, and member's behavior in this process is effected by many psychological activities including conformation, recognition and internalization (Zhou & Lu, 2009). For given above, learners' behaviors is diversified in this context, for example, some commonly play roles as promulgators tend to be active, while others focus on expressing their own opinion independently tend to take part in discussion. Besides some members in common situation acting passively, just play roles as audience and absorbers.

In recent decades, researchers are dedicated in studying the relationship between learners' attitude and their technology usage behaviour. According to Davis's (1989) research, the Technology Acceptance Model (TAM) is comprised by two significant variables, perceived usefulness and perceived ease of use. These two variables are considered as the primary elements to determine use's acceptance. Perceived usefulness refers to user's subjective perception whether a technology application will improve one's performance and productivity when using it. Perceived ease of use is user's belief that use a technology will be easily operate (Timothy Teo, 2009). Many research have suggest that TAM has been adopted as the framework to study learner's acceptance towards virtual online learning, whose results show that the higher the usefulness is, the greater acceptance level is (Ngai, Poon, & Chan, 2007). We thus hypothesize the following.

H1: Usefulness positively effect technology acceptance in VSC.

H2: Ease of use positively effect technology acceptance in VSC.

Self-efficacy refers to an individual's belief in one's capability to carry out a specific task or behavior. The strength of learner's effectiveness beliefs play an important role in whether people will make great efforts to handle given situations. A number of researchers consider self-efficacy as an critical determinant to affect learner's learning cognition or behavior. Higher efficacy expectations can stimulate learner's more study motivation and creation in a particular task. Many research have frequently showed that learners with higher efficacy expectations have greater performance attainments (Bandura, 1991).

H3: Individuals' self-efficacy have positive influence on VSC technology acceptance.

As every knows, comparing to traditional face-to-face class, learning with VSC, such as QQ and Wechat, have no limitation of time and location. The core course is presented based on the virtual learning community, which transfers "class teaching" into "course teaching" and saves unnecessary expenses of teacher as well as increases teaching efficiency, which were favored and supported by instructors (Xiaohua Zhu 2014). Hence, amount of teachers are increasingly advocating expanding traditional class model to virtual learning community. We thus hypothesize the following.

H4: Teacher's support have positive influence on VSC technology acceptance.

The frenquency of user's interactions decide the level of QQ memebership in a QQ learning group. Since QQ group is established by learners who own a similar and particular expectation. Students in the same class would be the largest boby of a QQ group. They can upload or download digital files in VSC with learners of same interest. Therefore, learners can not only share information with members (Blanchard, 2004), but also conduce to knowledge building in virtual self-organized community (Humphreys & Grayson, 2008; Ritzer & Jurgenson, 2010). The support of classmates' social network contribute to learners acceptance toward virtual self-organized community. We thus hypothesize the following.

H5: Classmate's mutual aid have positive influence on VSC technology acceptance.

Given above, the proposed model shown in Fig. 1 focuses on five key antecedents of VSC (Usefulness, Ease of use, Self-efficacy, Teacher's Support and Classmate's mutual aid).

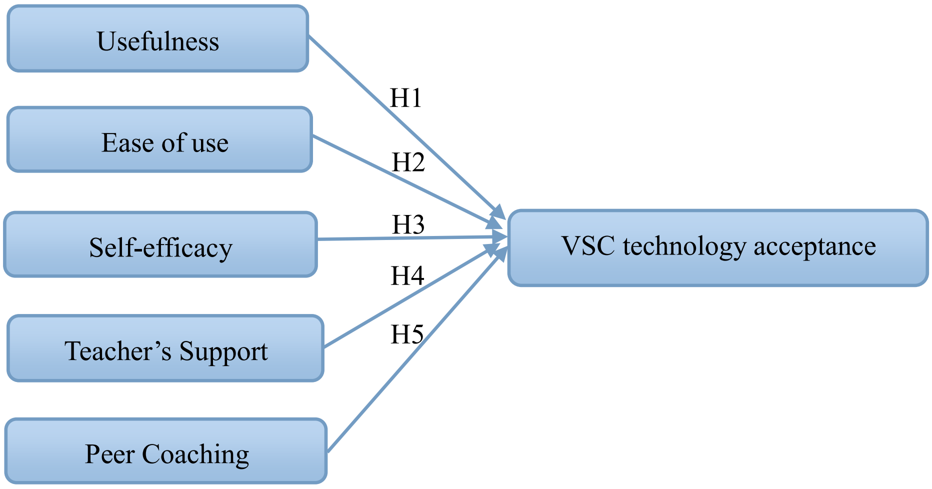

Figure 1. The hypothesized model of learner's ASC technology

3. Methodology

3.1 Participants

The sample for the study was taken from Anhui Jianzhu University and Hefei University to explore the technology acceptance on English study with virtual self-organized communities, like WeChat and QQ. Selected participants were required having experience on learning with VSC based on QQ group or Wechat VSC. As shown in Figure2 learner raise questions about English learning for discussion in QQ group or Wechat group. Afterwards, students in the group are free to voice their opinions on the question. After discussion among students, the problem would be solved if they all come to an common conclusion. Otherwise, they can ask teacher for help so that the problem can be settled precisely and quickly. A total of 70 questionnaires were distributed to students who participated in virtual self-organized communities. Although the number of participants was limited, the results of Table1 indicated that this sample is relatively representative.In order to maximize the response rate and validity, are survey questionnaires were collected on the spot, and some small gifts were provided to the sample students with the survey. Finally, all surveys were returned, 5 of which were excluded due to the uncompleted information in questionnaire and the percentage of valid surveys is 93%.

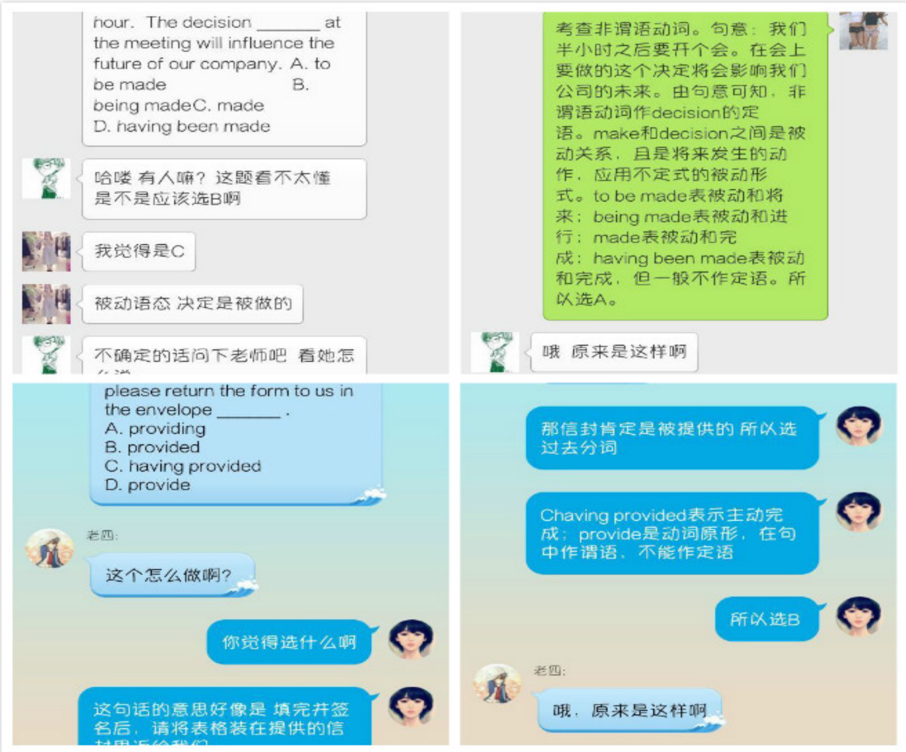

Figure 2. learning procedure with QQ group and Wechat

Table1. Demographic profile

Variables	Classification	Total (%)
Gender	Male	29 (0.45)
	Female	36 (0.55)
Grade	Freshman	17(0.26)
	Sophomore	19(0.29)
	Junior	14(0.22)
	Senior	15(0.23)
Spending Time Online (1 day)	<3h	13(0.20)
	3-6h	18(0.27)
	6-9h	15(0.23)
	>9h	19(0.29)

3.3 Instrument

A self-report questionnaire was adapted and adopted for the survey, which measured 5 constructs and a total of 17 items concerning usefulness, ease of use, self-efficacy, teacher's support and classmate's mutual aid. Respondents were asked to indicate the items on a 5-point Likert scale ranging from strongly disagree (1), slightly disagree (2), neither agree nor disagree (3), slightly agree (4), and strongly agree (5). These items were adapted from various published sources and were found to be reliable and valid, which were shown in Table 2. Furthermore, psychometric quality of the instrument of this study has been conducted to confirm its reliability and validity. A five-point Likert scale was employed and all items were presented in Chinese. Considering the translation errs may happen to effect students' comprehension, we asked two English teacher to check all the items, and five students were selected to pretest the validity and reliability of the scale. Finally the 18 items in this study are listed in the Table 2, which shows the detailed items and the sources from where they were adapted and adopted for this study

Table 2. List of constructs and corresponding items.

Construct	Item	
Usefulness (adapted from Teo, 2009)	U1	Using Virtual Self-organized Community will improve my work.
	U2	Using VSC will enhance my effectiveness.
	U3	Using VSC will increase my productivity.
Ease of Use	EU1	My interaction with VSC is clear and understandable.
(adapted from Teo,	EU2	I find it easy to get VSC to do what I want it to do.
2009)	EU3	I find VSC easy to use.
Teacher's Support	TS1	I often get teachers' support when using VSC.
(adapted from	TS2	I often benefit much from teachers' support when using VSC.
Hooker, T. 2014)	TS3	Overall, teachers' support bring me encouragement to use VSC.
Peer Coaching	PC1	My classmates often offer me much support when using VSC.
(adapted from	PC2	My classmates' aid is significant to my learning in VSC.
Stichter, J. P. et al., 2006)	PC3	I like discuss learning problem with my classmates in VSC.
Self Efficacy	SE1	I feel confident using VSC such as "QQ" or "Wechat".
(adapted from Liang,	SE2	I feel confident reading others' messages in a VSC.
J.-C.et al., 2011)	SE3	I feel confident providing information or answering others' questions in VSC.
Acceptance to VSC	AV1	VSC make my learning more interesting.
(adapted from	AV2	Working with computers is fun
Compeau & Higgins, 1995)	AV3	I like using VSC to support my learning.

4. Results

As shown in table 3, each α value is bigger than 0.5 suggesting acceptable reliability. Besides, all the factor loadings are greater than 0.50, indicating strong relationship with their associated constructs.

Table 3. Loadings, Cronbach's Alpha (α) of questionnaire

Variable	Loading	Cronbach's α
Usefulness	0.66-0.81	0.77
Ease of Use	0.70-0.82	0.75
Teacher's Support	0.77-0.78	0.75
Peer Coaching	0.55-0.60	0.61
Self-Efficacy	0.59-0.86	0.60
Technology Acceptance	0.51-0.80	0.75

Table4 shows the inter-correlation among the variables. The correlation between learner's acceptance to VSC and usefulness, ease of use, teacher's support and , peer coaching, self-efficacy are 0.576, 0.245, 0.422, 0.579 and 0.390, respectively. Due to their close relationship to technology acceptance, peer coaching was the most significant factor, followed by scores on the usefulness, teacher's support and self-efficacy . Thus, we can safely draw a conclusion that teacher's support and usefulness, ease of use, peer coaching and self-efficacy have close relationship with sample students' technology acceptance toward virtual self-organized community.

Table4. Descriptive analysis and correlation

	1	2	3	4	5	6
Usefulness of WeChat						
Ease of Use	0.221					
Teachers' Support	0.408**	0.459**				
peer coaching	0.536**	0.299*	0.347**			
Self-Efficacy	0.238	0.362**	0.121	0.477**		
Technology Acceptance	0.576**	0.245*	0.422**	0.579**	0.390**	

Note: **. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Regression analysis was used to explain the causality between students' acceptance and each independent variable. According to table 5, usefulness of virtual self-organized community (*t*=2.644) and peer coaching (t=2.033) were positively related to students' acceptance toward virtual self-organized community. Teacher's Support (*t*=1.825) posed a slight significant effect on students' acceptance toward virtual self-organized community. Surprisingly, ease of use (*t*=0.642) and self-efficacy (*t*=1.328) isn't statistically related to learners' acceptance of virtual self-organized community.

Table 5. Regression analysis

Variable	Under standardized coefficients		Coefficients	t	p
	β	Standard Error			
(Constant)	-0.588	0.565		-1.042	0.302
Usefulness	0.347	0.131	0.309	2.644	0.010
Ease of Use	0.086	0.138	0.066	0.642	0.535
Teacher's Support	0.195	0.107	0.196	1.825	0.073
peer coaching	0.293	0.144	0.256	2.033	0.047
Self-Efficacy	0.172	0.129	0.147	1.328	0.189

5. Discussion

Technology acceptance toward virtual self-organized community is an important character to reflect learning performance (Davis, 1993). An important factor influencing learners' acceptance of virtual community is whether this way is enough efficient or not. If WeChat is proved effective in English studying in more situation, the acceptance of this way will become stronger, as a result of that usefulness of WeChat is significantly influence technology acceptance.

The characteristics of virtual self-organized community which including online interactive discussion and timely communication, assist learners in communicating effectively without the limitation of time and location（Bressler & Grantham , 2000). Users who have common identity would be spontaneously gathered together via WeChat and QQ. Learners in the same virtual self-organized community usually have similar and specific expectation. They join diversified virtual communities according to themselves demand and interest to acquire information and build new personal network. A large part of relation in virtual communities comes from relation in real world (Brandon & Hollingshead, 1999). On the basis of the statement above, it could not be very hard to understand why peer coaching plays an important role in technology acceptance. Therefore, software developer should put emphasis on broadcasting applications among students and their social network to improve coverage as well as learner’s technology acceptance.

Besides, the results showed that teacher’s support have relative weak influence on technology acceptance. Teachers commonly play a role directing students’ behavior, which corresponds to Chinese learners’ traditional recognition. This fact might be explained by teachers’ leading effect in study and use of WeChat and their mental direction to students’ emotion in virtual community. However, relatively speaking, in this research, teacher’s support have weak influence on technology acceptance on virtual self-organized community. The possible explanation is the teacher-student relationship are relative passive and unfamiliar in Chinese universities, which hinder the improvement of learner’s technology acceptance in virtual self-organized community.

Self-efficacy is an individual's belief in one's capability to perform a particular task or behavior. The strength of their effectiveness beliefs play a critical role in whether people will make an effort to handle given situations. self-efficacy is expected to affect various aspects of learner, including task effort, persistence, and the level of goal difficulty selected for performance(Gist, 1987). Surprisingly, in this research, self-efficacy has no significant relation with technology acceptance in virtual self-organized community. The possible reasons may exist as follow: Firstly, the participants’ purpose of using virtual community are mostly for solving problems at a medium difficult level, which diluting the perception and understanding about their self efficacy. Besides, nowadays almost every university student is required to take basic information and computer courses so that their skills in using virtual self-organized community can keep pace with the times. What’s more, since Wechat and QQ are easy to be handled,there is no need to worry about operating them, which is also a evidence to support the results why ease of use have insignificant regression relation with learners’ acceptance to VSC.

6. Limitations and Future Research

The findings of this study must be considered in light of its limitation. First, since our research sample only comes from English major in Anhui Jianzhu university and HeFei University, and this sample size was fairly small, consisting of only 65 English majors. Secondly, this research concerned merely on field of higher education but did not reflect on the perception of other study groups, such as employees or postgraduates. Finally, we limited the research variables to five factors, while additional factors concerning individual characters, such as individual activity, barely be considered in this survey but may influence students’ acceptance towards virtual self-organized community.

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Model for Developing Teachers' Theoretical and Practical Performance regarding Learning Management by Using LIISMF

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Abstract: The purpose of this paper were to (1) synthesize the model for developing the teachers' performance both theory and practice regarding to learning management by using Learning Innovation Integrated with Sufficiency Economy, Moral, and Fundamental Thai Values (LIISMF); (2) study the teachers' understanding on learning management by using LIISMF; and (3) explore the teachers' opinion toward workshop on LIISMF. The target group consisted of 26 teachers, teaching primary in Thailand. Survey research, gathering both of quantitative and qualitative data, was employed in this study. The research instruments were (1) document analysis record form; (2) the teachers' understanding test; and (3) opinionnaire and interview form for the teacher's opinion toward workshop. Data were collected and analyzed. Analytical description and interpretation was used to synthesize the model and analyze the teachers' opinion. Descriptive statistics: means and standard deviations were used to analyze the teachers' understanding. The results revealed that: (1) The model for developing the teachers' performance both theory and practice regarding to learning organization by using LIISMF consisted of 3 crucial elements as the following: 1) Constructing fundamental concept, 2) Building experiences, and 3) Creating confidence; (2) The teachers' understanding of the learning management by using LIISMF was shown at high level (Mean =18.03 and S.D. = 1.70); and (3) Teachers' opinions toward workshop showed that they understood the method of learning management by using LIISMF and have confidence to utilize it in their actual classroom.

Keywords: developing teachers, Thai Context, Sufficiency Economy, Thai Values

1. Introduction

The recent changes that took place around the world brought with them continual crises all countries including Thailand which had to face; especially, concerning economy, culture, and western values. It has become important to build sustainable protection to the country so that we will survive foreign profit-making acts. In the past, we applied economic means with emphasis on land, machine, fund, and labor. In the future awaiting us; however, the man is the heart of development and the major foundation for national strengthening. His Majesty the King's sufficiency economy should be the leading philosophy for the living of all levels of Thai people. The government should also develop and administer the country based on moderate practice, particularly in economic development in order to catch up with globalization. Sufficiency means adequacy, reasonability, and necessity for preventive measures against impact from both external and internal changes. In this regard, omniscience, cautiousness, and carefulness must be relied on in applying all technical know-how in planning and implementation. Meanwhile, the people should be instilled with moral, integrity, and appropriate omniscience. An individual should not only be developed as an intelligent person, but one who is able to apply technical knowledge or "bodies of knowledge" for benefits of oneself, the others, and the country. The desired society is not only the society of news and information, but the society of sustainable learning (Rung Kaewdaeng, 2006). Thus, the most vital mission of the government lies in reforming education by emphasizing preparation of the people to be consumers as well as knowledge creators and developing necessary skills for confidently entering the modern society.

The National Education Act 1999 and the amendment version 2002, which brought about educational reform, stated that learners were the most important part of education. All learners must be considered to be able to learn and develop themselves. Education should emphasize knowledge, moral, learning processes, and appropriate integration in order to encourage learners to naturally develop themselves to their full capacity. The heart of educational reform was reengineering instruction and learning with teachers and educational personnel being the major mechanism. Hence, the role of teachers in this reform age included studying, searching, finding approaches for advising, facilitating, and encouraging learners, all of which are based on the principle of learner-centered method. Learners should be provided with chances to practice their skills and thinking process that interrelate knowledge learned with the real life situation. They should be trained to apply knowledge in problem solving in different contexts. Teachers should arrange the learning environment that facilitates knowledge building that leads to life-long learning, apply research work as an instructional component since research process enables teachers to build efficient learning models and is adjustable according to learners' needs and strategies. From the roles stated above, teachers and educational personnel should be able to design efficient learning activities according to the reform purpose. This research was conducted for development of learning, especially the use of efficient learning innovations that can enhance learners' potentiality to acquire knowledge. Nevertheless, learners should not only be encouraged to learn, but also to form a concept for life in Thai context which was based on sufficiency economy. It was vital for teachers to take this into account when arranging learning environment that promotes knowledge building and integrates moral and Thai values which were the basis for living. Students should be trained how to face problems in their living, such as social problems and debts, so that they can live in this world happily. Additionally, it was necessary to rely on educational processes as the basis for development and improvement of instruction models that apply learning innovations. With this reason, our study saw the importance of teachers' development in terms of knowledge and understanding of innovative instruction that integrates sufficiency economy, moral, and Thai values appropriate to Thai social context.

2. Research objectives

2.1 To study the teachers' knowledge and understanding of instructional management and use of learning innovations that impartially and sustainably integrate sufficiency economy, moral, and Thai values

2.2 To construct a teacher development model for instructional design and use of innovations that impartially and sustainably integrate sufficiency economy, moral, and Thai values

2.3 To study the teachers' attitudes towards workshop on instructional management innovations that impartially and sustainably integrates sufficiency economy, moral, and Thai values

3. Research methodology

3.1 The target group for the study consisted of 10 school administrators, 26 teachers of science, social study, religion, and culture, and 811 students in primary school in Thailand.

3.2 The survey research method was applied to collect both qualitative and quantitative data.

4. Research instruments

4.1 A test measuring knowledge and understanding of teachers on learning management and the use of learning innovations that integrating the sufficiency economy philosophy, moral, and Thai values for sustainable and well-balanced development - This test was administered after the training and workshop. It was a 20-item objective test.

4.2 A survey form on teachers' attitudes towards the workshop on the use of learning innovations that integrate the sufficiency economy philosophy, moral, and Thai values for sustainable and well-balanced development – This was an open-ended rating scale administered with the target teachers who participated in the said workshop. The scale items included expectation on learning innovations application, knowledge acquired, utilization in teaching and learning, and developed aspects.

4.3 An interview form for interviewing teachers on the workshop on the use of learning innovations that integrate the sufficiency economy philosophy, moral, and Thai values for sustainable and well-balanced development – This was an unstructured interview form used with teachers participating in the workshop. Questions included expectation on learning innovations application, knowledge acquired, utilization in teaching and learning, and developed aspects.

5. Data collection

The data was collected for the study of the effect of conceptual and practical development of the target teachers in instructional management and the use of learning innovations that integrate the sufficiency economy philosophy, moral, and Thai values for sustainable and well-balanced development. The workshop was held at the Faculty of Education Khon Kaen University, Muang District, Khon Kaen province. Data collection was conducted following these steps:

4.1 Providing knowledge on learning management and the use of learning innovations that integrating the sufficiency economy philosophy, moral, and Thai values by the researchers and experts. The important contents and elements were concluded for development of concepts and practices for the teachers. Open plenary session was arranged for exchanging of ideas.

4.2 The target teachers obtained direct experiences from learning the innovations that integrating the sufficiency economy philosophy, moral, and Thai values at 3 learning resource stations:

4.2.1 Station 1: Multimedia of learning innovations that integrate the sufficiency economy philosophy, moral, and Thai values on household garden vegetables for Grade 4.
4.2.2 Station 2: Multimedia of learning innovations that integrate the sufficiency economy philosophy, moral, and Thai values on sufficiency economy for Grade 5.
4.2.3 Station 3: Multimedia of learning innovations that integrate the sufficiency economy philosophy, moral, and Thai values on life and the environment for Grade 6.

4.3 The participating teachers, the experts, and the researcher drew conclusions of the results together.

4.4 The participants took a trip to study sufficiency economy at Huay Chan Learning Center, Sila Sub-district, Muang District, Khon Kaen and visited Mr. Sawat Boonma, the village sage who successfully carried out the philosophy.

4.5 The participating teachers took the test on knowledge and understanding, answered the survey on attitudes of the workshop, and took the interview.

6. Data analysis

The analysis was performed on the following variables:

6.1 Knowledge and understanding of the teachers on learning management and the use of learning innovations that integrating the sufficiency economy philosophy, moral, and Thai values derived from the objective true/false test – The results were analyzed by calculating the means and standard deviations.

6.2 The teachers' attitudes on the workshop on the use of learning innovations that integrate the sufficiency economy philosophy, moral, and Thai values – comprising 2 parts:

Part 1 – Rating scales – the results were analyzed in means and standard deviations (S.D.)
Part 2 – Open-ended questions on the attitudes of the workshop from interviewing – The results were interpreted and concluded.

7. Conclusion and discussion

7.1 The mean score of the teachers' knowledge and understanding on learning management and the use of learning innovations that integrate the sufficiency economy philosophy, moral, and Thai values was 18.03, and the standard deviation was 1.70.

7.2 The model for development of teachers on learning management and the use of learning innovations that integrate the sufficiency economy philosophy, moral, and Thai values was found to be efficient. This model was synthesized from the principle of constructivist learning theory, cognitive apprenticeship, education supervision, and studies of institution contexts. Results of survey on attitudes towards the workshop were also taken into account. The model structure was shown in the following figure 1:

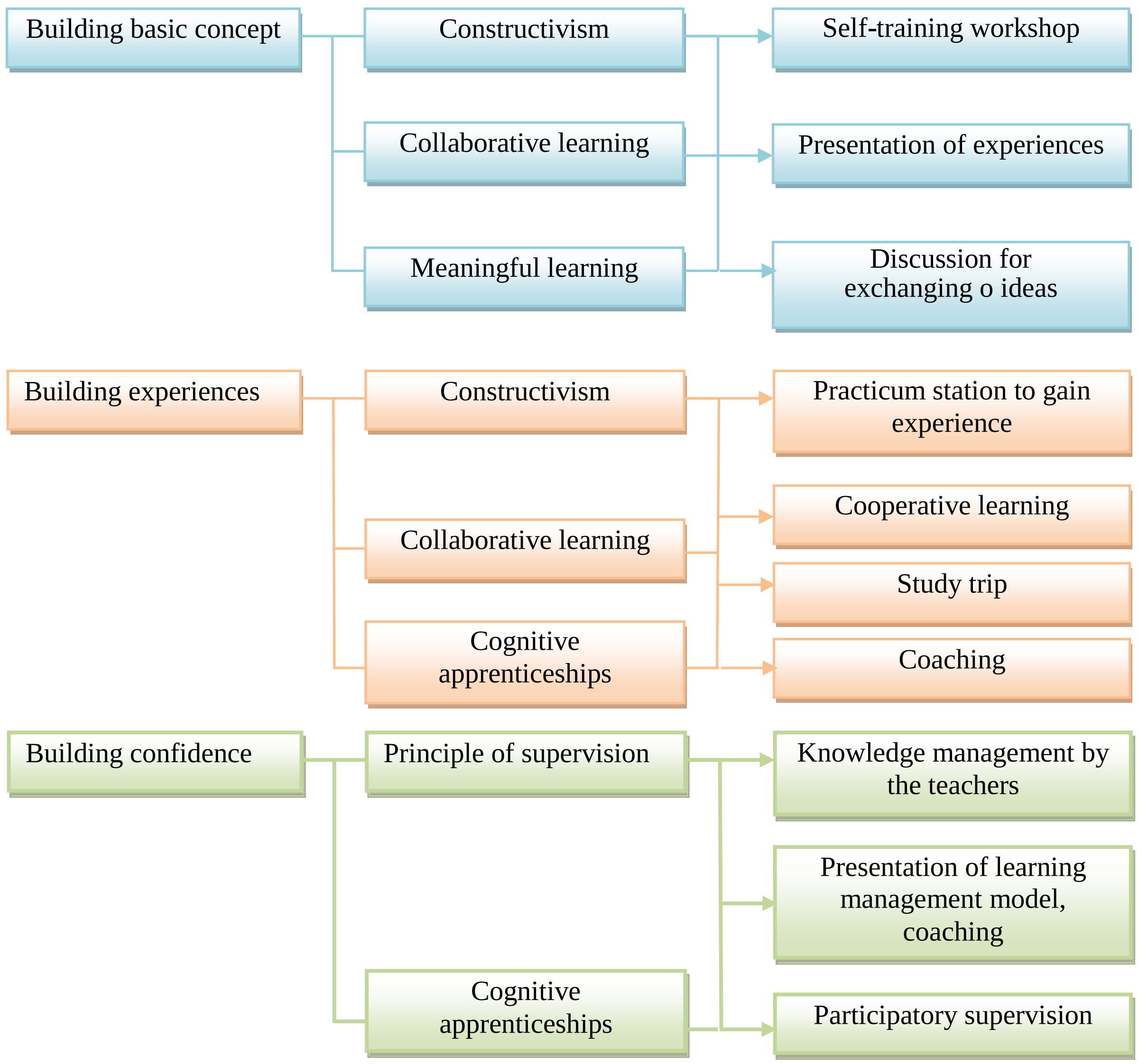

Figure 1. The figure showing the model for teachers' development on learning management and the use of learning innovations that integrate sufficiency economy, moral, and Thai values for sustainable and well-balanced development

From the above figure, we could see that the model for developing the teachers' learning management and the use of learning innovations that integrating sufficiency economy, moral, and Thai values consisted of 3 major principles:

7.2.1 Building of basic concept – this was synthesized from the constructivism theory that emphasizes teachers' creation of bodies of knowledge, implementation from the concept through collaborative learning with researchers and participating teachers, presentation of experience on instruction management that enhances integration of sufficiency economy, moral, and Thai values. The teaching context was also studied for trainees to build knowledge and understanding from their direct experiences.

7.2.2 Building of experiences was based on the constructivist theory in which cognitive apprenticeships were emphasized. The teachers were given a chance to be exposed to learning management and the use of learning innovations that integrate sufficiency economy, moral, and Thai values through their thinking process and exchanges of knowledge among themselves, the experts and the researchers. In so doing, the teachers as a novice received concepts from the experts and obtained experiences from the study trip. Thus, the workshop provided direct experiences for the participants in learning from innovative leaning management. They were able to collaborate in problem solving, sharing knowledge, discussing, thinking, presenting knowledge and understanding together with learning management concept. All of these meant the teachers constructed their knowledge through experience, thinking process, and sharing.

7.2.3 Building confidence was based on the principle of educational supervision and cognitive apprenticeships. Confidence was built by enhancing conceptual knowledge and practices on learning management and innovations that integrate sufficiency economy, moral, and Thai values. The learning management and innovations were then applied in real classroom where researchers provided participatory supervision following these steps: 1) the teachers and researchers were trying to understand the learning management process and learning innovations together, 2) the teacher introduced the lesson, 3) the researchers explained to the learners the method of learning with innovations in details, 4) Learners learned by the innovations, 5) the teachers acted as a coach, 6) the teacher drew conclusion of the lesson with learners. After completion of the learning process, the teacher, co-teacher, and researchers reflected the results of innovative learning together so that the teacher and co-teacher understood and became confident in the use of learning innovations.

7.3 The attitudes on the workshop on learning management and innovations that integrating sufficiency economy, moral, and Thai values could be classified into 3 types:

7.3.1 As regards expectation from the workshop, the participating teachers expected to obtain knowledge and understanding, experiences in learning management and innovations that integrate sufficiency economy, moral, and Thai values so that they would be able to encourage learners to apply in their daily life. The knowledge obtained can be linked to the school's curriculum and local wisdom especially the sufficiency economy. Students would be instilled with good attitudes towards their own community and locality.

7.3.2 It was found that the workshop participants were acknowledged of the principles, theories and related research work on learning management that enhances learners' knowledge. The participants were then able to apply learning innovations that integrate sufficiency economy philosophy, moral, and Thai values to synthesize a teaching model. The teachers found the innovations, after experimenting, appropriate to students at all level. Students enjoyed the lessons without feeling bored. The teachers were confident that the innovations could be used effectively, since the technique and design were based on new technology. The content was also close to the students' everyday life, and hence they were able to see the importance of sufficiency. The teachers also saw the importance of learners in instructional design.

7.3.3 The participating teachers saw that workshops on learning management and use of innovations are very important. Such workshops, as they reflected, would enable the teachers to understand successful transfer of knowledge. Learners would be able to learn by themselves, the learning activities and innovations can be well integrated to sufficiency economy philosophy, moral and Thai values. The learning resources or centers are the interesting components that provide knowledge as well as life experiences, enabling learners to understand the subject content better. The innovations used and experimented on could be applied in the design of innovations for other classes or levels of students.

7.3.4 Practices at different learning resources stations enabled knowledge acquisition. Skills in operating teaching aids and media were practiced. At each station, the knowledge content was complete and well integrated, and participants were able to train or practice their thinking skill, train to do and solve their problems. Learners would have fun; enjoy the lesson without getting bored. The teacher at each learning resource station would facilitate and coach the training or practicing of skills using IT. Students learning under these activity arrangements would be encouraged to show their idea and become more enthusiastic to learn.

7.3.5 Cooperative learning allowed exchanges of ideas and experiences. Learners helped each other to perform activities. They learned that all types of work could not be done alone, and every job required teamwork in order to achieve the goal. Working alone meant a lot of chances to make mistakes. Working together enhanced unity and disciplines. Learners would be trained to listen to and accept other's opinions, opening up the chances to acquire more knowledge. Learning at stations or learning resources enables learners to search knowledge by themselves. They became more curious to seek answers to questions and practice thinking continuously. When students were able to answer questions, they became proud of themselves. Collaboration, unity building, accepting others' ideas, showing one's idea, and generosity contribute to moral and wide scope of knowledge.

7.3.6 The learning management and innovations according to sufficiency economy, moral, and Thai values enabled students to solve problems in everyday life. They had fun learning and hence the achievement was improved. The innovations could be applied in many aspects, especially in the instruction management of other subjects. Teachers could integrate learner-centered activities in the learning resource centers or stations. Moral-enhancing tales could be incorporated as part of the activities. Learning could also be integrated or linked with the internet so that learners could gain access to other learning sources.

7.3.7 The use of innovations that enhance knowledge acquisition according to sufficiency economy, moral, and Thai values enabled teachers to come up with new ideas in teaching using innovative media. Teachers therefore learnt the constructivist's theory which can be applied in developing learners' potential, promoting their learning capacity, and analytical technique. Teachers were able to design lessons and assessment that emphasized good ethics and moral, and obtain various ideas for producing teaching aids. Learners can apply sufficiency economy in their living.

7.3.8 The participating teachers wanted to develop teaching media. They believed that modern innovations could enable them to do this and should be promoted in other subjects. The workshop provided learning development for rural teachers, and hence should be continuous. Other workshops should also be organized so that learners would benefit from the new approach that enhanced students to learn according to their potentiality and so they were happy to learn. Demonstration of the use of different media should be provided for teachers.

8. Recommendations

8.1 Studies should be conducted on beliefs, values, and attitudes of teachers on learning management and the use of learning innovations that enhance knowledge building with integration to sufficiency economy, moral and Thai values.

8.2 Studies should be conducted on models for developing teachers in learning management and use of learning innovations to enhance knowledge of learners, which integrate sufficiency economy, moral and Thai values and are based on beliefs, values, and attitudes of teachers.

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The Impact of Badges on Course Participation and Interaction

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Abstract—Badges have long been used to encourage users in achieving specific goals in video or computer games. Recent studies have shown that badges can be effective to incentivize learners to complete specific tasks in online learning environments. This study examined the impact of a badge system on class participation and interaction for both online and face-to-face classes in a graduate program. Badges were issued for students who contributed to quality class discussion and peer project comments in two different types of courses. Results of student online postings in different types of online classes with and without a badge system implemented were analyzed. The findings indicate that badges can enhance student interaction in traditional online courses where activities mainly consist of reading, writing, reflecting and commenting.

Keywords—*badges; online learning; interaction, online participation, gamification*

I. Introduction

A new movement of digital badges for lifelong learning is on the rise. Many higher education leaders, practitioners, educators, and researchers have plunged into the development of various badge systems to engage and enhance student learning (ACCLAIM, 2013; Educause, 2012). Digital badges are defined as "an assessment and credentialing mechanism that is housed and managed online. Badges are designed to be visible and validate learning in both formal and informal settings, and hold the potential to help transform where and how learning is valued" (MacArthur Foundation, 2015). Badges are often seen on display in online learning management systems, mobile apps, social media, and a variety of digital networks. Educational institutes and organizations such as museums, Massive Open Online Courses (MOOCs), K-12 schools, and universities/colleges are adapting the use of badges for a variety of purposes. The proponents of the badge systems emphasize that badges allow learners to choose the best learning paths to complement their goals and interests, earn credits for skills acquired, share their accomplishments for new employment, and manage their learning credentials (ACCLAIM, 2013). Badge system seen by the supporters as a mean to facilitate students to meet criteria associated with instructional goals and to improve achievements bringing forth their passion for learning. The opponents of the badge systems are concerned that the use of badges would decrease student's intrinsic motivation and focus only on winning badges (OpenBadge, 2012). Recent badge studies have shown a strong association between student participation and high achievement (Anderson, Huttenlocher, Kleinberg, & Leskovec, 2013; Sullivan, 2013). However, most of these studies have focused on large-scale courses with an automatic badge-issuing system, such as the MOOCs (Anderson, et al., 2013; Sullivan, 2013). Little is known of the role and impact of badge systems in higher education graduate programs, which are different from the MOOCs in not only their smaller class size but also their class dynamics. Little also is known of whether and to what extent the efficacy of badges vary by course delivery format, student demographics, and type of student involvement. In order to address this gap, this pilot study will examine the impact of a badge system on student participation and interaction in both online and face-to-face graduate courses.

2. Literature Review

Class participation and interaction is a well-known pedagogy measurement associated with better learning outcomes. Student engagement, broadly defined, has become increasingly important in higher education (Handelsman, Briggs, Sullivan, & Towler, 2005). Studies have found that in-class participation is important with Millennial students who demand more interaction from their classroom experience (Allred & Swenson, 2006; Howe & Strauss, 2000). Therefore, student engagement has become a significant part of higher education assessment in an increasing number of universities (Kuh, 2001). On the other hand, studies have also found that students in online courses can often feel isolated and overwhelmed due to the lack of face-to-face communication with their instructor and peer students. "Without a feeling of community, people are on their own [and] likely to be anxious, defensive and unwilling to take the risks involved in learning" (Wegerif, 1998, p. 48). Therefore, with the growth of distance learning, one of the major challenges is in how to create a genuine learning community atmosphere which fosters critical thinking, desired learning outcomes and student satisfaction by well-structured information flow, learning support, and group collaborations (Dede, 1996; Wellman, 1999).

Up to now, the most widely used approach to enhance interactivity in online courses is the adoption of asynchronous discussion forums. With the proliferation of social networks, many learning management systems have incorporated interfaces similar to social media to motivate student interaction. Badges are often embedded in the system to allow instructors to "steer" students to certain online activities. A recent study on badges from Stanford University has provided evidence on the positive role of badges. Anderson, Huttenlocher, Kleinberg, and Leskovec (2013) found increased course participation in three badge-integrated MOOCs that had an enrollment size around 120,000. The research team developed an algorithm to award students badges when their online behaviors reached a certain level of cumulative contribution, such as answering a question, asking two questions, or voting on three answers, and so forth. The researchers concluded badges a great way to incentivize learners based on the finding that the number of frequent voters and heavy readers in MOOCs with a badge system is five times more than that in MOOCs without a badge system.

Studies in the literature also suggest that the efficacy of a badge system depends on many factors and badges could trigger desirable behaviors if used by specific learners for specific purposes (Denny, 2013). The study of badges is emergent and most acknowledge that more research of the mechanisms and context is needed. In particular, more research are needed to better the understanding of the role and impact of badge systems in classes which are different from the MOOCs in enrollment, embedded activities, and dynamics. More research also is needed to explore the impact of badges within a range of contexts, such as organization settings, technical infrastructure, learner demographics and characteristics, purposes of tools, and the relevance of badges in encouraging desirable behaviors.

Secondly, improvement is also needed in operationalization of badges and the scope data collected for analysis. So far, most research was implemented based on automatic badge issuing systems and collected predominantly student perception data (Deterding, 2012; Haaranen, Ihantola, Hakulinen, & Korhonen, 2014). Socially and psychological, badges are more likely to be effective when they are symbolically significant. In other words, to truly engage learners and bring forth meaningful student participation and interactions, badges should be embedded as an integral part of learning activities and systematically aligned with course objectives. Automatic badge issuing systems tend to issue students badges based on whether a learner has tasks and the amount of tasks completed. Such a system has limitations in taking into proper account of the quality of work accomplished and the extent to which the completed tasks align with course objectives. Recognizing such a limitation, some studies had adopted student self-report questionnaires to determine the student engagement level. However, this approach is limited in perspective and may be susceptible to a strong positive response bias toward giving a higher self-evaluation of the level of engagement in order to gain a better course grade.

Lastly, there are different types and natures of student involvements, however most studies did not distinguish them. Therefore, it remains unclear if badges have differentiated effects on different types of courses and nature of student engagement. Research findings along this line, can better inform the incorporation and design of badges into course activities, which target at encouraging specific types of student participation and interaction.

3. Research Design

This study utilized student online postings to examine the impact of badges on student participation and interaction in both online and face-to-face courses.

3.1. Background

This study consists of five graduate courses with a total of 77 graduate students (20 males and 57 females) over the span of one year. Two courses were titled “Principles of Educational Research” (hereafter research course) and three courses were titled “Use of Technology for Effective Instruction” (hereafter technology course). These graduate courses were offered every semester to graduate students at the School of Education at a mid-size comprehensive private university in Midwestern USA. The majority of the students are pre-service and in-service educators or school administrators. The courses with the same titles have the same learning modules, assignments, and assessment. The students used Blackboard, a course management system, to retrieve course content. They also used Edmodo, a Facebook-like social and learning management system, to post course assignments and provide peer feedback on assignments. The badge system was incorporated into the courses via Edmodo in Fall 2014 for the following purposes: (1) encouraging student online participation, (2) providing a progress report on their participation, (3) acknowledging student submission of various assignments throughout the course, and (4) motivating student contributions to peer project comments. In order to ensure that badges acknowledge and symbolically resonate the level and quality of student participation and involvement, the instructor systematically and timely reviewed students’ assignment submissions, contribution to topic-related discussions, feedbacks to peer projects and assignments and issued badges on Edmodo only to quality posts. Badges received were counted toward course participation grade or 20% of the total grade. Students could receive up to 20 badges for completing assignments and contribution to peer comments. The badges also kept the students informed on their course participation. The students could check their badges number any time to keep track of their online contributions. One of the researchers was also the course instructor. The frequency of online posting was used as an indicator for course participation and peer comments an indicator for student interaction.

3.2. Research Questions

In order to explore the impact of badges on student participation and interaction, this study compares courses with and without badge systems as well as online vs. face-to-face courses. Three indicators were used in the comparison. Original postings refer to on-time assignment postings or initiations of discussions which could advance learning experiences on class-related topics. Comments/replies refer to feedback on peer projects or replies to class-topic related discussions. Total postings denote the combination of original postings and comments/replies. The project focused on the following research question: *What is the impact of a badge system on student participation and interaction in both online and face-to-face courses?*

Specifically, we tested the following null hypotheses:

1. There is no statistically significant difference in the mean numbers of total postings, original postings, and comments/replies by whether there was a badge system implemented.
2. There is no statistically significant difference in the mean numbers of original postings and comments/replies between technology and research courses.
3. There is no statistically significant difference in the mean numbers of original postings and comments/replies between online and face-to-face technology courses with a badge system.

4. Data Analysis And Discussion

For hypotheses 1 and 2, we hold the delivery format constant by excluding the face-to-face course and analyzed only students enrolled in online courses. Table 1 shows results of the two-way ANOVA with interaction of the mean total number postings made by students enrolled in online courses by badge system, gender, and course type. The test for homogeneity of variance was not significant, Levene $F(7, 56) = 0.823$, $p = 0.573$, indicating that this assumption underlying the application of the two-way ANOVA was met. The results indicate a significant main effect for badge system ($F(1, 59) = 26.63$, $p < 0.001$) and a significant main effect for course type ($F(1, 59) = 81.21$, $p < 0.001$) on the number of original postings plus comments and replies of students enrolled in online courses. After controlling gender and course type, students in courses with a badge system contributed more posts than those in courses without a badge system (19.3 vs. 15.0). After controlling badges and gender, students enrolled in online technology classes were found to make more posts than those enrolled in online research classes (20.9 vs. 13.5 posts). Because the interaction term of badges and course type in Table 1 are statistically significant ((F1, 59) = 18.53, p <0.001), it is necessary to examine the simple main effects. Analysis of the simple main effects (Table 1.1) shows that badges did not have a statistically significant effect for online technology courses (F(1,60) = 0.04, p =0.5290) but did have a statistically significant effect for online research courses (F(1,60) = 54.35, p <0.001) on increasing the total number of original postings, comments and replies. Students in online research classes with a badge system made an average of 17.4 postings, which were 7.9 more postings than the average of those in online research classes without a badge system. It suggests that a badge system seems to have an effect on enhancing the student's participation in online research classes.

Table 1: Results of the ANOVA with interaction of the total posts by badge system, gender and pedagogical orientation

Source	Sum of Squares	df	Mean square	F
Corrected model	1545.99	4	386.50	37.51
Badge system	274.42	1	274.42	26.63 ***
Gender	0.59	1	0.59	0.06
Course type	836.84	1	836.84	81.21 ***
Badge system * Course type	190.94	1	190.94	18.53 ***
Error	607.95	59	10.30	

Levene F(7,56)= 0.823, p=0.573; R-square = .718; ** p< 0.01; ***p<0.001

Table 1-1: Simple main effects of badges and course type on the number of total posts

Variable	Category	Mean (N)	Mean Differences	SE
Main Effects				
Badge system	Yes	19.34 (33)	4.30 ***	0.579
	No	15.05 (31)		0.667
Gender	Male	17.30 (17)	0.22	0.794
	Female	17.08 (47)		0.477
Course type	Technology	20.90 (28)	7.42 ***	0.666
	Research	13.48 (36)		0.573
Simple Main Effects				
Technology Course* Badge	Yes	21.24 (17)	0.78	0.772
Technology Courses*Badge	No	20.46 (11)		0.960
Research Course*Badge	Yes	17.38 (16)	7.88 ***	0.796
Research Course*Badge	No	9.50 (20)		0.712

Course type		Sum of Squares	df	Mean square	F
Technology	contrast	4.07	1	4.07	0.40
	error	608.54	60	10.14	
Research	contrast	551.25	1	551.25	54.35 ***
	error	608.54	60	10.14	

** p< 0.01; ***p<0.001

Table 2: Results of the ANOVA with interaction of the number of original posts by badge system, gender and course type

Source	Sum of Squares	df	Mean square	F
Corrected model	486.54	4	121.63	33.92
Badge system	3.23	1	3.23	0.90
Gender	0.21	1	0.21	0.06
Course type	452.99	1	452.99	126.32 ***
Badge system * Course type	3.72	1	3.72	1.04
Error	211.57	59	3.59	

Levene F(7,56)= 1.022, p=0.426; R-square = 0.697; ** p< 0.01; ***p<0.001

Table 2-1: Main effects of course type on the total number of original postings of students enrolled in online courses

Variable: Course type	Mean (N)	Mean Difference	S.E.
Technology	10.40 (28)	5.46***	0.393
Research	4.94 (36)		0.338

F(1,66) = 112.34 and p<0.001: ** p<0.01; *** p<0.001

In order to better understand the dynamics between badges and student involvement, we further decomposed student engagement (i.e., total number of postings) into "active participation" (measured by the number of original postings) and "interaction" (measured by the number of comments and replies). Table 2 and Table 3 show the results of ANOVA of original postings and comments/replies respectively.

Table 2 shows the results of a two-way ANOVA on student participation via original postings. There is a significantly difference in original postings between the different types of courses (p<0.001). After controlling gender, badges, and the interaction term of badges, students enrolled in online technology classes were found to make more original posts than those enrolled in online research classes (10.40 vs. 4.94 posts) as shown in Table 2.1. Badges, gender, and the interaction term of badge system, on the other hand, did not have a statistically significant effect on the number of original posts.

Table 3: Results of the two-way ANOVA with interaction of the number of comments/replie: badge system, gender and course type

Source	Sum of Square s	df	Mean square	F
Corrected model	483.76	4	120.94	13.57
Badge system	159.09	1	159.09	17.84 ***
Gender	24.23	1	24.23	2.72
Course type	89.01	1	89.01	9.98 **
Badge system * Course type	103.50	1	103.50	11.61 ***
Error	526.00	59	8.92	

Levene F(7,56)= 1.661, p=0.138; R-square = .479; ** p< 0.01; ***p<0.001

Table 3-1: Simple main effects of badges by course type on the number of comments and replies

Variable	Category	Mean (N)	Mean Differences	SE
Main Effects				
Gender	Male	10.28 (17)	1.41	0.739
	Female	8.87 (47)		0.444
Badge system	Yes	11.21 (33)	3.27 ***	0.579
	No	7.94 (31)		0.667
Course type	Technology	10.78 (28)	2.42 **	0.666
	Research	8.36 (36)		0.573
Simple Main Effects				
Technology Course* Badge	Yes	11.12 (17)	0.67	0.772
Technology Courses*Badge	No	10.45 (11)		0.960
Research Course*Badge	Yes	11.30 (16)	5.88 ***	0.796
Research Course*Badge	No	5.42 (20)		0.712

Course type	Sum of Squares		df	Mean square	F
Technology	contrast	2.93	1	2.93	0.33
	error	525.99	59	8.92	
Research	contrast	300.32	1	300.32	33.69 ***
	error	525.99	59	8.92	

** p< 0.01; ***p<0.001

Table 3 shows the results of a two-way ANOVA on student interaction, i.e., comments and replies to each other. Badge system, course types, and their interaction term all had a statistically significant effect on the mean number of comments/replies. Table 3.I presents analysis of the main effects and simple main effects. It shows that course type had a statistically significant effect on student comments/replies. After controlling gender, badges, and their interaction term, students enrolled in online technology classes were found to contribute more comments/replies than those enrolled in online research classes (10.8 vs. 8.4 posts). The paired comparison of students in online technology classes with a badge system and those in online technology classes without a badge system shows badges did not have an effect on enhancing the student's participation in online technology classes. Paired comparison of students in online research classes, on the other hand, indicates that students in classes with a badge system made an average of 11.3 comments/replies which almost doubled the amount made by those in classes without a badge system (5.2 posts). It suggests that badges seem to have an effect on enhancing the student interaction in online research classes.

For hypothesis 4, we examine if course delivery format, i.e., online vs. face-to-face, matters for classes with a badge system. Because there was no face-to-face research course section offered by the same instructor of the online research courses, only data on the three technology courses were examined. The T-test results show that the delivery format did not have a statistically significant effect on the original postings or comments/replies (Table 4).

To sum up, in a graduate program setting, badges did not have a uniformed effect on student involvements. This study found the effect of badges did not vary by gender but did vary by course type and type of student involvements. Badges were found to be more effective in online research courses and particularly in enhancing student interactions. Secondly, there was no significant difference between the online and face-to-face courses in number of original posts or that of comments/replies. At least on technology courses, course delivery format did not affect the effect of badges on either student participation or interaction. Students were equally active in the both online and face-to-face technology courses.

The differentiated effects of badges by course type in this study may have to do with pedagogical orientation of the two courses. Although both types of courses required students to post their assignments, technology courses emphasized strongly on activity such as project-based learning and student-generated content. The instruction activities for the research courses were mainly reading, writing, reflecting, and commenting (RWRC). The results of this study seem to suggest that badges might be more effective for RWRC type of courses. The instructional activities for the technology courses have contributed to active interaction with or without badges. Therefore the effect of badges were not obvious in technology courses.

Table 4: Mean differences in number of original posts and comments/replies by delivery type among students enrolled in technology courses with a badge system

	Delivery Type	N	Mean	Std. Deviation	t-test	Mean Differences	SE
Total postings	*Online*	17	21.2	3.15	-0.41	-0.38	0.93
	Face-to-face	13	21.6	1.26			
Original postings	*Online*	17	10.4	1.70	-1.24	-0.59	0.47
	Face-to-face	13	11.0	0.00			
Comments/replies	*Online*	17	10.8	1.67	0.38	0.21	0.56
	Face-to-face	13	10.6	1.26			

** $p < 0.01$; *** $p < 0.001$

5. Conclusion

This research has contributed to the literature on badges by comparing the effects of badges by online course type, two different delivery formats, and student demographics in a graduate education program setting. Instead of being issued automatically based on quantitative attributes, badges in this study were awarded only if the student engagement was assessed by the instructor to be of quality. This study found that the effect of implementing a badge system on student participation and interaction in online courses vary greatly by the type of courses and the type of student participation. A badge system could work well for online courses that consist mainly reading, writing, reflecting and commenting (RWRC) types of activities. The research findings confirmed previous research (Anderson et. al, 2013; Haaranen et. al, 2014) on the role of badges to increase learner participation in either large courses or smaller graduate courses. Badges appear less critical in courses that are already highly interactive by pedagogical orientation. Badges are still emerging and require further research. The limitations of the study are the small sample size and a lack of student perspectives. It would be helpful to include more classes in the data collection to achieve a better representation. Student perceptions may help explain how and why badges contribute or hinder their learning outcomes. Future research could also include qualitative data such as student and teacher interviews to provide a fuller picture.

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Applying Social Media for Measure Earth's Circumference from Different Locations on the Vernal Equinox

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Abstract: The calculation of the Earth's circumference using Eratosthenes' method requires that; (1) the vertical angle of the sun at solar noon between two locations along the same line of longitude, and (2) the distance between the two locations. The Earth's circumference measurement on 2014 Vernal Equinox operated with the same method and difference technique. On the Vernal Equinox the Sun move on the Equator, the vertical angle and distance between two locations could be referred with the Equator. The naïve participants (N=67) from different locations (Thailand, Lao, and New Zealand) successes the measurement through the social media which was applied to support this project. The results reveal that the online network highly supported teachers and students to complete the activity. They only learning the content from the weblog, 82.32% of them intensively understand the activity and using the Google earth program for measure the distance between their locations to equator. The scientific results have 0.02-12.50 % error which less than the Eratosthenes error (15.60%). It also indicated that social media could be used to create a collaborative network for science laboratory and developing astronomy teaching and learning in both Thailand and ASEAN country.

Keywords: Earth's Circumference, Eratosthenes Method, Social Media

1. Introduction

Eratosthenes (276 - 197 B.C.) was a Greek mathematician, astronomer, geographer, poet, and even a music theorist, who live in Alexandria, Egypt. He is credited with the first remarkably accurate measurement of Earth's circumference in about 2,300 years ago.

Eratosthenes knew that on the summer solstice (on June 21), at noon, in Syene (now Aswan, Egypt, 23.5° north latitude), a city located south of Alexandria, gnomon and pillars cast no shadow. This observation meant that the Sun was directly over the city of Syene, as shown in Figure 1. However, the same thing was not happening in his home town, Alexandria. He saw that a gnomon planted in the ground cast a shadow measuring 7.2 degrees. (See Figure 1.)

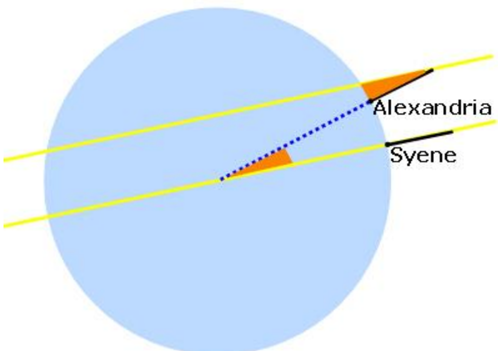

Figure 1. Syene and Alexandria are separated by an angle of 7.2 degrees
(Resource: http://www.sciencebuddies.org/Files/2677/3/Astro_img061.jpg)

In Figure 1., If extend the gnomons until they meet at the center of the Earth. Since the sun's rays are parallel and that alternate angles are equal, it can mention that Syene and Alexandria are separated by an angle of 7.2 degrees.

Eratosthenes paid the team to pace out the distance between Syene and Alexandria, and he found to be 5,000 stadia (the stadia is an ancient unit of length equal to about 1/10 of a mile). Then, using proportion he found the circumference from the following equation:

$$\frac{Circumference}{5{,}000 stadia} = \frac{360^o}{7.2^o} \qquad \ldots (1)$$

He calculated the circumference of Earth and found it to be 250,000 stadia or about 25,000 miles. If Eratosthenes used the present Egyptian stadia of about 185 meters, his measurement turns out to be 46,250 km, an error at 15.60% to today's numbers. The circumference of the Earth between the North and South Pole is 40,008 km (Boonyotayan, 2013).

Eratosthenes' method requires known that; (1) the vertical angle of the sun above the horizon or from the zenith (a point directly overhead) at solar noon (solar noon is the time at the sun reaches its highest point in the sky and is closest to being directly overhead) at two locations along the same line of longitude and (2) the distance between the two locations.

Since the World Year of Physics 2005, Eratosthenes' method was used to promote science in high schools. Particularly, in the International Year of Astronomy (2009), on the summer solstice, the Argentinean project Eratosthenes 2009 on June 21^{st}, and Eratosthenes America 2010 between 18 and 24 June, have more than 15,000 students at more than 200 schools each year used a web network for learning content and found the partner determined the Earth's circumference. Groups of students at two distant schools and the same longitude will take data and then communicate and collaborate on the same way that Eratosthenes measured the circumference of the Earth (Bekeris at al., 2011).

In Thailand, the National Science Museum (NSM) also training teachers on Eratosthenes' method for measure the circumference of the Earth that is started since 2008. Some attended teachers brought this activity to successfully calculated with pair secondary schools such as Eratosthenes projects on 2010 Winter solstice (December, 21^{st}) between Sri Buabarn Wittayakom school, Nakornpanom province, and Ampawan Wittaya school, Ubon Ratchathani province (Boonyotayan, 2013). However, workshop in each school was used for understanding Eratosthenes' method and using the telephone for communicate throughout the activity.

The author, while he stayed in University of Waikato, New Zealand thought that the Earth's circumference measurement using Eratosthenes' method could be operate on the Equinox day (21 March or 23 September). Because of the Sun move on the Equator in these days, the vertical angle of the sun at solar noon and the distance between two locations could compare with Equator.

The author also used the Eratosthenes' method, and add a difference technique for measure Earth's circumference. He suggested the Google Earth free online program for measured the distance from the participants' location to the Equator and applied social media to support the Earth's circumference measurement on 2014 Vernal Equinox (21 March) from different location (Thailand, Lao PDR, and New Zealand) (Anantasook and Yuenyong, 2014).

Social media is a 21st century term used to broadly define a variety of networked tools or technologies that emphasize the social aspects of the internet as a channel for communication, collaboration, and creative expression, and is often interchangeable with the terms Web 2.0 and social software (Dabbagh & Reo, 2011). The different types of social media were used in this measurement included the blog, facebook, and google docs.

A weblog (blog) is a web-based technology that allows people to quickly share their thoughts and comments with the entire web population (Huang, 2011). The author created many articles about the Eratosthenes' method, and step of using the Google Earth program on the astronomy education's blog (www.astroeducation.com). The participants will learn the content and follow the authors' idea and Eratosthenes' steps from the blog.

Facebook is a popular free social networking website that allows registered users to create profiles, up load photos and video, send messages and keep in touch with friends, family and colleagues (Kabkhum, 2010). The author invited teachers who need attended in the measurement on his facebook address (www.facebook.com/krusmart) and add participants' address in the "Wisuwat Earth's Size" facebook's group. He used this online group to directly contact them, shared the content from the blog, assigned work, uploads the participants' activity pictures, and reported the results of the measurement.

Google Docs is a word processor program, a free web-based software office suite offered by Google. The users could be created, edited documents online while collaborating with other users in an internet connection. It had the form of questionnaire and the program could connect and show on the weblog (Anantasook, 2014). It was used for participants immediately reported the results and comment their opinions after they finished the measurement.

2. The purpose of the study

2.1 Applying social media for measured the circumferences of the Earth on the 2014 Vernal Equinox.

2.2 Evaluated activities used by participants in term of the result of the measurement, and their opinions.

3. Methodology

Participants

The project involved 18 teams (N=67); the author from New Zealand, team of 3 students from Pakse teacher collage, Lao PDR., and Thailand teams that includes the team of 4 students from Rajabhat Surin university and 15 teams from different both location and education level (8 teachers and 19 students from the primary school, 13 teachers and 19 students from the secondary school).

Idea of instrument; Eratosthenes' measurement on the Vernal Equinox

The measurements were made between 20 and 21 March 2014 (as shown in Figure. 3-10). On the Vernal Equinox day the Sun move on the Equator, so at noon, the sun was directly overhead, the gnomon cast no shadow while in others latitude a gnomon planted in the ground cast a shadow (as shown in Figure 2.).

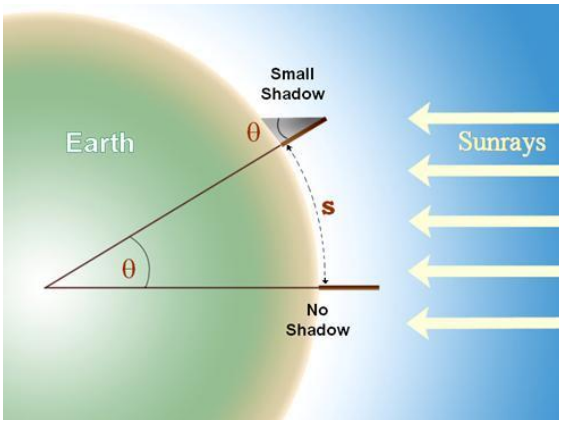

Figure 2. Relationship between the direction of Sun's ray, the gnomon and the vertical angle (Resource: http://www.iucaa.ernet.in/~scipop/Obsetion/eratos/image008)

In Figure 2., if we know the height of the gnomon and the length of the shadow, the vertical angle of the sun between two locations along the same line of longitude (or difference between their latitude) (θ) could be found which using the following equation:

$$\tan\theta = \frac{length\ \ of\ \ the\ \ shadow}{height\ \ of\ \ the\ \ gnomon} \qquad \ldots (2)$$

In addition, the distance between location from the equator to the school's locations at the same longitude (s) in this projects have two ways for participants selected; one using the Google earth program and another was compare and calculate from scale on the book map.

Then, the Earth's circumference could be found from this following equation:

$$\frac{Earth's\ circumference}{DisTance\ between\ \ location} = \frac{360^{O}}{difference\ \ in\ \ lattitude} \qquad \ldots (3)$$

Data Collection and Analysis

1. Design integrated and participatory learning activities for measured the Earth's circumferences on the 2014 Vernal Equinox using mathematics, astronomy, and information technology (the Google Earth program).

2. Applying social media that included the blog, facebook, and google docs on the astronomy education's blog (www.astroeducation.com) supported the Earth's circumferences measurement.

3. Invite author's friends page who interested to join in the project through his facebook, add participants' address in the facebook's group (Facebook/groups/372550369554908/), and use it for any communication throughout the measurement.

4. The participants learn the lesson of Vernal Equinox Eratosthenes' measurement from the blog three days before starting the project.

5. The Vernal Equinox Eratosthenes' measurement included 2 days activities. In the first day, 20 March, all participants using gnomon and shadow plot (during 11 a.m.-1 p.m.) to identify true north, south, east and west in their location. Then, on the vernal Equinox day, 21 March, they also using the same both gnomon and location to measure the length of shadow at solar noon time which the shadow must cast to the true north for the Northern countries or cast to the true south for the Southern countries. Finally, they could be measure the distance between their locations to equator base on their decision and using equation (3) for calculated the Earth's circumference.

6. The participants reported the results of the measurement and gave their opinions about the activity through the facebook's group and Google Docs questionnaire online.

7. The result of the measurement and participants' opinions were analyzed and described.

4. Finding and Discussion

4.1 The scientific results of the Earth's circumference measurement.

The results of the Earth's circumference measurement on the 2014 Vernal Equinox from different geographic locations (20-21 March), as shown in Table 1.

Table 1. The results of the Earth's circumference measurement on the 2014 Vernal Equinox

Team	Geographic locations Longitude, Lattitude	Height of gnomon (cm)	Length of shadow (cm)	tan θ	θ (degree)	Distance between location (km)	Earth's circumference (km)	Error (%)
NZ	37:47S, 175:19E	3.8	3.2	0.842	40.1	4,183.72	37,559.58	6.12
Lao	15:07N, 105.49E	7	2.1	0.300	16.7	1671.96	36,042.25	9.91
1	14:51N, 103.29E	4.6	1.4	0.304	16.9	1643.33	35,005.84	12.50
2	17:30N, 104.40E	4.4	1.1	0.250	14	1892.08	48,652.94	21.61
	16:06N, 104.14E	8.6	2.3	0.267	15	1780.49	42,731.76	6.80
3	15:41N, 100.07E	54	15	0.277	15.52	1736	40,268	0.65
4	15:41N, 101.45E	7	2	0.285	15.50	1717	39,878.71	0.32
5	15:41N, 101.45E	7.2	2	0.278	15.52	1717	39,827.32	0.45
6	8.2N, 100.02E	21.5	3.3	0.153	8.7	911.27	37,707.56	5.74
7	15:41N, 100.07E	15	4.5	0.300	16.7	1736	37,445	6.40
8	15:59N, 103.29E	10.5	3.10	0.295	16.4	1771.97	38,885.05	2.80
9	15:59N, 103.29E	13	3.5	0.269	15.06	1771.97	42,357.84	4.69
10	16:3N, 99:51E	13.30	3.70	0.278	15	1777.14	42,651.36	6.60
11	16:30N, 103:30E	3.6	1.2	0.472	18.43	1846.61	36,060.78	9.86
12	102:46N,17:10E	60	18.4	0.307	17	1888.94	40,001.08	0.02
13	15:41N, 101.45E	14	3.5	0.250	14.5	1717	42,628.96	6.55
14	15:41N, 101.45E	15.8	5	0.316	17.5	1717	35,321.14	11.72
15	14:56N, 102.19E	5	1	0.200	11.31	1250	39,791.31	0.54
16	14:56N, 102.19E	10	2	0.200	11.31	1250	39,791.31	0.54

Note ; Team 6, 15, and 16 measured the distance from the equator to the school's locations using scale comparing on the book map while others using the Google earth program.

According to Table 1, the participants from different geographic locations successes the Earth's circumference measurement through the social media. The scientific results have 0.02-12.50 % error which less than the Eratosthenes error (15.60%). It could be firmly that the Earth's circumference measurement could operate on the Vernal Equinox with in the author's assumption. In addition, the social media which created for this activity very useful and effective online network because it highly supported teachers and students to completed the measurements. All of them never know about Eratosthenes method before attended in the project but they could be calculated the Earth's circumference between the North and South Pole nearly present number (40,008 km).

4.2 Participants' Opinions after attend in the Earth's circumference measurement

After students did the Earth's circumference measurement on the 2014 Vernal Equinox, some like the project the most since the following opinions:

Although the weather so hot, It was fun.
I learned something that I didn't know.

It let me know about the easy method to know the earths' size.
We and teachers did the experiment themselves together.
I first time used the Google earth program, I saw my house from the space.

Some teachers also liked this activity the most and evaluated the effect to students after attend in the measurement since the following opinions:

It was interesting activity. I would apply for my teaching.
It is the way to make students fun, participatory and exciting at all steps.
It lets students take the action, get knowledge and be fun.
It is good for practicing observation and experiment.
I got the ideas of applying social media for teaching and learning.
We are astronomy educator online network.

According to participant's responds, the author consider that they have more technological skill such as the following reasons;

1. All participants know the Earth's circumference measurement on 2014 Vernal Equinox from the author's facebook and they submit to this activity through the facebook.
2. Each facebook participants addresses were added to the "Wisuwat Earth's Size Group". They usually communicated, collaborated, contacted, asked the problem, and reported the result through this channel. The members sometime give some ideas for solve the problem, and also received spirit from many friends on the group.
3. They were only learning the content from the weblog, 82.32% of them intensively understand all steps before the measurement.
4. They first time downloads, setting and using the Google earth program, 82.32% of teams selected it for measure the distance between their locations to equator, while others (17.68%) using scale comparing and calculating from the book map.

In addition, all teachers could be a good advisor for supported students to complete the scientific projects. They showed more competencies on using the social media for astronomy activity. They got the ideas of applying social media for teaching and learning such as create the blog's content and used it in their classrooms.

5. Conclusion and Suggestion

The naïve participants from different locations completed the measurement through the social media. The results reveal that the online network highly supported teachers and students to success the activity. They only learning the content from the weblog, 82.32% of them intensively understand the activity and using the Google earth program for measure the distance between their locations to equator. The scientific results have 0.02-12.50 % error which less than the Eratosthenes error (15.60%). This measurement technics could be used useful and effective in every the Vernal Equinox and also in the Autumn Equinox (23 September). It was suitable for all student level but it was the best for secondary students.

Furthermore, the worksheet of "The Earth's circumference measurement on the 2014 Vernal Equinox" was translated from Thai version to Lao language and it was used in the student team from Pakse teacher collage measurement. The astronomy education blog could build astronomy teachers' community up. Again, the weblog provided more interaction between experts and naïve astronomy teachers. It build atmosphere of professional development through the blog (Anantasook and Yuenyong, 2014). The blog also give naïve participants more chance to argue for developing their scientific conclusion (Pimvichai and Yuenyong, 2014). This situation can mention that social media could be used to create a collaborative network for developing astronomy teaching and learning not only in Thailand but also effective at the international level, in ASEAN community.

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<u>Appendix</u>: Some of the participants' measurement on the 2014 Vernal Equinox

Figure 3. The author at the Waikato Uni., NZ

Figure 4. Students from Pakse, Lao PDR.

Figure 5. Students from Rajabhat Surin university

Figure 6. Team 6 Tangpoon wittayakan school

Figure 7. Team 7 Satree Nakhonsawan Schools

Figure 8. Team 10 Sahatsakhan Suksa Schools

Figure 9. Team 11 Nongsang Wittaya Suksa Schools

Figure 10. Team 13 Jaturat Wittaya Schools

The Application of Blackboard Platform in a Chinese Higher Education Setting: A Case Study of Beijing University of Posts and Telecommunications

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Abstract: This study reported the application of the Blackboard platform in a Chinese higher education setting. It gave an overview of the application of Blackboard platform in different subjects and course at Beijing University of Posts and Telecommunications (BUPT). Then, based on the survey and interview results, the current paper indicated learners' perceptions of and teachers' attitudes towards the integration of the Blackboard platform in learning. Finally, the present research disclosed the problems and challenges that universities may encounter in the process of applying the Blackboard platform in Chinese higher education settings. Suggestions are then proposed for the better utilization of the platform in the purpose of further improving the effectiveness of integration.

Keywords: Blackboard platform, higher education, Chinese higher education setting

1. Introduction

Information and Communication Technology (ICT) has been changing the way in which teachers enlighten students and learners acquire knowledge. The computer technology not only allowed students to be more engaged in learning, but also led to a significant improvement in their learning performance (Andrew et al., 2014). It also provided various possibilities to promote teaching in higher education. The application of the Blackboard platform in education is a typical example of integrating ICT with education. A number of previous studies have discussed user experience of the Blackboard platform and how to design a course with this platform. For example, Boggs and his colleagues (2004) used the Blackboard system in developmental mathematics courses and reported the system made contribution to increase learners' success rate in completing coursework. Dagmar (2015) introduced how to develop learners' English learning skills in the Blackboard-based virtual learning environment. However, there was still a lack of research concerning application of the Blackboard platform in Chinese higher education setting with the support at the University's administration level. The Blackboard platform was widely acknowledged as a learning system widely used in e-learning around the world, with a great variety of features which can be included in the course such as learning material, quizzes, discussion forums, assignments, and so on (Graf & Liu, 2008). It was a popular network teaching platform and was extensively used by different types of educational institutes in China (Peng, 2010). Earlier literatures proved the advantages of employing the system. For instance, it was verified that Blackboard platform contributed to enhance instructors' efficient management of students' assignments, improve teachers' asynchronous communications with students and create an online community for collaborative learning (Chan, 2012; Chang & Hao, 2008). According to Chan (2014), the Blackboard system also furnished a channel for teacher investigators to evaluate students' progress and to examine teaching strategies (Chan, 2014). Blackboard created an interactive and community-based virtual learning environment that supplements traditional classroom-based language instruction (Brandl, 2005)

Beijing University of Posts and Telecommunications (BUPT) in China is a comprehensive university with information technology as its main feature. Since 2014, the University's teaching administration office started the "ICLASS" project, which promoted the integration of the Blackboard platform with classroom teaching and learning.

2. Application of the Blackboard Platform at BUPT

2.1 Favorable policies for promoting the application

In order to promote the application of the platform at BUPT, two favorable policies have been adopted. Firstly, the university has initiated the research project named "ICLASS" in the purpose of fostering and facilitating the application of the Blackboard platform in classroom teaching in various courses in the year of 2014. This research project has sponsored 42 courses with substantial research funding. The courses have covered outstanding courses with national-level, municipal-level or school-level awards at the university.

Secondly, the university has encouraged teachers' engagement in online teaching with the Blackboard platform. For instance, the university acknowledged the teachers' efforts in constructing course materials and resources online as part of their daily teaching work. Moreover, the university has selected the well-maintained projects and awarded teachers' online performance accordingly. Teachers' active participation in online teaching has been considered as pre-conditions for the "Teaching Achievement Award" at the university.

2.2 Facilitating conditions for promoting the application

The university also provided various facilitating conditions for promoting the application of the Blackboard system. For example, a number of training workshops and forums were organized for teachers to have face-to-face communication about problems they encountered in the process of using the platform. The university also set up a public instant messenger account and a public Email account which further enabled the online communication between the faculty members. Furthermore, the university issued the user manual and a video demo about the Blackboard platform, offering vivid demonstration for the application of the system.

3. Results and Discussion

3.1 Overview of the application

The Blackboard platform at this university is capable of accommodating a total number of 20,000 users. Until 2015, there are 15,516 registered users, a total of 79 active courses (active courses refer to courses which updates within this month) and approximately 2275 active users (active users refer to users who log into the platform during this month). Teachers of BUPT are also proactively exploring the platform. The overview of the platform usage statistics is shown as follows:

Table 1 An overview of the application of the Blackboard platform at BUPT

Subjects	Number of Activated Courses	Annual Average Page View	Online Resources(MB)
Information Engineering	13	169,761	13,522.461
Social Sciences	19	79,853	10,646.791
Computer Science	16	8,864	119.834
Physics and Mathematics	10	203,658	23,689.249
Electronic Engineering	5	301,093	224.744
Economics and Management	1	8,883	141.857
Software Engineering	2	144,178	3,334.713

3.2 Learners' attitudes towards the application

In order to explore learners' attitude toward Blackboard platform, this paper conducted a survey among the active users. More than 90 percent of the subjects majored in science and engineering and over 50 percent of the platform users participating in the survey were freshman.. Based on the data from the survey, we found learners' attitudes towards the application as follows:

1. The advantages of using the platform included its rich courseware, audio and video resources, multi-functional interaction modules, interesting team-work activities and convenient online tests.
2. Approximately half of the students agreed that the platform can eliminate the time and space limitation. They reported that they can learn in and after classes and can use the resources more efficiently. About one third of the students liked the way of interaction the platform provided. They can get feedback and their learning results on time. Moreover, they enjoyed the collaborative learning online and found it was an efficient way for them to learn.
3. About 95% students held positive attitudes towards the use of the Blackboard platform and the efforts and contributions made by the teachers.
4. More than half of the students intended to learn courses and course-related materials, and 46% students was inner-motivated to improve their learning and research abilities. 30% students wanted to improve their team work skills through the platform.
5. More than 70% students were ready to continue to use the platform in the future.

3.3 Teachers' perception of the application of Blackboard platform

Teachers who participated in the survey mainly taught science, engineer, computer, language and social courses. 85% of these teachers have taught at the university for more than 8 years. According to the survey, we made the following conclusions:

1. Using the platform helped the teachers to improve the quality of teaching. 60% teachers claimed that using the platform helped them to enhance the interaction with the students since they could interact with the students even after class. 70% teachers thought the platform could improve learners' learning efficiency since the teachers could take advantage of both online and in-class teaching. About 20% teachers agreed that the platform helped the learners improve learning motivation. Besides, they thought the online group discussion also improved the learning efficiency.
2. The platform provided many functions for online learning. The most frequently used function was for courseware uploading. The second most frequently used function was homework assigning and evaluation. Other frequently used functions included notifications and online communication publishing.
3. Over 80% teachers agreed one of the advantages of applying the platform was eliminating the time and space constraints. The students could learn online after class. Other advantages included optimizing the course resources to improve the learning efficiency. The application of the platform could achieve interactive learning and facilitate collaborative learning among the students by providing feedback and tracking the learning process.

3.4 Problems and Challenges

Though the students and teachers generally held positive attitudes towards the application of the Blackboard platform, we still found a number of problems and challenges. Two main defects of the platform were the lack of video storage space and the slow playback speed for video. One of the solutions may be purchasing streaming media on-demand system and integrating it in the platform. What's more, teachers and students were still not very familiar with the operation system and not very satisfied with the user experience, since the platform was newly introduced in the university. Therefore, more operational trainings should be prepared by the academic office to enable the teachers and students to get more and more familiar with the platform.

4. Conclusion

This paper reported on the application of the Blackboard platform in a Chinese university setting. The research results indicated that Blackboard platform provided various possibilities for promoting the collaborative learning and autonomous learning for learners in China. On one hand, the Blackboard platform has become an essential supplement for the traditional classroom teaching. It also improved the interaction between students and teachers. On the other hand, the successful application of the Blackboard platform in higher education settings still faced various challenges. Policy makers should create a more favorable environment for using the platform. Moreover, both teachers' and learners' ICT literacy still needs to be improved.

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Application of the Blackboard System in an EFL Course for Science and Engineering Students in China

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Abstract: In light of the growing popularity of the use of computer management systems (CMS) in higher education, this study examined Chinese science and engineering students' experiences and acceptance of the Blackboard system in an EFL course named *International Business Etiquette*. Sixty-one university students took part in the research. Survey and interview results showed students held favorable attitudes toward the Blackboard system. The participants also reported the integration of the Blackboard system with the course developed their English proficiency and knowledge of international business communication.

Key words: the Blackboard system, EFL, curriculum integration

1. Introduction

The developments in information technologies have created exciting opportunities in education and provided new possibilities in language teaching and learning (Alavi 1994; Hubbard 2005). With the advancement of computer technology, course management systems (CMSs) have become the most prominent and promising educational innovation since their development in the 1990s (Cappel & Hayen, 2004; Cloete, 2001; Leahy, 2004), and there is a growing number investigating the pedagogical effects of CMSs in the EFL classrooms (Mekheimer, 2012; Grgurović, 2013; Cheng, 2013). Among CMSs, the Blackboard system has been widely applied. This study investigated the application of the Blackboard system in an EFL course at a university in North China. It attempted to investigate how the system could be integrated with the teaching and further explored learners' experiences and acceptance of the integration.

2. Literature Review

In the last two decades, researchers around the world have fully studied the integration of modern information technology and education. Many researches have proven that in a less stressful e-learning environment, students could be more collaborative, and have more time for rehearsal before participating in class activities (Chun, 1994).

A course management system is defined as a software system that is specifically designed for staff and students to use in teaching and learning (Morgan, 2003). It contains common tools such as course content organization and presentation tools, communication tools, student assessment tools, gradebook tools and functions. A number of empirical researches have been conducted on the adoption of CMSs in language courses for specific skills (Chan, 2014; Mekheimer, 2012) and strategies used among EFL students (Tsai, 2014). In China, CMSs were also used and discussed in literature for English majors (Wu, 2009). Among the CMSs, the Blackboard system is widely used around the world and has become common for teachers, especially in higher education contexts (Ene & Upton, 2014).

This study aims to investigate science and engineering students' acceptance of and attitudes towards the Blackboard system for the integration with an EFL course named *International Business Etiquette.* It was primarily guided by the following two research questions:

1. How can the Blackboard system be integrated with the course?
2. What is the students' acceptance of the Blackboard system as an extension of the EFL course?

3. Methodology

3.1 Research setting and participants

The empirical research was conducted from February 2015 to June 2015 and took 2 hour per week at a comprehensive university in North China. 61 junior undergraduate students (Male=35, Female=26) enrolled in the EFL course and participated in the research.

3.2 Procedure

An orientation session was conducted at the beginning of *International Business Etiquette* course. In that session, students were required to get familiar with the course functions of the Blackboard system. During the semester, students conducted course assignments via the Blackboard system, and presented in class under the direction and supervision of the instructor. Some of their performances and presentations were filmed and shared with other students on the Blackboard system. Assessments were based on students' attendance, performances, and their engagement in the supplementary online exercises and activities on the Blackboard system. At the end of the semester, a survey and a face-to-face interview were used to collect quantitative and qualitative data.

3.3 Application of the Blackboard system in International Business Etiquette Course

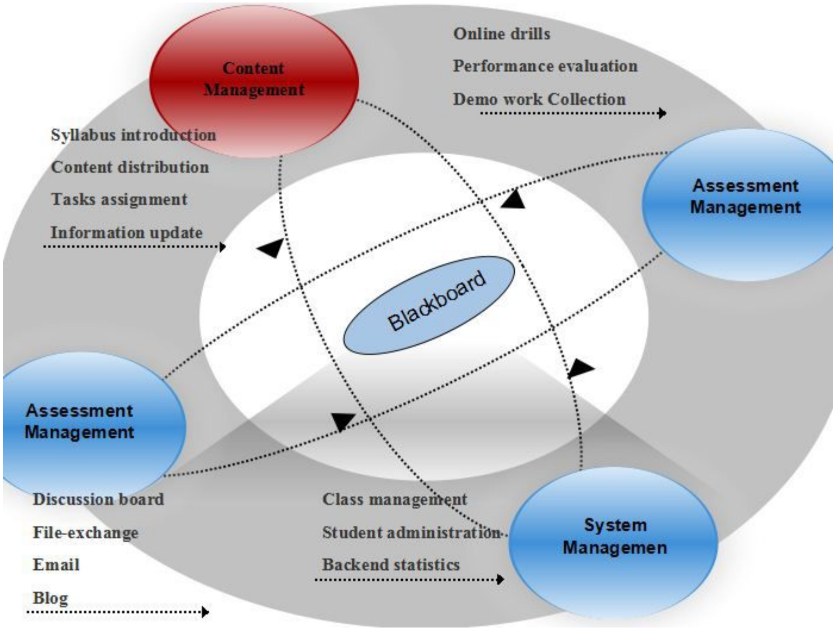

Figure 1: Modules and Functions of the Blackboard system.

The Blackboard system is organized to manage all kinds of online teaching resources and provide a new model for the integration of information technology and EFL curriculum. Like all course management systems, the Blackboard system can enhance instructors' management of assignments, their asynchronous communications with students and create an online learning community and provides opportunities of collaboration (Chang & Hao, 2008). Meanwhile, through tracing online discussion, the instructors can find students' interests and concerns, adjust the teaching strategy, constantly update the teaching mode, and accomplish a better integration.

4. Results and Discussion

Quantitative and qualitative data were collected through a survey and an interview. The questionnaire was originally developed by Davis (1989) and Zheng (2015) about users' satisfaction on online platform. A 5-point Likert scale ranging from one (Strongly Disagree) to five (Strongly Agree) was used to gauge students' views of the Blackboard system.

Table 1 shows the result of the learners' acceptance of the Blackboard system which based on the three dimensions: perceived usefulness; perceived ease of use and learning satisfaction. Using SPSS for processing, we can see that the data have high reliability as 0.82(max) and 0.74(min). The results show that students held positive attitude toward the use of the Blackboard system in the EFL course. However, students gave relatively lower score on "ease of use" (Mean=2.95), which indicates that it is urgent for the Blackboard system to be more user-friendly.

Table 1. Results of Questionnaire on Learners' Acceptance of the Blackboard System.

Dimensions	No.	Questions	Mean	SD	Cronbach α
Perceived usefulness	1-5	I think Blackboard is useful for improving my oral English.	3.07	0.91	0.82
		I think Blackboard is useful for improving my English proficiency.	3.36	0.82	
		I think Blackboard is useful for enhancing my interest and motivation in English learning.	3.15	0.98	
		I think Blackboard is useful for enhancing my interest and motivation in International Business Etiquette learning.	3.66	0.93	
		I think Blackboard is useful for developing my intercultural ability.	3.30	0.95	
Perceived ease of use	6-10	I think Blackboard platform is very easy to use.	2.95	1.07	0.74
		I think it is easy for me to learn how to use Blackboard platform	3.26	1.09	
		I think the interface of Blackboard is friendly.	3.33	1.06	
		I think the functions of Blackboard can meet my requirements.	3.33	1.00	
		I think I can learn to operate Blackboard skillfully soon.	3.39	1.04	
Learning satisfaction	11-14	I am satisfied with English learning on Blackboard.	3.10	0.91	0.76
		I am satisfied with international business etiquette learning on Blackboard.	3.44	0.92	
		I would like to keep using Blackboard to study English.	3.07	0.95	
		I would like to keep using Blackboard to learn international business etiquette.	3.13	0.94	

In order to secure in-depth understanding of students' attitudes towards the Blackboard system, a 30-minute interview was conducted after the survey. Based on Yu's study, students' satisfaction with the technology, as well as their intention to adopt it, largely depended on their attitudes towards the systems (Yu et al., 2010). From the interview, we found that learners were more willing to use the Blackboard system for diversified learning. Most of the students expected to improve speaking and listening to "communicate with foreigners freely in English in Business settings". Students realized that there is still room for improving the Blackboard's ease of use. As far as our university is concerned, students suggested that the school should invest funding to maintain and update the system regularly; Moreover, the administration office should provide technical solutions so that teachers and students can enjoy the benefits of CMSs without being overwhelmed by technical difficulties (Curti & Shinall, 1987; Decoo & Colpaert, 1999).

5. Conclusion

The purpose of college English education is not only to improve learners' English proficiency, but also help them to communicate effectively in the target field. This study employed mixed methods and provided a better comprehensive understanding of the students' experiences and perceptions of using the Blackboard system in an *EFL* course. The findings indicated that the students in this study generally held positive attitudes towards the Blackboard system, most of students admitted they had improved personal qualities and developed English skills via the Blackboard system. Future research should employ a wider range of participants. More in-depth qualitative studies are also recommended to explore the issue.

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Investigating the Changes in Teachers' Technological Pedagogical Content Knowledge through Mobile Material Development Activities

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Abstract: This study investigated the changes in teachers' technological pedagogical content knowledge (TPACK) through the mobile material development activities. The TAPCK for mobile learning were administered to 25 pre-service and in-service teachers who participated in a semester course for mobile material development activity. The results indicated that through the mobile material development activities, the teachers had significant changes in their TPACK in all scales, including content knowledge (CK), pedagogical knowledge (PK), pedagogical content knowledge (PCK), knowledge about mobile technology, technological pedagogical knowledge (TPK), technological content knowledge (TCK), and technological pedagogical content knowledge (TPACK). Moreover, the relationships among their TPACK and scores were also examined.

Keywords: Technological pedagogical content knowledge (TPACK), mobile learning

1. Introduction

Many studies revealed the important of the teachers' knowledge about pedagogy, content and technology (Chai, Koh, & Tsai, 2013; Mishra & Koehler, 2006; Schmidt, Baran, Thompson, Mishra, Koehler, & Shin, 2009). In those studies, a well-known framework, namely the technological pedagogical content knowledge (TPACK), has been applied to investigate the teachers' knowledge about the integration of information and communication technology (ICT). The TAPCK framework has seven factors, including content knowledge (CK), pedagogical knowledge (PK), technological knowledge (TK), pedagogical content knowledge (PCK), technological pedagogical knowledge (TPK), technological content knowledge (TCK), and technological pedagogical content knowledge (TPACK). CK, PK and TK are the main knowledge sources, and others are derived from the interactions among these three main knowledge sources.

Since the rapid progress in information technology, many researchers explored pre-service and in-service teachers' TPACK in different conditions, such as web-based learning environments (Archambault & Crippen, 2009; Lee & Tsai, 2010), game learning (Hsu, Liang, Chai, & Tsai, 2013), professional development activities (Chai, Koh, Tsai, Ismail, & Rohman, 2013; Nadelson, Callahan, Pyke, Hay, Dance, & Pfiester, 2013). Lee, Chai, and Koh (2012) indicated that the effective of professional development course can support teachers to improve their TPACK. Recently, according the popular of mobile devices, mobile learning plays an important role in educational contexts. Many studies showed that students had better learning outcomes in mobile learning environments than those in traditional learning environments (Hwang, Wu, Zhuang, & Huang, 2013). However, there are a limit number of studies which have explored teachers' knowledge about pedagogy, content and technology in mobile learning. This study attempts to investigate the changes in teachers' TPACK through mobile material development activities. In additional, the relationships among teachers' TPACK and the works of mobile materials (as learning outcomes) are also investigated. The research questions are:

- Are there any changes in the teachers' TPACK for mobile learning through the mobile material development activities?
- What are the relationships among teachers' TPACK for mobile learning and the works of mobile materials (as learning outcomes)?

2. Method

2.1 Participants

The participants in this study were 25 per-service and in-service teachers, including 5 males and 20 females. All of them did not have any teaching experience for mobile learning. They were enrolled in semester courses to develop learning materials for mobile devices, such as start phone and tablet computers. Figure 1 shows the examples of mobile learning materials the teachers developed.

Figure 1. The examples of mobile learning materials the teachers developed.

2.2 Instrument

In this study, the TPACK for mobile learning (TPACK-M) survey which was developed by Chai et al. (in press) was adopted to investigate teachers' knowledge about content, pedagogy, teaching methods and technology integration. The TPACK-M survey consisted of seven scales, including content knowledge (CK), pedagogical knowledge (PK), pedagogical content knowledge (PCK), knowledge about mobile technology (TK_M), technological pedagogical knowledge (TPK), technological content knowledge (TCK), technological pedagogical content knowledge (TPACK), and pedagogical beliefs (PB).

The survey was undertaken before and after the activities to investigate the changes in teachers' knowledge about content, pedagogy, teaching methods and technology integration before and after the mobile material development activities. 7-point Likert scale was utilized for scoring the teachers' responses, such as 1 for strongly disagree and 7 for strongly agree. The reliability of the teachers' TPACK-M scales before activity were from 0.79 to 0.94, and those of after activity were from 0.72 to 0.96, showing that the TPACK-M survey had reliability to investigate teachers' TPACK for mobile learning. The definitions of each TPACK-M scale are as follows:

- Content knowledge (CK) indicated teachers' subject matter knowledge.
- Pedagogical knowledge (PK) presented teachers' teaching methods knowledge.
- Pedagogical content knowledge (PCK) indicated teachers' knowledge about teaching their teaching subjects.

- Knowledge about mobile technology (TK_M) presented teachers' knowledge about mobile technology.
- Technological pedagogical knowledge (TPK) explored teachers' knowledge about using technology to teach.
- Technological content knowledge (TCK) indicated teachers' knowledge about technology used in their subject area.
- Technological pedagogical content knowledge (TPACK) presented teachers' ICT integration knowledge.

2.3 Data collection and analysis

The survey was undertaken before and after the activities to investigate the changes in teachers' knowledge about content, pedagogy, teaching methods and technology integration before and after the mobile material development activities. In addition, the works of mobile materials teachers developed were scored by two experts as participants' learning outcomes. Inter-rater reliability was 0.92, showing the high level of reliability.

For explore the changes in teachers' knowledge about content, pedagogy, teaching methods and technology integration before and after the mobile material development activities, paired-samples *t* tests were utilized in this study. Moreover, Pearson's correlation was also utilized in this study to explore the relationship among the teachers' TPACK and learning outcomes.

3. Results

3.1 The changes in teachers' TPACK

As shown in Table 1, the average scores and standard deviations on the seven scales of TPACK-M survey for each of the pre-test and post-test are presented.

Moreover, the results of paired-samples *t* tests showed that there were significant differences found for all of seven scales of TPACK-M survey. The teachers' agreements after the mobile material development activities were significantly higher than those before the activities. It implies that through the mobile material development activities, the teachers held more knowledge about content, pedagogy, teaching methods and technology integration, including content knowledge (CK) ($t(24) = -2.20$, $p < 0.05$), pedagogical knowledge (PK) ($t(24) = -4.16$, $p < 0.001$), pedagogical content knowledge (PCK) ($t(24) = -2.13$, $p < 0.05$), knowledge about mobile technology (TK_M) ($t(24) = -3.36$, $p < 0.01$), technological pedagogical knowledge (TPK) ($t(24) = -2.98$, $p < 0.01$), technological content knowledge (TCK) ($t(24) = -3.07$, $p < 0.01$), and technological pedagogical content knowledge (TPACK) ($t(24) = -2.14$, $p < 0.05$).

Table 1: Average scores, standard deviations and results of paired-samples *t* tests.

Surveys	Factors	Pre-test		Post-test		*t*-value
		Mean	SD	Mean	SD	
TPACK	CK	5.46	1.04	5.90	0.76	-2.20*
	PK	5.13	1.01	5.66	0.93	-4.16***
	PCK	5.03	1.37	5.58	0.93	-2.13*
	TK_M	5.08	1.09	5.70	0.84	-3.36**
	TPK	5.25	1.00	5.66	0.86	-2.98**
	TCK	5.15	0.83	5.71	0.86	-3.07**
	TPACK	5.17	0.83	5.64	0.99	-2.14*

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

3.2 The relationships between teachers' TPACK and learning outcomes

Pearson's correlation was utilized to show the relationships among teachers' TPACK after the activities and learning outcomes. The results are shown in Table 2. It was found that teachers with stronger agreement with the TK_M (correlation coefficient = 0.49, $p < 0.05$) and TCK (correlation coefficient = 0.44, $p < 0.05$) factors tended to have higher scores of learning outcomes. This implies that the teachers held more knowledge about mobile technology and technology used in their subject area tended to have higher learning outcomes.

Table 2: The relationships between teachers' TPACK and learning outcomes.

TPACK scales	CK	PK	PCK	TK_M	TPK	TCK	TPACK	Learning outcomes
CK	1	0.38	0.43*	0.26	0.23	0.34	0.19	0.12
PK		1	0.82***	0.12	0.72***	0.02	0.78***	-0.02
PCK			1	0.21	0.60*	-0.05	0.65***	-0.11
TK_M				1	0.50*	0.44*	0.24	0.49*
TPK					1	0.42*	0.84***	0.27
TCK						1	0.06	0.44*
TPACK							1	0.04
Learning outcomes								1

* $p < 0.05$; *** $p < 0.001$

4. Discussion and conclusions

The present study explored the impact of mobile material development activities on changes in teachers' TPACK. The results showed that through the activities, the teachers held more knowledge about content, pedagogy, teaching methods and technology integration, including content knowledge (CK), pedagogical knowledge (PK), pedagogical content knowledge (PCK), knowledge about mobile technology, technological pedagogical knowledge (TPK), technological content knowledge (TCK), and technological pedagogical content knowledge (TPACK). Chai et al. (2013), Lee et al. (2012) and Nadelson et al. (2013) revealed that the effective of professional development courses help teachers to improve their TPACK. The similar findings are shown in this study that the effective of developing learning materials for mobile learning can support teachers to improve their TPACK for mobile learning.

Moreover, this study also examined the relationships among teachers' TPACK and learning outcomes. The results showed that teachers with more knowledge about mobile technology and technology used in their subject area tended to have higher learning outcomes. This implies that the roles of mobile technology and teachers' knowledge of subject matter representation with technology are the basis in the mobile material development activities. The teachers learned those perceptions in the mobile material development activities, and also represented in their works. It is suggested that educators should consider more TPACK factors when design the professional development activities

Acknowledgements

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A Case Study on the Problem Representation of College Science Students in the Lego Building Process

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Abstract: The purpose of this study is to analyze the problem representation of college science students in the Lego Building Process. The present study selected fourteen college science students as participants. Using the thinking-aloud method and triangulation to collect materials, the study found that the selection tendency of problem representation, ranging from more to less, was action representation, image representation and symbolic representation. That is, there are significant differences in action representation and image representation between participants with Lego building experience and those without Lego building experience. There is no significant difference in the proportion of different problem representations between different types of tasks by gender or experience. Additionally, there is no significant difference in the selection tendency of problem representation between high building-capacity students and low building-capacity students, but there is a significant difference in the transformation rule of problem representation. This study provides some suggestions on teaching practices for college Lego education based on the results.

Keywords: Lego building, problem representation, transformation rule

1. Introduction

Lego education, drawing widespread attention, recently has been introduced into education systems in developed countries such as Britain, America, and Japan. Domestic studies on Lego Education largely focus on primary education (K12), but are lacking in higher education (Benitti, F. B. V., 2012;Xue Qingping, & Li Weihong, 2012). Studies on Lego Education in higher education primarily involve engineering courses and computer courses in universities (Danahy, E., Wang, E., Brockman, J., Carberry, A., hapiro, B., & Rogers, C. B., 2014; Foundation Coalition, 2001; McWhorter, W. I., 2008). Correct and effective problem representation is the key to solving problems (Moreno, R., Ozogul, G., & Reisslein, M., 2011). Studies on problem representation primarily focus on mathematics and physics in primary and secondary schools at present (Krawec, J., 2014; Orrantia, J., & Múñez, D., 2013), and on lack of practice in such disciplines (Chae, K. H., & Lee, G., 2011; Shai, O., 2003). Through a long observation of Lego building courses, we found that the building capability of college science students is not at a high level. Requirements for problem solving and a practical ability for self-discipline are higher for science students than for art students. This paper, aiming to study cases in which college science students build Lego, tries to ascertain the features of cases that involve hands-on activities and provides suggestions and a theoretical basis for Lego building courses in college. In addition, this paper summarizes the features of adults' problem representation to provide suggestions for problem solving. This study involves three problems as follows:

(1) During the Lego building process, what is the selection tendency of college science students' problem representation approaches?

(2) Is there a significant difference in college science students' selection tendency and proportion of problem representation approaches among different variables (gender and with experience of building Lego)?

(3) Is there a significant difference between students who have high (H) and low (L) building-capacity in selection tendency and transformation of problem representation approaches?

2. Literature Review

2.1 Problem Representation

Representation, an important concept in psychology, means the modes of presentation in the brain (Bruner, J. S., 1966). It is the central part of problem solving. The problem is half solved if you obtain correct representation (Simon, 1986). Due to different purposes and fields of research, researchers keep to different standards of classification of problem representation. Fu Xiaolan considered that problem representation is the process of finding problem structure and building problem structure to convert external physical stimuli to internal psychological symbols (Fu Xiaolan, & He Haidong, 1995). Problem representation is both a process, that is, the understanding and internalization of the problem and a result of problem understanding, that is, the problems presenting in the brain (Xu Xingchun, 2002). Boqin, Huang Xiting and Fan Wei classified the problem representation into four types: character representation, naive representation, physical representation and figure representation (Boqin, Huang Xiting, & Fan, 1997).

2.2 Methods of Problem Representation

Researchers adopt different methods when studying problem representation. Some researchers analyzed participants' types and features of problem representation by designing problem situations and observing the process of problem solving (Domin, D., & Bodner, G, 2012). Some researchers adopted interview and questionnaire methods (Stylianou, D. A., 2011;Krawec, J. L, 2014;Wang Libing, 2009), whereas some researchers adopted the content analysis method (Feng Meiling., 2003) or the Thinking-aloud method (Kammerer, Y., & Gerjets, P, 2013).

2.3 Related studies

Recently, Lego Education, drawing widespread attention, has been accepted into education systems in developed countries such as Britain, America, and Japan. Domestic research on Lego Education largely focuses on primary education (K12), but is lacking in higher education (Benitti, F.B.V., 2012; Xue Qingpin, &Li Weihong, 2012). Studies on Lego Education in higher education primarily involve in engineering courses and computer courses in universities (Danahy, E., Wang, E., Brockman, J., Carberry, A., hapiro, B., & Rogers, C. B., 2014; Foundation Coalition, 2001; McWhorter, W. I., 2008). McWhorter (2008) did a survey in a college computer programing course's lead-in course to study the effect of the activities relevant to using Lego Mindstorms on college students' learning motivation, learning strategy and students' master level to course objectives, but the results showed no effect on the three questions. Danahy (2014) studied the effect of Lego Mindstorms on the engineering courses of a university. The study concluded that Lego Mindstorms enabled students to reach higher accuracy without extensively learning circuit design and artificial intelligence. Currently, fewer studies are underway on Lego building problems representation.

Studies on problem representation largely focus on mathematics and physics in primary and secondary schools at present (Krawec, J., 2014; Orrantia, J., & Múñez, D., 2013). Krawec (2014) did a study on students with learning difficulties, low learning effect and average learning effect on problem representation solving math problems. In the field of hands-on practice, there are a few studies, primarily involving engineering design and drawing (Chae, K. H., & Lee, G., 2011; Shai, O., 2003). Problem representation in engineering design primarily focuses on the purpose of image representation that aims to discover the connection between knowledge from a system of math knowledge generated from engineering methods (Shai, O., 2003). Examples include analyzing an entire engineering system (Shai, O., & Rubin, D., 2004), designing an engineering system (Shai, O., 2003), finding a connection between engineering systems (Shai, O., 2001), and matching knowledge in an engineering system field with knowledge in other fields (v Shai, O., 2002). Chae (2011) studied problem representation in the field of drawing. The study compared the cartographic representation and drawing approaches of Korea and the United states and discussed how to improved cartographic representation and drawing approaches after introducing Building Information Model (BIM) into drawings. They found that the readability of a drawing is increased after removal of redundant information between drawings.

2.4 Brief summary

From the literature review, we found that different reasearchers have different concepts on problem represention due to different research views and aims. After analyzing those different concepts, this paper defined problem representation as the strategy adopted when an individual is understanding a task. We divided it into action representation, image representation and symbolic representation according to the classification of Brune. Action representation means an individual understands things by acting on them; image representation means an individual understands things by forming images; symbolic representation means an individual understands things by symbols, particularly via language (Bruner, J. S., 1966). With Lego building, action representation means an individual seeks building ideas by building; image representation means an individual forms images, situations or uses experience to build; symbolic representation means an individual understands a task requirement by retelling the task or identifying keywords of the task. Basing on the analysis of those studies on Lego and problem representation, we know that there are few studies on problem representation in the field. This paper adopted the Thinking-aloud method and Triangulation to analyze the college science students' approach to problem representation during the Lego building process and further analyzed adults' features of problem representation, hoping to giving advice and a theoretical basis for college Lego building courses and adult education to foster problem solving ability.

3. Design

3.1 Participants

This study selected fourteen college science students aged 22 to 24. We consider those students who have taken Lego building course experienced participants; these included three men and four women. We considered those students who had not taken Lego building courses inexperienced participants; these included four men and three women,. The males outnumber females by one, and students with Lego building experience outnumber those without Lego building experience by one.

3.2 Method

3.2.1 Thinking aloud method

Duncker and Lees (1945) first proposed the Thinking-aloud method, an important research method in the field of problem solving. At present, the Thinking-aloud method is primarily used to study problem representation during the process of web evaluation (Kammerer, Y., & Gerjets, P, 2013). The method's main feature is requiring participants to speak their thinking process aloud when they are doing the designed task; that is, they must report what they are thinking. Then, researchers analyze the oral report material to detect the thinking process and its problem and regulations.

3.2.2 Triangulation

Triangulation includes material triangulation, investigation triangulation, theory triangulation and methodology triangulation (Huang Youchu, 2014). Our study used material triangulation to obtain more-accurate information, thus ensuring validity. The Thinking-aloud method has some limitations; for example, it may affect the participant's thinking process because he or she must talk while thinking. Moreover, many scholars have questioned the integrity and facticity of data from the Thinking-aloud method because the thinking process is implicit (Hauge, C. H，2015). Therefore, our study performed questionnaire investigation and conducted an interview immediately after the participant finished the building task to obtain more information as complementary explanation to videos. Observation, questionnaire and interview form a triangulation.

3.3 Problem Representation Tasks

3.3.1 Tasks Set

In this study, the research team and educational technology experts identified two Lego building tasks according to difficulty level.

The first task is to build a "vertical clover fan" and is marked T1. T1 requires the Gear-driven blades to rotate rapidly while the fan stands steadily on the table. To increase the difficulty of building, certain aspects of building are specified in this study such as the height of the fan, the length of the blades, that the blades evenly distribute and so on. It takes approximately 50 minutes to finish T1. The building process is more difficult and relates to some physical knowledge including triangle stable structure and secondary transmission gear.

The second task is to build a "seesaw" and is marked T2. T2 requires that the seesaw maintains balance and stands steadily on the table in the natural state. To examine the application capacity of the subjects on the equipment, the length of various seesaw parts, the width of various seesaw parts, the number of blades and specific lengths of blades are required. It takes approximately 10 minutes to finish T2. The building process is less difficult and relates to some physical knowledge including triangle stable structure and the Lever principle.

3.3.2 Score Standard

The score standards were based on a mature score standard pattern which has been used by an instructor with rich experience in teaching the Lego Mindstorm course at the selected university for three years. Referring to her evaluation form, our score dimensions are given for three aspects including completeness, aesthetics and innovation.

3.4 Triangulation Tool

3.4.1 Coding Book

This study used two types of coding tables involving the various stages of the Lego building process and the type of problem representation. The first coding table, which aims at distinguishing between the various stages of the Lego building process, is based on the general problem settlement pattern proposed by M.L. Gick et al. (Gick, M.L., & Holyoak, K.J., 1980). It combines strong practical features of Lego building, all phases of the Lego building process are identified as understanding and characterizing tasks, trying to build, evaluate and others . The second coding table aimed at distinguishing the types of problem representation, divides the type of problem representation into action representation and image representation, symbolic representation and other representation mode according to Jerome Seymour Bruner's division of representation (Bruner, JS, 1966).

3.4.2 Questionnaire

To supplement the content of video observation, this study further deigned the questionnaire to immediately followthe subjects' completion of the building tasks. It primarily aims at learning subjects' selection tendency toward representation and order of representation in the building process.

3.4.3 Interview Table

The interview table was used after the coding was finished. Interview subjects were questioned to understand the specific thought processes within the time slice in which coders were uncertain in the coding process. Coding tables, questionnaires and interview table form the triangulation tools.

3.5 Pilot Study

Two experts recognized the coding tables. After ensuring validity of the coding tables, two subjects with no Lego building experience were tested in the pilot study before the formal study to ensure a feasible study, test task difficulty, set the time to build and modify the coding table. After the pilot study, researchers selected T1 and T2, which are more in line with the level of subjects from six candidate tasks, and substantially determined that the building times of T1 and T2 were 50 minutes and 10 minutes respectively. Then, two coders made a pre-coding that pauses 10s once based on a 40-minute video selected from a 60-minute video of one of the subjects. Two coders' Kappa values of the two coding tables were 0.7211, 0.525 respectively, they were highly consistent and standards-compliant.

3.6 Materials Collection

3.6.1 Observation

Researchers stated the requirements of the tasks to the subjects, asked them to complete the tasks using the method of thinking aloud and recorded the entire building process and all speech of the subjects with a video recorder at the same time. The researchers would provide reminders or queries when the subjects appeared to pause for a long time during the thinking-aloud process, but tried not to interfere with their thinking processes.

3.6.2 Questionnaire

After the building tasks were finished, subjects were asked to complete the questionnaire, which covering subjects' selection tendency toward representation, order of representation and the design programs of tasks in the building processes of T1 and T2.

3.6.3 Interview

After coding, researchers summarized uncertain time slices in the coding process. Interview subjects were asked about their thought processes at those uncertain times to supplement data collection.

3.7 Materials Analysis

Researchers sorted out and input the coded data into spss20 to analyze them as follows. (1) Analyzed the proportion of students' various representations using a descriptive statistical analysis method. (2) Used a U-test to analyze whether there are significant differences between the representation of subjects who have Lego building experience and those who do not, and the representation of subjects in different types of tasks and whether there was a significant difference in the representation of different gender subjects. (3) Test scores were set up in descending order, taking the first 30% as high building-capacity students, marked H, and the last 30% as low building-capacity students, marked L. Researchers analyzed whether there were significant differences in problem representation and transformation of problem representation of high building-capacity students and low building-capacity students using the U-test analysis method.

4. Results and Discussions

4.1 Results

4.1.1 Selection tendency toward the types of problem representation

Figure 1 shows that the proportion of various types of problem representation is different in the Lego building process. Among the four types of problem representation, the action representation is 73%, the image representation is 15%, the symbolic representation is 9% and the other representation is 3%. The percentage of the action representation is highest in the Lego building process.

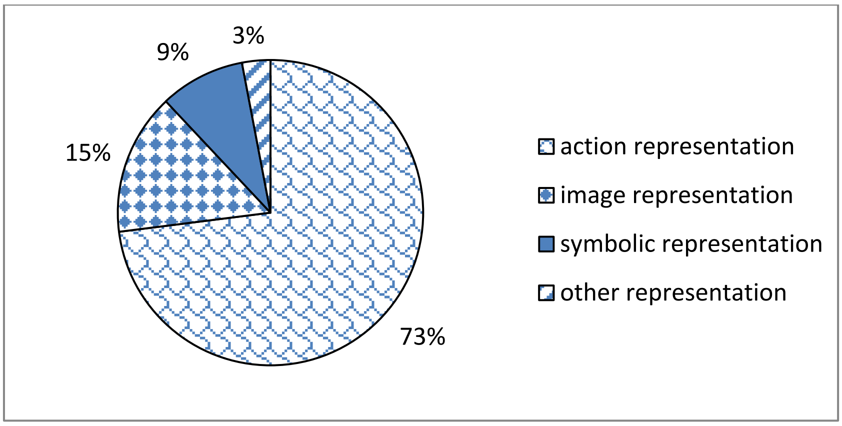

Figure1: The proportion of each Representation

4.1.2 Analysis of the selection tendency and the time proportion

Table 1: The analysis of the selection tendency toward representation (Mean)

		Action Representation	Image Representation	Symbolic Representation
Task Type	Task1	0.79	0.11	0.08
	Task2	0.67	0.19	0.10
Gender	Male	0.71	0.18	0.10
	Female	0.75	0.13	0.08
Experience	Experienced	0.61	0.24	0.12
	Inexperienced	0.85	0.06	0.06

Table 2: The U-test of Task Type, Gender and Experience

		Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-sided)
Task Type	Action Representation	57	135	-0.87	0.386
	Image Representation	52.5	130.5	-1.13	0.260
	Symbolic Representation	70	148	-0.12	0.908

Gender	Action Representation	66	144	-0.35	0.729
	Image Representation	63.5	141.5	-0.49	0.623
	Symbolic Representation	72	150	0.00	1.000
Experience	Action Representation	28	106	-2.54	0.011
	Image Representation	23.5	101.5	-2.80	0.005
	Symbolic Representation	30.5	108.5	-2.40	0.017

Table 3: The analysis of time scale of representation

			Time scale of representation	
			M	SD
Task 1	Experience	Experienced	0.35	0.09
		Inexperienced	0.28	0.11
	Gender	Male	0.33	0.07
		Female	0.31	0.13
Task 2	Experience	Experienced	0.32	0.14
		Inexperienced	0.25	0.11
	Gender	Male	0.27	0.15
		Female	0.30	0.11

Table 4: The U-test of Experience and Gender in different type of tasks

		Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-sided)
Task1	Experience	14	35	-0.64	0.522
	Gender	14	35	-0.64	0.522
Task2	Experience	12	33	-0.96	0.337
	Gender	15	36	-0.48	0.631

As seen in Tables 1, 2, 3 and 4,there is no significant selection tendency difference between the action representation ($Z = -0.87$, $p>0.05$), image representation ($Z = -1.13$, $p>0.05$) and symbolic representation ($Z = -0.12$, $p>0.05$) in different tasks. In different tasks, different gender subjects showed no significant differences in the tendency toward selection of the representation and the time proportion. In the T1 and T2 tasks, subjects who had Lego building experience showed similar time proportion for the presentation, while showing significant differences in the selection tendency of the action representation and the image representation.

4.1.3 Analysis of the types of representation selection and transformation of high (L) and low (L) building-capacity students

Table 5: The tendency toward representation selection of high and low building-capacity students

	Action representation	Image representation	Symbolic

						representation	
		(M,SD)		(M,SD)		(M,SD)	
Task1	H	0.72	0.19	0.20	0.18	0.05	0.03
	L	0.81	0.08	0.05	0.05	0.12	0.13
Task2	H	0.52	0.30	0.31	0.27	0.13	0.09
	L	0.83	0.07	0.08	0.08	0.04	0.03

Table 6: The U-test of the type of representation in different tasks

		Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-sided)
Task1	Action Representation	6	16	-0.58	0.564
	Image Representation	3.5	13.5	-1.32	0.189
	Symbolic Representation	5	15	-0.87	0.386
Task2	Action Representation	3	13	-1.44	0.149
	Image Representation	3	13	-1.44	0.149
	Symbolic Representation	3	13	-1.44	0.149

As shown in Tables 5 and 6, in T1, the tendency toward selecting action representation ($Z = -0.58$, $p>0.05$), image representation ($Z = -1.32$, $p>0.05$) and symbolic representation ($Z = -0.87$, $p>0.05$) of the high building-capacity (H) and low building-capacity (L) students suggested no significant difference. Additionally, in T2, there is no significant difference in choices of the high building-capacity (H) and low building-capacity (L) students among action representation ($Z = -1.44$,$p>0.05$), image representation ($Z = -1.44$, $p>0.05$) and symbolic representation ($Z = -1.44$, $p>0.05$).

4.1.4 Analysis of the transformation of problem representation of high (H) and low (L) building-capacity students

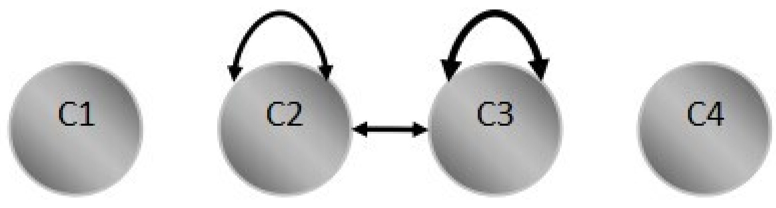

Figure 2 : The transformation of high（H）building capacity students' problem representation

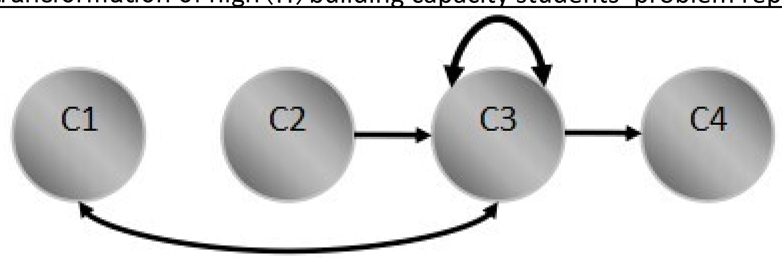

Figure 3 : The transformation of low (L) building capacity students' problem representation

This study further counted the transformation of the problem representation that the high building-capacity students (H) and low building-capacity (L) students made in T1 and T2 during the Lego building process. The researchers obtained C1, C2, C3, C4 and the transformation scale in and between each other (C1 on behalf of symbolic representation, C2 on behalf of image representation, C3 on behalf of action representation and C4 on behalf of others). They then finally selected the four high scales to draw the figure of the transformation of the problem representation (Hou, H. T., 2012). The study found that both the high building-capacity students (H) and low building-capacity (L) students showed similar transformation characteristics in different tasks. The transformation of high (H) and low (L) building-capacity students' problem representation is shown in Figures 2 and 3. The figure suggests that the majority of the transformation is the action representation internal transformation, which is the similarity of high (H) and low (L) building-capacity students, and the proportions are 60% and 74%. Moreover, concerning high building-capacity (H) students, the internal transformation of C2 and the transformation between C2 and C3 are a significant share. There are many transformations betweenC1and C3, and C3 to C4 with regard to low building-capacity students.

4.2 Discussions

Previous studies suggested that people can make a direct explanation with representation, then affect the process of their deduction (diSessa,1993).Various means of representation have close relationships with the solutions of the problems (Kohl, Rosengrant, & Finkelstein, 2007). Based on the data analysis, the study suggested that students preferred to choose action representation at first, then image representation, and symbolic representation at last when building Legos. However, in language learning, people were more willing to adopt the image representation generally (Orrantia, J., & Múñez, D., 2013), which was different from this study. With Triangulation, we found that action representation generally was used to determine whether the tools chosen were suitable, whether the steps adopted were good, whether the work was perfect and so on by the students. Moreover, students used image representation to form a static image or dynamic situation about the tasks in their brains. Students also could combine their previous Lego building experience, such as the characteristics of all the tools, with their life experience, such as previous knowledge that the obvious characteristic of a triangle is that it is stable, to finish the tasks. Some students repeated the key words of the tasks though symbolic representation.

By analyzing the time scale of the problem representation in different types of tasks, we found that there was no significant difference; namely, whether the task is difficult or easy, the time proportion of the problem proportion is similar, indicating that with certain time proportions of representation, the task can be complete successfully. In the process of solving a problem, the process of representation is the process of transforming information, which affects problem-solving (Vessey,2006), and representation plays an important role in the process of problem-solving (see, e.g., de Jong &Ferguson-Hessler, 1996). In the study of adult representation, Chen et al. (2006) found that there was no significant gender and age difference in the level of problem representation, and adult problem representation is stable. In the process of Lego building, there was no significant gender difference in the tendency toward selecting different types of problem representation, and the tendency of subjects toward selecting various types of representation is action representation, image representation and symbolic representation in descending order. In tennis, experts can create more integrated, diverse and complex conditions and actions than novices can (McPherson, S. L., 1999). Similarly, in the process of Lego building, there exist significant differences in the selection of action representation, image representation and symbolic representation by experienced and inexperienced students. Compared with experienced students, inexperienced students used more action representation and less image representation and symbolic representation. Reasons for this difference may be that inexperienced students were unfamiliar with the function and the possible combination of the equipment; however, experienced students can use their previous experience to choose the appropriate equipment and make the correct combination. Inexperienced students needed to choose the right equipment and make right combination to achieve the desired tasks through several attempts that were parts of action representation.

Appropriate use of spatial representations can support reading, mathematics and science learning, spatial representations can also simulate psychological situation, realize visualization, to promote innovation and scientific discovery (Sawyer,R.K.,2005) .Therefore, the types of representation affect problem solving. Through Triangulation, this study found that the selection scale of image representation of the high building-capacity students (H) was significant higher than that of low building-capacity (L) students, which suggested that the high building-capacity students (H) can better combine life and Lego experience. As for the transformation of the problem representation, the similarities of high (H) and low building-capacity (L) students were that the majority of the transformation was the action representation internal transformation, which was consistent with the characteristics of Lego building requiring many equipment components to verify suitability. Previous studies suggested that experts can form the external and internal relationship of the problem, and can solve the problem in a forward-looking manner (Tua A. Björklund, 2013). In this study, the researchers found that high building-capacity (H) students can use image representation more effectively, use their previous experience to develop an overall understanding of the problem, and then guide their building; in other words, they can consider the entire assembly at the beginning of building. The low building-capacity (L) students can only focus their attention on part of the problem, completing the whole before making a part combination. Moreover, they always adjusted the tasks when they found defects or errors; therefore, there were many setbacks during their building. Some studies have shown that novices tend to work backward, whereas the expert tends to work forward based on the specific student (Larkin, McDermott, Simon, & Simon, 1980; Sweller, Mawer, & Ward, 1983). Additionally, this study suggested that high building-capacity (H) students can provide image representation meaningful feedback with the action representation inspecting the equipment to prompt the process of building. Low building-capacity (L) students cannot think meaningfully after action representation, but become dazed or stagnant.

5. Conclusions

5.1 Conclusions and Suggestions

Correct and appropriate problem representation plays a very important role in the successful resolution of the problem. This study provided appropriate advice and inspiration for hands-on courses based on analyzing and discussing the features of science students' problem representation in the process of Lego building. First, individuals tend to use action representation and image representation to finish the tasks in the case of solving hands-on problems. Therefore, Teachers should encourage students to form an effective action representation through several attempts and develop possible solutions by combining the effective representation with their specific living and learning experience. The integrated use of a variety of problem representations is very important for the successful resolution of problems (Kohl, Rosengrant, & Finkelstein, 2007). In the teaching process, teachers should encourage students using a variety of methods to solve the problems from multiple angles.

When a problem representation cannot solve the problem effectively, one can change it or use a variety of representations to think about and then resolve the problem. Therefore, students should focus on expanding and enriching their own knowledge and experience in daily life. If teachers in the teaching process find and hold in reserve an effective solution to a particular problem students lack experience to solve, the teachers can provide it as a certain degree of knowledge supplement to enable the students to solve the problem successfully. Meanwhile, teachers can provide students a certain degree of knowledge supplement to enable them to solve a particular problem successfully if they find that students lack the experience necessary for an effective solution to the problem in the teaching process. Next, the problem representations of individuals functioning as part of a team and acting as individuals are different; the former are more abstract (Schwartz, 1995). Therefore, complex hands-on activities are more suitable for the teamwork form. The advantages are that complementary capabilities of students can better promote the completion of the task. Finally, in the adult stage, the level of problem representation does not change significantly with increased age (Bo Chen and JiLiang Shen, 2006). Therefore, cultivating an individual's problem-solving skills through hands-on must start early. In addition to teaching declarative knowledge in the teaching process, teachers should also create more opportunities for students to learn hands-on to form a deep understanding of knowledge.

5.2 Limitations

First, this is a small-sample study because of the small number of subjects. Therefore, the study is limited by the number of subjects. Second, the study lasted more than two months, a relatively short time that is not sufficient to follow students' problem representations in a different period. Furthermore, because different scholars' points and the content of their studies differ, the definition of the concept of problem representation is divergent; it is not yet a unified understanding in the academic world.

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Lea's Box: A Competency-oriented Approach to Facilitate Learning Analytics in School Settings

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Abstract: Learning Analytics is a key term of recent research and development in the educational sector. However, the uptake of such techniques is oftentimes limited to online courses and it is sparsely used in schools. The reason is that school-based teaching and learning is still an 'analogue' and personal process that is not producing the digital data that are necessary to conduct in-depth learning analytics. The Lea's Box project is addressing this problem by supporting teachers in their daily practice to collect data as easy and complete as possible to have at least the 'little data' required to make their teaching more individual and more formative. In addition, the project attempts to develop competence-oriented techniques for learning analytics on the basis of solid theories that have been developed in the context of intelligent tutorial systems. In this paper we present a summary about the developments and experiences with the tools and techniques in schools.

Keywords: Learning Analytics, Competence-based Knowledge Space Theory, Formal Concept Analysis, School Teaching

1. Introduction

Educational technologies are advancing rapidly; new solutions and online platforms appear every day. Mobile learning, learning on demand and media rich curricula are recent buzz words describing the "*techno-pedagogical*" state of the art. And not least, the research and development community is encircled by the hovering spirit of "*big data*", *learning analytics* and *educational data mining*. In educational practice, there is an increasing conceptual change towards a formative evaluation and support of learners and a strong orientation to competencies and meta-competencies such as the so-called 21st century skills. There is no doubt, that the pace and mode of learning must adapt to ever fast changing societal challenges.

Well, looking into classroom reality in Europe, we can find a very diverse situation: The most frequent situation in schools is that they are *technology lean*; there is little hardware and software, internet access is often not available, too slow or restricted. There are schools and regions in Europe where the use of the Internet in school is prohibited or strictly limited based on local policy, public opinion and/or parents' consent. It is seen as a source of danger (for example due to well-known cases of cyber mobbing, addictive gaming, etc.) where children need protection rather than the development of digital skills. Of course, there are schools and regions where the opposite is the case and technology is seen as an - still emerging - but already basic literacy skill. The use of (new) technologies is often dependent on the enthusiasm of individual teachers. However, even if teachers are motivated and enthusiastic about using and adapting ICT equipment, they might face obstacles due to mandatory security and organizational policies. Organizational structures usually do not support the use of massive personal devices like laptops, tablets and mobile phones in the classroom. Ultimately, the use of ICT (specifically with the aim of formative assessment) means collecting data on a large scale. With respect to this data collection and assessment the fear exists that assessment results (including data from the Programme for International Student Assessment, PISA) are used to measure the performance of an individual teacher and are thus opposed by teacher unions. Studies show, that if standard assessments like PISA become important, there is more "training for the test" going on and hence less time spent for individual student development. This makes a significant number of teachers' sceptic about the benefits of assessments and analyses in general (Rowlet, 2013).

In conclusion, there is sparsely "big data" and sometimes we do not even find "little data" in European school realities. Even if this perspective is perhaps a little bit larger than life, it nonetheless becomes obviously a long way to widely applied learning analytics with the key goal to make teaching more formatively inspired and more focusing on the individual as opposed to standardized "action - test - outcome" pedagogies.
The key question is how to support teachers in the real life's best. In this paper we introduce a European imitative, the Lea's Box project (www.leas-box.eu), which aims at providing simple and usable and realizable solutions, close to teacher practice, and which aims at bringing all the tiny little bits of data that are available together – for good.

2. Lea's Box – A learning Analytics Toolbox

Learning analytics (LA) and educational data mining (EDM) are more than recent buzz words in educational research: they signify one of the most promising developments in improving teaching and learning. While many attempts to enhance learning with mere technology failed in the past, making sense of a large amount of data collected over a long period of time and conveying it to teachers in a suitable form is indeed the area where computers and technology can add value for future classrooms. However, reasoning about data, and in particular learning-related data, is not trivial and requires a robust foundation of well-elaborated psycho-pedagogical theories. The fundamental idea of learning analytics is not new, of course. In essence, the aim is using as much information about learners as possible to understand the meaning of the data in terms of the learners' strengths and weaknesses, abilities, competences and declarative knowledge, attitudes and social networks, as well as learning progress, with the final goal of providing the best and most appropriate personalized support. Thus, the concept of learning analytics is quite similar to the idea of formative assessment. "Good" teachers of all time have strived to achieve exactly this goal. However, collecting, aggregating, storing and interpreting information about learners that originates from various sources and over a longer period of time (e.g., a semester, a school year, or even in a lifelong learning sense) requires smart technology. To analyze this vast amount of data, give it educational meaning, visualize the results, represent the learner in a holistic and fair manner, and provide appropriate feedback, teachers need to be equipped with the appropriate technology. With that regard, a substantial body of research work and tools already exist. Lea's Box aims to continue and enrich on-going developments and facilitate the broad use of learning analytics in the "real educational world".

Lea's Box concentrates on a competence-centered, multi-source formative assessment methodology based on sound psycho-pedagogical models, such as the *Competence-based Knowledge Space Theory* (CbKST) and the *Formal Concept Analysis* (FCA) which are to the very concrete demands and requirements of teachers and learners.

The tangible result of Lea's Box manifest in form of a Web platform for teachers and learners provide links to the existing components and interfaces to a broad range of educational data sources. Teachers will be able to link the various tools and methods that they are already using in their daily practice and that provide software APIs (e.g., *Moodle* courses, electronic tests, *Google Docs*, etc.) in one central location. More importantly, the platform hosts the newly developed LA/EDM services, empowering educators to conduct competence-based analysis of rich data sets. A key focus of the platform will enable teachers not only to combine existing bits of data but to allow them to "generate" and collect data in very simple forms, not requiring sophisticated hard- or software solutions. Finally, we want to open new ways to display the results of learning analytics - leaving the rather statistical dashboard approach, moving towards structural visualizations and towards opening the internal learner models.

2.1 Generating and Collecting Data

The major difference between typical learning analytics scenarios and school reality is the degree to which an instructor and a learner are supposed to face some sort of digital device. Typical scenarios are e-learning courses, perhaps popular *MOOC*s, where a learner is producing data with each and every mouse click. In school, students are most often required to make their homework the old-fashioned paper pencil style. So, at best, the amount of data that is generated is a final grade for the homework.

Teachers are building their appraisal of students rather intuitive and experience-based instead of a solid, fair, objective data-based and evidence-based approach.

Thus, we developed a tool to allow teachers collecting data using a simple and cheap tablet computer. Based on design workshops with over 100 teachers from Austria, the Czech Republic, Germany, and Turkey, we set up the key needs, the key obstacles, and the key mental models of teachers. The outcome was a tool, named *myClass*, to collect and record data about activities, learning processes, and achievements very easily and independent from Wi-Fi connection. The tool is device-independent and can be used with smartphones, tablet computers, or regular computers. The following figure shows a screen shot of the *myClass* tool.

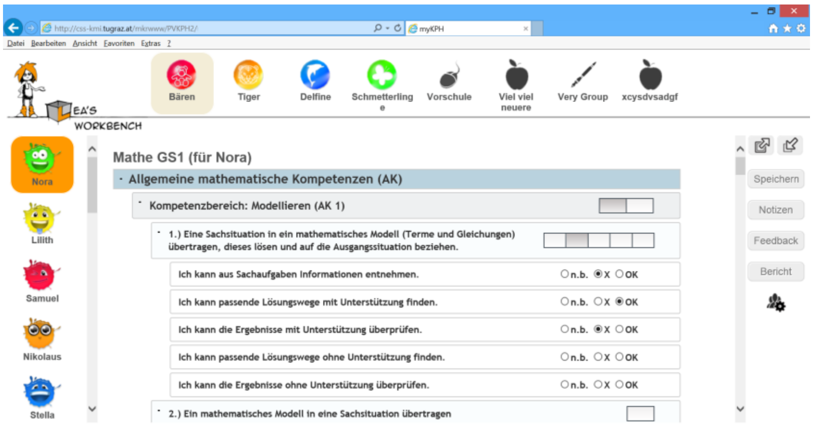

Figure 1. Screenshot of the lightweight classroom tool *myClass*.

The tool is composed of various modules that can be easily arranged by the teachers themselves to find exactly the configuration and feature they need and prefer most and. Now, not only the data collected by a single teacher might be of interest, *myClass* allows bringing together all the data from all teachers of a school; this, in turn, provides extra information for teachers. For example, the appraisal of the regular math teacher with the view of the afternoon tutor can be compared with each other. If there appear severe differences, there would be a clear need for reflect upon the reasons of these different evaluations.

Certainly, we cannot expect a perfect data source. The policy of Lea's Box is to make the maximum of whatever is available. A nice example from our experiences with applying the solutions in schools is a project named "personal responsibility". In this project, a partner school in Austria attempts to bring all students and teachers together once a month. In the plenum, certain agreements are made on a school-wide basis; for example, to take more personal responsibility in social conflicts. The key question for teachers and the principle is whether such "costly" efforts of bringing all people together and spend a certain amount of time on such projects, pays off in the end. Using *myClass*, a teacher can freely define positive and negative activities. These defined activities are accessible through the *myClass* system and can be counted with a single finger touch on a tablet computer. A key features of the *myClass* application which is of high relevance for teachers is the opportunity to generate report cards automatically and to generate materials and reports for teacher-parents conferences.

2.2 A Focus on Competences rather than on Performance

2.2.1 Competence-based Knowledge Space Theory

While the primary platform of Lea's Box provides needful yet simple tools tailored to the basic demands of teachers, it puts a string emphasis on student´s competencies. The foundation for our work is a conceptual psycho-pedagogical theory named *Competence-based Knowledge Space Theory* (CbKST).

The original *Knowledge Space Theory* (KST), founded by Doignon and Falmagne (1999, 2011), and extensions such as the CbKST, are coming from the genre of autonomous intelligent and adaptive tutoring systems. The idea was to broaden the ideas of the linear Item Response Theory (IRT) scaling, where a number of items are arranged on a single, linear dimension of “difficulty”. In essence, KST provided a basis for structuring a domain of knowledge and for representing the knowledge based on prerequisite relations. More recent advancements of the theory accounted for a probabilistic view of test results and they introduced a separation of observable performance and the actually underlying abilities and knowledge of a person. Such developments lead to a variety of theoretical, competence-based approaches (cf. Albert & Lukas, 1999 for an overview). An empirically well-validated approach to CbKST was introduced by Korossy (1999); basically, the idea was to assume a finite set of more or less atomic competencies (in the sense of some well-defined, small scale descriptions of some sort of aptitude, ability, knowledge, or skill) and a prerequisite relation between those competences.

In a first step, CbKST attempts to develop a model of the learning domain, e.g. algebra. Examples for such competencies might be the knowledge what an integer is or the ability to add two positive integers and so on. The level of granularity to which a domain is broken down depends on the envisaged application and might range from a very course-grained level on the basis of lessons (for example to plan a school term) to a very fine-grained level of atomic entities of knowledge/ability (for example as the basis of an intelligent problem solving support application). In a second step, CbKST looks into a natural course of learning and development and into logical prerequisites between competencies. Usually, learning and the development of new abilities as well as the stabilization of skills occurs along developmental trajectories. On the basis of a set of competencies and a set of prerequisite relationships between them, we can formally derive a collection of so-called competence states (Figure 2). Due to such prerequisite relations between the competencies, not all subsets of competencies (which would result in the power set) are plausible competence states.

So far, the structural model focuses on latent, unobservable competencies; loosely speaking the model makes hypotheses about the brain’s black box. By utilizing interpretation and representation functions the latent competencies are mapped to evidence or indicators relevant for a given domain. Such indicators might be test items but might refer to all sorts of performance or behavior (e.g., the concrete steps when working with a spread sheet application). Due to these functions, latent competencies and observable performance can be linked in a broad form. This means that an entire series of indicators can be linked to underlying competencies. The CbKST accounts for the fact that indictors such as test items cannot be perfect evidence for the latent knowledge or ability. There is always the possibility that a person makes a lucky guess or exhibits a correct behavior/activity just by chance. In turn, a person might fail in a test item although the necessary knowledge/ability is actually available, for example, by being inattentive or careless. Thus, CbKST considers indicators on a probability-based level, this means

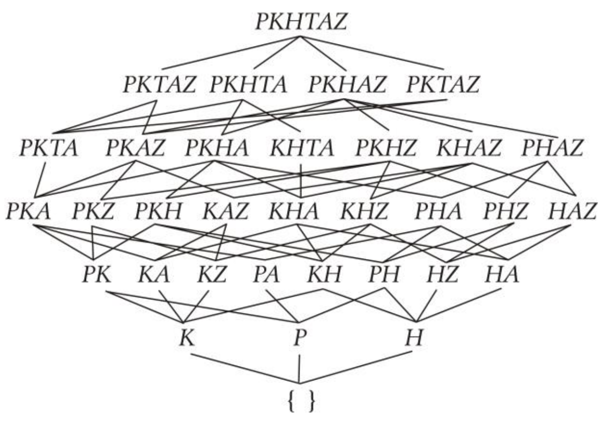

Figure 2. A prototypical competence space.

That mastering a test item suggest having the underlying competencies with a certain probability. Conceptually, this view constitutes a probability distribution over the competence structure. A further significant advantage of such approach is that learning is not only considered a one dimensional course on a linear trajectory, equal for all learners. Learning and development rather occur along one of an entire range of possible learning paths.

Recent advancements of CbKST primarily concern the integration of theories of human problem solving (given that most indictors can be interpreted as solving some sort of problem). This work was essentially driven in the genre of smart, educationally adaptive computer games for learning – loosely speaking for developing an educational AI support the players of the game (Kickmeier-Rust & Albert, 2012).

2.2.2 Formal Concept Analysis

Formal Concept Analysis (FCA) describes concepts and concept hierarchies in mathematical terms, based on the application of order and lattice theory (Wille, 1982). The starting point is the definition of the formal context which can be described as a triple consisting of a set of objects, a set of attributes, and a binary relation between the objects and the attributes (e.g., object *A* has attribute *B*). A formal context can be represented as a cross table, with objects in the rows, attributes in the columns and assigned relations as selected cells. An example of a formal context is shown in Figure 3. Teachers use the tool to define the formal context and to add learning resources which can be assigned objects and to attributes.

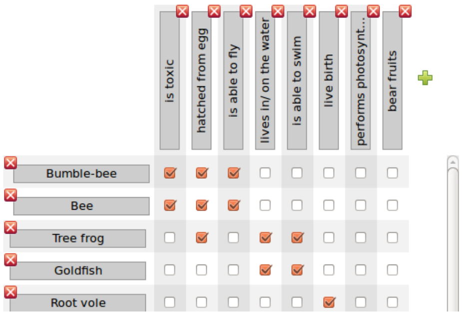

Figure 3. FCA-tool´s Editor View for creating a domain with objects, attributes, and relations.

Theoretically speaking, in order to create a concept hierarchy (called concept lattice), for each subset $A \in G$ and $B \in M$, the following derivation operators need to be defined:

$A \mapsto A' := \{m \in M \; I \; g \; I \; m \text{ for all } g \in A\}$, which is the set of common attributes of the objects in *A*, and $B \mapsto B' := \{g \in G \; I \; g \; I \; m \text{ for all } m \in B\}$, which is the set of objects which have all attributes of *B* in common.

A formal concept is a pair *(A, B)* which fulfils $A' = B$ and $B' = A$. The set of objects *A* is called the extension of the formal concept; it is the set of objects that encompass the formal concept. The set *B* is called the concept’s intension, i.e. the set of attributes, which apply to all objects of the extension. The ordered set of all formal concepts is called the concept lattice $\mathfrak{B}(K)$ (see Wille, 2005), which can be represented as a labelled line diagram (see Figure 4).
Every node of the lattice represents a formal concept. The extension *A* of a particular formal concept is constituted by the objects whose labels can be reached by descending paths from that node. As an example, the node with the label “Goldfish” has the extension {Goldfish, Tree frog}. The intension *B* is represented by all attributes whose lables can be reached by an ascending path from that node. In the example above, the formal concept´s intension consists of {is able to swim, lives in / on the water}.

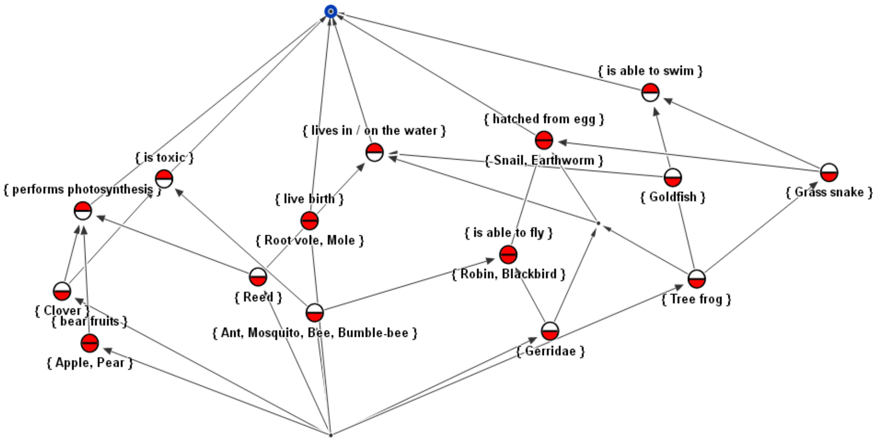

Figure 4. Concept lattice.

Similar as described by Rusch and Wille (1996) who were the first who applied the FCA with students and their performance data, we suggest formal contexts with student as “attributes” and competencies and skills as “objects”. The relation between these two sets means “student *m* holds competency *g*”. By such a concept lattice, a variety of different information can be displayed. Examples are overlaps and differences of students’ skills and competences or the visualization of the learning progress of an entire class over time.

3. Visualizing Competence-centered Learning Outcomes

One of the project partners in Lea’s Box is a company named *Scio* (www.scio.cz) from the Czech Republic. This company is responsible for nationwide standardized school entry exams. This gives us one the one hand a rich data basis for research and, on the other hand, access to Czech teachers. In an evaluation study we modelled a standard school entry test for secondary school mathematics. This knowledge domain covers essentially basic mathematical skills (such as solving simple equations) as well as skills like logical thinking or reasoning abilities. For this domain we identified a set of involved skills and competencies and we derived the competency space. Finally, we linked the competency states to the items of the national test. The competence model encompasses the competences and the prerequisite relations between them can represented as a Hasse-diagram as shown in Figure 6. Based on this competence model, the competence space which consists of of the ordered set of all plausible competence states can be derived (see Figure 7).

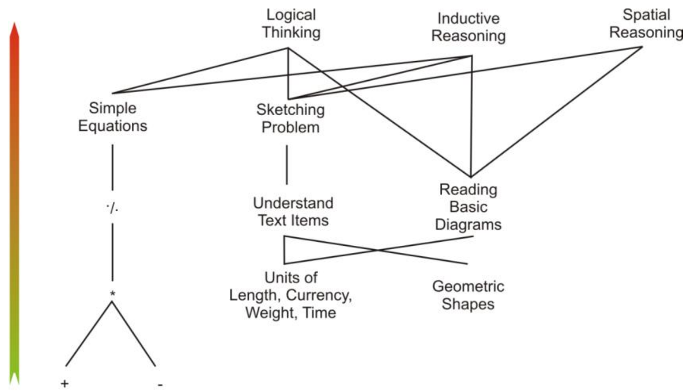

Figure 6. A competence model in the domain of mathematics
(the difficulty level increases from bottom to top)

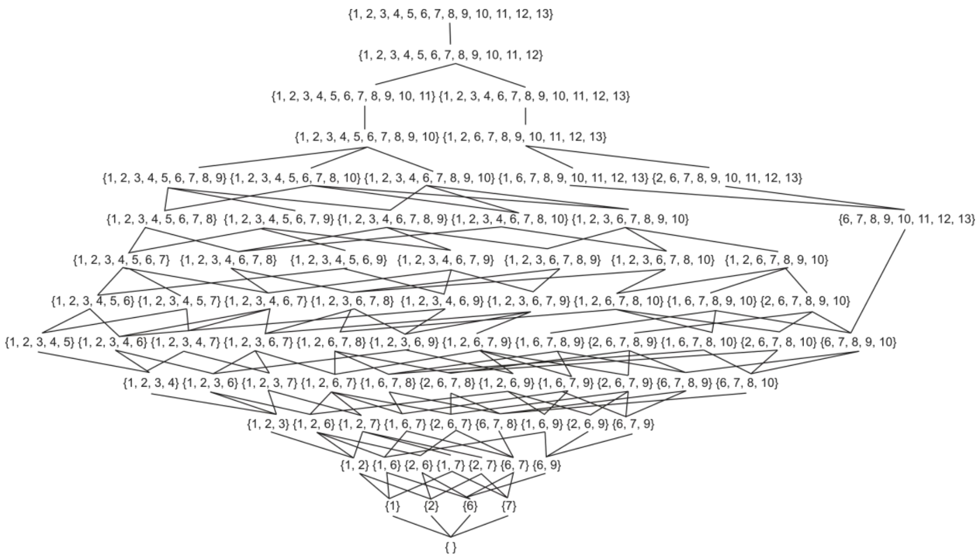

Figure 7. The competence space derived by the relation in Fig. 6.

Twelve teachers were exposed to the model and various visualizations in the context of qualitative design studies. Figure 8 illustrates a weak and a strong performer. As results, we found a reasonable trade-off between information density (complexity) and comprehensibility. Based on the concrete recommendations, we reduced the amount of information and adopted broader color coding features. The new features are presently investigated on a quantitative basis.

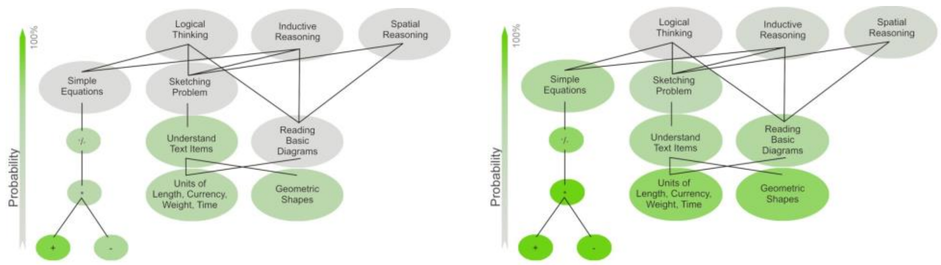

Figure 8. A visualization for teacher to display weak (left image) and good (right image) performes and their competencies.

4. Conclusions

There is little doubt that frameworks, techniques, and tools for LA will increasingly be part of a teacher's professional life in the near future. Some indications for that were already mentioned in section 2.1 of this paper. The benefits are convincing – using the (partly massive) amount of available data from the students in a smart, automated, and effective way, supported by intelligent systems in order to have all the relevant information available just in time and at first sight. The ultimate goal is to formatively evaluate individual achievements and competencies and provide the learners with the best possible individual support and teaching. The idea of formative assessment and educational data mining is not new but the hype over recent years resulted in scientific sound and robust approaches becoming available, and usable software products appeared. However, when surveying the educational landscape, at least that of the EU, the educational daily routines are different. We face technology-lean classrooms and schools, we face a lack of proper teacher education in using ICT in schools – not mentioning of using techniques of LA in schools. We face a certain aloofness to use breaking educational technologies and a well-founded pedagogical view that learning ideally is analogous and socially embedded and doesn't occur in front of some kind of electronic device. These are all experiences and results of a large scale European research project named Next-Tell (www.next-tell.eu) that was looking into educationally practices across Europe and that intended to support teachers where exactly they are today with suitable ICT as effective and as appropriately as possible.

Psychologically-sound frameworks such as the CbKST and new developments and extensions of the FCA which offer a rigorously competence-based, probabilistic, and multi-source approach account for the recent conceptual change in Europe's educational systems; which is a shift towards a more competence-oriented education including multi-subject competencies and superordinate 21st century (soft) skills.

No matter if data are rich or lean; a teacher is supported to the best possible degree and with a variety of important information about individual and group-based learning processes and performance of learners as well as about the educator's own performance. The probabilistic dimension enables teachers to have a more cautious view of individual achievements – it might well be that a learner has a competency but fails in a test; vice versa, a student might luckily guess an answer.

From an application perspective, in the context of European projects we developed and evaluated tools that cover the techniques and approaches described in this paper (available through the Lea's Box website www.leas-box.eu). We piloted various school studies and gathered feedback from teachers. In the end, and this can be considered an outlook for future developments, we had to find out that the 'massive' visualizatons (i.e. Hasse diagrams and concept lattices) are overburdening teachers' understanding and mental models about individual and class-based learning. Moreover, in order to understand the classical Hasse diagrams, it required (too) massive efforts in training teachers to fully utilize the potentials of those diagrams.

Therefore, recent efforts, e.g., in the Lea's Box project, seek to adjust and advance the classical Hasse diagrams to such visualizations that are intuitively understood by educators and, at the same time, hold the same density of information. In conclusion, the utility of competence-centered approaches to LA, involving a separation of latent competencies and observable behaviors and performances, as well as having a conservative, probabilistic, multi-source approach appears to be a striking classroom-oriented, next-level contribution to LA, learner modelling, and model negotiations.

Acknowledgements

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Analysis of how the students' behaviors in doing homework relate to their learning performance

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Abstract: As an important way of reinforcing learning and honing skills, homework plays a significant role in students' academic life. This study intends to investigate the relationship between the behaviors of students in doing homework (self-regulation and time spend on homework) and their academic achievements. The results show that homework self-regulation behaviors have significant effects on academic achievements yet the time spent on homework is not a convincing variable in predict students' grades. Propose a complex algorithm to classify homework behaviors and identify the learners who possibly yield poor learning performance will be our next work.

Keywords: Homework behavior, academic achievement, learning analytics

1. Introduction

Homework has always been an import role in students' academic life since K-12 education starts. While the relationship between homework and academic achievements has been discussed for years, the associations between them remains disputable. A review of early research on homework reveals, the time spent on homework has always been set as the key predictor of academic achievement. The measure of homework time is mainly acquired from the self-report of students (students were asked to answer questions like 'How long have you taken to do your homework every week?'), which may not accurately learn the time spent on homework, and therefore mislead the conclusions. This paper investigates the homework from the view of self-regulation behaviors and homework time and intends to rethink the association between homework and academic achievements.

2. Literature Review

2.1 Homework and academic achievements

As a hot issue in education research, homework and its effect on academic achievements have always been talked. Cooper, Robinson, and Patall (2006) found mostly positive associations between homework time and achievement. Dettmers et al. (2009) conducted a multilevel analysis in 40 countries and concluded that the relationship between homework time and the academic achievement is not universally evidenced. These previous studies on the homework-achievement relationship typically use the time spent on homework as the main predictor of academic achievement, while other important homework behaviors, such as engagement, studying attentively in a quieter environment, have been ignored (Cooper et al., 2006; Ramdass & Zimmerman, 2011). Furthermore, Plant et al. (2005) found that the amount of study time was a significant predictor of cumulative GPA only when the quality of study time and prior performance were considered. In reviewing the literature of the relationship between homework and self-regulation from the elementary grades to college, it reveals that quality measures of homework such as managing distractions, self-efficacy and perceived responsibility for learning, setting goals, self-reflection, managing time, and setting a place for homework completion are more effective than only measuring the amount of time spent on homework.

2.2 Self-regulation and homework

Homework is generally done at home independently, either with or without supervision and students take responsibility to self-regulate their learning and decide where, when, how, why, and what to do with the assigned homework (Zimmerman, 1998). So self-regulation can and should be considered when measuring homework behaviors. Self-regulation is usually a convincing indicator of the behavior from the social-cognitive point of view (Zimmerman, 2000), which is defined as the thoughts, affects, and behaviors of students that are used to attain learning goals. Three areas of psychological functions essential in learning will be appointed with self-regulation, which are cognitive functions like learning strategies; motivational functions such as self-efficacy and task values; and metacognitive functions including self-monitoring and self-reflection (Bandura, 1993; Hong, Peng, & Rowell, 2009; Trautwein & Köller, 2003; Ramdass & Zimmerman, 2011). As previous researchers defined: the motivational domain of self-regulation implies that students believe in their capabilities and value homework as a task that would enhance learning. Valuing the task and having high self-efficacy for the assignment can enhance one’s persistence when faced with difficulties. The cognitive component of self-regulation relates to the strategies students use to complete homework and process the information more effectively. Strategies vary depending on the homework task. For example, writing an essay requires brainstorming ideas and making an outline before writing. By contrast, solving fraction problems requires a different set of strategies. Metacognition component refers students set goals and monitor their progress as they complete homework assignments (Pintrich, 2000). Students engage in metacognition when they reflect on why they do not understand a text or a problem during homework completion and use strategies such as rereading the text or seeking help in solving the problem (Ramdass & Zimmerman, 2011). Obviously, homework behavior is closely associated with these three components of self-regulation. Students’ self-beliefs, expectations of success, task value, strategy use, and self-monitoring influence homework behavior and learning (Trautwein & Köller, 2003).

There are few studies focusing on the homework self-regulation as an indicator of homework behavior when study homework-achievement relationship. Zimmerman and Kitsantas (2005) examined the mediational role of self-efficacy for learning and perceived responsibility beliefs between students’ homework reports and their academic achievement. In their research, participants consisted of 179 high school girls from a parochial school who had 3 hours of homework daily. The measures were a personal data questionnaire and a homework survey that measured the quantity and quality of homework. The results implies that the use of self-regulatory strategies when complete assignments can predict student

GPA at the end of the academic semester. Hong, Peng, & Rowell (2009) defined homework self-regulation with three components including task value, motivational outcome, and metacognitive strategy. In this research, participants are 368 seventh graders and 437 eleventh graders from four schools, which are similar in student achievement and socioeconomic status. A self-assessment questionnaire was conducted to measure students' homework utility value, intrinsic value, effort, persistence, planning, and self-checking applied during homework process. The results found that the differences of these indicators had relationship with the difference of the students' achievement levels.

Based on previous study, this paper tries to survey the homework from the view of homework time and homework self-regulation behaviors. Homework self-regulation behaviors, according to Zimmerman's theory, are split into three components: motivational domain (task value and self-efficacy), cognitive component (learning strategies and self-evaluate) and metacognition component (self-reflect).

3. Method

3.1 Participants

The study was conducted in an elementary school in East China, as part of an ongoing learning analytics project, to model students' learning behaviors within a learning technology system. Fourteen classes of 400 students range from Grade 4 to Grade 5 were involved in this research.

3.2 Instrument

The students' homework behaviors were approximated to the variables of their self-regulation and the time spent on doing homework. The self-regulations of students on their homework were measured with a self-assessment questionnaire. The questionnaire consist 20 items and include 6 factors: task value, self-efficacy, learning strategies, self-monitoring, self-evaluate and self-reflect. 400 students were the initial sample. After inspecting their completed questionnaires, 12 from Grade 4 and 11 from Grade 5 were eliminated due to the following issues: not completing a page or two, showing insincerity in their responses (e.g., all "5"s on one page), missing final examination scores, or multivariate outliers (20 cases), leaving 357 available data.

Students' daily homework time is collected from the learning technology system. All the homework time were counted by their mean value. Meanwhile, students' final test scores of Math, Chinese and English are collected as the indicators of their academic achievements.

4. Results and analysis

4.1 Homework self-regulation and academic achievements

As below the table 1 shows, all the homework self-regulation behaviors significantly relate to the students' academic achievements. Specifically, task value has positive correlation with scores of Chinese, Math and English, which means that a highly value on homework task contributes to desired grades. While when it comes to self-efficacy, a negative correlation was found. In another word, a highly self-efficacy on homework somehow would relate to students' low scores. Learning strategies and self-reflect share the same negative correlation with grades. But learning strategies only has significant negative effects on Math scores and self-reflect on English scores. Self-evaluation is positively and significantly relates to Math and English grades, which means that self-check and evaluate your homework is helpful to students' academic achievements when finishing homework.

Table 1: homework self-regulation and academic achievements.

	Chinese	Math	English
Task value Pearson Correlation	.156** .003	.114* .032	.184** .000
Self-efficacy Pearson Correlation	-.094 .075	-.104* .050	-.113* .033
Learning strategies Pearson Correlation	-.061 .248	-.108* .041	-.078 .140
Self-evaluation Pearson Correlation	.085 .107	.111* .036	.131* .013
Self-reflect Pearson Correlation	-.059 .262	-.076 .153	-.107* .043

* p< .05   ** p< .01

4.2 Homework time and academic achievements

However, no significant relationship was found between the time spend on the homework and student's academic achievements in the study so far.

5. Conclusions and future work

This paper intends to explore how the behavior of doing homework relates to their academic achievement. Self-regulation behaviors were introduced in analyzing homework behaviors. The results show that homework self-regulation behaviors are all significantly related to students' grades. Behaviors such as task value and self-evaluation are positive to students' scores. While self-efficacy, learning strategies and self-reflect behaviors are negative. Time on homework alone has no significant effects on grades. Our next work is to classify students by their homework behaviors and find a regression model to predict students' grades and finally help identify the learners who possibly yield poor learning performance

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Learning Analytics of Core Competencies: A Comparative Study of Students, Academics, and Industries

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Abstract: Core competencies are the combination of pooled knowledge and technical capacities that allow a person to be competitive in the marketplace. In this study, we applied a curriculum-level, competency-based visualized analytic system (the VACC) that has been developed by Yuan Ze University to analyze the levels of students' core competencies. The VACC system provides visual diagnostic functions for quickly understanding and positioning levels of students' core competencies. The course-taken data of 335 students from the Information Management Department at Yuan Ze University were collected and analyzed. In addition, to understand whether students' core competencies have matched marketplace, we surveyed 21 professors from the department and 53 managers from related industries to understand their perceptions of importance of core competencies. The results of competency perceptions from the academia and industries were further compared to students' core competency charts that were generated from the VACC system to measure the gaps among these three stakeholders. The diagnostic results of VACC showed that students have taken more courses on building their competencies of cultivating a broad knowledge and skills in the field of information management. There was a huge gap when students' core competency radar charts were matched to those from academia and industries. While faculties perceived the development of professional skills and the capacity of problem solving was more important than the other competencies, managers from industries suggested whether students can collaborate and team up with others was the crucial competency that market needs. Through learning analytics of students' core competencies and comparison of competency perception among faculties and managers, we can refer these results to diagnose current curriculum and facilitate course design in the future.

Keywords: Core competency, learning analytics, visualization, curriculum

1. Introduction

Trends in higher education are influenced by rapidly changing global, societal, political and economic forces. To stay relevant, institutions of higher education must be positioned to adapt quickly and deliver education in new ways. Combined with innovation of technology information, the impact of globalization and the development of the global knowledge economy, these competitive forces have currently shaped higher education (Rust & Kim, 2012). Nowadays, college graduates are facing tough competitive challenges in the marketplace. Students in higher education need to build up distinctive capacities and enhance unique competitiveness for their career planning. In this stream, competency-based education continually gains its spotlight in the higher education curriculum design.

The World Economic Forum (2008) viewed higher education as an economic asset and recognized transcendent development of higher education can contribute greatly to the level of national competitiveness. Nowadays, competitors in job market are not only from domestic counterparts, college graduates encounter competition from all over the world. How to effectively graft a students' core competency that has been cultivated from school to the global, competitive workforce has become a great challenge in higher education. To have a competitive niche and good quality of education, educators have suggested that primary task of higher education is to correspond teaching objectives and set goals for developing students' core competencies (Marginson, 2006). Gallon, Stillman, and Coates (1995) defined core competencies in an organization as "aggregates of capabilities, where synergy is created that has sustainable value in the face of potential competition". From an individual perspective, core competencies indicate the combination of knowledge, skills, abilities, and attributes needed to perform specific professional tasks, they are the available advantages for students when face furious competition in the marketplace (Prahalad & Hamel, 1990; Lahti, 1999).

The cultivation of skill-training and management of talent has become a strategic priority in higher education, it is important for departments and institutes to set educational goals and to correspond these goals with curriculum design (Pope & Reynolds, 1997; Vincent & Focht 2009). For course planning, it is feasible to establish an association between competency-based curriculum and development of student capacity (Pembridge & Paretti, 2010). However, there is a lack of proper techniques and universal tools to estimate students' core competencies in practice. To this end, we applied a curriculum-level, competency-based visualized analytic system (the VACC) that has been developed by Yuan Ze University (YZU) to actually calculate levels of students' core competencies for each student. By using this system, the quantity and quality of students' courses taken and grades were automatically collected and calculated to estimate the levels of students' core competencies. This study investigated levels of students' core competencies by using the VACC system. In addition, different aspects of core competencies from faculties and managers were surveyed to compare with that of students'. Through learning analytics of students' core competencies and comparison of competency perception among faculties and managers, we can refer these results to diagnose current curriculum and facilitate course design in the future.

2. Methods

An archive of learning behaviors and data of 335 students who attended the Department of Information Management at the YZU from the year of 2013-2015 was selected from the databank of YZU Virtual Classroom. After selecting the cases, students' longitudinal learning records of course taken history and grades were automatically collected and analyzed by the Visualized Analytics of Core Competencies system. The VACC system has embedded in the Virtual Classroom since 2013 at the YZU. The current version of VACC system provides descriptive analytics and a learning dashboard for students' reflection. When a student logs in the core competency page of YZU Portal site, the VACC system will automatically calculate the extent of correspondence between student's courses taken and his/her position of core competencies, and presents nine radar charts of core competencies from both quantity and quality aspects. In addition, the system visualizes rankings of students' competencies in comparison with peers and provides diagnostic outcome.

To understand whether students' core competencies have matched the labor market, we further surveyed 21 professors from the Information Management Department and 53 managers from related industries to understand their perception of importance of core competencies. A survey questionnaire was designed for this purpose. Based on the educational objectives of Information Management Department at Yuan Ze University, 5 core competencies are expected to cultivate in the curriculum design. The questionnaire surveyed faculties and managers from industry and use the Analytic Hierarchy Process (AHP) method to rank the importance of these 5 core competencies. Finally, we compare the results of competency perceptions from the academia and industries to students' competency charts at the VACC to explore gaps among these three stakeholders

The 5 core competencies are as followed:

1. Students should be able to use analytical and appropriate technologies to demonstrate the capacity of problem-solving (A).
2. Students should be able to collaborate and team up with others (B).
3. Students should have a broad sense and pooled knowledge in the information management field (C).
4. Students should be able to demonstrate the capacity of integration for decision making (D).
5. Students should understand the importance of work ethic (E).

3. Results

3.1 Analytics of student' core competencies

The results of students' learning analytics of core competencies by the VACC system from the year of 2013 to 2015 are shown in Figure 1. Green line in the radar charts indicates the high credit hour group that has taken competency-related courses (the credit hours was over 75% percentile). Red line indicates the low credit-hour group (below 25% percentile in the population). Blue area reports those with average credit hours in related competencies. Numbers in the radar charts indicate average credit hour of courses taken in each of the 5 competencies.

Cross-time comparison in Figure 1 indicates that students were relatively consistent in competency-related courses taking over 3 years. In general, students took more of the C competency-related courses which designed to cultivate students with a broad sense and pooled knowledge of information management. Secondly, students were more likely to take courses that related to B competency which demonstrated their capability to team up and collaborate with others. Next were the A and D competencies. While students took a few more course in related to the D (decision making) competency in year of 2013, students in year of 2015 took more on the A (problem solving) competency-related classes. The competency that students took the fewest courses over 3 years of time was the understanding the importance of work ethics (E). Department and institute can use these students aggregated results to diagnose and adjust current curriculum, evaluate teaching objectives and provide suggestion for future course design.

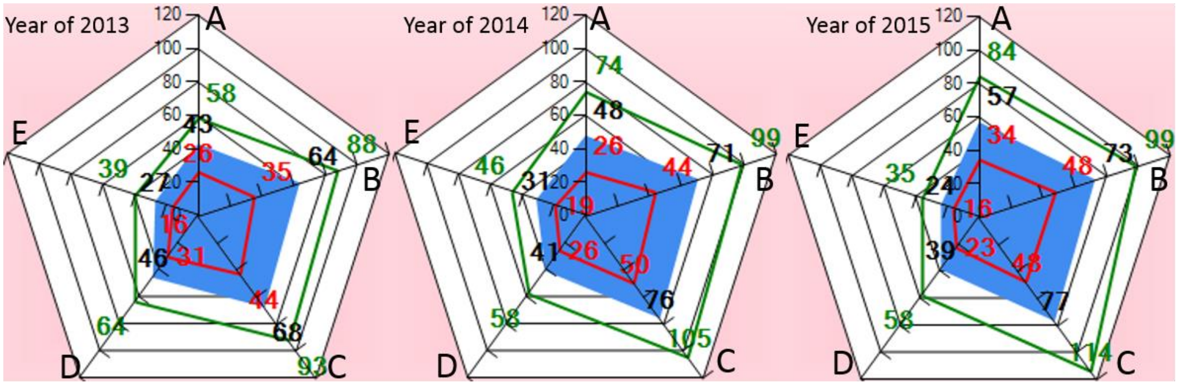

Figure 1. Radar charts of students' core competency in year of 2013-2015.

3.2 Perceptions of core competency among academia and industries

To understand whether students' core competencies have matched with other stakeholders, specifically, those in the marketplace, we calculated and weighted the ranks of 5 competencies from university professors in the department and managers in related industries. Figure 2 shows their perceptions of importance among these 5 competencies. The left side of radar chart in Figure 2 illustrates academic priority of core competency regarding students at the information management department. The AHP results indicated that professors concerned the most on students' capacity of problem-solving (A, score 5). The competencies of students' decision making (D) and have a broad sense and pooled knowledge of information management (C) ranked the second and the third highest priorities at the score of 4.86 and 4.71 respectively. Relatively, faculties from the department concerned less on students' understanding of work ethics (E, 2.93) and students' competencies of collaborating and team up with others (B, 2.81).

The right side of radar chart in Figure 2 illustrates industries' perspective on the five core competencies. In general, managers from the industries pinpointed the capacity of collaboration and team up with others was the crucial competency in the related fields (B, score 5), followed by the competencies of problem-solving (A, 3.19) and decision making (D, 3.08) that managers in the industries thought were important for graduates from information management departments. Consistent with faculties' perception, industries concerned less on the competency of work ethics (E, 2.97). Different from others, the competency that managers considered the least important was whether students have a broad sense and pooled knowledge of information management (C, 1.97). Apparently, industries have very much different point of views of competency C in compared to the others.

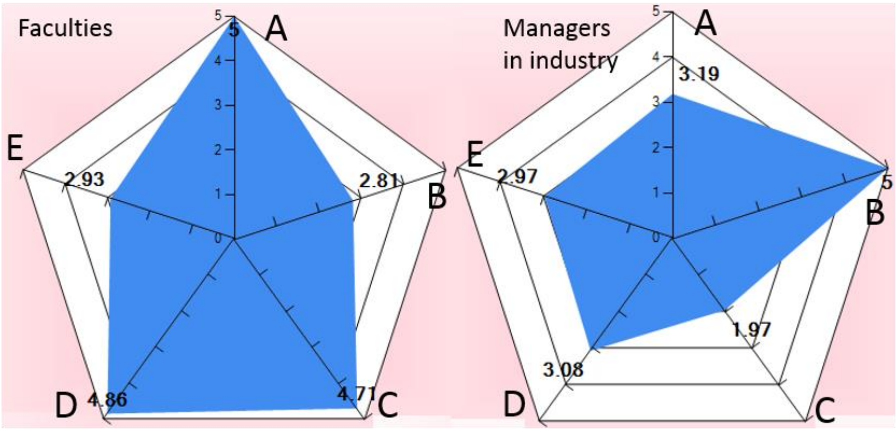

Figure 2. Perspectives of faculties (left) and managers in industry (right).

4. Conclusion

The diagnostic tool of radar charts in the VACC system showed that students have taken more courses on building their competencies of cultivating a broad knowledge and skills in the information management field. The competency that students concerned the least was the understanding the importance of work ethics. The visualization of radar charts of students, academia and industrial managers suggested their perceptions of core competency differ significantly from one of the others. While university faculty perceived the development of professional skills and the capacity of problem solving was more important than the other competencies, managers from industries suggested that the capacity of collaborating and team up with others was the crucial competency that market needs.

Through learning analytics of students' core competencies and comparison of competency perception among faculties and managers, we can refer these results to diagnose current curriculum and facilitate course design in the future. A tight correspondence of curriculum design and core competencies is necessary to cultivate competitive niche for college students. The institutes of higher education need to take into account aspects from different stakeholders, initiate more diverse curriculum designed to provide choice (Baynes, 2010). There has been a growing emphasis of higher education on the use of core competencies to design and implement curriculum. The VACC system provides a diagnostic tool to reflect students' core competencies and supports descriptive analytics for assisting not only students in self-directed learning but also teachers in counseling and curriculum enhancement.

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Analysis on Learning Efficiency in the Context of Mobile e-Learning

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Abstract: Mobile internet is now rapidly developing, it expands traditional Internet and benefits people's life in every aspect, including e-learning. With mobile e-learning, a learner can get online courses not only stick to a PC but could also be on a toilet, in a bed, or everywhere. This paper abstracted those ways out into 3 basic situations, combined with learning time periods to learning situations, then proposed a model to illustrate how the learning situations affects learning performance and introduced a method of iterative regression to evaluate the learning efficiencies of each situation with the learning data of 200 subject learners recorded in the Sophia Learning Management System (SLMS). The results demonstrate that different learning situations have unequal learning efficiencies, learning with a PC has higher learning efficiency, and sitting learning with a mobile also has a little higher rate than lying. Different courses have different learning efficiencies. It's helpful to compare learning efficiencies among courses so that learners could get recommendations of scheduling efficient learning.

Keywords: e-Learning, Learning Analytics, Learning Efficiency, Regression

1. Introduction

According to StatCounter Global Stats (2014), by the time Aug 2014, mobile internet usage increased to 35.3% (mobile 28.5%, tablet 6.8%) from 21.9% in Aug 2013 while desktop devices access decreased to 64.6%, which means that mobile internet access makes up one-third of the whole internet access. Mobile internet is now rapidly developing, providing more services for people, including e-learning. One of various benefits of e-learning is that the online educational data can be gathered and analyzed with analysis techniques. This process is called Learning Analytics (LA). Learning Analytics has been defined as “the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs” (U. S. Department of Education, Office of Educational Technology, 2012). The purpose of LA is to statistic and analyze the learner profiles and behavioral data and to learn the patterns for improving learning efficiency. Techniques like social network analysis or predictive modelling are rapidly used for this. With the result generated by the techniques, conclusions for improving learning could be made.

Compared to traditional ways, mobile internet grant e-learning more flexibility and diversity, learners can get courses at any time in any occasion even sitting on toilet or lying in bed just with a mobile device. Diverse situation generates diverse data, this paper grouped the ways to 3 basic situations: learning through a PC, lying learning through a mobile device and sitting learning through a mobile device. combining the 3 basic situations with when does the learner learn, the authors proposed a model to illustrate the relationship between those factors and learning efficiency, analyzed how these factors affect learning performance and evaluated the learning efficiencies with a method of iterative regression, and compared different courses to find the variance in learning efficiencies.

The rest of this paper is organized as follows. In section 2, the related works are described. In section 3, the learning situations partition is presented. In section 4, the model and the method for evaluating learning efficiencies are presented. In section 5, the final conclusion and the future work are presented.

2. Related Works

To learn the success factors of e-learning, there has been lots of researches accomplished, here shows some of them related to this paper. Hassan M. Selim (2007) proposed the confirmatory factor model for calculating the criticality level of e-learning critical success factors (CSFs). The 53 e-learning critical success factors were grouped into 4 categories, i.e. instructor, student, information technology, and university support, e.g. “The instructor is enthusiastic about teaching” (in category “instructor”) and “The student enjoy using personal computers” (in category “student”). They can be further categorized into 8 kinds, each includes several CSFs, and its level of criticality was measured by its validity coefficient. Wannasiri Bhuasiri et al. (2012) also revealed 6 dimensions and 20 critical success factors that affects learning performance for e-learning systems, recommended implementing e-learning systems. Rabeb Mbarek and Dr. Ferid Zaddem (2013) extended an e-learning effectiveness model by adding the factor social presence to other studied factors like computer self-efficacy, perceived usefulness, perceived ease of use, and interaction between trainer and trainees, the model is to identify the influence of those factors to e-learning effectiveness. Haiping Zhu et al. (2014) analyzed learning behaviors and nonintellectual factors such as emotion, submit time of assignments, login time, and learning style, to find out the influence to learning performance. Those researches learned e-learning success factors, further, in the context of mobile e-learning, there could be more unstudied influences to be found out, and that’s what this paper presents.

3. Data Extracting and Pretreatment

3.1 Learning Situation Distinguish

To examine how learning situation affects learning efficiency, it's necessary to define the learning situations. According to what a learner learns through, the 2 situations learning with PC and learning with mobile can be defined. Learning with a mobile is a flexible way to learn, but also can be summarized to 2 kinds: lying and sitting, combined with the PC occasion. So there are now 3 basic situations: lying learning through mobile, sitting through mobile, and learning through PC. It's easy to distinguish learning through PC and learning through mobile because the former is to visit the Learning Managing System (LMS) site and the latter is to use the LMS Application in the mobile. While to distinguish the lying situation and sitting situation through a mobile, an accelerometer which a smart phone should have one could be used for body position and posture sensing (Foerster, Smeja, & Fahrenberg 1999). Accelerometers calculate the direction of the gravity, so that the orientation of the mobile phone could be determined. According to this, a posture recognition program could be built in the LMS application to recognize the learner's posture.

3.2 Posture Recognition Program

When the accelerometer identifies change on acceleration (forces including gravity are essentially accelerations), the program will receive a sensor event including 3 directions of axis of acceleration, i.e. x, y, and z, as shown in Figure 1.

Figure 1. Axis of Accelerometer.

The values of x, y, z are represented by the values of components of the gravity in opposite axis directions. E.g. while the screen surface is facing upward, it will be *(0, 0, 10)*. Thus the orientation of a mobile device can be represented by *(x, y, z)*.

3.2.1 Sitting Learning With a Mobile

While a learner is sitting or standing using a mobile device, it could have one of the 3 orientations:

- The mobile device lies on a plane with the screen orients upward, the vector should be *(0, 0, 10)*.
- The learner holds the mobile in hand, screen of the mobile orients the horizontal direction, the vector should be *(0, 10, 0)*.
- The learner holds the mobile in hand, screen of the mobile orients oblique upward, the vector should be between *(0, 0, 10)* and *(0, 10, 0)*.

Summarizing the above situations, it can conclude that when the learner is sitting or standing using a mobile, the vector *(x, y, z)* should met the following conditions:

$$\begin{cases} \exists e(x = 0 + e) \\ \exists e(y \geq 0 + e) \\ \exists e(z \geq 0 + e) \\ \exists e(\sqrt{y^2 + z^2} = 10 + e) \\ e \in [-E, E] \end{cases}$$

The *E* represents acceptable maximum error for that a mobile device should always tilt a bit, e.g. while *E* equals to 2.93 (i.e. $\left(1 - \frac{\sqrt{2}}{2}\right) \times 10$), the device could at most tilt 45 degrees from aligned situations mentioned before.

While the device is accelerating that is to say the resultant acceleration is significantly greater than 10, the above conditions will never met.

3.2.2 Lying Learning With a Mobile

While a learner is lying using a mobile device, it could have one of the below orientations:

- The flat lying learner holds the mobile over his face, the screen orients downward, the vector should be *(0, 0, −10)*.
- The side lying learner holds the mobile to the left of his body, the left side of the device orients downward, the vector should be *(10, 0, 0)*.
- The side lying learner holds the mobile to the right of his body, the right side of the device orients downward, the vector should be *(−10, 0, 0)*.
- The lying learner holds the mobile above his face, the screen orients oblique downward, the vector could be between *(0, 0, −10)* and *(10, 0, 0)*, or between *(0, 0, −10)* and *(−10, 0, 0)*.

It can be concluded that when the learner is lying using a mobile, the vector *(x, y, z)* should met the conditions:

$$\begin{cases} \exists e(y = 0 + e) \\ \exists e(z \leq 0 + e) \\ \exists e(\sqrt{x^2 + z^2} = 10 + e) \\ e \in [-E, E] \end{cases}$$

The *E* represents acceptable maximum error. In the SLMS it was set as 2 for precision.

3.3 Partition of Time Periods

200 subject learners were asked to learn *Computer Architecture* through SLMS, and their learning data has been recorded. Figure 2 shows 40 of all the recorded learning time periods distribution.

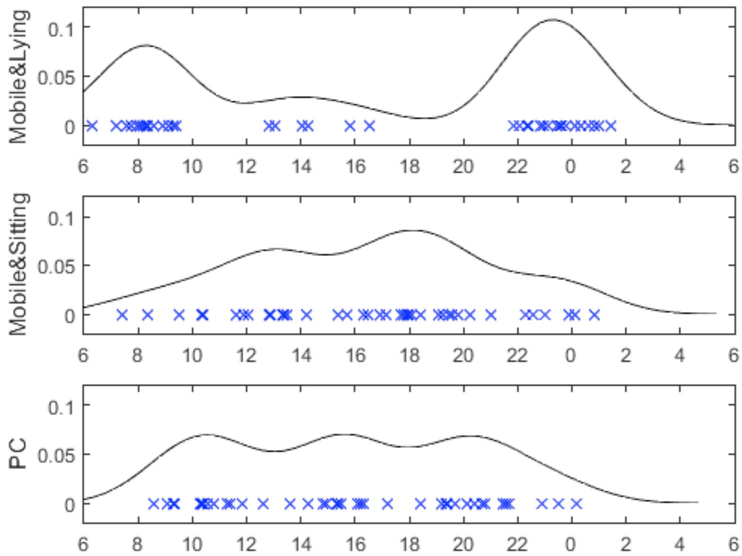

Figure 2. Learning Time Periods Distribution.

Each spot represents a period of learning, and the curves represent probability densities of each basic situation. The X-axis indicates when the period of learning happens, it was measured by the average time of starting learning and stopping learning. The Y-axis indicates probability density for the curves.

As the figure shows, learners' learning time periods dispersed throughout all the time of a day. To classify them, a cluster analysis should be performed, with k-means algorithm (MacQueen, 1967) which was applied and studied in diverse disciplines. Although the k-means algorithm was presented for nearly 50 years, it's still considered as one of the most popular clustering algorithms (Anil, 2010).

K-means algorithm's process is to minimize the sum of distances of each spot to the center spot of the class which the spot belongs to. It can be presented by the following expression:

$$J = \sum_{n=1}^{N} \sum_{k=1}^{K} r_{nk} \left\| x_n - \mu_k \right\|^2$$

While spot n is in class k, $r_{nk} = 1$, otherwise $r_{nk} = 0$.

In this case, the distance represents the time difference. While time of a day is circular, e.g. the time difference between 23:00 and 1:00 is 2 hours but not 22 hours, so the expression can be adjusted as follows:

$$J = \sum_{n=1}^{N} \sum_{k=1}^{K} r_{nk} \times \min^2\left(\left\| x_n - \mu_k \right\|, 24 - \left\| x_n - \mu_k \right\|\right)$$

The probability density curve shown in Figure 2 implies that those periods of learning could be classified into 3, 2, and 3 clusters respectively for each basic situation. Figure 3 shows the k-means clustering results.

The different styles of the marks represents different clusters, as Figure 3 indicates, the 3 basic situations can be divided into the 8 kinds of situations shown in Table 1.

With the clustered samples as the training data, further collected data could be classified into one of those 8 situations with k-Nearest Neighbor algorithm (Fix, & Hodges, 1951) which is considered as one of the top 10 algorithms in data mining (Wu, et al. 2008).

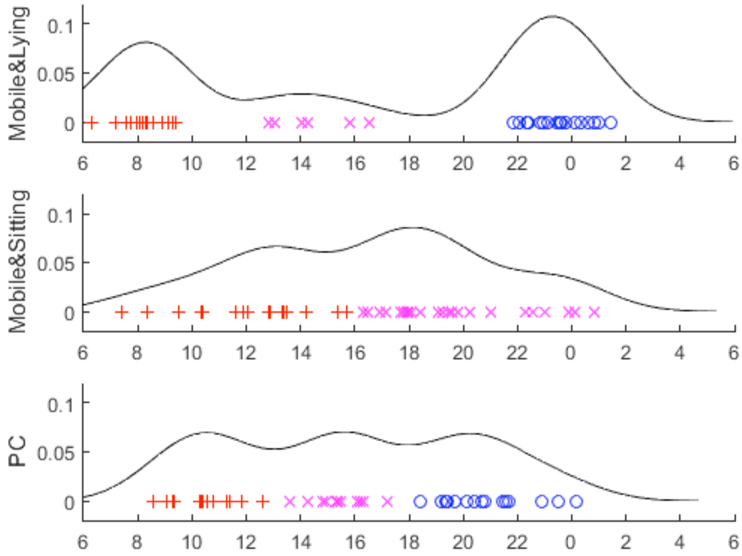

Figure 3. Learning Time Periods Clustering.

Table 1: Situations.

Situation	Indicator
mobile, lying, forenoon	T_1
mobile, lying, afternoon	T_2
mobile, lying, evening	T_3
mobile, sitting, daytime	T_4
mobile, sitting, evening	T_5
PC, forenoon	T_6
PC, afternoon	T_7
PC, evening	T_8

4. Analysis on Learning Efficiency

4.1 Relationship Between Learning Efficiency and Score

The learning efficiencies of learning in different situations of the 8 above are unequal. Learning in some situations may be faster while some other may be slower. To evaluate the efficiencies of situations it's practicable to find clues from how they affects learners score of this course, it can be abstracted to the following expressions:

$$T_e = \sum_{i=1}^{n} b_i T_i \middle| n = 8$$

$$S = f(T_e) \middle| S \in \{A^+, A, B, C, D\}$$

For each subjective learner of the 200 taken part in the learning of *Computer Architecture*, the experiment recorded his/her learning time duration happened in each situation respectively, and his/her score of this course. In this case, $n = 8$ for there are 8 situations. The score recorded is indicated by one of the 5 ranks $\{A+, A, B, C, D\}$.

Accumulate each learner's daily learning time duration in ith situation as T_i, each situation has a learning efficiency, which is represented by b_i. The bigger it is, the more efficient learning in that situation is. Multiply the efficiency b_i by the time duration learning in corresponding situation T_i, there comes the equivalent learning time duration in ith situation, then sum up these equivalent time durations, here comes the total equivalent learning time duration T_e which affects the score a learner can get. The total equivalent learning time duration of a learner has a non-linear relationship *f()* to the score he could perform.

4.2 Method for Evaluating the Learning Efficiencies

To figure out the learning efficiencies b_i and the mapping relation *f()* between the score S and the equivalent learning time duration T_e, the following method can be used, it is iterative regression.

Before the iterations start, assume that $b_{i(0)}|i \in [1,n] = 1$, that is where the iteration starts. So in the first iteration, there comes the expression $T_{e(1)} = \sum_{i=1}^{n} b_{i(0)} T_i = \sum_{i=1}^{n} T_i$, in which $T_{e(1)}$ is the equivalent learning time duration based on the assumption that all the situations have a same learning efficiency, it updates in further iterations. Gather all students' equivalent learning time durations of a same score and calculate the mean equivalent learning time duration $t_{mj(1)} = mean(\{T_{e(1)}|EQT(j,T_{e(1)})\})|j \in \{A+,A,B,C,D\}$ where $EQT(j,T_e)$ means that a j scored learner has an equivalent learning time duration of T_e. Then there comes the inverse function $f^{-1}_{(1)}(j) = t_{mj(1)}|j \in \{A+,A,B,C,D\}$, in where the j is a discrete enumeration which represents the score of a learner. With the function $f^{-1}_{(1)}()$ there comes a possibly more accurate total equivalent learning time duration $t_{mj(1)}|j \in \{A+,A,B,C,D\}$ of a j scored learner. Then regress the learning time durations in each situation $T_i|i \in [1,n]$ and the total equivalent learning time durations $t_{mj}(1)|j \in \{A+,A,B,C,D\}$ for the linear relationship between them, then there comes more accurate learning efficiencies $b_{i(1)}|i \in [1,n]$ of each situation. With $b_{i(1)}$, a second iteration can be performed. But before that, there is one thing should be clear that the factor truly affects is the ratio among b_is but not the exact values of b_is. Iteration by iteration b_is may get smaller and smaller, so it is necessary to fix the total value of b_is to a certain value (can be n), holding the ratio among each b_is. Here did $b_i := b_i \times \frac{n}{\sum_{I=0}^{n} b_I}$ so that the sum of b_is can be fixed to n.

Formally, in pth iteration:

$$T_{e(p)} = \sum_{i=1}^{n} b_{i(p-1)} T_i \big| i \in [1,n]$$
$$t_{mj(p)} = mean\left(\left\{T_{e(p)} \big| EQT\left(j, T_{e(p)}\right)\right\}\right)$$
$$T_{m(p)} = t_{mj(p)} \big| SC(j)$$
$$b_{i(p)} = regress\left(T_{m(p)}, \left\{T_i \big| i \in [1,n]\right\}\right)$$
$$b_{i(p)} := b_{i(p)} \times \frac{n}{\sum_{I=0}^{n} b_{I(p)}} \big| i \in [1,n]$$

EQT(j, T_e): a j scored learner has an equivalent learning time duration of T_e.

SC(j): the learner has a score of j.

Once the b_i converges to a certain value, it can be decided as the learning efficiency of ith situation.

4.3 Calculated Results

After running the algorithm for 10 iterations with the data of 200 learners, the values of b_i in each iteration comes in Figure 4.

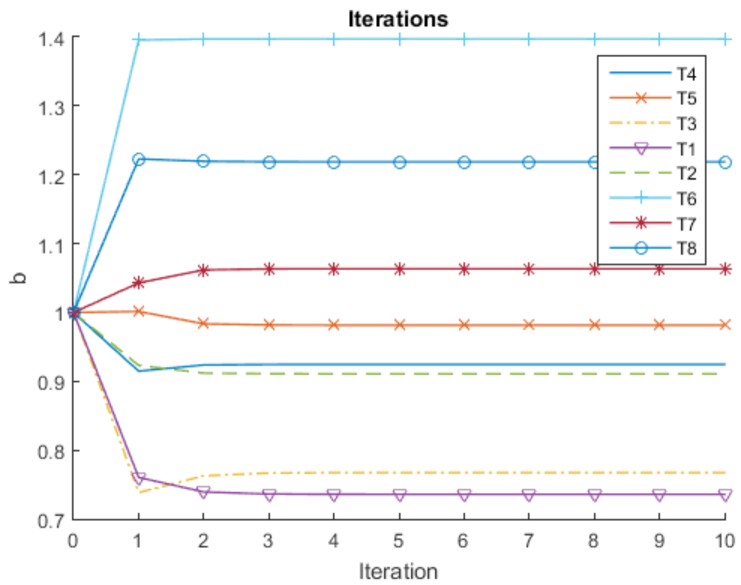

Figure 4. *b*s in Iterations.

The 8 lines represent b_is, the X-axis indicates iterations, and the Y-axis indicates the value of them. As Figure 4 shows, in 5th iteration, the learning efficiencies $b_{i(5)}$ have converge to stable values as follows:

$$\begin{cases} b_1 = 0.7359 \\ b_2 = 0.9108 \\ b_3 = 0.7674 \\ b_4 = 0.9246 \\ b_5 = 0.9816 \\ b_6 = 1.3974 \\ b_7 = 1.0634 \\ b_8 = 1.2189 \end{cases}$$

This result reveals learning efficiencies in each situation, 6th situation i.e. learning through PC in a morning is the most efficient learning situation, followed by 8th situation i.e. learning through PC at night. Generally, learning through PC has a higher efficiency than through mobile, for mobile situation, sitting has a little higher rate than lying.

The standard deviations of equivalent learning time durations of learners of each same score are shown in Figure 5.

The X-axis indicates iterations, and the Y-axis indicates standard deviations. As the figure shows, with the iteration continues, standard deviations of equivalent learning time durations are getting smaller, which means these calculated equivalent learning time durations are gathering up, they are more accurate than that in last iteration.

With the stabilized b_is, calculated learners' equivalent learning time durations classified by the score are shown in Figure 6.

Each dot indicates each learner, its X value is his equivalent learning time duration, and each circlet indicates the mean of those equivalent learning time durations classified by score.

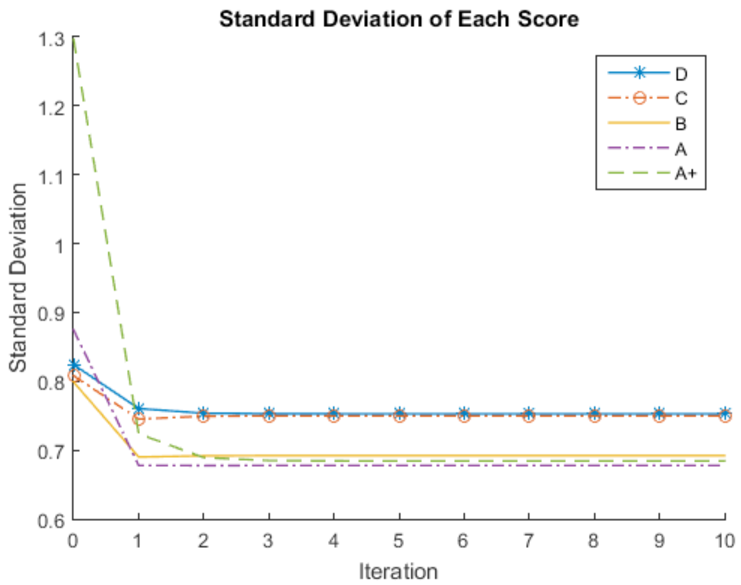

Figure 5. Standard Deviations of Equivalent Learning Time Durations.

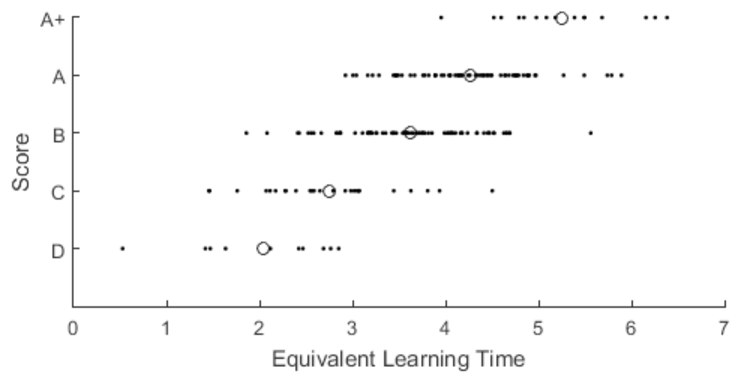

Figure 6. Equivalent Learning Time Durations Distribution.

4.4 Difference Between Courses

Former result reveals each situation's learning efficiency about the course *Computer Architecture*, but different course has different efficiency in each situation, following Table 2 shows the result of the course *Business English* gained using the above method with records of 200 subject learners, compared to *Computer Architecture*:

Table 2: Learning Efficiencies of Different Courses.

Situation	Computer Architecture	Business English
mobile, lying, forenoon	0.7359	0.8813
mobile, lying, afternoon	0.9108	0.8990
mobile, lying, evening	0.7674	0.8888
mobile, sitting, daytime	0.9246	0.9744
mobile, sitting, evening	0.9816	1.0312
PC, forenoon	1.3974	1.1898
PC, afternoon	1.0634	1.1233
PC, evening	1.2189	1.0123

Business English also has a higher learning efficiency through PC, but slighter than *Computer Architecture*. That makes *Business English*'s learning efficiency through PC relatively lower, mobile relatively higher. Due to the learning efficiencies, it's possible to recommend that in situation T_1, T_3, T_4, T_5, T_7, it's better to learn *Business English*; in situation T_2, T_6, T_8, learning *Computer Architecture* is better.

Formally, for a learner who has a course selection list C, in situation i, the recommended course due to learning efficiency is

$$r \middle| b_{ir} = \max\left(\left\{ b_{ic} \middle| c \in C \right\}\right)$$

The b_{ic} indicates course c's learning efficiency in situation i. With this expression, a recommendation system about when to learn what could be built.

5. Conclusion

With the growth of mobile internet, mobile e-learning is also rapidly developing. Learning Analytics in this environment is introduced in this paper. The influence of learning posture and time period defined as learning situation on learning efficiency was considered. Each situation has a different learning efficiency which affects the learning performance. Then the paper proposed a model to evaluate learning efficiencies of each situation, and used the method with collected data of the course *Computer Architecture* and *Business English* to get results. Those results demonstrates that learning through a PC has a higher learning efficiency than mobile, and sitting also has a little higher rate than lying. Difference in *Business English* is slighter than *Computer Architecture*. The results and the model with the method could help making suggestions about improving courses, especially those for mobile. Also, with the results, a recommendation system based on learning efficiencies could be made, which helps learners learn better. This paper simply considered 3 basic learning situations, which could not completely represent the real situations. So in the future, the authors would improve the posture recognition program to identify more realistic situations and make analysis on these more detailed data, as well as more other facts that may influence the learning efficiency.

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Who Will Pass? Analyzing Learner Behaviors in MOOCs

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Abstract: Massive Open Online Courses (MOOCs) have gained worldwide attention recently because of their great potential to reach learners. MOOCs provide a new option for learning, yet the impacts of MOOCs usage on learning still need to be clarified and empirically examined. By collecting data of three MOOCs at Yuan Ze University (YZU), this paper presented a study that classified learning behaviors among 1,230 students on MOOC platform at YZU. In addition, this study examined the impacts of learner behaviors in MOOCs on course completion. The effectiveness of online learning features was examined to expand our knowledge about how students respond to these learning tools. In this study, we used the Ward's and K-means clustering algorithms to determine number of cluster and to classify different types of learners in MOOCs. By cluster analysis, we classified three types of MOOC learners—active learner, passive learner, and bystander. While most students were classified as bystanders (90%), there were only 1% of students labelled as active learner. In these courses, whether a student handed in assignments greatly determined his/her odds of completing course. The results of descriptive analysis indicated that students with various types of learning behaviors in MOOCs did reveal different levels of learning outcome. Active learners who handed in assignments on time and frequently watched videos have significantly shown higher rates of passing the course than the others. Additionally, those who actively participated in online discussion forum received a much higher grade in the class than inactive users.

Keywords: MOOCs, learning behavior, learning outcome, learning analytics

1. Introduction

Massive Open Online Courses (MOOCs) has been one of the disruptive innovations in the field of education. MOOCs are online courses with open registration, a publicly shared curriculum, and open-ended outcomes (Clow, 2013). "A MOOC generally carries no fees, no prerequisites other than Internet access and interest, no predefined expectations for participation, and no formal accreditation" (McAulay et al., 2010). In MOOCs, a collection of video lectures, readings, projects, quizzes, peer-graded assignments, and discussion forums drew learners together. These features were designed to motivate learning and enhance students' learning outcome. Yet whether MOOCs result in a better learning outcome is now needed to be explored in depth. The main purpose of this study is to classify learning behaviors in MOOCs and examine their impacts on learning outcome.

After the first American MOOCs launched by Stanford University in 2011, many of the world's elite universities are now offering some of their best courses for people to learn free online. In Taiwan, Yuan Ze University (YZU) is one of few universities that provide MOOCs. The university has created its own MOOCs platform and provided five MOOCs to students in 2014. We collaborated with the Office of Information Services at campus and collected learner behaviors and their navigation patterns from MOOCs at YZU. In all, we analyzed learning behaviors of 1,230 MOOCs students and examined the relationships of their MOOC usage and course completion.

One of the main objectives in this study is to understand how students use MOOCs and offer insight to what engages or disengages them in MOOC environments. The online learning environments and features were examined to expand our knowledge about how students respond to these learning tools.

2. Literature Review

2.1 Types of MOOCs learners

By counting students' learning behaviors of watching videos and submitting assignments, Anderson et al. (2014) classified MOOCs learners into 5 types: viewers, solvers, all-rounders, collectors and bystanders. In their study, Koller et al. (2013) classified "browsers" and "committed learners" in MOOCs. They further differentiated "committed learners" into passive and active learners. Passive learners were those who frequently watched lecture videos but less submitted assignments, participated in discussion forum and took tests. Active learners completed requirement in the course and contributed to community where they enthusiastically participated in the course, facilitated discussion in forum and assisted in foreign language translation. Kizilcec et al. (2013) labelled four types of learner engagement: "on track" (did assignment on time), "behind" (handed in assignment late), "auditing" (didn't do assignment but watched videos or took tests), and "out" (didn't participate in course at all). In the same vein, they further clustered MOOCs students into "completing", "auditing", "disengaging", and "sampling" groups.

2.2 Learner usage of MOOCs and outcome

Kizilcec and colleagues (2013) suggested that we may have a better understanding of students' goals by investigating how students use MOOCs, including features such as video and discussion forums. Two studies (Karpicke & Roediger, 2008; Karpicke & Blunt, 2011) showed that MOOCs leaners who watched videos did have a better learning outcome. In particular, viewing short quizzes in the videos can improve students' learning. Santos et al. (2014) analyzed students' behaviors in MOOCs and found that students who participated more on courses activities have a better chance to pass the course. Students who frequently communicated, discussed, shared and collaborated with others show a better learning outcome. Their study also suggested that those who posted often in discussion forum would have a higher rate of passing the course.

3. Methods

YZU is one of few universities in Taiwan that provides MOOCs. Students' learning data, such as videos watching, assignment submission, forum posting from MOOCs were collected. Totally, we collected learning behavioral data of 1,230 students from the MOOCs platform at YZU.

In this study, two main learning behaviors--assignment submission and video watching—were used for clustering criteria. We used the Ward's and K-means clustering algorithms to determine number of cluster and to classify different types of learners in MOOCs. Descriptive analyses, including Chi-square tests and Mean-difference tests (ANOVA) were conducted to measure learning outcomes among different types of learners. Moreover, participation of discussion forum was examined to explore the impacts of social media usage on learning.

4. Findings

4.1 Learning behaviors in MOOCs

Trends of students' learning behaviors in MOOCs, including login records, video watching, and assignments submitting were analyzed. Figure 1 shows the average numbers of logging in 5 MOOCs. In general, the average numbers of login were low. Only students in "C# Programming" class have closely reached the average number of 1 in the first two weeks, indicated that students in this class might log in the system once in a week during the first two weeks of class. After the second week, the average numbers of login decreased gradually across weeks in this class. Actively watched lecture videos were merely seen in "C# Programming" and "Computer-aided Design and Manufacture" courses (Figure 2). Figure 3 shows that students in "C# Programming" course had higher average numbers of handing in assignments across the whole 9-week course (Figure 3) than the other two courses.

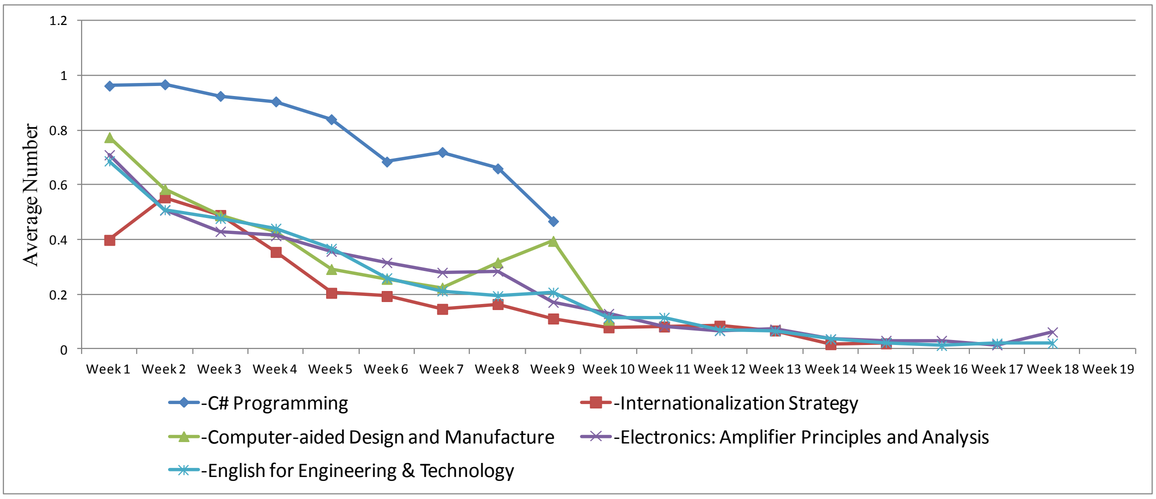

Figure 1. The average number of logging in MOOCs

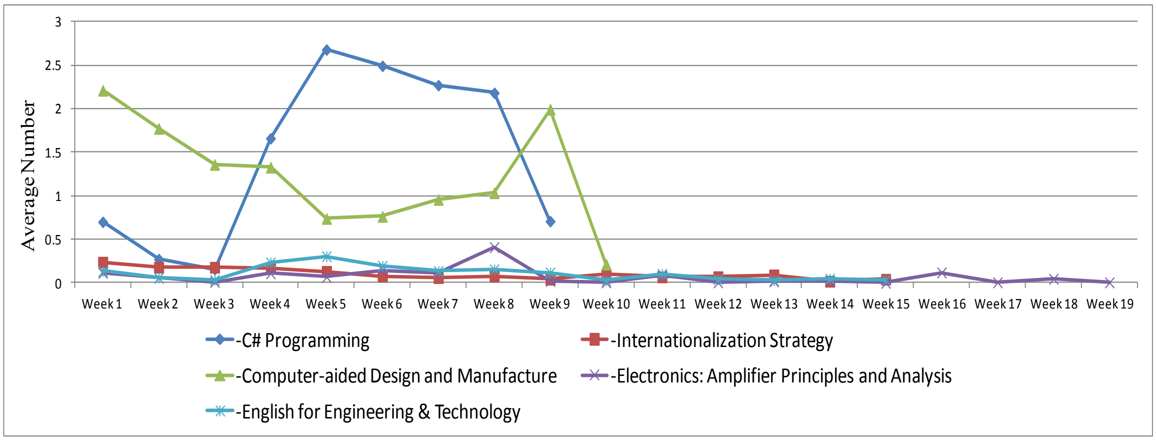

Figure 2. The average number of video watching

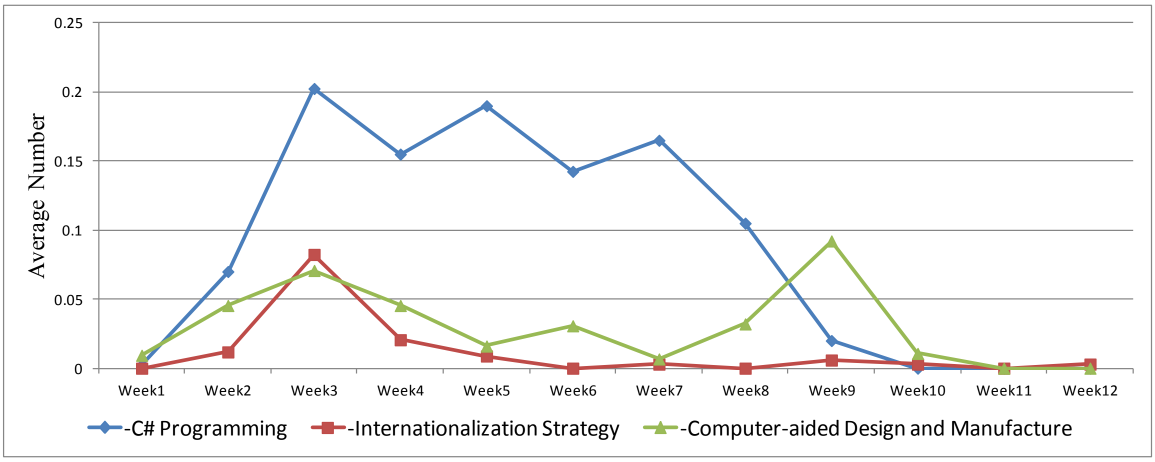

Figure 3. The average number of assignment submission

4.2 Classify learners by Cluster analysis

We employed the Ward's and the K-means clustering algorithms to determine number of cluster and to classify 1,230 students into different types of leaners. Based on behavioral patterns of watching video and submitting assignment, three groups of learners were clustered: active learner, passive learner and bystander. Figure 4 shows the proportions of different types of leaners. In three MOOCs, most students were bystanders (90%), only 1% of students were active learner and 9% of them were passive leaners. While "C# Programming" course had the higher proportions of active (2%) and passive (13%) learners, students in "Internationalization Strategy" composed most of bystanders (97%).

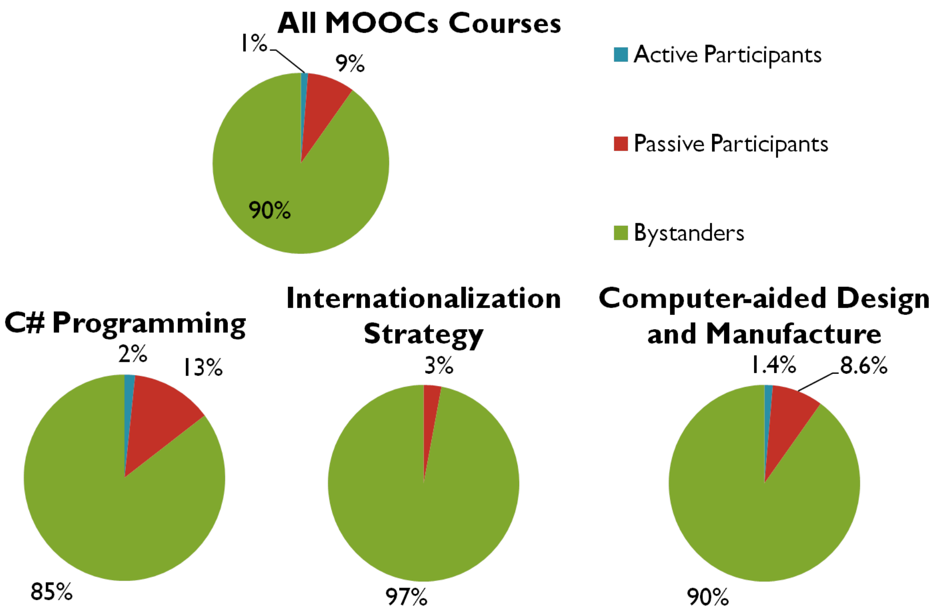

Figure 4. The proportions of different types of learners in MOOCs

4.3 Learning outcome of different clusters

Chi-square and ANOVA tests were conducted to measure learning outcomes among different types of learners. The results indicated that students with various types of learning behaviors in MOOCs did reveal different levels of learning outcome. Active learners who handed in assignments and watched videos more often have significantly shown higher rates of passing the course than the others. In all three courses, while 42% of active learners passed the course, only 33% of passive learners and 3% of bystanders completed the course. The pass rate was highest in "C# Programming" course. There was a rate of 85% among active leaners in "C# Programming" course who passed the course, in compared to only 27% of active learners passed "Computer-aided Design and Manufacture" course.

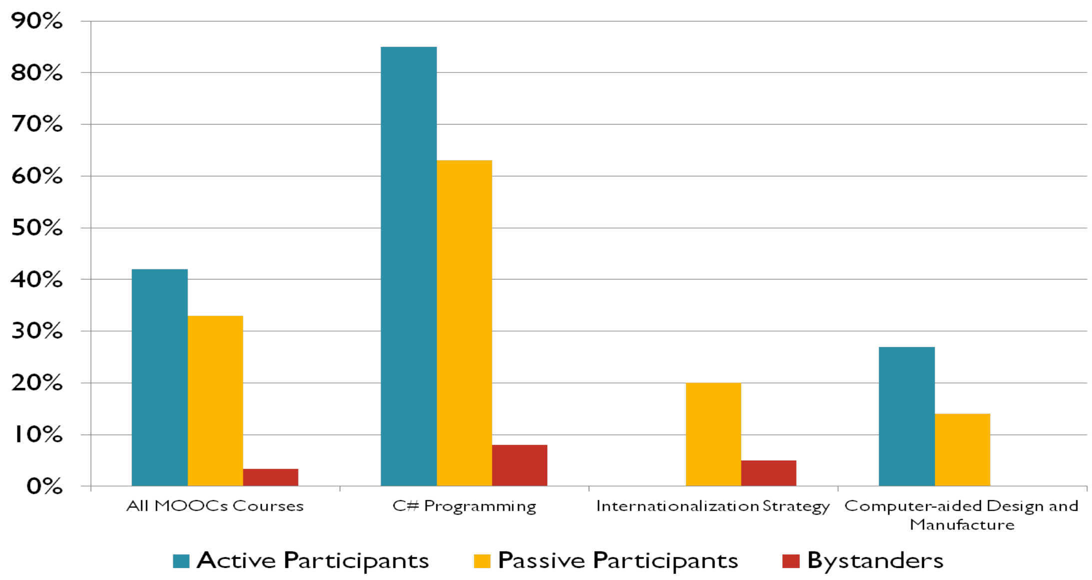

Figure 5. The different types of learners passed the course in MOOCs.

4.4 Impact of discussion forum

In this section, we examined the impact of discussion forum on learning outcome. There was only one course-"C# Programming"-applied this tool on MOOC platform at YZU. A discussion forum was provided for students to discuss and collaborate with each other while they undertake their learning in the course. Chi-square test and mean difference test were employed to explore the effects of forum usage in MOOCs. First, we classified two groups of students: active and inactive users of discussion forum. Active users accounted for about 8% in this class. Then, course pass rates of these two groups and their average grades of this course were calculated. The results indicated there was a 68% pass rate among active users compared to only 11% of inactive users who passed the course. Chi-square test showed a significant difference between these two groups. The test of mean difference also revealed a much higher score among active users (mean score of 72.1) than inactive users (mean score of 12.5) in their final grades. Those who participated more often in discussion forum show a better learning outcome than the others. In all, this result suggested featuring discussion forum in MOOCs was needed to facilitate learning outcome in online environment.

5. Discussion

In this study, we first described trends of usage behaviors in MOOCs. Then, K-means cluster analysis was employed to group students by their learning behaviors. Further, we examined the relationship of MOOC usage and learning outcome. The first part of results suggested that login frequencies among students started to show a dropping trend in the second week of the courses. Except for two courses, students in most courses show a low rate of logging in system and few number of video watching. Assignment submission varied by section design in each of the courses. Secondly, learners in MOOCs at YZU can be classified into three groups: active learner, passive learner, and bystander. In three courses, only 1% of students counted as active learners, while 9% and 90% of them were passive learners and bystanders respectively. Those active learners did show a better course complete rate of 42% than that of passive learners (33%) and bystanders (3%). These results suggested that types of learners played a determined factor on learning outcome. In addition, statistical tests showed that active use of discussion forum in MOOCS did enhance students' learning outcome.

The trends of learning curve in MOOCs at YZU indicated the first two weeks was a critical point of time to retain students in MOOCs. For students' retention, MOOCs instructors need to carefully design course sections and pay more attention on students' feedbacks in early of the classes. The results of cluster analysis suggested most students fell into the "bystander" category. The course complete rate was merely 3% in this group. To motivate this group to engage in MOOCs is a great challenge. Researchers need to examine these "bystanders" further and explore how different patterns of behavior and engagement in these MOOC learners reflect different motivations. In terms of learner activities within discussion forum, this study found that actively participate in discussion forum influence course completion. The presence of forum discussion is correlated with higher course retention and students' performance. Recently, Sharif and Magrill (2015) have suggested discussion forums in MOOCs represent a unique opportunity for insight into the formation of learning communities. It is essential for instructors to effectively use the features of discussion forum and facilitate active forum discussion in MOOCs.

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Heartbeat Feedback for Learners' Emotional Self Control

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Abstract: The authors propose a heartbeat feedback system for learners. It works on Web browser and utilizes PC equipped Web camera, so is portable on various types of laptop PCs. The proposed system visualizes heartbeat change on a graph in real time manner. Preliminary experiment result shows that the proposed system is effective to recognize learners' emotional status, especially in nervous state. The result also suggests that this effect is effective for self-regulated learning.

Keywords: Learning analytics, heartbeat, biofeedback, emotion, self-regulated learning

1. Introduction

1.1 Learning Analytics

Learning analytics (LA) has become a major area in learning science and learning technology research in the trend on digitization of education. Ferguson (2012) described a definition of Learning Analytics as follows: "Learning analytics is the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs." A trend of digitization of learning, education and training can be divided into three categories. First one is an adoption of digital learning resources, e.g. LMS-based digital material delivery and client PC-based digital textbooks/ references/ dictionaries. Second is an application of digital environment for learning activities, e.g. interactive learning environment, group or peer-to-peer communication environment for discussion or information sharing, and various active learning supporting tools. The first is considered to be an upper stream of learning, whereas the second one is to be a midstream of learning. Compared to them, LA is considered to be a downstream process of learning. It means collection, analysis, and utilization of learning activity log data.

The learning activity log data has been collected and analyzed since hundreds years ago, even in age of paper-based learning environment. In 2000s, LMS (Learning Management System) based learning environments have been spread. During this period, many types of learning activity logs have been collected in these LMSs and analyzed. These data came from instruction-based activities, e.g. class participations, material views, and answers to quizzes. Also they included active learning-based ones, e.g. enrollments, utterances, interim and final products of group activities. In 2010s, usage of laptop or tablet PCs has been common in K-12 education in various countries. In this environment, various fine-grained learner related information have been available for Learning Analytics, e.g. page flip, learners' actions, eye-track, voice and environmental sound, GPS information, and even heartbeat with use of PC-equipped camera. In future, many types of physiological data like blood pressure and sweating will be available with use of wearable devices. This trend is summarized in Figure 1.

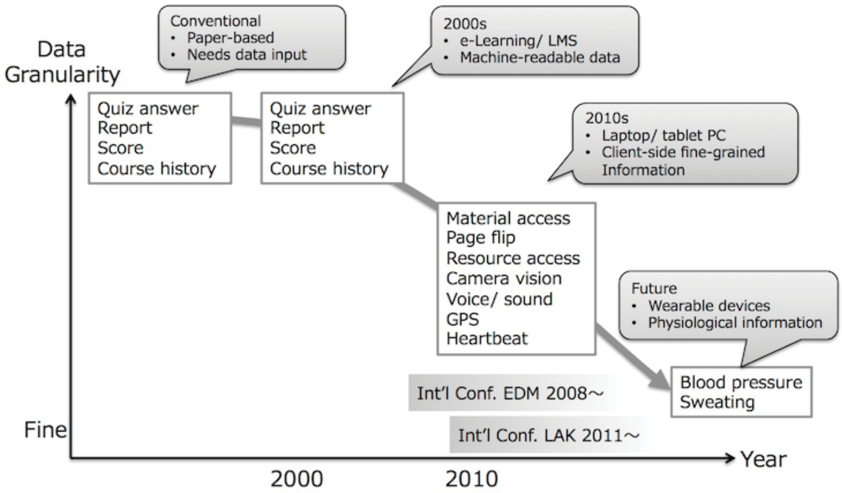

Figure 1. Trend of Learning Activity Data

There are many types of research-based information resources for Learning Analytics. An academic journal called Journal of Learning Analytics is published from SOLAR (Society for Learning Analytics Research) (SOLAR, 2015). Also, two types of International Conferences: Learning Analytics and Knowledge (LAK) and Educational Data Mining (EDM). LAK publishes proceedings from Long et al. (2011) through Baron et al. (2015). Also EDM publishes proceedings since Baker et al. (2008) through Santos et al. (2015). As a general survey, Shum (2012) classifies 5 types of LA activities: (1) analysis dashboard of LMS or VLE, (2) predictive analysis, (3) adaptive learning analytics, (4) social network analysis, and (5) discourse analysis. Especially for active learning and collaborative learning, Shum and Ferguson (2012) shows some LA goal and future issues of these activities. Up to date discussion and information are available on Google Groups on Learning Analytics (2015).

Standardization organization of ISO/IEC JTC1/SC36 has started WG8, devoted to Learning Analytics in June 2015. In the WG8 meeting in Rouen France, an overall framework of Learning Analytics was discussed. Figure 2 is based on this discussion, and includes some expansion.

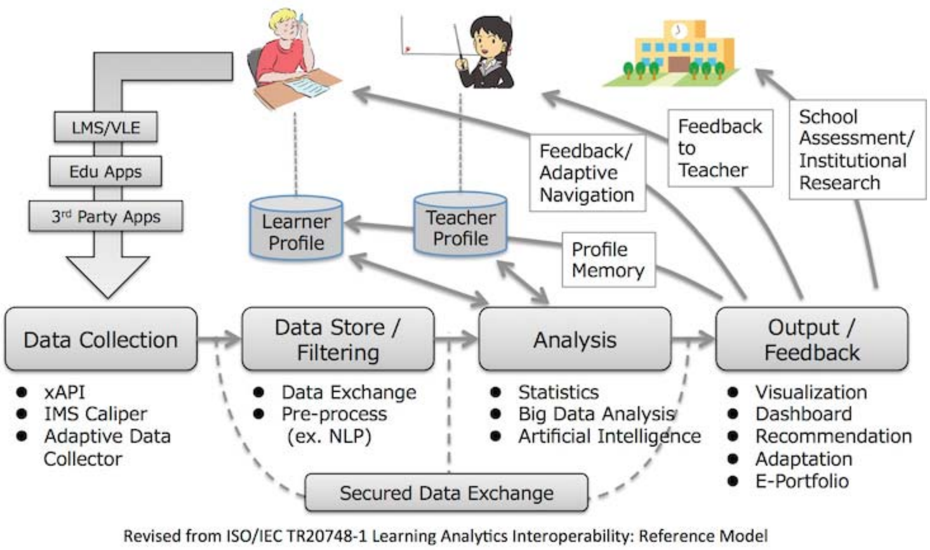

Figure 2. Overall Framework of Learning Analytics

There are major 4 steps: (1) data collection, (2) data store/ filtering, (3) analysis, and (4) output/ feedback. In the first step of data collection, learning activity data is collected with use of LMS, VLE (Virtual Learning Environment), education application or 3rd party application programs that are used by learners.

1.2 Learning Strategy and Biofeedback

Learning strategy is one of core skills to support effective learning activities. Oxford (1994) classified it in six categories below: (1) memorizing, (2) analysis and reasoning, (3) compensation, guess and application, (4) self / situational awareness, (5) emotional control, and (6) cooperation with others. Among them, the authors focus on (5) emotional control. It means that a learner needs to recognize his emotional status objectively, in order to execute his learning activity effectively. If his emotional status is hazardous for learning, he is possible to recognize and improve it by himself or with other's assistance. In this paper, the authors focus on a method to assist self-awareness of a learner's emotional status with use of biofeedback method.

Biofeedback is a method to visualize and feedback one's biological information such as blood pressure, heartbeat, myoelectric, sweating, blood pressure or respiration. The Association for Applied Psychophysiology and Biofeedback defines it as: "Biofeedback is a process that enables an individual to learn how to change physiological activity for the purposes of improving health and performance. Precise instruments measure physiological activity such as brainwaves, heart function, breathing, muscle activity, and skin temperature. These instruments rapidly and accurately "feed back" information to the user. The presentation of this information — often in conjunction with changes in thinking, emotions, and behavior — supports desired physiological changes. Over time, these changes can endure without continued use of an instrument" (AAPB, 2015).

Generally, learning activity with continuous biofeedback training is called "biofeedback training". This training is said to reduce learner's stress and anxiety. Tansey (1984) shows a clinical treatment regime for pathological interhemispheric dysfunction with respect to a population of learning disabled boys. Amon and Campbell (2008) investigated "The Journey to Wild Divine" as a biofeedback management tool teaching breathing and relaxation skills to children with Attention-Deficit/Hyperactivity Disorder (AD/HD).

In psychological view, there are some preceding researches to examine relationship between mindfulness training and cognitive abilities (Chiesa, 2011) (Meiklejohn, 2012). These papers shows that a sort of training effects to improve cognitive abilities of learners. The proposed system does not include some training, but just measurement of heart beat, which implies their mental status.

In this paper, the authors applied the biofeedback to general learners. The learners receive the feedback of their change of heartbeat with use of PC camera based heartbeat monitor system, due to solution of various quizzes. They recognize their emotional situation with use of the proposed system. This feedback also encourages them to self-control their emotional situation.

2. Developed System

The authors developed a system with three functions: (1) to calculate one's heartbeat with use of PC equipped Web camera, (2) to visualize one's change of heartbeat in a graph, and (3) display quizzes. This system is working on Web browser. A screenshot is shown in Figure 3. Pink background section (upper left) shows a quiz. White graph with red dots (upper right) shows change of heartbeat. This graph section utilizes a freeware.

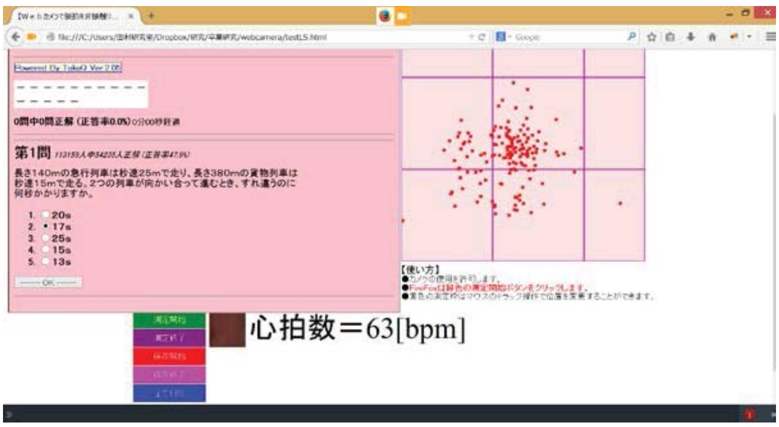

Figure 3. Screenshot of the proposed system

The proposed system has the following features. (1) Since it is written in JavaScript, it works on PC based Web browser. It does not need to install, nor depend on types of operating systems. (2) The system utilizes only a Web camera connected to the client PC to measure heartbeat from user's face. This camera is popular to equipment many laptop PCs. No other special and dedicated equipments are needed. (3) Measured results of heartbeat and quiz answers are stored in the local storage (HTML5 feature) of the Web browser. These results can be transferred to another server automatically.

The graph section in Figure 3 shows heartbeat change by every second, with manner of X-axis (t = n-1) and Y-axis (t = n). According to this drawing, the state and the following changes can be interpreted as a graph in Figure 4.

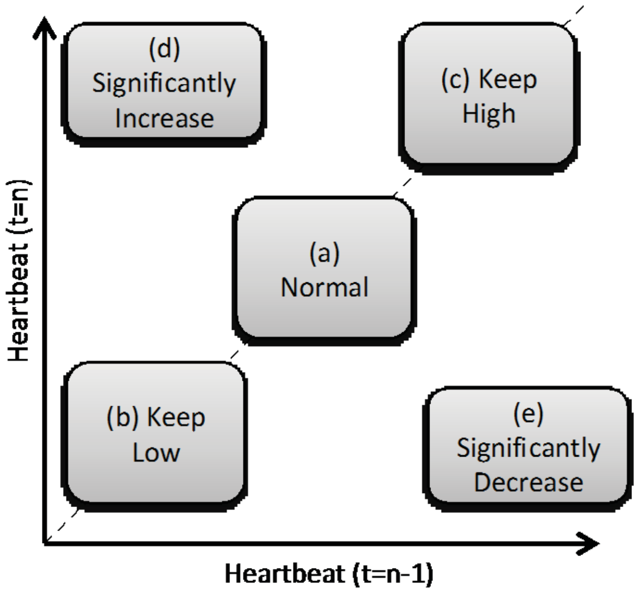

Figure 4. Interpretation of heartbeat change graph

3. Preliminary Experiment

As a preliminary experiment, the authors applied the proposed system to 6 testees. All testees are required to solve 7 problems with various difficulties. Testee A to testee C (target group) are given their heartbeat feedback with use of the proposed system, while testee D to testee F (control group) are shown just problems without heartbeat feedback. A heartbeat monitor result of testee A is shown in Figure 5, where X axis for time (second) and Y axis for heartbeat.

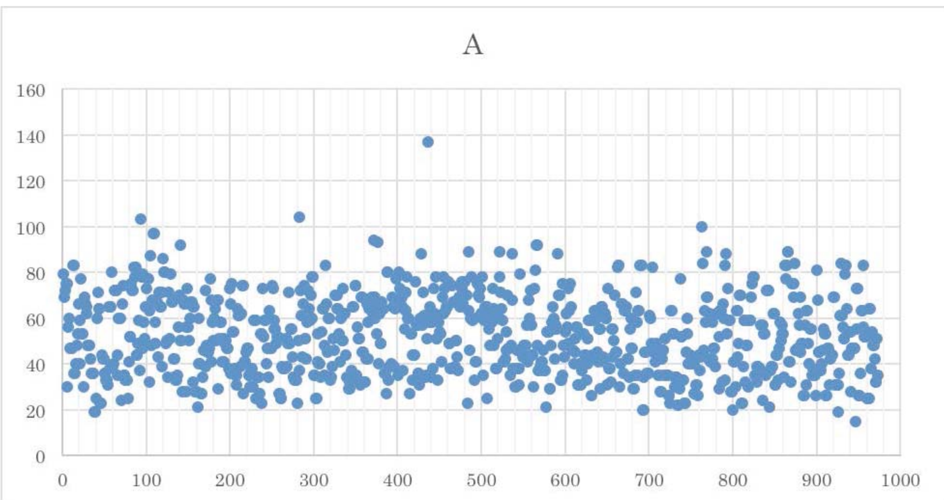

Figure 5. Sample heartbeat result

After the experiment, testees answered questionnaires about their mental status during solving problems. They were asked to feel themselves stressful, nervous, and depressed. Result of answer amount (summation of answers for all quizzes: full score is 21=7x3) is shown in Table 1.

Table 1. Experiment result

	Target group	Control group
Feel stressful	1	2
Feel nervous	3	1
Feel depressed	2	4

Observed from this table, the target group testees recognize themselves to be nervous. On the other hand, the control group testees significantly feel to be depressed, while the target group testees don't feel so. This result shows that the proposed system supports self-recognition of their emotional status. This self-recognition also helps to keep self-motivation of problem solving, without to be depressed. This result means that this biofeedback feature is also effective for self-regulated learning.

This experiment is just a preliminary one. The first reason is that there are too few number of testees. In order to be statistically correct, there need more than 40 testees for both target and control groups. The second is that the authors need to clarify correlation between answer correctness and usage of the proposed system. The third is that interface of the proposed system is not enough familiar. The graph in Figure 3 only shows quantitative change of the heartbeat. Ideally, some qualitative message to the learners (e.g. “You feel stressed” or “You feel nervous”) is desirable. These are left to future works.

4. Conclusion

The authors developed a simple heartbeat visualization and feedback system. It visualizes one's change of heartbeat in real time manner. This function is considered to be effective to identify and control learners' mental status, in order to solve problems more efficiently. Preliminary experiment results shows that the proposed system supports testees to identify their nervous state, and prevents from dropping into depressed status. However, it needs further investigation and refinements of the proposed system.

Acknowledgements

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Error Log Analysis for Improving Educational Materials in C Programming Language Courses

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Abstract: Many universities choose the C programming language (C) as the first programming language to teach to students. As novice programmers, students frequently make simple mistakes such as syntax and typographical errors. Students often find it difficult to locate these errors, as students are not yet thoroughly familiar with C's syntax. Usually educational materials are very useful tools for students to locate errors and find solutions. This study aims to facilitate teaching and learning of C. We propose a system that undergraduate novice programmers may use to easily locate syntax errors in C and get recommendations from educational materials. We analyze error logs of programming and reading logs of educational materials, with the learning by doing mode (learning-practicing-reflection) to discuss key findings and their implications for programming education.

Keywords: C programming, educational materials, learning by doing, learning analysis

1. Introduction

Novice programmers typically do not understand C's syntax very well. Students learning C frequently make simple errors, such as typographical errors or careless use of syntax. Though these errors are simple, novices typically find their resolution difficult. Novices may struggle to locate the cause of errors, and may find the nature of the error obscure (Fu et al., 2015).

Robins and Rountree (2003) reviewed and discussed teaching and learning of programming. Their study examined novices, and discussed educational materials and showed that students considered programming courses difficult. However, most recent research examines improving learning of programming styles. Extant research examining effective education of novices is limited.

It is therefore necessary to facilitate the teaching and learning of C. C is the first programming language taught to students at our university, as a sound understanding of C is very helpful to learning other programming languages. Sharan (1980) showed that most traditional programming instructions usually focus on syntax, logics through lecturing and take place in classroom. Ala-Mutka (2004) suggested that "technical tools and visualizations are simply learning aids and materials. Teachers must thoroughly design their instructional approach to the issues in the course, and how the aiding materials are incorporated into education."

In Kyushu University, we used Booklooer-a e-book reader for digital teaching materials, we can collected logs during class (Yin et al., 2015).Teaching materials has been uploaded to BookLooper, students can use BookLooper anytime. We are able to gather materials reading logs from BookLooper's server.

We collected logs from students learning programming, and we had classified error types using error logs from undergraduate novice programmers (Fu et al., 2015). By using the research results, in this paper, we proposed a learning support system through using programming error logs and Booklooper reading logs. The research in this paper will mainly relevant to four points:

- Supporting students to locate students' errors and recommend related teach materials.
- Feedback the most common visited pages and related common error messages to teachers.
- More accurately to locate error by associated with error messages in the same error logs.
- Find the typical programming which contains same error messages, share these kinds of programming to students using in testing and self-checking.

The remainder of this text is structured as follows: section 2 provides a review of relevant programming and computing education literature. Section 3 provides a description of our study. Finally, we discuss our findings' implications, and indicate scope for further research.

2. Related Research

Burton (1998) suggested that teachers should keep in mind the principle distinct from the following modalities "what actually gets taught; what we think is getting taught; what we feel we'd like to teach; what would actually make a difference" in teaching Java. However this could equally apply to any kinds of educational situation. Of course for teaching C, teachers also should keep in mind of these problems.

Thus, extant research predominantly examines cooperative programming and self-education systems. Hwang et al. (2012) discussed cooperative learning of ASP.NET using the WPASC (Web-based programming assisted system for cooperation). The research they made found that cooperative programming style is useful for many students. We consider that if the WPASC system does not effectively manage cooperative programming, less able students may not do their best to resolve errors in their programs.

Nagao and Ishii (2003) proposed an agent support system for C. This system is also a type of cooperative programming: students may share knowledge and error resolutions through agent software. Park et al. (2015) analyzed HTML and CSS syntax errors in a web-development course. They examined the JavaScript programming language, and used the open HTML editor system, to analyze difficulties that novices experienced in learning HTML and CSS' syntax.

Problems in learning and teaching programming also be discussed (Robins at el., 2003; Ala-Mutka, 2004). However limit research are focus on the beginning stage or education materials. Chang et al. (2000) discussed the strategy approach of programming learning for beginners. Some research on programming tutors are listed in their research. However, it is not easy for beginners to initiate a program out of the blue, and that will make students lower their learning motive. How to make students faster and better understand the basic knowledge is really important.

Research examining initial education in the C language is limited. In our study, we propose a system that may facilitate students' understanding of why errors may be made, as well as how to resolve them. Further, we aim to analyze the logs between error logs and BookLooper reading logs to perfect the educational materials.

3. System Design and Methods

3.1 Environment and Data Source

Figure 1 illustrates our system's architecture. Students may connect to the server through terminal software TERA-TERM using his or her student ID and password. Students are not required to install any programming software; the compile software GCC (GNU Compiler Collection) has already installed in the server. Students can get themselves' workspace by using themselves account. All reports of GCC compiling will be stored in directory "./log". Students' compiling logs will be stored in the directory which named by student ID. We are able to gather logs from the server through SFTP.

In our previous work, we had used 53505 errors made a simple analysis on C error logs among novices. These logs are from 909 students attending a C programming course; 164 from autumn 2014, and 745 from spring 2015. All students did not have knowledge on programming.

In addition, the educational materials are uploaded to BookLooper with different topics. To better survey novices' syntax errors, we analyzed error messages with respect to the course schedule. Table 1 provides the course schedule, with topics and assessments organized by week. Students need to login BookLooper using student ID and password during classes, and download the educational materials to acquire knowledge. We are able to gather the BookLooper reading logs from BookLooper's server. Booklooper reading logs can refer to (Yin et al., 2015).

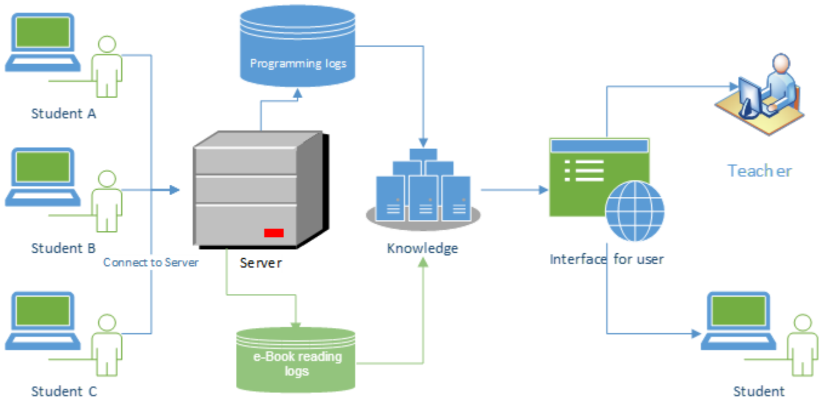

Figure1. The architecture of our system

3.2 Learning by doing in Course

Every C programming language course has 90 minutes in our college. Teachers will give more time for students to do the programming exercises. Figure 2 illustrates the structure of learning by doing in course. Teachers usually begin the course with about 15 minutes of instruction using the teaching materials in BookLooper. The remaining time will be used by students to finish 6 exercises. During practicing time, many programming errors will be made among students. Once the errors occurred, some students will ask TA (teaching assistants) or teacher for help. TA is not enough to follow every student (Nagao and Ishii 2003). Most students will reflect the knowledge in BookLooper. But sometimes knowledge introduced in educational materials on BookLooper may not so clear. We are thinking about how to make the error logs and BookLooper reading logs more useful and how to make the educational materials more specific. Problems like how to make the logs more useful, how to make the error types more accurately and how to reuse the error programming will be discuss in the following sections.

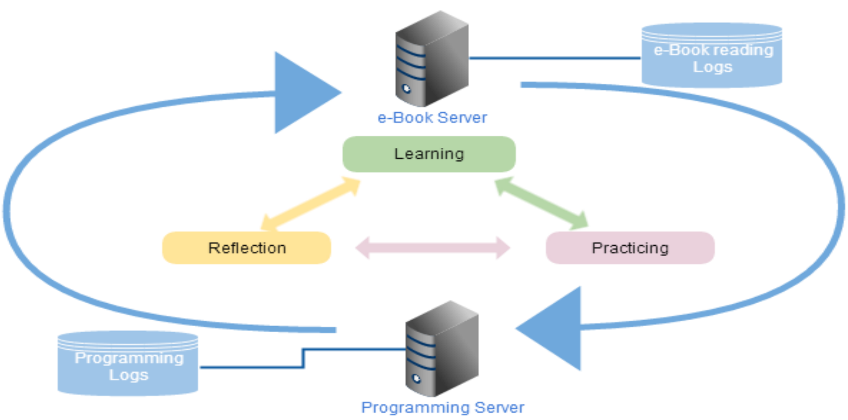

Figure 2. Illustrates the structure of practice learning in course

3.3 How to make logs more useful

The purpose of this research is to make C more easily for learning and make educational materials more effective on helping teaching C. Educational materials are very important reference material for novices during courses. We analyze educational materials using two kinds of logs: C programming error logs and BookLooper reading logs. Through the analyzing results to find which part of educational materials are not clearly clarifying and what contents need to be added.

In our previous work, we had already analyzed the most common error types of each course topic. For the next work, we propose to combine the analysis results of error types with the reading logs of BookLooper to analyze of the following problems. One is once one type error happened, which page is most visit for helping among all the students. The other one is whether the material on that page can help students to solve the problems. If it can't, what kinds of materials need to be added.

3.3.1 Scenario

Through using our system, when one error occurs, system will analyze the most visited pages of BookLooper to judge related materials. For example, when the type of misuse of switch statement error happened, the most happened error type in topic 6 which is expect the most common error types like missing semicolon: Multiple If-else and Switch-case. One program example is showed in figure 3. In this example, there have the errors in case statement, where have already changed to Bold.

By using the system mentioned in this paper, we find during the time of error happened page 9 of topic 6 are frequently visited. Figure 4 shows the page 9 on BookLooper. It is about very simple explanation on syntax of switch-case. In page 9 we notice that no special instructions are explained for the statement that after case should use ":", not ";". For novices, it is very easy to think that ";" should be used after every line, but in this case, it should be different. If teachers make an ambiguous interpretation for this syntax, it will make students make errors.

As a result, we will make a feedback on this to teachers. Send some typical error programs and the pages associated with the errors to teachers. Use the feedback teachers will know the explanation on which part is not enough. It is easy for teachers to make a decision on what should be added into the materials and which part should be explain more clearly in class. On the other hand, these kinds of often visit pages also will be used for students. As most of the pages is useful for modifying errors, we plan to recommend these pages to students in our future work. When they meet the same errors, the pages will be presented regarded as reference in student's homepage on our web system.

```
#include<stdio.h>
int main(){
int n;
printf("順位を入力してください¥n");
scanf("%d",&n);
switch (n){
case 1;
printf("優勝者には、100 万円の賞金です。\n");
break;
case 2;
  printf("2 位には、10 万円の賞金です。\n");
break;
default;
printf("記念品をどうぞ。\n");
}
return 0;}
```

Figure 3. Program with misuse of switch statement error

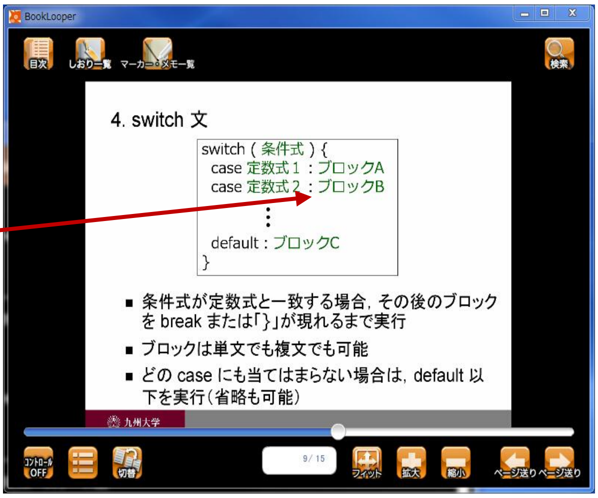

Figure 4. Details of topic 6 in page 9 on BookLooper

3.4 How to make error types more accurately

In our previous work, we had already classified the error logs into 26 types, the types will be added with the error logs added. During the process of analysis we found that in one program, usually will reports many error messages. We estimated every error message and feedback to students and teaches in our previous work. However, we found some error messages are depend on the early error message, the following part error messages are not so important. It is meaningless to recommend solution for these kinds of messages. Figure 5 give a simple example of this kind of program and the error messages.

Form the example, we notice that error: 'c' undeclared (first use in this function) is caused by missing semicolon of line 4. We just need to tell novice that the fundamental error of this program is missing semicolon in line 4. Based on this findings, we propose to combine error messages to make more accurately on classifying error logs. For example, error message "expected '=', ',', ';', 'asm' or '__attribute__' before" is happened before "undeclared (first use in this function)" in one program, it is usually because of the error "expected '=', ',', ';', 'asm' or '__attribute__' before", we will make a model to indicate the root cause is from message “expected ‘=’, ‘,’, ‘;’, ‘asm’ or ‘__attribute__’ before”. We hope to make a more accurate way that can help novice locate the error more accurately.

```
#include<stdio.h>
int main(int argc, const char * argv[]){
    int a,b,c
    a=5;b=3;
    c=a+b;
    printf()"%d\n", c);
    return 0;
```

```
$ gcc example2.c
example2.c: In function ‘main’:
example2.c:3: error: expected ‘=’, ‘,’, ‘;’, ‘asm’ or ‘__attribute__’ before ‘a’
example2.c:5: error: ‘c’ undeclared (first use in this function)
example2.c:5: error: (Each undeclared identifier is reported only once
example2.c:5: error: for each function it appears in.)
example2.c:6: error: too few arguments to function ‘printf’
example2.c:6: error: expected ‘;’ before string constant
example2.c:6: error: expected statement before ‘)’ token
example2.c:7: error: expected declaration or statement at
```

.

Figure 5. An example of error program with the error message

3.5 How to reuse error programming

Programming contains errors also very valuable resources. In this paper we also consider how to reuse error programs from novices. We collect students programs, and analyze error logs. We found some errors are common errors among students. We propose to change these programs to exercises and send to students at last of every course or in final test. We consider to use this programs on checking whether students really understand the syntax. Moreover we hope use these programs to make a self-checking for students. It is usually easier for students to remember knowledge through reflection.

4. Conclusions and Future Work

In this paper, we outline four main tasks on effectively assist learning of C. Our results may effectively perfect educational materials and help students to locate the cause of errors more accurately. Further, we will recommend the educational materials to students accurately, and help students check learning conditions using themselves’ programs. In our next work, we intend to discuss on how to make the error classify model accurately. We plan to finish our system quickly, and deploy it in a C programming course, in order to verify its usefulness. In addition, we will consider analyzing various methods such as social network analysis and visualization of graph theory (Mouri et al., 2014; 2015).

Finally, as students in C programming courses are a mixture of computing majors and general education students, we wish to analyze potential differences in rates of error types between majors, and adapt course teaching accordingly to each major. We intend to implement an online system for all novices studying C programming, and collect and examine more error messages and error types. It is our hope that our system may serve a greater number of learners, and be useful in more complex programs.

Acknowledgement

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Appendix table 1. Weekly Overview of the Course Schedule

Week	Topics	Assessments
1	Introduce to C Language	3 Exercises of Using "Printf" Statement
2	Variables	6 Exercises of Variables
3	Functions	6 Exercises of Using "Scanf" Statement and Operator Symbol like "+", "-", "*", "++".
4	Mathematical Functions	6 Exercises of Mathematical Functions
5	Decision Making Structures If-else	6 Exercises of If-else
6	Multiple If-else and Switch-case	6 Exercises of Multiple If-else and Switch-case
7	For Loop	6 Exercises of For Loop
8	Array	6 Exercises of Array
9	Multi-dimensional Array	6 Exercises of Multi-dimensional Array
10	Multiple For Loop	6 Exercises of Multiple For Loop
11	While--Do-while Loop	6 Exercises of While--Do-while Loop
12	String Functions	6 Exercises of String Functions
13	User-defined Functions	6 Exercises of User-defined Functions
14	File I/O	6 Exercises of File I/O
15	Programming Practise	1 Exercises of Final Test of Semester

A Clustering Method using Entropy for Grouping Students

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Abstract: This study suggests a novel clustering method using entropy in information theory for setting cut-scores. Based on item response vectors from the examinees, we construct the Ordered Item Booklets (OIBs) based on the Rasch model which is a kind of Item Response Theory (IRT). The approach of the proposed method is to partition the scores into n-clusters and to construct probability distribution tables separately for each cluster from the item response vector. Using these probability distribution tables, mutual information and relative entropy (Kullback-leibler divergence) were computed between each of the clusters and then cut-scores were determined by the cluster's partition to minimize mutual information values. Experimental results show that the approach of this proposed entropy method has a realistic possibility of application as a clustering evaluation method.

Keywords: entropy, clustering, item response data, test score

1. Introduction

This short paper reports on a method involving a specific set of mathematical operations on performance data created by examinees. Specifically, item test scores are analysed and ordered in terms of difficulty (as perceived by examinees) to determine abilities of the examinees. It also makes use of entropy, or disorder, within the data collected. Within computer science and using standardized evaluation criteria educational evaluation can be broadly classified as either a criterion-referenced evaluation or a norm-referenced evaluation. A norm-referenced evaluation (or test) is a type of evaluation method that produces an estimate of a ranked position of a tested individual within a defined population, with respect to a particular trait being measured. This estimate is derived from by combining an analysis of test scores with other relevant data from a sample drawn from the population. That is, this type of test identifies whether the test taker has performed better or worse than other test takers, but not whether the test taker actually knows more or less material than is necessary for the given purpose.

A criterion-referenced test is one that provides a translation of test scores into a statement about the behavior to be expected of a person with that score or their relationship to a specified subject matter. A criterion-referenced assessment can be contrasted with norm-referenced assessment and both have advantages and disadvantages. Typically, it is the context and purpose of evaluation that determines the choice of which method is used.

Recently, it has become more important to classify students according to their test scores in school for instruction with a variable curriculum, usually by achievement level enabling selection of excellent students. A great deal of research across numerous courses is currently being carried out to teach students appropriately for their ability and level. The main drawback, however, in classifying students according to their test scores is a lack of reasonable criteria that reflects ability.

This study presents a clustering method in order to split the class into groups according to similarity of individual student scores. An instance of a clustering problem consists of a set of objects and a set of properties for each object into groups using only the characteristic vectors.

2. Analysis of Item Response Data

Research relevant to the proposed method uses analysis of item response data. Kim et al. (2005) proposed information-based pruning for identifying interesting association rules in item response data through data mining techniques. Park et al. (2002) applied goodness to classify scores in item response using relaxation error which is one type of clustering method. But, their proposed algorithm is a type of greedy algorithm, thus creating a local minimum problem. Richard (1979) applied goodness to classify scores in item response also using relaxation error as a clustering method. In general, only certain aspects of the characteristic vectors will be relevant, and extracting these relevant features is one field where clustering plays a major role (Tishby, 1999). Clustering is a fundamental tool in unsupervised learning that is used to group together similar objects (Jain and Dube, 1988), and has practical importance in a wide variety of applications such as text, web-log and market-basket data analysis. The crucial point of all clustering algorithms is the choice of a proximity measure.

3. Clustering Evaluation Methods

After a set of cluster is found, we need to assess the goodness of the clusters. Unlike classification, where it is easy to measure accuracy using labeled test data, for clustering nobody knows what the correct clusters are given.

3.1 Sum of Squared Error

SSE is the sum of the squared differences between each observation and its group's mean. It can be used as a measure of variation within a cluster.

$$SSE = \sum_{j=1}^{k} \sum_{x \in C_j} disk(x, m_j)^2 \qquad (1)$$

k is the number of required clusters, is the *j*th cluster, is the centroid of cluster (the mean vector of all the data points in), and is the distance between data point x and centroid.

In Euclidean space, the mean of a cluster is computed with:

$$m_j = \frac{1}{|C_j|} \sum_{x_i \in C_j} x_i \qquad (2)$$

where $|C_j|$ is the number of data points in cluster C_j. The distance from a data point to a cluster mean is computed with Eq.(3).

$$\begin{aligned} dist(x_i, m_j) &= \| x_i, m_j \| \\ &= \sqrt{(x_{i1} - m_{j1})^2 + \cdots + (x_{ir} - m_{jr})^2} \end{aligned} \qquad (3)$$

3.2 Relaxation Error

Relaxation Error is a method that measure ‘goodness’ of conceptual clustering.

$$RE(C) = \sum_{i=1}^{n} \sum_{j=1}^{n} P(x_i) P(x_j) | x_i - x_j | \qquad (4)$$

where x_i, x_j are property values and $P(x_i)$, $P(x_j)$ are probability of in cluster *C*.

RE(*C*) is error value calculated between each cluster, this error is high means a goodness of clustering is low. If Partitions of C is $P = \{C_1, C_2, \cdots, C_n\}$, *RE*(*P*) is calculated by Eq.(5).

3.3 *Entropy*

Entropy measures the amount of impurity or disorder in the data. For each cluster, we can measure its entropy as follows:

$$entropy(D_i) = -\sum_{j=1}^{k} P_i(c_j)\log_2 P_i(c_j) \qquad (6)$$

where $P_i(c_j)$ is the probability of class c_j in data set D_i. The total entropy of the whole clustering (which considers all clusters) is:

$$entropy_{total}(D) = -\sum_{i=1}^{k} \frac{|D_i|}{|D|} \times entropy(D_i) \qquad (7)$$

4. Experimental Classification Results and Analysis

In general, item response data such as that represented in Table 1 can be obtained as an outcome through one test. In the item response data, each transaction (i.e., student) has its own score and is considered differently, with '1' indicating a correct answer and the '0' indicating a wrong one.

Table 1: Item response data

Student	I1	I2	I3	…	In	In	score
S1	0	1	0	…	1	1	TS1
S2	1	1	0	…	1	1	TS2
S3	1	0	1	…	0	0	TS3
…	…	…	…	…	…	…	…
S_{m-1}	1	0	0	…	1	1	TS_{m-1}
S_m	0	1	1	…	0	0	TS_m

For our experiments, we used a sample dataset for 13611 students which is an item response data of ICT literacy Test carried out in 2007. Figure 1 shows score frequent analysis in sample data. As shown the Figure 1, test score is a continuous numeric attribute.

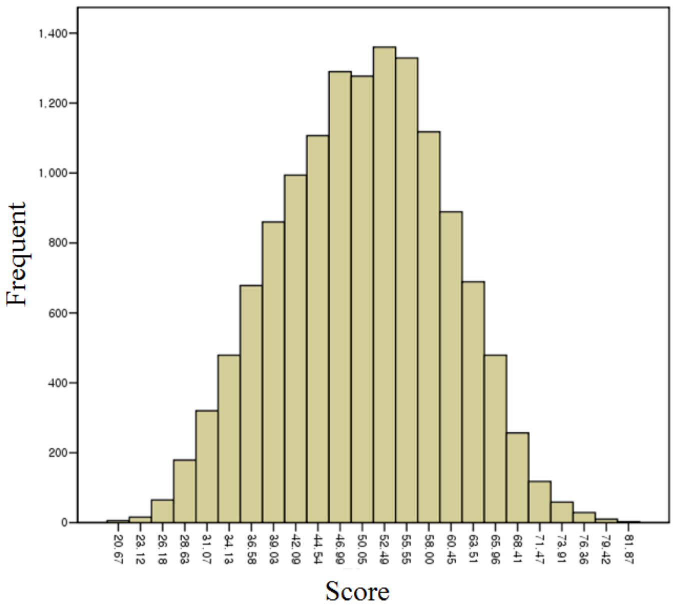

Figure 1. Score frequent in sample data

SSE and Relaxation Error uses one variable is score ($TS_{1,\ldots,}$ TS_m) in item response data.

Table 2: Confusion matrix with each method with instance No.153

Cluster	SSE	Relaxation error
1	68114	210.92
2	92569	
3	68944	
total	229627	210.92

But Entropy required two variables for calculating.

Table 3: Confusion matrix with each method on Item No.1 with instance No.153

Cluster	Correct	Wrong	entropy
1	483	3114	0.150
2	1354	5009	0.349
3	1309	2342	0.253
total	3146	10465	0.752

Table 4 shows a result of clustering evaluation entropy, SSE and RE.

Table 4: Top 20 Rank Results of Clustering Evaluation (# is a instance No.)

#	entropy	#	SSE	#	RE
153	18.19	152	215015	140	187.52
152	18.20	138	220811	154	187.88
138	18.20	153	229627	141	194.44
166	18.20	166	244336	125	198.09
167	18.21	165	246347	126	199.69
154	18.23	139	256420	155	199.79
139	18.23	167	257092	167	200.41
137	18.24	154	258582	153	210.92
165	18.24	123	259733	139	214.22
151	18.26	137	265565	168	215.82
123	18.27	151	273607	166	216.33
179	18.27	168	277523	142	217.93
122	18.27	179	278272	127	219.62
168	18.27	178	281492	110	220.55
178	18.29	180	283124	109	222.10
180	18.29	122	287683	156	225.92
140	18.31	155	293991	124	226.39
155	18.32	177	297593	111	236.27
124	18.33	107	304079	169	243.22
106	18.34	140	304329	179	245.66

As shown in the Table 4, the entropy method is more similar to the SSE than the RE method. This result means that entropy is suitable for clustering continuative numeric attribute than RE.

5. Conclusion

We have developed a method for clustering item response data using entropy within a continuative numeric attribute as test score. In order to prove the effectiveness of this method, we have compared Sum of Squared Error (SSE) and Relaxation Error (RE). Experimental results, as shown, highlight more similarity with SSE rather than RE. Building on this approach we can verify a result's similarity of entropy and SSE statistically in future work.

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A method of visualizing students' reactions by creation of a time series cross table from the in class page view history of the Learning Management System

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Abstract: Lectures in classrooms reach dozens of students at a time, but the lecturer can find it extremely difficult to gauge students' individual reactions to the teacher's instructions and the content being presented. For this paper, about the blended learning that is carried out in the classroom, we conducted a time series analysis by utilizing the viewing times of digital teaching materials that have been stored in the Learning Management System. And we have proposed the creation of a time series cross table to visualize the students' reactions numerically, along with the teacher's instructions, regarding the browsing of digital teaching materials. The digital teaching materials were created in a PDF file and installed in the Moodle learning management system. We created a time series cross table by utilizing the time of the page view histories collected, and thus we indicate that we could visualize the student's reaction to the teacher's instructions indicating a list of transition of values that represents the status of students viewing the digital teaching materials. The students' reactions when the teacher's instructions are through, including when materials were opened with a delay, are visualized by a numerical value list on time series cross table. The proposal of the time series cross table indicates parts of teacher instruction that might not be clearly understood; thus, the benefit of its utilization for future class improvement was revealed. This information can serve to improve instructions given to students in future classes.

Keywords: time series analysis, cross table, page view, e-learning, educational data mining, learning history

1. Introduction

Currently, the active digitization of teaching materials in the field of education as well as the utilization of digital teaching materials in lessons is widely practiced. Furthermore, the classes to be performed by equipping with digital teaching materials on Learning Management System (LMS) have carried out the accumulation of learning histories and the application of data mining has been made possible.

This field has developed into a field called Educational Data Mining (EDM) (Baker & Yacef, 2009; Romero & Ventura, 2013). In recent years, EDM has been positioned in the more important area of research at an international conference that will be held every year (Barahate, 2012).

The background of EDM has become important. This is largely due to the development of a LMS that utilizes tools such as the web browser and the access analysis on the internet (Google, 2015). These tools have also been applied to the research of EDM.

In lectures, however, which are performed by gathering dozens of students, the function of e-learning systems, such as the current state of Moodle, the digital teaching materials the teacher instructs for viewing, and whether the student is viewing as instructed is often hard to know.

In this context, about the blended learning that is carried out in the classroom, we have been conducted a time series analysis by utilizing the viewing times of digital teaching materials that have been stored in the LMS. And also have been making a research creating a time series cross table to numerically visualize the students' reactions to and the teacher's instructions of digital teaching materials browsing (Dobashi, 2015).

In classroom teaching, there are students who open the digital teaching materials late, after the teacher's instructions. There are also students who do not open the digital teaching materials at all and therefore have a limited view of the teaching materials. Correspondence is often required in these situations. Reading of the materials is essential for students. If teachers are able to know instantly when a student views inappropriate digital teaching materials in class, they can draw attention to the student and it is possible to add a twist as to how to proceed with the class as soon as possible.

Therefore, for teachers who use an e-learning system as a teaching tool in class, we have created a commentary in PDF format to be utilized in preparation and review for students. Data regarding the use of the digital teaching materials in the weekly class, such as the date and time, student ID number, and page view history (for example, the page title) were collected (Romero & Ventura & Garcia, 2007a).

Using the page view history of Moodle, which describes which digital teaching materials were opened and when students opened them during class, we cross tabulated as time series data in a list format using Excel. In addition, we have created a cross table of the time series by collecting data on the number of students, viewing time, and digital teaching materials the teacher used in class and materials the teacher did not use.

From an analysis of the page view history, there were many students who opened digital teaching materials that the teacher did not instruct them to open. It is possible to identify these students, as well as when and which digital teaching materials were opened, by the time series data via cross tabulation.

Furthermore, from the time series analysis of the page view history during class we were able to identify cases in which materials were opened by students at a later time than that instructed by the teacher. This information can serve to improve instructions given to students in future classes. The time series cross table can be used to show which parts of teacher instructions are unclear, serving to improve instructions given to students in future classes and improving overall learning. The time series cross table can be used to show which parts of teacher instructions are unclear, serving to improve instructions given to students in future classes and improving overall learning.

2. Related research

The object of Educational Data Mining that utilizes a LMS is lesson improvement. For example, in e-learning systems such as Moodle, the use of digital teaching materials in class can be easily exposed, and via the management functions of learning history, such as the page view history of digital teaching materials and quiz results, it is possible to collect some of the data (Romero & Ventura & Garcia, 2007b). By means of applying data mining based on the statistics of the collected learning history of students who participate in the lesson, viewing conditions of digital teaching materials, and score distribution of quizzes, it is possible to check several features (Lai & Sanusi, 2013).

As summarized in Romero & Ventura's paper (2007a), digitizing such materials as conventional paper texts and quizzes and posting them on an e-learning system makes it possible to collect learning history that is useful for improving teaching methods from various viewpoints, such as through page view history and test results. Also, in targeting accumulated learning history data, by applying data mining techniques to find data directly related to class improvement, the development of new methods to enhance the training effect was expected.

In order to clearly understand the effects of materials and motivation when addressing class improvement, collecting learning history data accumulated early via e-learning systems is an important issue to be analyzed (Ueno, 2004). In past lessons of blended learning, numerous studies were carried out as a result of the analysis of page views and the scores of quizzes that corresponded to materials and teaching evaluation questionnaires (Adachi, 2007). These studies have revealed that the implementation of quizzes and the times of access to digital materials are related to the improvement of learning effects. In these studies, a number of different materials were used, such as booklets, textbooks, websites, PowerPoint slides, quizzes, commentary articles, fill-in-the-blank questions, etc.

Romero et al. (2007b) also classified the trends of data mining in the field of education in such areas as statistical analysis, visualization, and text mining, and investigated the various methods that have been attempted (Romero & Ventura & Garcia, 2007b). Furthermore, it has been shown that using learning history data in Moodle to classify learners with features from the results of mining can be applied to improve the educational effects of data mining (Romero & Ventura & Espejos & Hervas, 2008; Romero & Ventura, 2010; Huebner, 2013).

In addition, Google Analytics provides a wide-access website analysis service that makes it possible to analyze different perspectives. With the help of these services, it is also possible to help improve digital teaching materials and lessons (Google, 2015). The service provided by Google Analytics, such as aggregate visitors and visit time to a given web site, the number of users that have accessed the website, the website content being viewed etc., can be grasped in real time. It is also possible to visually analyze the user who is doing any kind of operation in the page.

Although Google Analytics can be used only by an administrator of Moodle, however, the method proposed in this paper can be utilized by any Moodle user. Also, as regards previous learning history, the number of studies using the time series cross table in class, which we have proposed in this paper, is extremely small.

3. Time series cross table

This study investigated a class that corresponded to the blended learning model and that was performed while viewing digital teaching materials on Moodle in traditional face-to-face teaching. In order to accumulate the learning history of the students using Moodle, it is necessary to provide digital teaching materials or provision a method such as a link to an external URL. We must prepare in advance the digital teaching materials to be browsed by students. In this paper, we have mainly used the digital teaching materials (PDF files) that were created for the sole purpose of this study.

3.1 Overview of the digital teaching material

Files were created in PDF format, a format that can be viewed via PDF Viewer by clicking on a link in the table of contents that we created in the Moodle Topics format. Since it is possible to freely enter the name of the topic in Moodle, we created a digital section that corresponds to the table of contents of the paper textbook by entering the heading that corresponds to the chapter-section and small items of materials.

When the students click these topics and browse the digital teaching materials (corresponding to the resource in Moodle), the name of the topic (resource name) is recorded in the log, in addition to any digital teaching material that was browsed, and is displayed in a table format. In this way, the page view history is obtained (Figure 1).

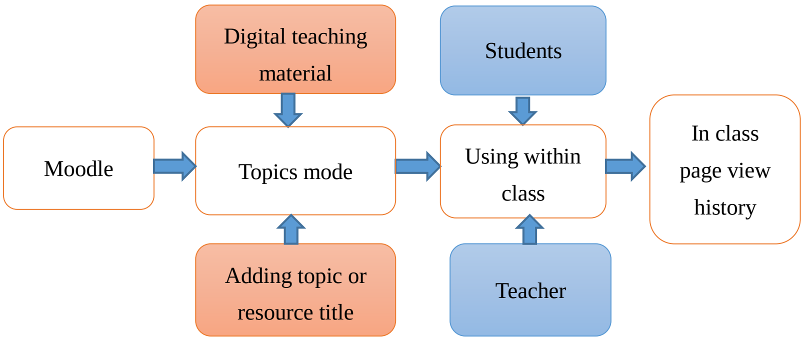

Figure 1. Outline of the flow to accumulate the page view history by Moodle

3.2 Page view history and data cleaning

In the Moodle log report page, a record was kept of students' learning history from enrollment (Course) and the first lesson conducted. Information detailing the time resource pages were viewed (Time), the accessed PC's IP address, student ID and name (User full name), the operations performed in Moodle (Action), and the resource page title opened by students (Information) was stored in a table which can be viewed.

The resources and topics described below are the headlines and subheadings corresponding to the chapter-section and small items of digital teaching materials uploaded on Moodle. In addition, this paper used a file downloaded from Moodle (in Excel format) of the page view history of students using Moodle. The performance of the lesson was carried out by the teacher (who instructed the viewing of digital teaching materials that were prepared in advance) and the teacher logged in to Moodle from the teacher's desk. Students logged in at the start of classes.

There was sometimes a lack of data (for example, there was no title data for the resources that were accessed, etc.) in the log file downloaded from Moodle. Moreover, the date and time are described in the same column, since it is inconvenient to process and perform data cleaning before performing the analysis. In the following analysis, sample data from the page view history concerning date, month, viewing time, student ID, and the title page of the digital teaching materials used was aggregated using the cross tabulation function (pivot table) of Excel.

3.3 Time series analysis of page view history in class

In this study, we published all of the digital teaching materials that were created for lessons. Students were able to view the materials that were used on the day of the class. Moreover, students were able to read ahead and view materials to be used in future lessons. Also, students were able to use the materials as a tool for review.

From the perspective of teacher, when doing a lesson at the teacher's desk it is often difficult to know whether each student is viewing the digital teaching materials in accordance with the teacher's instruction. Therefore, we distinguished between the materials used in the lesson and the materials not being used in the lesson by the teacher.

In this paper, the digital teaching material that was used refers to the materials opened by the teacher for the lesson of the day. Also, the unused materials refer to the digital teaching materials opened by students that were not used by the teacher during the lesson of the day.

And then we separated the data into five stages, in 1- to 5-minute intervals. We then created a time series cross table from the number of students and the viewing time of each of the digital teaching materials. We also created a time series cross table from the number of page views and the viewing time for each student (Figure 2).

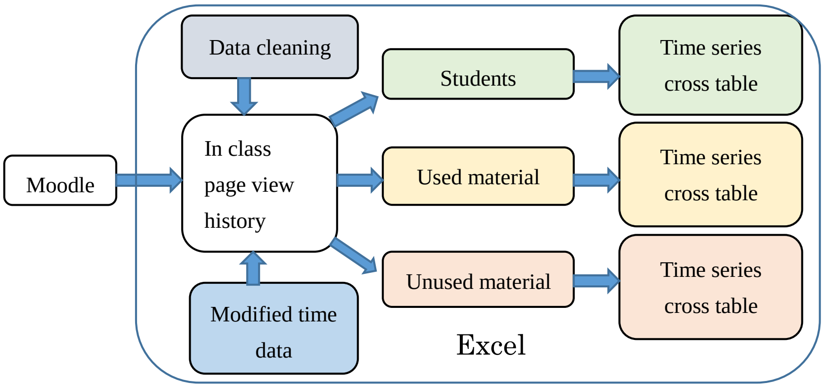

Figure 2. Flow of data mining for time series cross table

4. Time series cross table of page view history

4.1 Course enrollment - Example from "Multimedia Creation" -

Table 1 and Table 2 show the time series cross table of the page view history of digital teaching materials collected in a class called "Multimedia Creation". In this class, we learned about the creation of animation and video works. This course has become a common subject for undergraduates and students in any year of studies can enroll in the class.

The class from which we created the time series cross table was an introductory lesson and occurred in the spring semester on 2015/04/08. One page of digital teaching materials was used (A4 size, eight pages). Table 4 was obtained by counting the total number of students who opened the digital teaching materials.

Table 1: Time series cross table of page view history of digital teaching materials that were used in the lesson (“Multimedia Creation”, 2015/04/08, 5 minute intervals)

2015/4/8	Time (5 minute intervals)										
Resource name	10:55	11:00	11:05	11:10	11:15	11:20	11:25	11:30	11:40	12:05	Total
Role assign	35	4									39
Multimedia creation	71	19	2	12	1	2	1	6			114
Processing of figures	2	23	12	2	2		1	44	1	1	88
Total page views	108	46	14	14	3	2	2	50	1	1	241

Table 2: Time series cross table of page view history of digital teaching materials that were used in the lesson (“Multimedia Creation”, 2015/04/08, 3 minute intervals)

2015/4/8	Time (3 minute intervals)													
Resource name	10:57	11:00	11:03	11:06	11:09	11:12	11:15	11:18	11:21	11:27	11:30	11:39	12:06	Total
Role assign	39													39
Multimedia creation	86	4		3	11		1	1	1	3	4			114
Processing of figures	13	12	12		2	2				33	12	1	1	88
Total page views	138	16	12	3	13	2	1	1	1	36	16	1	1	241

Table 3: Teacher’s page view history (“Multimedia Creation”, 2015/04/08)

2015/4/8 Teacher's page view history				
Time	IP address	User full name	Action	Information(Resource name)
2015/4/8 10:54	192.168.11.7	teacher	role assign (http	Role assign
2015/4/8 10:54	192.168.11.7	teacher	course view (htt	Multimedia creation
2015/4/8 11:26	192.168.11.7	teacher	resource view (h	Processing of figures
2015/4/8 11:27	192.168.11.7	teacher	resource view (h	Processing of figures

Table 4: Time series cross table of page view history of students that participated in the lesson (“Multimedia Creation”, 2015/04/08, 3 minute intervals)

2015/4/8	Time (3 minute intervals)													
StudentID	10:57	11:00	11:03	11:06	11:09	11:12	11:15	11:18	11:21	11:27	11:30	11:39	12:06	Total
StudentID	3													3
StudentID	4													4
StudentID	3									1				4
StudentID	3									1				4
StudentID	3									1				4
StudentID	3									1				4
StudentID	3									1				4
StudentID	3									1				4
StudentID	3									1				4
StudentID	3									1				4
StudentID	3					1								4
StudentID	3									1				4
StudentID	3									2				5
StudentID	3	1								1				5
StudentID	3									1	1			5
StudentID	3									1	1			5
StudentID	3				1					1				5
StudentID	4		1											5
StudentID	3	1								1				5
StudentID	4									1				5
StudentID	4									1				5
StudentID	3			1						1				5
StudentID	3	1								1				5
StudentID	3									2				5
StudentID	3									1	1			5
StudentID	3			1						1			1	6
StudentID	3									3				6
StudentID	3									1	2			6
StudentID	6	1												7
StudentID	6	1												7
StudentID	3					1				1	2			7
StudentID	4				2			1		1				8
StudentID	3		5											8
StudentID	3		6											9
StudentID	7	1			1						1	1		11
StudentID	7	1		1						3	1			13
StudentID	3				1		1		1		7			13
StudentID	3	9								2				14
StudentID	5				8					1				14
Total page views	138	16	12	3	13	2	1	1	1	36	16	1	1	241
Total students	39	8	3	3	5	2	1	1	1	29	8	1	1	39

This lesson began at 10:45 and ended at 12:15. There were 39 people in attendance. Table 1 and Table 2 show the time series of aggregated results separated into 3 and 5-minute intervals respectively. Table 3 also shows the teachers' page view history in order to make clear the time at which the teacher performed each instruction.

The Moodle system requires students to initially perform enrollment in the course and to assign roles. The role displays the use rights on the Moodle system. In the case of students, each student is assigned the role of "Student" (Role assign in Table 1 and Table 2). The teacher is given an enrollment key at the beginning of the lesson and students enroll in the course on their own.

Table 1 shows the enrollment situation from 10:55 through 11:00. Via comparison of the time series cross tabulation of 5-minute intervals, 35 students were enrolled until 10:55 and then four more people were enrolled until 11:00. This lesson contained students who were late for class, and this it can be seen in the slight variations that occurred as a result of the reactions of the students.

Also on that day, students opened the page called "Processing of figures" in addition to a page outlining the course contents (entry page, course view of "Multimedia Creation" in Table 2). We went on to practice the creation of a shape with Microsoft Word. At that time, the time that the teacher instructed the file to be opened, it was 11:26 or 11:27, as seen from the page view history for the teacher.

From the Table 2 at 11:27 and 11:30, the numerical value is larger because many students have opened the digital teaching materials according to the teacher's instructions. But, at the same time, we also found that many of the students opened the same file immediately after the start of class and prior to the teacher's instruction. We can also see that 12 students were slightly delayed in their opening of the digital materials.

Table 4 shows the time series cross table of students' page view history, and it is possible to see the time each student opened the materials. For example, in the time between 10:57 to 11:00 everyone enrolled in the course and opened the table of contents (entry page). It is understood that the students opened the digital teaching materials as a result of the instructions of the teacher sometime after or around 11:27.

4.2 Multiple digital teaching materials - Example from "Introduction to Social Data Analysis" -

Table 5 shows the time series cross table of the page view history of digital teaching materials (separated in 5-minute intervals) and collected during a class called "Introduction to Social Data Analysis". The contents of this course and the digital teaching materials contain a commentary concerning introductory statistics using Excel and related exercises. The aim was to learn the basic techniques required for the analysis of statistical data in the classroom while actually using Excel.

This class was also an introductory class, occurring in the spring semester (2015/04/08). 10 PDF files (A5 size, 24 pages) of digital teaching materials were used. The content includes "Excel Introduction" and "Basic operation with worksheet," etc., as well as a review for students who have already learned the information literacy (Table 6). Thirty-two students were in attendance that day. First, students had to enroll in the Moodle portion of the course (Role assign). Then, students opened the table of contents (entry page: Social data analysis). Looking at the table right sum of Table 5, there is a smaller number of attendees (32). From these numbers, it can be understood that students who did not open the digital material were present.

Table 7 was obtained by counting the total number of students who opened the digital teaching materials. At 13:10, the students initially opened the enrollment page to the course, and it can be seen that it is they opened the entry page. In Table 7, the 13:15, 13:30, 13:40, 13:45, 13:50, 14:00, 14:15, 14:20, 14:25 columns contain increased values, and these columns also include the time that the teacher instructed students to open the digital teaching materials. A delay in students opening the digital teaching materials can also be seen at 13:15, 13:35 etc..

Also in Table 7, at 14:20 and 14:25, the teacher requested that students open the digital teaching materials. This was just before the end of the lesson, and the students who opened these two files were relatively few in number: nine and 17 students. In the lesson, the teacher opened the 10 PDF files of digital teaching materials. However, the least page views were five and that most page views 24, as seen at the rightmost sum of Table 7.

Table 5: Time series cross table of page view history of digital teaching materials that were used in the lesson ("Introduction to Social Data Analysis", 2015/04/08, 5 minute intervals)

2015/4/8	Time (5 minute intervals)																	
Resource name	13:10	13:15	13:20	13:25	13:30	13:35	13:40	13:45	13:50	13:55	14:00	14:05	14:10	14:15	14:20	14:25	14:30	Total
Role assign	31	1																32
Social data analis	65	8	4	3	1			1							3		2	87
1.0 Excel Introdu	4	19	15	16	1													55
1.1 Starting and	1		1		26	2												30
1.2 Reading and						1	23	2										26
1.3 Screen struct			1			1		23										25
1.4 Data input an			2						25	1			1			1		30
1.5 Basic operati			1								21	3		2				27
1.6 Making of a c		1										1		22				24
1.7 Text and inpu									1					29	3	1		34
1.8 Data moveme												1			6	4		11
1.9 Form of data		1														16		17
Total page views	101	30	24	19	28	4	23	26	26	1	21	5	1	53	12	22	2	398

Table 6: Teacher's page view history ("Introduction to Social Data Analysis", 2015/04/08)

2015/04/08 Teacher's page views history				
Time	IP address	User full name	Action	Information(Resource name)
2015/4/8 13:14	192.168.11.74	teacher	role assign (http://ir	Role assign
2015/4/8 13:14	192.168.11.74	teacher	course enrol (http://	Social data analisys
2015/4/8 13:14	192.168.11.74	teacher	resource view (http:	1.0 Excel Introduction
2015/4/8 13:26	192.168.11.74	teacher	resource view (http:	1.1 Starting and ending of Excel
2015/4/8 13:35	192.168.11.74	teacher	resource view (http:	1.2 Reading and preservation of a file
2015/4/8 13:40	192.168.11.74	teacher	resource view (http:	1.3 Screen structure and the function
2015/4/8 13:46	192.168.11.74	teacher	resource view (http:	1.4 Data input and data processing
2015/4/8 13:55	192.168.11.74	teacher	resource view (http:	1.5 Basic operation with worksheet
2015/4/8 14:13	192.168.11.74	teacher	resource view (http:	1.6 Making of a chart
2015/4/8 14:14	192.168.11.74	teacher	resource view (http:	1.7 Text and input a figure
2015/4/8 14:18	192.168.11.74	teacher	resource view (http:	1.8 Data movement
2015/4/8 14:20	192.168.11.74	teacher	resource view (http:	1.9 Form of data

Table 7: Time series cross table of page view history of students that participated in the lesson ("Introduction to Social Data Analysis", 2015/04/08, 5 minute intervals)

2015/4/8	Time (5 minute intervals)																	
Student ID	13:10	13:15	13:20	13:25	13:30	13:35	13:40	13:45	13:50	13:55	14:00	14:05	14:10	14:15	14:20	14:25	14:30	Total
Student	3	1				1												5
Student	4				1													5
Student	3		2											1				6
Student	3	1			1		1	1	1		1							9
Student	3		1		1		1		1					2	1			10
Student	3			4										2		1		10
Student	3	1		1			1	1			1			2				10
Student	3	1	1		1			1			1	1		1				10
Student	3		1		1		1	1	1		1			1				10
Student	3	2			1		1	1	1		1							10
Student	3	1			1		1	1	1			1			1	1		11
Student	4		1			1	1	1	1		1			2				12
Student	3		1	1	1		1		1			1		2		1		12
Student		4	1		1		1	1	1		1			1		1		12
Student	4		2		1				1		1			3				12
Student	3	1			1		1	1	1		1			2	1	1		13
Student	3	1			1		1	1	1		1			2	1	1		13
Student	3	1		1	1	1		1	1		1			2		1		13
Student	3	2	2			1	1	1			1			2				13
Student	5	1		1	1		1	1	1		1			1				13
Student	3	4			1		1						1	1	2			13
Student	3	1		1	1		1	1	1					3		1		13
Student	3			1	1		1	1	1		1			2	1	1		13
Student	5			1	1		1	1	2					3				14
Student	4			1	1		1		1		1			1	2	3		15
Student	3		2		1		1	1	1		1			2		1	2	15
Student	3		1	1	1			2		1	1			2		3		15
Student	3	1			2		2	1	2		1			3		1		16
Student	3	1		1	1		1	1	1			2		2	2	1		16
Student	3	3	1		1			1	2		1			3		1		16
Student	3		3	1	2			3	1		1			3		2		19
Student	3	3	5	4	1		1	1	1		1			2	1	1		24
Total page views	101	30	24	19	28	4	23	26	26	1	21	5	1	53	12	22	2	398
Total students	31	18	14	13	26	4	22	23	23	1	21	4	1	27	9	17	1	32

In the classroom, the teacher manipulated the computer at the teacher's desk and displayed the digital teaching materials on the projector. Therefore, the number of students viewing the digital teaching materials is smaller because they were looking at the projector screen while listening to the teacher's instruction; i.e. they received the lesson without opening the digital teaching materials on their own PC.

4.3 Implementation of the quiz within class and others

Table 8 shows the time series cross table of the page view history of digital teaching materials collected in a class of "Introduction to Software", separated into 5-minute intervals. The contents of this course and the digital teaching materials contain commentary concerning introductory HTML and CSS, and students learned how to make and design web pages.

Table 8: Examples of the time series cross table and the implementation of the quiz ("Introduction to Software", 2015/04/27, 5 minute intervals)

2015/4/27	Time (5 minute intervals)																	
Resource name	13:05	13:10	13:15	13:20	13:25	13:30	13:35	13:40	13:45	13:50	14:00	14:05	14:10	14:15	14:20	14:25	14:30	Total
Introduction to S	56	45	121	16	2	2	3	2				2	2	3	1	1	1	257
Quize Chapter 2	301	358	231	1														891
Syllabus			16	19	2													37
Sample of japane			2	23					8	44	12	1	6	1	1	1		99
The first report su		1	6	56	47	3				3	2							118
4.0 Internet & We				1		53	1	1		1								57
4.1 Hyper Text							45		1									46
4.2 Introduction t							32	7	37	1								77
4.3 Introduction t								25	36				1					62
4.4 Grammar of H								1	46	1	7		1			1		57
4.5 Function of T								1	14	4			1	3				23
4.6 Editing HTML									29	3	1	37	4	3	2	2	4	85
Total page views	357	404	376	116	51	58	81	37	171	57	22	40	15	10	4	5	5	1809

Table 9: Teacher's page view history ("Introduction to Software", 2015/04/27)

2015/4/27 Teacher's page view history				
Time	IP address	User full name	Action	Information(Resource name)
2015/4/27 13:04	192.168.10.103	teacher	course view (http:/	Introduction to Software
2015/4/27 13:04	192.168.10.103	teacher	quiz view (http://lm	Quize Chapter 2
2015/4/27 13:13	192.168.10.103	teacher	course view (http:/	Introduction to Software
2015/4/27 13:14	192.168.10.103	teacher	resource view (http	Syllabus
2015/4/27 13:15	192.168.10.103	teacher	resource view (http	Sample of japanese
2015/4/27 13:16	192.168.10.103	teacher	resource view (http	Sample of japanese
2015/4/27 13:18	192.168.10.103	teacher	resource view (http	Sample of japanese
2015/4/27 13:19	192.168.10.103	teacher	resource view (http	The first report submitting
2015/4/27 13:25	192.168.10.103	teacher	resource view (http	4.0 Internet & Web page
2015/4/27 13:31	192.168.10.103	teacher	resource view (http	4.1 Hyper Text
2015/4/27 13:34	192.168.10.103	teacher	resource view (http	4.2 Introduction to Programing
2015/4/27 13:38	192.168.10.103	teacher	resource view (http	4.3 Introduction to HTML
2015/4/27 13:40	192.168.10.103	teacher	resource view (http	4.4 Grammar of HTML
2015/4/27 13:43	192.168.10.103	teacher	resource view (http	4.5 Function of Tags
2015/4/27 13:43	192.168.10.103	teacher	resource view (http	4.6 Editing HTML
2015/4/27 13:43	192.168.10.103	teacher	resource view (http	4.5 Function of Tags
2015/4/27 13:43	192.168.10.103	teacher	resource view (http	4.4 Grammar of HTML
2015/4/27 13:43	192.168.10.103	teacher	resource view (http	4.3 Introduction to HTML
2015/4/27 13:43	192.168.10.103	teacher	resource view (http	4.2 Introduction to Programing
2015/4/27 14:03	192.168.10.103	teacher	course view (http:/	Introduction to Software
2015/4/27 14:03	192.168.10.103	teacher	resource view (http	4.6 Editing HTML

Fifty-three students attended the lesson that day. First, we carried out a small test in the classroom, and the teacher opened the three files (including the contact regarding this report). Furthermore, seven digital teaching materials (A4 size, total of seven pages) were the subject of discussion in the creation of HTML files.

The quiz began at the same time the lesson started, 13:00, and went until 13:10. Because each time limit in which it was carried out was seven minutes, the numerical value at columns of 13:00 and 13:10 is large. The 13:15 column is due to the time taken to confirm the results of the quiz (Quiz Chapter 2), and it was also numerically large.

Meanwhile in Table 8 the 13:20 and 13:25 columns reflect the figures that have been described for submitting the report. In the 13:45 column, the teacher opened the files (4.5 Function of Tags), but only 19 people opened the files, as instructed by the teacher during that period. This is less than half the students. In the same time zone (the end portion of 13:45) the teacher's page view history indicates the same file was opened repeatedly but the students' page view history shows a variation in the data. It is believed that instruction was not sufficient at this point.

5. Time series cross table of unused digital teaching material

During lessons, browsing the parts of the teaching materials as instructed by the teacher is considered desirable as it encourages students to focus on the lesson as much as possible.

In this study, there were cases in which students opened digital teaching material that the teacher did not use in class, and this information was also recorded. The digital teaching materials that the teacher did not use in class, the title of the materials, the number of page views, and the opening times were cross tabulated in a time series and investigated to see whether there was a trend.

Table 10: Time series cross table of page view history of unused digital teaching materials in the lesson ("Multimedia Creation", 2015/4/8, 3 minute intervals)

2015/4/8	Time (3 minute intervals)										
Resource name	10:57	11:00	11:03	11:09	11:12	11:15	11:21	11:27	11:30	12:09	Total
Participants Teac	2										2
Participants Stud									1		1
1.2 Install				1							1
Participants Stud						1					1
3 Basic Usage				1							1
3 Creating a slide				1							1
4 Drawing tool				1							1
6 Title caption cre					1	2					3
Animation softwar	1			1	1						3
News forum	1			1							2
Processing of figu							1			1	2
Participants	7	5	8		1	3		5	2		31
Effective video sh	1	1		1	1						4
Recent activity				1							1
Totla page views	12	6	8	8	4	6	1	5	3	1	54

Table 11: Time series cross table of page view history of students of digital teaching materials that were unused in the lesson ("Multimedia Creation", 2015/4/8, 3 minute intervals)

2015/4/8	Time (3 minute intervals)										
Student ID	10:57	11:00	11:03	11:09	11:12	11:15	11:21	11:27	11:30	12:09	Total
Student	1										1
Student					1						1
Student									1		1
Student				2							2
Student					1	1					2
Student	2										2
Student								2		1	3
Student	1	1			1	1					4
Student					1	4					5
Student	5										5
Student				6							6
Student	3	5	8				1	3	2		22
Total page views	12	6	8	8	4	6	1	5	3	1	54
Total Students	5	2	1	2	4	3	1	2	2	1	12

Table 10 and Table 11 in the lesson of the aforementioned "Multimedia Creation" (2015/4/8) is obtained via a time series cross table of the page view history of the 3-minute intervals digital teaching materials that were not used. Table 10 shows the number of page views and the time that each digital teaching material was accessed, while Table 11 shows the number of views and the time of access for each of the students.

Looking at the right side of the Total column in Table 10, the numerical value is a portion (31) of the participants. This portion shows that it was open to the list page of class participants. Because it was the first lesson of the semester, participants are believed to be concerned about their participation. Via the number of student page views as shown in Table 11, it was discovered that 22 times out of 31 times one student browsed the pages as not instructed by the teacher.

6. Conclusion and future work

From the data collected via the time series cross table regarding opening the digital teaching materials used in class, when the description and instructions of the teacher are clear and thorough, more students will open their own digital materials on their computer, and there is a tendency towards shorter differences in viewing start times.

If the teacher's instructions are not clear, variations occur in the time at which the student views the digital teaching materials, and a tendency toward delayed viewing of the digital teaching materials appears in the time series data. When such a case happens, the teacher needs to think out a way of indication. Furthermore, students found it increasingly difficult to concentrate in the latter half of each class, and therefore a tendency towards delayed viewing of the digital teaching materials can be seen.

There were students who viewed unused digital teaching materials often. This seems to be related to the teaching method and contents of the lesson in question. If there are many students who view unused digital teaching materials there is a risk that they are not focused on the lesson at hand. However, a detailed discussion is an issue for future research.

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Exploring Forum Dynamics in a Chinese MOOC: A Longitudinal Probabilistic Social Network Analysis [1]

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Abstract: This study attempts to answer the fundamental question of how the overall nature of relations in a network affect the network's potential to foster or inhibit the different forms of social learning. The study adopts longitudinal probabilistic social network analysis to identify the patterns and evolution of relationships formed in a MOOC discussion forum. Three network effects – homophily, network closure, and preferential attachment – are used to explore the dynamics of the discussion networks formed in the MOOC forum. Understanding the formation of the network of relationships will allow us to explore how social learning takes place and in turn improve the online learning experience in MOOCs.

Keywords: MOOC, network dynamics, social learning analytics, SIENA

1. Introduction

A massive open online course (MOOC) is an online course aimed at large-scale interactive participation and open access via the web (Daniel, 2012). In addition to traditional course materials, MOOCs provide interactive user forums that build learning communities for students and professors alike. Although MOOCs have a longer history, with roots in the better-known distance education movement, in 2012, they broke onto the educational scene as a new online teaching and learning phenomenon. This resulted in the New York Times dubbing 2012 "The Year of the MOOC" (Pappano, 2012).

Learning via MOOCs is a quickly rising global tide, and Chinese students have enthusiastically plunged into the new wave of MOOC learning (W. Wang, 2013). MOOCs' rapid development has aroused great scholarly attention. Studies have generally focused on three aspects: 1) introductory studies on the MOOC curriculum model and definitions, characteristics, application modes, and case studies (Li & Wang, 2012; P. Wang, 2013); 2) the impact of MOOCs on the reform of traditional classroom instruction and higher education (Zhang, Hong, & Wen, 2013; Zhu, 2012); and 3) applications of MOOCs in education (Waard, et al., 2011). In addition, some researchers have begun to focus on quality standards and the systematic quality assessment of MOOC curricula (Rossi & Mustaro, 2013).

Despite the significant attention paid to MOOC delivery systems, little attention has been devoted to what is happening in MOOC forums. Specifically, there is a dearth of research on the impact of forum discussion on Chinese MOOC learners. In China, up to now, only a few studies adopted social network analysis to understand the activity patterns of MOOC forums. The studies (e.g. Xu et al, 2015) that utilize social network analysis to explore interactions tend to use data from one time point on characteristics of the networks, implicitly assuming that the MOOC forums are stationary or in equilibrium conditions. There is no study that explicitly measures and analyzes network dynamics in China.

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Because of the unique "spirit of collectivism" in Eastern Asian educational tradition and culture, Chinese learners display different learning methods, learning habits, and even ways of thinking compared to their Western counterparts (Wang, 2013; Watkins & Biggs, 1996, 2001). Chinese learners tend to seek out group learning and follow group leaders to enhance the learning process. This presents a challenge for the traditional Chinese learner, given that most MOOCs and their corresponding learning communities use English as a lingua franca, complicating the search for a MOOC learning community. Using data collected from a Chinese MOOC course and applying probabilistic social network analysis, this study seeks to rigorously measure the dynamic mechanism by which discussion networks are formed among MOOC participants.

2. Network Concepts and Hypotheses

This study focuses on explaining how the network configurations and actor covariant form and reshape the structure of the interactions in a MOOC discussion network. Three network effects – homophily, network cohesiveness, and preferential attachment – are chosen to explore the discussion networks in a Chinese MOOC.

Network cohesiveness was measured by reciprocity and transitivity. Reciprocity is a very important measurement of mutual relationships in network settings. This metric is studied on the dyadic level through the process of dyad census. It is evident that students who are actively engaging in forum discussions are likely to receive more feedback from peers, and to develop their thinking further. The transitive relationship, in which A connects to B, B connects to C, and A also connects to C, may be more conducive to social learning, as participants are more likely to receive stimuli from multiple peers as the desired information diffuses through a network (Todo et al., 2013). Reciprocity as well as transitivity are likely to lead to network cohesiveness.

- *Hypothesis 1 (H1)*: The discussion network tends to become more cohesive.

Homophily, a term coined by Lazarsfeld and Merton (1954), refers to the tendency of individuals to associate with those similar to themselves. A network with a high degree of average homophily among actors is likely to disseminate information and (tacit) knowledge fast, i.e., the actors have a better source for learning (Cross et al., 2001). In this study, teaching staff (including instructors and teaching assistants (TAs)) and students are considered as two distinct groups of participants in MOOCs. To understand what role instructors play toward encouraging social interaction and supporting learning in MOOCs, as well as whether students can act as learning companions to assist learning, it is very important to unravel the interaction between students and instructors in MOOC practices.

- *Hypothesis 2 (H2)*: There is a tendency toward an increasing volume of interactions between students.

Outdegree popularity is a measure of how "uneven" the distribution of centrality is in a network. Centrality is an actor-related measure and can be defined in different ways that all relate to the "importance" or "power" of an actor in a network. Highly centralized networks appear to be conducive to the efficient transmission of information (Crona and Bodin 2006), as the central actors play an important role in delivering messages. These central actors, on the other hand, could manipulate the communications in networks.

- *Hypothesis 3 (H3)*: Participants who are actively involved in forum discussions are likely to become even more engaged.

3. Context of the Study

In 2013, Tsinghua University launched its new learning portal XuetangX to host local MOOCs as well as courses from a consortium of leading universities world-wide. XuetangX, powered by the open source platform edX, aims to increase Chinese students' access to quality education, while transforming universities' campus-based learning. A social science course, one of the first courses to be launched at XuetangX, was studied in this research. The course began in Spring 2014 and ran for about several weeks. More than 10,000 learners registered for this course. As one of the most popular MOOCs in China, the course was offered again in 2015. The instructor for this course has taught the course at Tsinghua University over a number of years. Two TAs joined the course, responsible for releasing course information and answering questions asked by students in the discussion forum.

Compared to the first release of other Chinese MOOCs at XuetangX, this course has a rather popular discussion forum where students can ask questions answered by others. In total, 5464 discussion messages were posted online, in which 217 are original posts, 2553 are replies to the original posts and 2481 are comments on the replies. These messages generally include enquiries on exercises, course materials, and the logistics of the course. Students also use the discussion forum as a platform to report their own study and seek social activities. Some of them left feedback on the course on the discussion forum.

4. Methods

The probabilistic analysis was performed by employing stochastic actor-driven models defined and evaluated with the program Simulation Investigation for Empirical Network Analysis (SIENA) (http://www.stats.ox.ac.uk/~snijders/siena/) jointly with the StOCNET graphical interface package (Snijders, 2011; Steglich, Snijders & West, 2010). The objective function, which is used in this research, depends on two types of effects: structural effects and covariate effects. The structural effects capture endogenous network mechanisms. In this research, the following structural effects were used:

- *Reciprocity* is represented by the number of reciprocated ties (measure of mutuality). Reciprocity estimates the probability of user B replying to A, given that A has replied to B.
- *Transitive triplets or transitivity* is represented by the number of ties to actors who are the friends of friends (measure of network closure, i.e. transitivity estimates the probability of user A replying to C, if A has replied to B and B has replied to C).
- *Outdegree popularity (also known as activity of alter)* is defined by the sum of the outdegrees of the others to whom the actor is tied (measure of activity attraction, i.e. actors who have already received many replies are likely to be replied to by others).

Unlike structural effects, the covariate effects estimate the network dynamics based on exogenous factors, e.g. role of actors. In this research, one dyadic constant covariate effect (*same role*) was used. The student role was coded as 0 and the non-student role (i.e., instructor and TA) was coded as 1.

As per the availability of the timestamp, the evolving network was split into six periods; each period has an approximately equal number of messages (i.e., posts, replies and comments). The Jaccard indices for two sequential periods were calculated, varying from 0.529 to 0.892. This means that network dynamics of six periods is "smooth" enough, which justifies the use of six periods as appropriate in this study. Each period contained ties from previous ones, i.e., all network changes are upward. This is natural because interactions within MOOCs are very asynchronous and replies to messages can occur several periods later.

5. Results

5.1 Descriptive Statistics of the Network

In this MOOC course, 1915 participants posted 5251 messages in total, in which 217 are original posts, 2553 are replies to the original posts and 2481 are comments to the replies. On average, each discussion thread attracted 23 replies and comments. The instructor led 26 discussion threads, replied to 17 messages, and commented on 91 messages. TAs posted two messages, replied to 24 messages and commented on 134 messages.

5.2 Reciprocity, Network Closure, Homophily and Preferential Attachment

Table 1 presents the results regarding Hypotheses 1, 2, and 3. Structural effects such as reciprocity and transitivity are significant ($p < 0.001$) and the coefficients for them are positive. Moreover, these structural effects were included in other models (Model 2 and Model 3) and results for them are similar to what was obtained for Model 1, i.e. these results are very consistent. The reciprocity effect is positive and significant. That means that there exists a tendency to create reciprocal links; for example, if the participant writes an original post, then he/she comments on or replies to this post. The "transitive triplets" effect was considered as a triadic-level effect. The positive transitivity effect means that actors prefer to create links with the rule "the friend of my friend is my friend". The positive effects of reciprocity and transitivity suggest that H1 was accepted – that is, the discussion network becomes more cohesive as participants contribute to the forum.

Table 1: SIENA estimation results.

Effects	H1 (Model 1)	H2 (Model 2)	H3 (Model 3)
Reciprocity	4.4197 (0.1304)	3.8991 (0.1875)	3.7338 (0.1818)
Transitivity	1.5132 (0.0799)	0.8713 (0.0918)	0.8516 (0.0968)
Same role	—	–4.5110 (0.0605)	—
Outdegree popularity (activity of alter)	—	—	0.0628 (0.0008)

H2 states that there is a tendency toward the increasing interactions between teaching staff and students. To test this hypothesis, the "same role" dyadic covariate was included in Model 2. Our findings show that same role is a significant covariate effect ($p < 0.001$) and its coefficient is negative. Thus, the network is considered heterophilic, i.e., participants do not have a preference for creating links with those similar to themselves. For example, students reply to the instructor and TAs.

In H3, the preferential attachment was tested with the outdegree popularity (earlier known as the activity of alter). In Model 3, the outdegree popularity effect is significant ($p < 0.001$) and its coefficient is positive but relatively small. This means that participants who are actively involved in forum discussions are likely to become even more engaging.

6. Discussion and Conclusion

In an attempt to understand how the overall nature of relations in a discussion network was formed in the setting of MOOC forums, a probabilistic social network analysis using the actor-based model was performed. This study is an empirical investigation of the network dynamics in a Chinese MOOC, which is essential to move the discussion on learning interactions inherent in a Chinese context forward.

The results of this study have shown that there is an increasing cohesiveness within the studied network, as participants tend to reply to the messages initiated by peers and connect to others in a transitive way. Participants are likely to become more selective when interacting with others. This reflects on the Chinese culture of creating small, cohesive groups in which Chinese students feel confortable residing. Interactions with peers in a rather open and large-scale space provoke more challenges for Chinese students.

Unlike previous studies (e.g. Kellog et al., 2014) that were conducted in a Western context, showing that MOOCs can be leveraged to foster robust learning networks and facilitate peer-supported learning, our study indeed demonstrates that Chinese students display different learning behaviors. In the studied discussion forum, Chinese students tend to respond to the instructor and TAs. They follow teachers' instructions to learn step by step. In a Chinese context, a teacher is highly respected by students, so students seek correct answers from the teachers. The discussion between teachers and students is regarded as an authentic learning process. Peer-supported learning has been recently introduced into Chinese classrooms, but the importance of peer-supported learning has not received sufficient attention. Nevertheless, in the studied network, the majority of Chinese students still tend to rely heavily on teachers, who are supposed to provide them the right answers to their inquires. In such a learning culture, MOOCs are undoubtedly vulnerable to criticism for their lack of learning support systems.

Preferential attachment is present in the studied networks, commonly referred to as "the rich get richer effect". In the studied networks, participants who are actively involved in forum discussions are likely to become even more engaged. On one hand, it is likely that some participants could manipulate the communications flow in the MOOC forum. If these participants drop out of the course, the discussions are likely to discontinue. Such a learning context is not a robust learning community, as was illustrated in the work of Kellogg and his colleagues (2014). On the other hand, some participants might feel that their contribution was not well received by others in forum discussions. It is likely that their questions were not answered by others. To support their learning in MOOCs, intervention is required.

To conclude, this study adopted a probabilistic social network analysis to explore the network dynamics in a Chinese MOOC forum. The results of this study demonstrate that MOOCs present a challenge for traditional Chinese learners, given that there is a lack of learning support in MOOCs. Traditional Chinese learners have high expectations of using MOOCs as an alternative channel to interact with professors from elite universities. Due to the massive number of registered learners, it is difficult for instructors to interact with individual students on a one-to-one basis in MOOCs. Thus, in a Chinese context, it seems to be essential to promote openness by creating a peer-supported learning environment. This peer-supported learning environment might not be a Western-style robust learning community where learners, who are intellectually open and accept the possibility of change, are supposed to be willing to share ideas and help each other. In a Chinese MOOC learning environment, human or intelligent tutoring intervention is key to facilitate balanced interactions in MOOCs.

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Designing a Reference Model for Learning Analytics Interoperability

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Abstract: The application of the learning analytics should overcome the challenge of effective integration of various information and processes into a unified framework to support the development of an open and extensible learning analytics systems. Based on our preliminary identification of the requirements for the learning analytics systems, we present a refined reference model that fulfills these requirements and provide a guideline for effective integration toward the goal of producing an explicit specification of the learning analytics architecture. We elaborate the comprehensive architecture with detailed descriptions, and then we discuss the experimental implementation of the reference model.

Keywords: Learning Analytics, Reference Model, Software Reference Architecture

1. Introduction

In spite of growing interest for learning analytics, the application of the learning analytics still faces the challenge of effective integration of various information and processes into a unified framework to support the development of an open and extensible learning analytics systems. In our preliminary analysis(Choi, 2014), we presented preliminary identification of the requirements for the learning analytics systems and summarized them as follows:

- **Open and extensible**: It should be open to incorporate new sensors or analytics functionality, desirably without interrupting the task being serviced. It also should ensure incorporation or modification of new workflows at the task level.
- **Distributed**: It should be able to handle multiple sources of data and functionalities distributed over multiple systems. It is also desired to be able to distribute data and to delegate functionality dynamically and transparently.
- **Interoperable:** It should provide compatibility for various learning platforms or VLE by providing interoperable interface to the data and operations.
- **Reusable and configurable**: The functional components and data interfaces should be modular and thus reused and configured for different tasks or more complex tasks as building blocks.
- **Real-time and predictable**: Learning analytics should be performed satisfying the real-time constraints and should be able to estimate the time to completion.
- **Usable:** It should have acceptable user experience (UX) by providing appropriate data visualization and user interfaces for monitoring and tasking throughout the learning analytics process.
- **Secure and traceable:** It should protect personal user information to secure privacy and preserve confidential information. Some analytics functionality should be ensured not to be performed as required. Furthermore, the history of execution of analytics functions and access to data should be recorded, if needed, to ensure traceability.

Based on these requirements, we also proposed an approach to adopt the major processing steps of big data, that is, data collection, data store and processing, analyzing, and visualization of data. In this paper, we present a refined reference model that fulfills these requirements and provide a guideline for effective integration toward the goal of defining an explicit specification of the learning analytics architecture as the international standard so that open and extensible learning analytics systems can be built for worldwide interoperability.

The remainder of this paper is organized as follows. Firstly, we survey some related works in the learning analytics field. Based on this survey, we present the overall architecture along with the basic requirements of the learning analytics systems. The comprehensive architecture with detailed description then follows. Finally we discuss the experimental implementation of the reference model and summarize the main results of this paper.

2. Related Work

In this we survey several related systems in the learning analytics field and compare our approach with them to refine our reference model.

The Society for Learning Analytics Research (SoLAR) is an inter-disciplinary network of leading international researchers who are exploring the role and impact of analytics on teaching, learning, training and development (The Society for Learning Analytics Research, 2015). The Open Learning Analytics (Siemens et al., 2011) project by SoLAR proposes the Integrated Learning Analytics System as an open platform with the following four major components.

- **Analytics Engine**: the analytics engine is a framework for identifying and then processing data based on various analysis modules.
- **Learning Adaptation and Personalization Engine**: the learning adaptation and personalization will include adaptivity of the learning process, instructional design, and learning content.
- **The Intervention Engine**: the intervention engine will track learner progress and provide various automated and educator interventions using prediction models developed in the analytics engine.
- **The Dashboard**: the dashboard presents visualized data to assist individuals in making decisions about teaching and learning. The dashboard consists of four views: learner, educator, researcher, and institutional.

It is worth noting that these components closely matches the major learning analytics steps in our reference model.

ALAS-KA (José A. Ruipérez-Valiente, Pedro J. Muñoz-Merino, Derick Leony, & Kloos, 2014) is a tool that extends the learning analytics features of the Khan Academy platform which includes visualizations for the entire class and individual students with various learning indicators. It helps teachers to make decision supported by the high level information provided and enables students to gain awareness of their learning process for self-reflection. It also can be used by the course instructors to detect class tendencies and learner models. The major components of the system include,

- **Datastore:** The Google App Engine Datastore provides storage for the Khan Academy platform data.
- **Data processing:** This module is in charge of making the proper computation to transform from different low level data from the Khan Academy models into higher level information that is stored as ALAS-KA models.
- **Visualizations:** The Google Charts API 3 was selected for the visualizations because of its simplicity and variety of charts. In our case, the data needed to build the visualizations are requested to the ALAS-KA models in the Datastore. Therefore, this required data could also be received from an external source such as a web service.
- **Recommender:** The function of the recommender is to analyze the results and send warnings to students or professors based on some rules.

The integration of Khan Academy platform and the ALAS-KA model by utilizing the Datastore and data transformation is the exemplary approach that is worth of adopting in our reference model.

The exploratory Learning Analytics Tool (eLAT) serves teachers to explore and correlate content usage, user properties, user behavior, as well as assessment results. Based on individually selected graphical indicators it supports reflection on and improvement of online teaching methods based on personal interests and observations (Chatti, Dyckhoff, Schroeder, & Thüs, 2012). The typical Learning Analytics process includes data-gathering, mining of the preprocessed data, and the visualization step, which confirms the cogency of the configuration of our reference model. Additionally, this tool provides an insight into what interactions need to be modeled and how interfaces are designed.

3. Reference model for learning analytics interoperability

A reference model, according to the Wikipedia (https://en.wikipedia.org/wiki/Reference_model), is an abstract framework or domain-specific ontology consisting of an interlinked set of clearly defined concepts produced by an expert or body of experts in order to encourage clear communication. In this section, we present a preliminary reference model for learning analytics by illustrating the set of entities and relationships between them as results of the examination of the systems surveyed in the previous section.

3.1 Abstract workflow of learning analytics

The goal of learning analytics to understanding and improve learning and its environment entails the tasks of the measurement, collection, analysis and reporting of data about learners and their contexts, while preserving confidential user information and protecting the identities of the users at the required level as needed. These abstract steps of learning analytics under the protection of privacy policy can be depicted as an abstract workflow as shown in Figure 1.

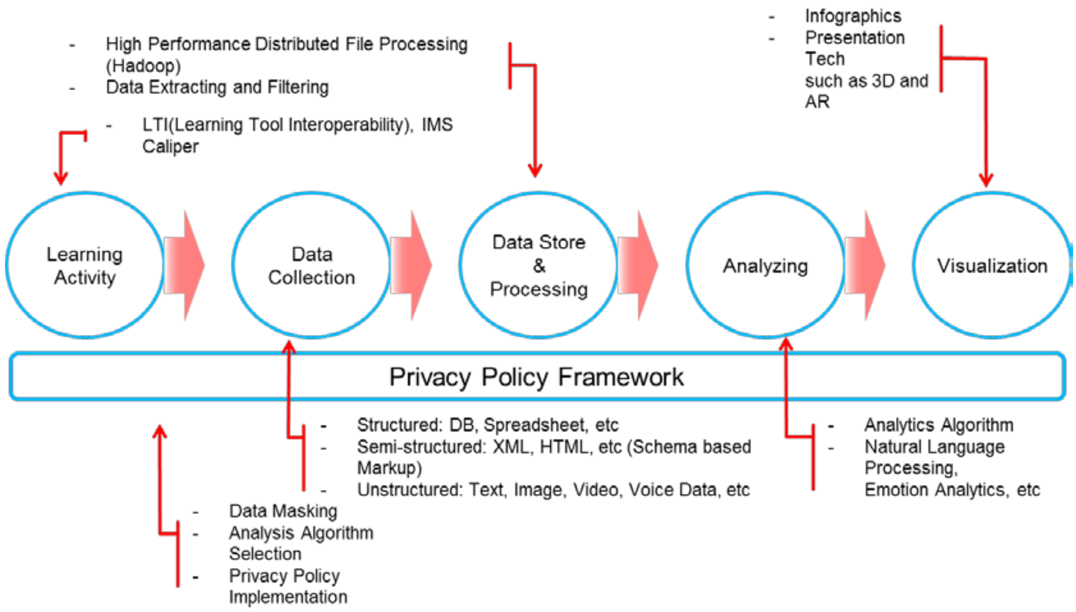

Figure 1. Abstract Workflow of Learning Analytics Service

3.2 Reference architecture derived from workflow and use cases

The abstract workflow in the previous section can be categorized into the four major steps with the associated input/output and processed data, as an overall architecture as shown in Figure 2.

- **Data Collection**: the process of gathering and measuring information on variables of interest in the learning and teaching activities.
- **Data Storing and Processing**: the process of preparing and storing data from diverse and heterogeneous data sources for interoperable data analysis by utilizing the standardized data model and representation.
- **Analyzing**: the process of systematic investigation of learning data by inspecting, and modeling the learning data with the goal of producing descriptive and possibly predictive knowledge.
- **Visualization**: the process of creating visual representation of abstract data including text and geographic information to allow users to see, explore, interact, and understand large amounts of information in analyzing and reasoning about data and evidence.

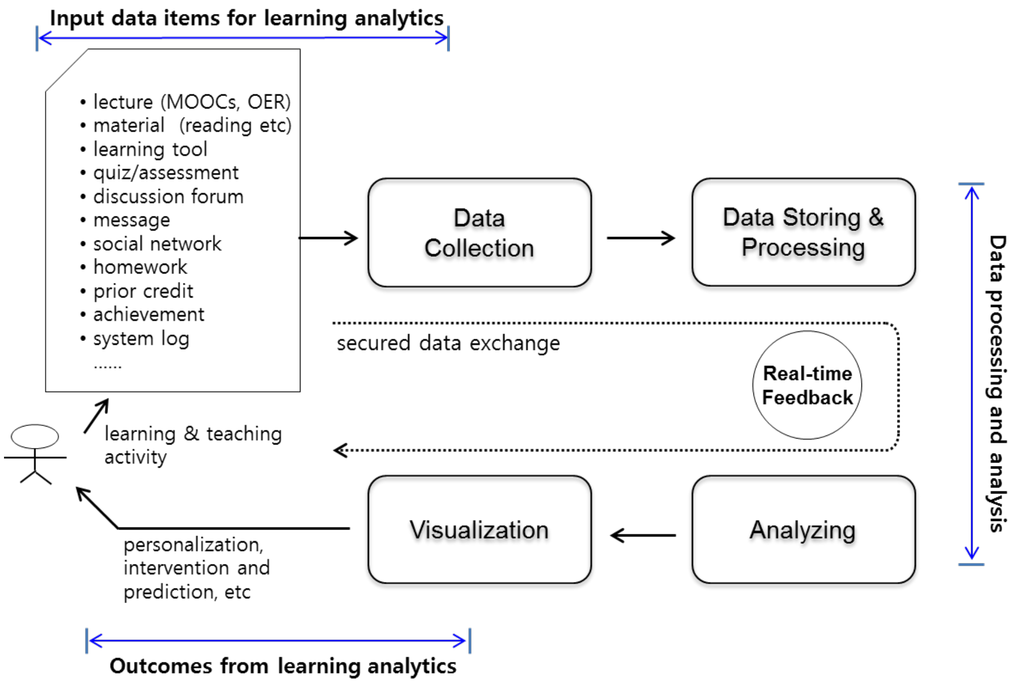

Figure 2: Reference Model for Learning Analytics Service

3.2.1 Zoom-in diagram for Data Collection

Data collection is the process of gathering and measuring information on variables of interest in the learning and teaching activities as shown in Figure 3.

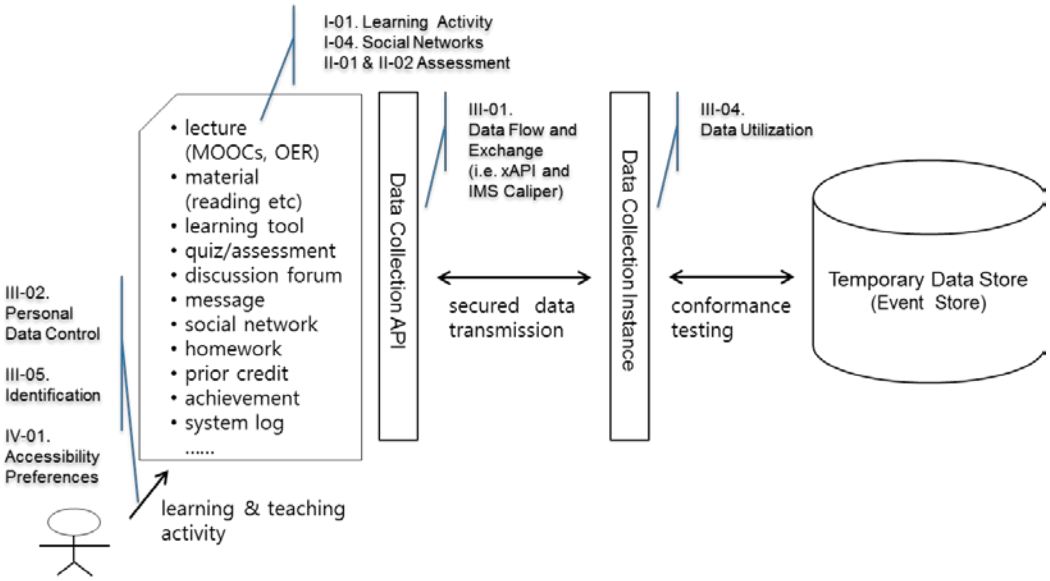

Figure 3: Reference Model of Data Collection for Learning Analytics

- Learning and teaching activities and related data sources such as learning devices and social networks produce various data. The sources include lectures, learning materials, learning tools, quiz or assessment, discussion forum, messages, social network, homework, prior credit, achievement, system log, and so on.
- Diverse learning data need to be collected standardized data collection APIs such as xAPI and IMS Caliper.
- Data collection APIs yields data collection instances, possibly via secured data transmission.

- Data collection instances may go through conformance testing before it is collected in an event store that is a temporary data store, for later processing.

3.2.2 Zoom-in diagram for Data Storing and Processing

Data storing and processing is the process of preparing and storing data from diverse and heterogeneous data sources for interoperable data analysis by utilizing the standardized data model and representation as shown in Figure 4.

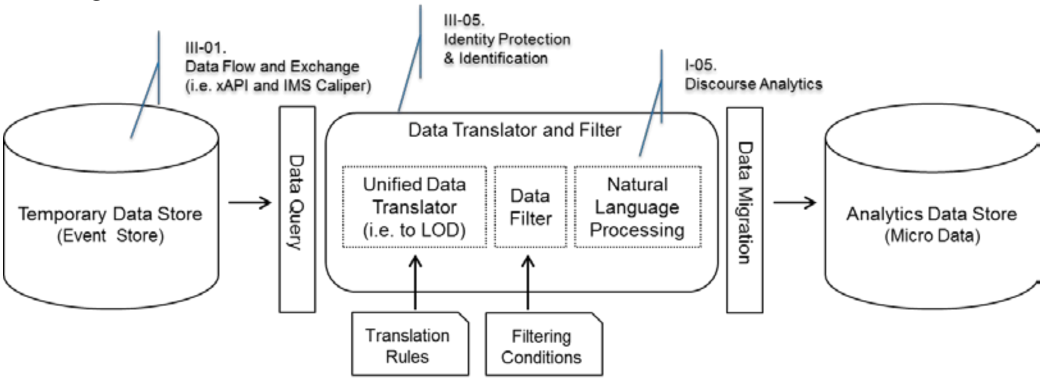

Figure 4: Reference Model of Data Storing and Processing for Learning Analytics

- The learning data stored in Temporary Data Store (event store) are processed by Data Translator and Filter and the processed results are stored into Analytics Data Store (Micro Data)
- The data translator and filter process may have Unified Data Translator which translates various data in heterogeneous representation into a uniform representation, such as LOD, by applying explicit translation rules, for an efficient and interoperable analysis process.
- A general-purpose Data Filter may be applied to the translation process driven by the Filtering Conditions to clean and transform the data.
- One of the main source of data includes discourse, writing, conversation, and communicative events. Such data may need to be processed by Natural Language Processing before the results are in turn translated into a uniform representation.
- The data stored in Temporary Data Store may be accessed via a standardized Data Query interface, and the processed data may be stored to Analytics Data Store via a standardized Data Manipulation.

3.2.3 Zoom-in diagram for Analyzing

Analyzing is the process of systematic investigation of learning data by inspecting, and modeling the learning data with the goal of producing descriptive and possibly predictive knowledge as illustrated in Figure 5.

- As well as the Micro Data stored in the Analytics Data Store, general domain data such curricula, learning resources, and preferences may be stored in Constant Information to be utilized by the Data Analysis.
- Privacy concerns exist wherever personally identifiable information or other sensitive information is collected and stored. Learning data analysis is not an exception. Privacy masking is a way of masking out identifiable information without diminishing the analysis function.
- Various external analysis algorithms such predictive analytics, adaptive analytics, discourse analytics, and other assessment using ICT are applied via Analysis Interface.
- Analysis Processing may consist of statistical analysis, topic analysis, network analysis, and social analysis as the low-level front-end analysis with the data secured with the privacy masking. The results of low-level analysis then may feed into pattern learning, dynamic modeling, and association analysis before they are used by dashboard integration, content recommendation, and learning path recommendation.
- The analysis results may be refined by Data Manipulation interface and then stored into Analytics Data Store for further analysis cycle or later processing steps such as the visualization process.

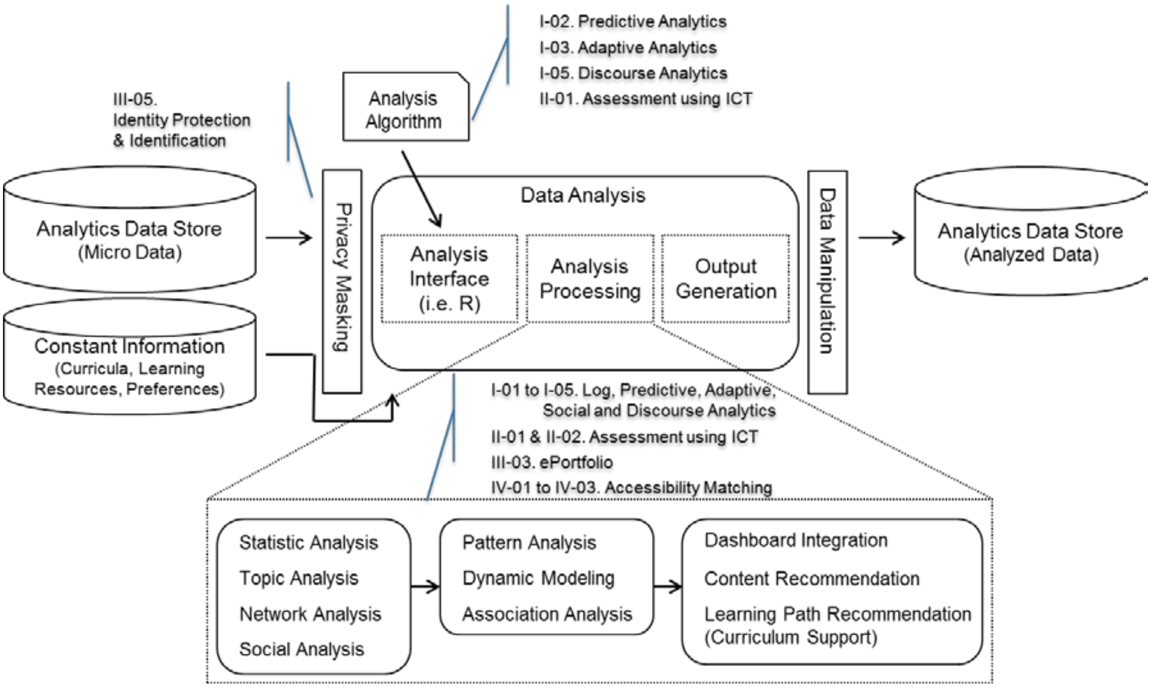

Figure 5: Reference Model of Analyzing for Learning Analytics

3.2.4 Zoom-in diagram for Visualization

Visualization is the process of creating visual representation of abstract data including text and geographic information to allow users to see, explore, interact, and understand large amounts of information in analyzing and reasoning about data and evidence. A primary goal of visualization is to communicate information clearly and efficiently to users via the statistical graphics, plots, information graphics, tables, and charts selected, and thus makes complex data more accessible, understandable and usable as outlined in Figure 6.

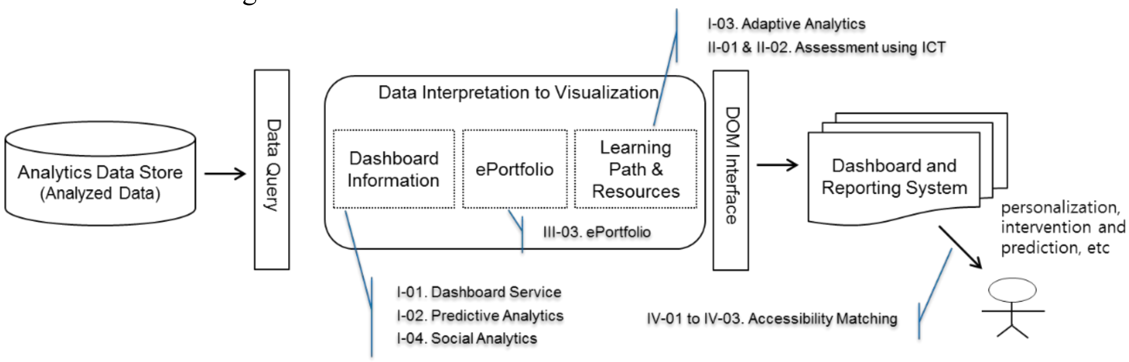

Figure 6: Reference Model of Visualization for Learning Analytics

- The data in Analytics Data Store may be accessed by the visualization process via Data Query interface.
- Visual representation for learning analytics may include dashboard information, ePortfolio, Learning Path & Resources.
- Various external analysis algorithms such predictive analytics, adaptive analytics, discourse analytics, and other assessment using ICT are applied via Analysis Interface.
- The dashboard information may show comparisons or progresses, recommendations, and real-time assessments, topic-based assessment, social-network graph, and so on.
- DOM Interface may provide an open interface to the external Dashboard and Reporting System to realize personalization, intervention and prediction for specific users with additional accessibility requirements as needed.

4. Deployment of the Reference Model

The conceptual reference model described in the previous section serves the purpose of designing the system clearly reflecting identified requirements. In this section, we present an experiment test system to validate the reference model and provide developers with guidelines in implementing the reference model.

4.1 Deployment for Data Collection

In our implementation of the data collection process, learning activity data are generated by the Readium (Readium.org, 2015), a reference system for rendering EPUB 3 publications, as depicted in Figure 7.

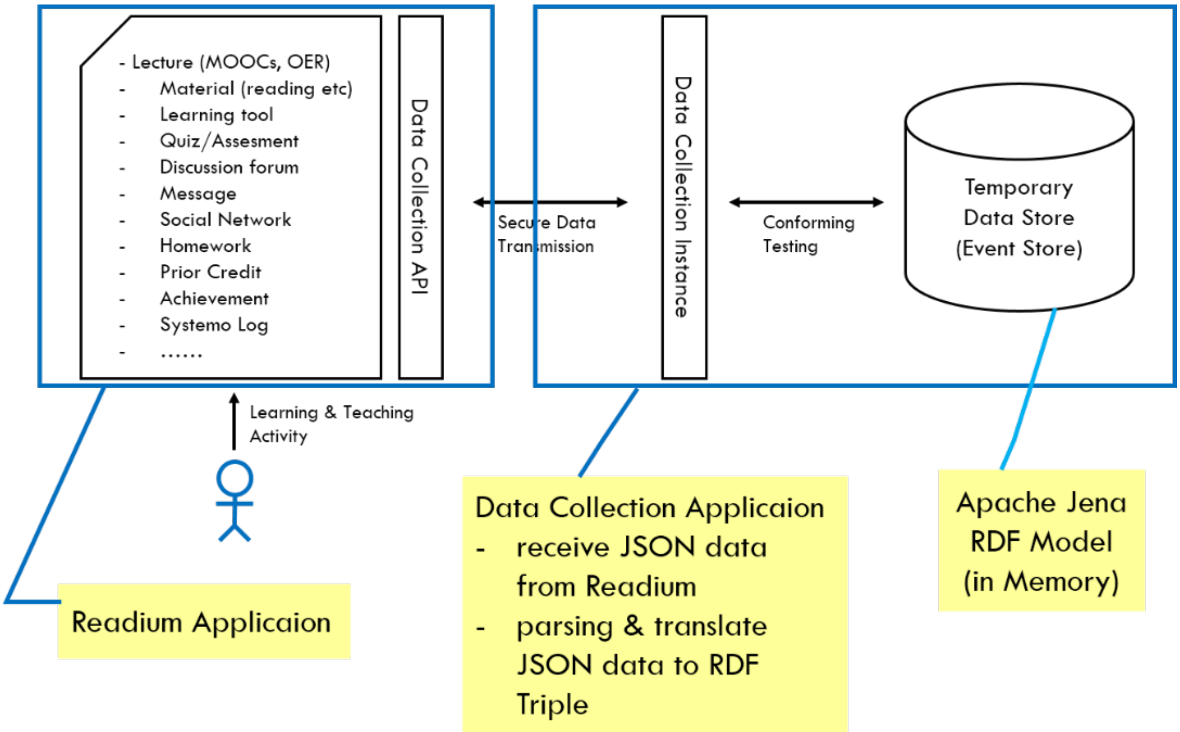

Figure 7: Deployment for Data Collection

Readium in Figure 8 and Figure 9 generates the Caliper (IMS Global Learning Consortium, 2015) event data in JSON format.

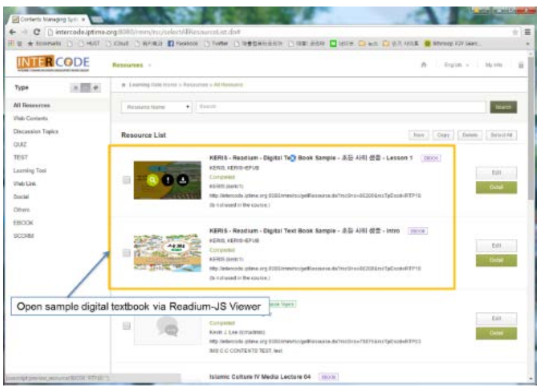

Figure 8: Bookshelf of Digital Textbook

Figure 9: Readium-JS Viewer

4.2 *Deployment for Data Storing and Processing*

In our implementation, the data stored in the Event Store are accessed via a data query interface using the web protocol. The RDF data are stored into Virtuoso Triple Store (OpenLink Software, 2015) for efficient access by the analysis applications as shown in Figure 10.

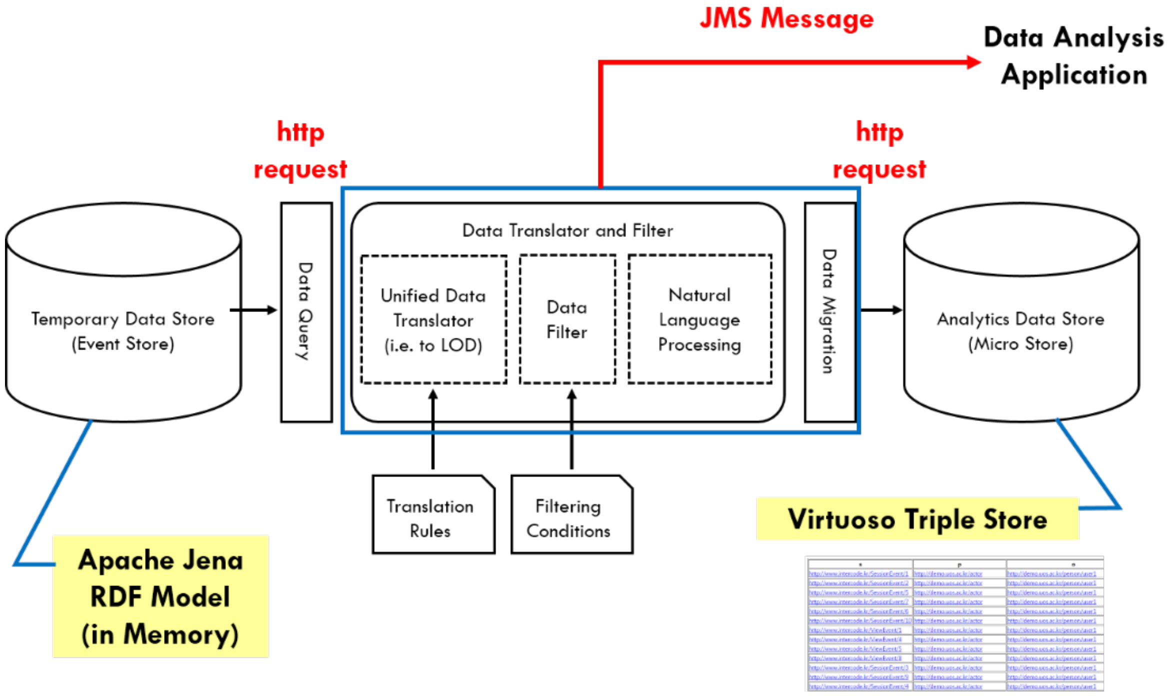

Figure 10: Deployment for Data Storing and Processing

The generated data in JSON format are in turn translated into RDF triples by the Data Collection Interface before they are stored into the Event Store as shown in Figure 11 and Figure 12.

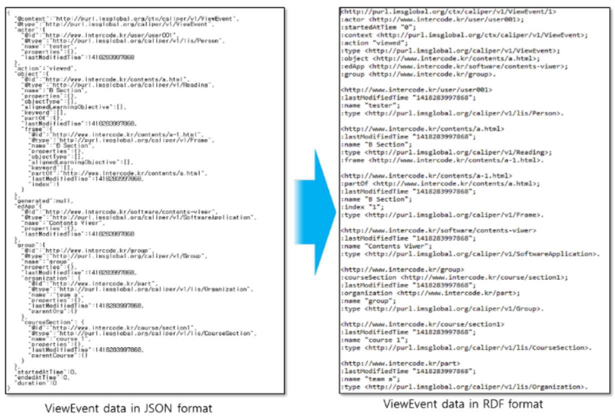

Figure 11: Reading Activity Data Translated to RDF format

Figure 12: Collected Data on Event Store in RDF Triples

4.3 *Deployment for Analyzing*

In this simple test implementation, we utilized a versatile class-based interface from R program to access the database for analysis as shown in Figure 13. R is a free software environment for statistical computing and graphics (The R Foundation, 2015). In order to achieve a uniform handling of input and output data, the Virtuoso Triple Store is used for the Analytics Data Store along with SPARQL ("SPARQL 1.1 Query Language," 2013)

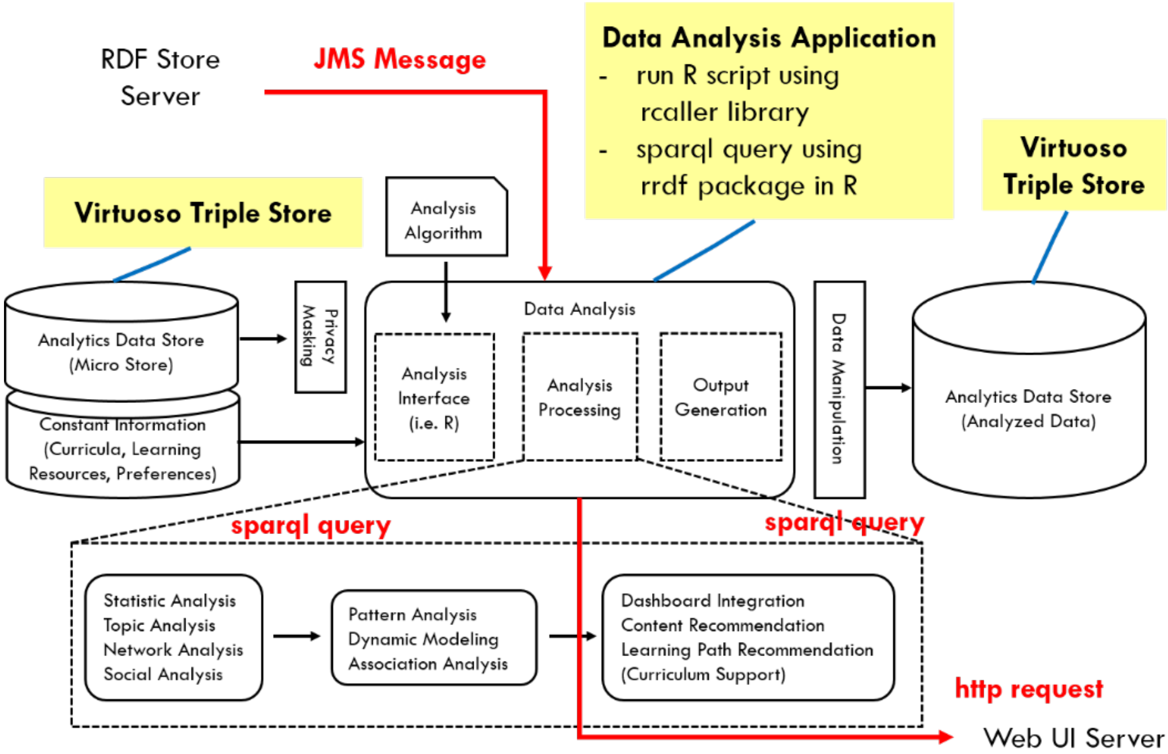

Figure 13: Deployment for Analyzing

4.4 Deployment for Visualization

The process of creating visual representation of the analyzed data stored in the Analytics Data Store is implemented using an asynchronous event driven framework, Node.js (Node.js Foundation, 2015) and JavaScript chart libraries as shown in Figure 14. The Web UI server not only query to pull data from the Analytics Data Store, but also receive updated data as new analytics data are stored to the Analytics Data Store to allow responsive visualization on the dashboard in Figure 15.

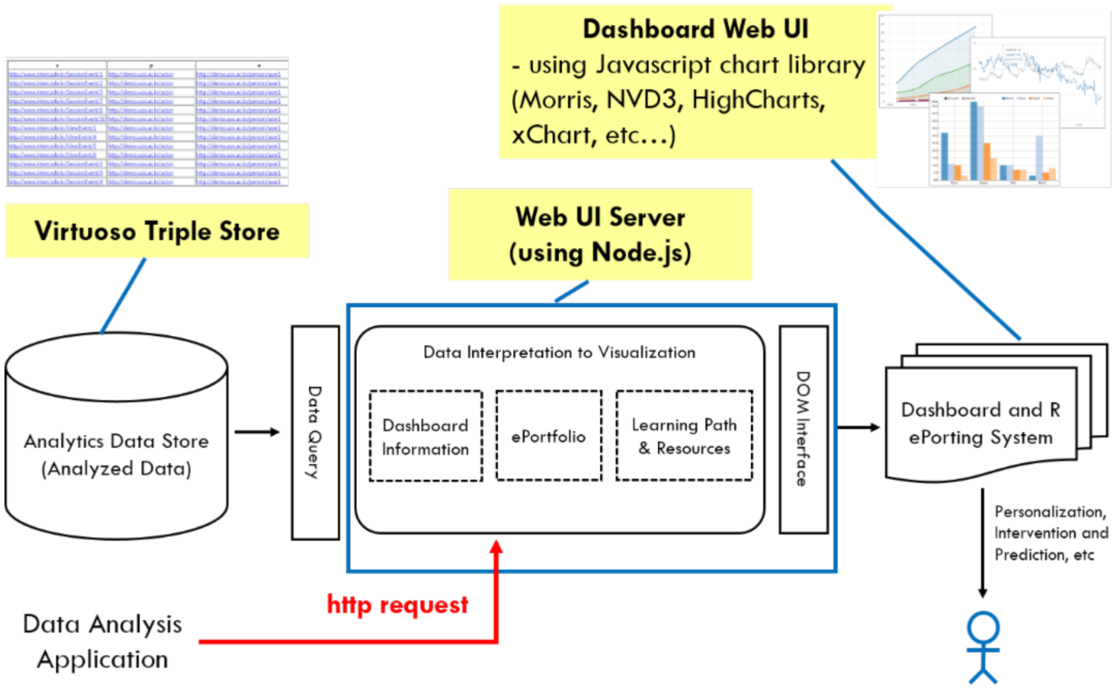

Figure 14: Deployment for Visualization

5. Discussion and Future Work

In this paper, we presented a reference model and an experimental implementation of a learning analytics system based on our preliminary identification of the requirements for the systems to be open, distributed, interoperable, reusable, real-time, usable, and secure. We believe that our approach of designing a reference model and testing with the experimental implementation is laborious but assured tactic to reach the goal of defining an explicit specification of the learning analytics systems as the international standard so that open and extensible learning analytics systems can be built for worldwide interoperability. Accordingly, our next step is to extract explicit data model and interfaces for the possibly distributed components based on our experiments and extensions of the experimental implementation.

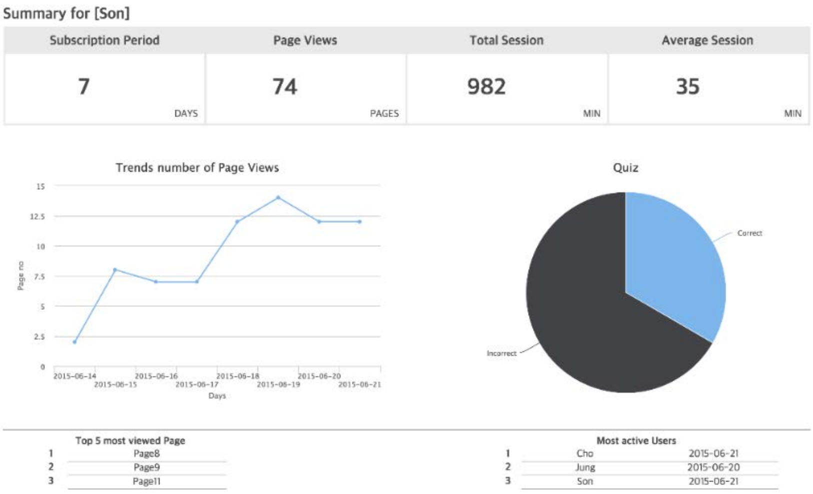

Figure 15: Simple Dashboard for Engagement Profile

Acknowledgements

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Design two systems to improve students Environmental Education knowledge - a case for the Barclay Memorial Park

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Abstract: In recent years, the rise of the Electronic map gradually replaced the use of traditional paper maps such as the Google Map, Bing Map, and Apple Maps. In the Google Maps which offers Street View, street maps, and satellite imagery etc. Especially, Google Street View was launched in 2007, it provide 360° panoramic views of streets, and make everyone to use the Street View to explore the world. However Google uses cameras, GPS equipment, computers and lasers to capture images, it need a lot of money. Such requirement is big challenge, so we use Digital Single Lens Reflex Camera (DSLR Camera), GPS and Tripod to design a simple Street View backpack. In order to makes everyone use simple equipment to produce panorama, we use Google Street View service to build two system: Street View system for "Testing Student degree" and Street View system for "self-education". In the Street View system for "Testing Student degree", we combined the Testing menu with Street View service let student browsing the street, landscape and answer the question. With this method, teacher can using Street View system for "Testing Student degree" to know how many ecological knowledge that the Student have. After used the Street View system for "Testing Student degree", we provide Street View system for "self-education" to make student learning by themselves. In the Street View system for "self-education", not only learn the knowledge about ecological, historical and humanistic, but also offer the Environmental information that make student learn more Information about the Barclay Memorial Park.

Keywords: Street View, GIS, Environmental Education

1. Introduction

With advances in internet technology, people have gradually replace the forms of traditional maps with Electronic maps. Electronic maps become more people used, because it is easier than traditional maps. For user to say, just input the place where they want to go, Electronic maps will display the destination. With Electronic maps you can also save the time to find the location and route. In addition, traditional maps can only provide information on paper, such as location, direction, and distance. However, Electronic maps is a virtual map, provide the same information and also provide extra services, such as Street View, geography and geology, transportation routes, satellite imagery, 3D buildings, and Environmental Information. After a period of time, Electronic maps will be updated, it is the reason that Electronic maps can replace traditional maps. Some studies have indicated that GIS have started to use in classroom. For example, Miller (2006) suggest that Google Maps applications allow user to make a mark values directly GIS-based maps. Yansen Wang (2013) suggests that Google Maps/Earth GIS takes advantages of resources in map, data visualization, image data handling, and it is offer from Google Maps/Earth Service.

In the 1992, United Nations Conference on Environment and Development (UNCED) are famous for the Earth Summit, it proposed Agenda 21 that make Environmental Education become a general knowledge. From the view of historical, Environmental Education has belong to conservation education, outdoor education, education for sustainable development, and Environmental literacy (Joe E. Heimlich，2010). However, the purpose of education is Environmental, preservation, and conservation, it is a point of thesis. Environmental evaluation has only recently become an outstanding component of Environmental Education. (Jacobson et al., 2006).

In this study, we use Google Street View Service as our tools, and produce two systems with the Street View Service. One is Street View system for "Testing Student degree", and the other is Street View system for "self-education". In the Street View system for "Testing Student degree", we use it to test student ecological knowledge and Environmental information of the Barclay Memorial Park. We hope that through this system can let teacher know how many ability they will have. In addition, in the Street View system for "self-education", we used the Barclay Memorial Park for instance, and combined Street View Service with the surroundings information to guide students to understand the Environmental information.

2. Literature review of Environmental Education

The Stockholm Conference (Dias, 2002) determined that the contents of Environmental Education would save the education issue able to manage the resources of nature, and make it sustainability. (Ministry of Science and Technology, 2007:12) In 1997, the main theme of the first World Conference is Environmental Education, and it held in Tbilisi. The classic Tbilisi Declaration definition were authored by 265 representatives from 66 member states, which emphasizes knowledge, attitudes, values, skills, and behaviors. (UNESCO, 1977) In the 21st century, the economy grows rapidly, we face more challenging task to protecting environment and the resources. In the West Country, Environment and Environmental Education has become people’s concern. Many countries have reached consensus on the necessity of Environmental Education provision in the school. (Shi & Liu, 2010) Environmental education strives to engage the global citizenry in new ways of thinking and acting for the environment. Environmental education is often delivered through an educational program and try to change the learner’s cognitive, affective and participatory knowledge, skills and behavior. (Annelise & J. William Hug, 2010) environmental education that heavily depends on direct experiences of natural phenomena outside the classroom. (Shultis, 2001)Researchers and evaluators also need to develop new research tools to learning in environmental education. (Heather & Lucy, 2014) Thus, we developed two system, and we will introduce it in next section.

3. Technology

3.1 Technology for photography

In our Street View system, we don't use the panorama of the Google Street View, and we use the images were captured by ourselves in the Barclay Memorial Park. The method of the panorama used Panorama stitching software (Panorama Studio 2 Pro) to stitching the images. However, in the shooting of the images have two way: One for vertical and the other for horizontal. In this study, we adopt vertical shooting that vertical shooting have much more range than horizontal shooting. In the test, we can see the difference between the horizontal shooting (left of Fig.1) and vertical shooting (right of Fig.1). In the Fig.2 show the method of shooting a panorama, we take every 30 degree for a shoot, and total we have shooting 12 images. After shooting the images, we used Panorama stitching software to make a panorama (see Fig.3). In this study, we have taken 492 images and make 41 panoramas.

Fig. 1. The method of shooting image.

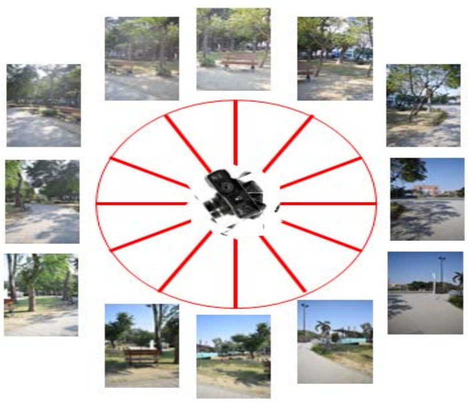

Fig. 2. The method of shooting panorama.

Fig. 3. The panorama.

3.2 Technology for making Street View

In the Technology for making Street View, we used the Google Maps JavaScript API (https://developers.google.com/maps/documentation/javascript/streetview). The First step, we set the number to each panorama (see Fig.4). The second step, we record the latitude and longitude of each panorama, and input the value to the Google Maps JavaScript API (see Fig.6). Finally, we use the service of Street View, set the setting about the number of panoramas, coordinate, direction, and show the result on the website (see Fig.5). For example, we set the images (01.jpg), input the value of coordinate (22.973228, 120.222538), and the Street View Service will show the result.

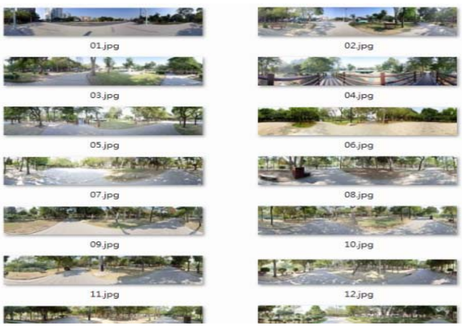

Fig. 4. Set the number to each panorama.

Fig. 5. Show the panoramas on the website.

```
streetViewPanoramaData["location"] = {
  latLng: new google.maps.LatLng(22.973228,120.222538)
};
```

Fig. 6. Input the value to the Google Maps JavaScript API

4. Process of the system production

In this section, we will describe two example systems of using Street View services.

4.1 Street View system for "Testing Student degree"

In the process of making Street View system for "Testing Student degree", we use this system is intended to test the ecological knowledge about the Barclay Memorial Park. We can divided this system into 2 parts: One for the Street View, and the other for the problem menu. In the part of the Street View, we went to the Barclay Memorial Park to shooting images, and used Panorama stitching software to stitching the images into a panorama. However, the panorama in the Google Street View not aim at the right direction (see Fig.7), so we using PhotoScape tools to do some process. We recut the panorama into 12 parts (see Fig.8), and change the number to the panorama that make the number 1 - 12 become 4 - 12 and 1 - 3(see

Fig.9). After change the number of the panorama, the incorrect direction change to the correct direction, and we can see the result in Fig.10. In the problem menu, we only collected ecological knowledge about the Barclay Memorial Park, such as what the name for this tree or what time will this flowers bloom. The reason of only collected ecological knowledge is we hope that teacher can through this system to testing students' knowledge.

Fig. 7. The panorama in the Google Street View not aim at the right direction.

Fig. 8. Recut the panorama into 12 parts.

Fig. 9. Change the number to the panorama

Fig. 10. The panorama in the Google Street View aim at the right direction.

4.2 Street View system for "self-education"

When we making Street View system for "self-education", we provide a system for students to learn. With this system, students can learn the relevant information and knowledge about the Barclay Memorial Park. We also divided this system into two parts: information menu and part of the Street View has mentioned above. In the Street View system for "self-education", we use the same set of the Street View service, but we don't test the student's ability. We use a different way to provide students to learn, students can see the tag and click the corresponding information menu. In the information menu, it provide about ecological knowledge, historical and humanistic knowledge, and Environmental information. For example, we will introduce the flowers and the trees in the Barclay Memorial Park, and introduce the history of Dr. Thomas Barclay.

5. The result of two system

In the result, show the Street View system for "Testing Student degree" and Street View system for "self-education" as follows:

5.1 The result of Street View system for "Testing Student degree"

In the show of Street View system for "Testing Student degree", can be students interface and teachers interface.

5.1.1 Students interface of Street View system for "Testing Student degree"

Fig.11 shows the process of students interface for operation, students can use the Street View to browse the panorama of the Barclay Memorial Park, and they can also see the problem tag to answer the questions (see Fig.12). With this system allow students to answer the ecological knowledge about the Barclay Memorial Park, and let teacher know the ability of these students. When students answer the question, we ask students to input the account, passwords, grade, class, number and gender (see Fig.13). After input the personal information, students can answer all of the questions, this system will display the answer what they do (see Fig.14).

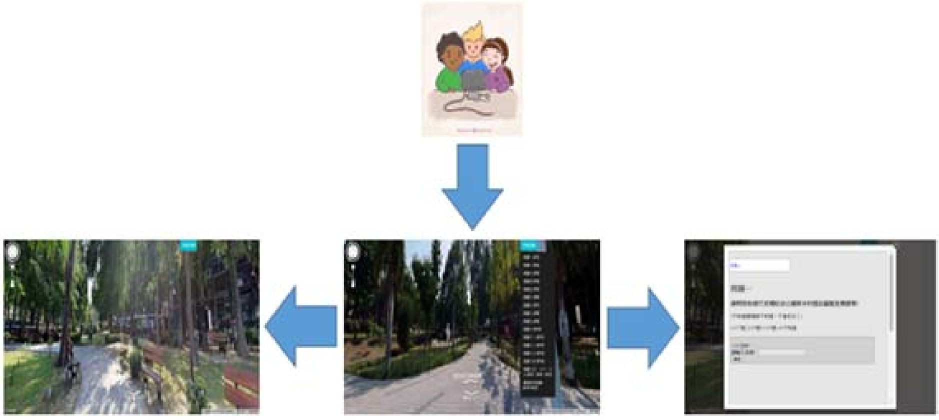

Fig. 11. The process of students interface for operation.

Fig. 12. Students answer the questions

Fig. 13. Students input the personal information.

編號	帳號	年級	班級	座號	性別	答案1	答案2	答案3	答案4	答案5	答案6
1	10101	1	1	1	女	1	2	2	4	1	2

Fig. 14. Display the answer what students do.

5.1.2 Teachers interface of Street View system for "Testing Student degree"

In the teachers interface, teachers can through this interface to know the situation what the students filled (Fig.15). When all of the students have completed this questions, teachers can go to the scores management interface to know the case of every student (Fig.16).

人員管理

編號	帳號	年級	班級	座號	性別	S1	S2	S3	S4	S5	S6
1	10101	1	1	1	女	1	2	2	4	1	2
2	10102	1	1	2	女	1	1	1	1	1	1
3	10102	1	1	3	男	2		3	1	3	4
4	10104	1	1	4	男	3	2	4	1	2	4
5	10105	1	1	5	女	3	2	2	1	4	2
6	10106	1	1	6	女	1	3	3		2	1

Fig. 15. Display the personal information and answer.

分數管理

基本資料						學生答題內容						學生答題狀況						各題分數						總分
NO.	帳號	年級	班級	座號	性別	S1	S2	S3	S4	S5	S6	Q1	Q2	Q3	Q4	Q5	Q6	分數1	分數2	分數3	分數4	分數5	分數6	總分
1	10101	1	1	1	女	1	2	2	4	1	2	O	O	X	O	X	O	10	10	0	10	0	10	40
2	10102	1	1	2	女	1	1	1	1	1	1	O	X	O	X	X	X	10	0	10	0	0	0	20
3	10102	1	1	3	男	2		3	1	3	4	X		X	X	O	X	0	0	0	0	10	0	10
4	10104	1	1	4	男	3	2	4	1	2	4	X	O	X	X	X	X	0	10	0	0	0	0	10
5	10105	1	1	5	女	3	2	2	1	4	2	X	O	X	X	X	O	0	10	0	0	0	10	20
6	10106	1	1	6	女	1	3	3		2	1	O	X	X		X	X	10	0	0	0	0	0	10

Fig. 16. Display the scores of each students.

5.2 The result of Street View system for "self-education"

After the introduction to the Street View system for "Testing Student degree", we introduced the result of Street View system for "self-education", the purpose of this system is intended to combined information menu with Street View. Let students use this system, can learn the knowledge about the Barclay Memorial Park. In the Fig.17 shows the home page of this system, students can click the left image to go to Street View Service, browse the view, and click the information menu to learn some knowledge. In the right of this home page, we can see the video from youtube, and this video were provide by Chongming Elementary School where the school near to the Barclay Memorial Park. This video has described the origin of the Barclay Memorial Park, the story about the Barclay Memorial Park, and the ecological introduction. After click the bottom of this home page will pop up a new window, it provide some interesting story about the plants ,in this system not only can learn the knowledge about the Barclay Memorial Park, but also offer some interesting story to make students know.

Fig. 17. The process page of this system

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Game-based Learning Combined with the Somatosensory Operation of Effectiveness Evaluation - global warming science myths solving

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Abstract: Through this study, the role of today's popular somatosensory technology and the market widely used playing game combines topics related to global warming myth concept to design a scenario-based learning modules. The module of assisting learning used in this study can increase learners' motivation. In this study, a public Tainan were administered test, using a group of computer-assisted teaching people 232 people, the use of somatosensory assisted Instruction 192 people. Based on the data collected, the effectiveness of learning effectiveness was analyzed by using a series studies. That scientific knowledge through the study of the effectiveness of the results of the analysis has a significant learning outcomes, in satisfaction of a learner will want to re-use this module learn.

Keywords: Situated learning, Game-Based Learning, Somatosensory operation, RPG-game

1. Introduction

In recent years, many studies have pointed out that the game-based learning as a teaching aid can enhance learning interest and motivate learners. Since the birth of the Earth 4.6 billion years ago, continuous operation of the climate system, and greenhouse effect too. But since the Industrial Revolution, the burning of fossil fuels such as increased greenhouse gas emissions, nature of the greenhouse effect and therefore imbalance. To solve this problem, the must right to establish the concept of basic education from the start. So this study set to improve children on the idea of global warming, for example deviations game-based learning methods. In order to increase children's motivation in learning, in this study, particularly the operation mode into the game, the game developed by combining motion sensing operation to improve student interest in learning and motivation. The subjects of this study architecture chosen game Role-playing game (RPG) RPG presented in a way, on the one reason models currently on the market many games begin RPG presented in a way, on the other reason, through role-playing game presents a way you can let children feel as if combined with a game situation himself inside the game, in order to achieve the effect of situational learning.

2. Literature review

2.1 Digital games in learning

In recent years, for children, games, entertainment and recreation in addition to features, it also includes learning, training and even the cultural heritage features (Shi, 2006). Many studies have pointed out that the game is an easy way to learn to drive learners to enter the environment, which makes the course more interesting and people immersed in the joy of learning (Chao, 2006), The game allows learners through investment in teaching situation, continuing to maintain freshness and attention, so that course content can be successfully transmitted to learners, promote good communication between teachers and students and interaction, students are able to participate more actively in learning in order to achieve the goal of entertaining (Hong al., 2002). However, while there are also studies mentioned game-based learning can be achieved following the teaching effect: (1) active learning; (2) increase interest in learning; (3) the individual experience of learning and knowledge; (4) to reduce the pressure of study; (5) creative thinking and learning; (6) remedial teaching (Li , 1999), Therefore, in the course of the game children try a variety of different games are played, and the development and creation of opportunities for exploration, students can experience the new behavior and unique way to express innovative ideas, so the game situation to expand children's creativity and imagination (Wu , 2001). So teaching the game-based learning, can enhance learning efficiency, to stimulate learners' interests and reduce the burden of courses (von Wangenheim & Shull, 2009). The game presents the way the market than the type of role-playing as the largest in recent years, many of the secondary educational learning tool also binds (Liu, 2010).

Compared to the general game mode of operation, somatosensory games more people into the game situation, and because the operation in the form of intuition allows users as experienced in the content of which (Lu et al., 2012).

Many who use a variety of teaching and learning-related knowledge and theory, and to consider all relevant factors affecting the learning process, the combination of theory and practice of teaching, teaching activities and planning process to become "instructional design." Including teaching activity planning, selection, preparation, practice and evaluation and other work in the hope that through the design and arrangement of the context of learning activities, so that students can actively participate in the learning process, to enhance learning. However, any teaching activities are required instructional design arrangements, teaching from the selected target analysis, analysis and choice of teaching strategies learners teaching content, these need to do before the formal teaching effective arrangements and Analysis (Tsai, 2010).

There are term teaching and research are important instructional design model proposed three main reasons. (1) teaching designed to assist educators to establish the direction of teaching, where the clear teaching objectives; (2) teaching designed to assist educators to establish evaluation goals, with the evaluation objectives, teaching and learners will be able to learn well aware goals; (3) teaching designed to provide a clear direction learners learn, help them towards the right goal (Mager, 1968).

2.1.1 Somatosensory Technology

In the past few years to bring to the people a lot of somatosensory operation of entertainment, and now the city also has an interview produced by different companies operating platform, which some studies have found the somatosensory platform can even integrate into a lesson in education for use in . Interim most typical example is Microsoft's Xbox360 Kinect platform(Evgenia Boutsika, 2014).

Kinect is a belonging to the NUI. It allows the user does not need to hold the remote control or worn props, direct use of physical manipulation. Kinect is also to be applied in many different areas. Compared with the traditional game props controlled manner, Kinect pluralism operation can not be replaced with a traditional game interaction, and allow the user into the game situation(Chao, Huang, Fang, & Chen,2012 、Chun-Yen Chang, Yu-Ta Chien, Cheng-Yu Chiang, Ming-Chao Lin & Hsin-Chih Lai,2013).

Kinect as a teaching tool for e-learning can achieve said increase student motivation and interactivity. (1) It is instructive tool if interaction between teachers and students teaching material and good if it can create a pleasant learning environment in the classroom. (2) Its software can be modified, so the teaching of design has a large ductility(Hsu, 2011).

2.1.2 Role-playing game

Role-playing game is a player controls the protagonist activities fictional world of the game. Role-playing games to promote the overall story and narrative elements, the player character growth, complexity, and integration of replayability. There are also studies proposed role-playing game for learning complex problem solving, conflict resolution and other most helpful, when learners actually play a role, through its view, the problem and the solution will become easier (Raybourn, 2006), There is also a scholar pointed out role-playing game is a popular favorite game modes, it is applied to the user in the textbooks for secondary teaching can reach a certain get into (Buchanan, 2004).

2.1.3 Situated Learning

Situational awareness and situational teaching learning from the situation two theories (Brown, Collins & Dugid, 1988). But before these theories have been proposed, Schon (1987) pointed out that many specialized industry knowledge, technology can not fully be described in detail in words or language, it must be thoroughly integrated into the situation through personal observation, participation and learning to be harvested. For example, plumbers, formwork workers, butchers, midwives and other industries mostly by "mentoring" tradition, rarely teach these skills to implement in the formal education system, at the most to learn from books some basic common sense, but it can master these workers or in accordance with the formal theory of law to solve all kinds of skilled work incurable diseases, deducing reason is through "learning by doing, namely to reflect amendments wrong" model to be improved, down to ensure the long-term and technical personnel of a high degree of professionalism, which is situated learning success, and therefore we can say that the teaching situation implies for students to learn by doing and by doing so on two major connotations Reflection (Suchman, 1987).

2.1.4 Global warming misconception

Since the rise of the industrial revolution of the mid-18th century, science and technology has brought a great surprise to human society and assistance, creating immense prosperity of human society, but accompanied by excessive exploitation of natural environment and resources, resulting in many ecosystems on Earth the withered. Which is very huge influence than the human misuse of natural resources, resulting in increased global warming in recent years, all over the disaster of success, human nature and therefore bear the counterattack, so we are bound to make some coping methods (Wei et al., 1997).Research has integrated the reason scholars misconceptions generated, which can be divided into two parts, students and teachers, student section including inadequate subject knowledge, as well as improper cognition; teacher component includes, overemphasize talk, for students of myth lack of awareness and interest in causing heart teaching properly. However, the issue of global warming, its complex scientific concepts are also the cause of student misconceptions of (Cgen, 2002).

In this study, we are hoping that through this situation user interactive operating system to learn the correct corresponding knowledge, by somatosensory operation to improve learning motivation and learning effectiveness.

3. Method

3.1 Research framework

In game-based learning and contextual learning theory, and then learning content, learning tools, learning integration, and then through the somatosensory system allows users to play the protagonist of the game.(Fig. 1)

Teaching Content: a story and authenticity, so that students perform tasks more easily manipulated by somatosensory into the situation.

Learning tools: a combination of a sense of science and technology and role-playing game developed situational learning environment, the user can very natural control game characters through the body, and then with the story progresses, reach into the game and thinking realm.

Learning ways: through games-based learning approach, the integration of cognitive conflict strategy, the number of teaching materials for students through the guidance and the characters to interact with, and then the problem of self-discovery and exploration, and finally establish the correct perception and get rid of the original myth.

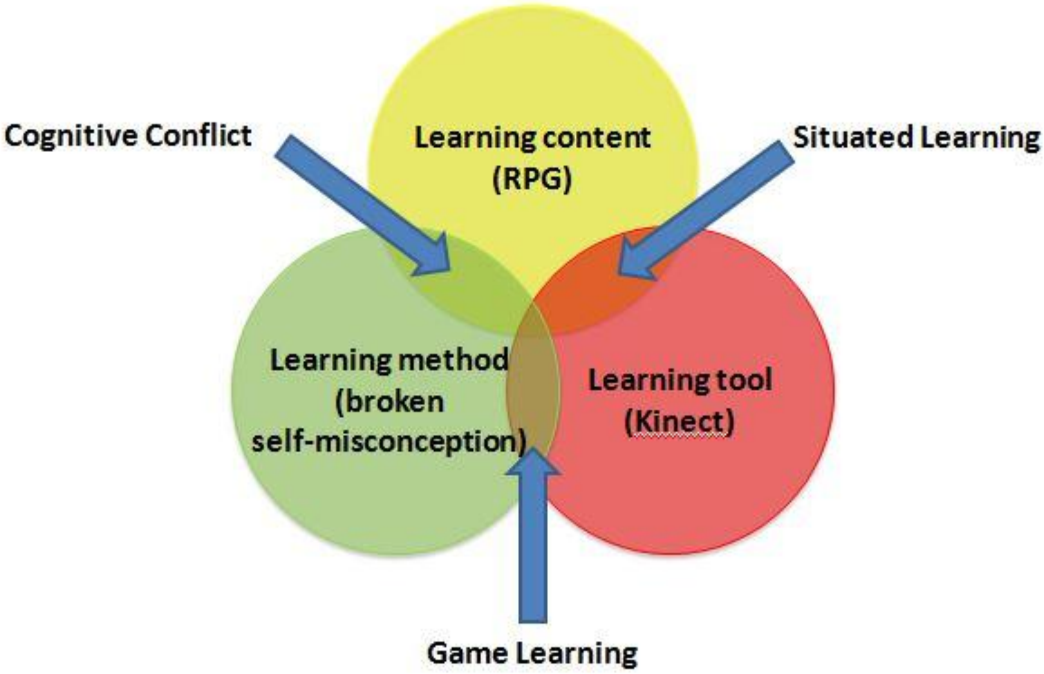

Fig. 1. research framework

4. Global Warming Misconception of material design

4.1 Learning material design

In this study, the use of cognitive conflict in teaching three steps: (1) understand the students had knowledge; (2) provide students with contradictory information; (3) the level measured before and after the assessment by the learner cognitive change. And adding a new concept to strengthen its correct new knowledge(Limón, 2001). First, when the pre-test before learning to understand the learner on the South, the Arctic ice melting will cause sea level rise if the original concept; then let learners game, with the game's story and dialogue, so that learners themselves after discovery south, the Arctic ice melt, will result in rising sea levels, finally provided the conflict, allowing learners to think for themselves; the end of the game, test, assess whether there is a change after cognition, whether myth is resolved, whether cognitive establishment; and finally to consolidate this concept, then teaching experiment movie, strengthen this perception. (Fig.2)

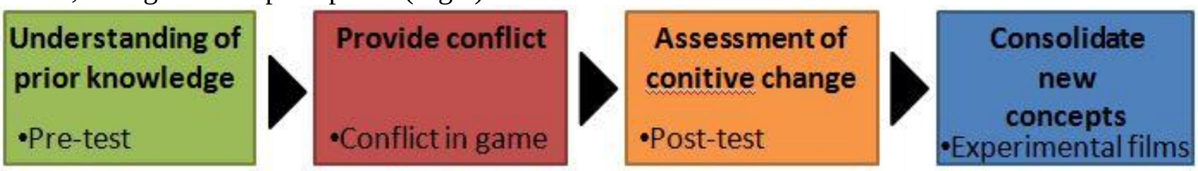

Fig. 2. Assessment of cognitive change.

4.2 Learning material design

The present study aims to design a concept to solve the global warming myth games. By KINECT body movements assisted learning, learners immersive. Including the Antarctic rescue penguins, polar bears in the Arctic rescue. Knowledge and education through the game screen conduction Antarctic, the Arctic ice melt will cause any kind of impact the Earth and the dialogue of knowledge to achieve the effect of learning (Fig.3). Action by the somatosensory technology and design aspects of running, jumping, climbing and direction of motion control to answer situational effect (Fig.4)

Fig.3. Knowledge of the game

Fig.4. Motion design

5. Results

This study used a quasi-experimental evaluation of the performance of the method, the samples were divided into experimental group and control group test, the total number of samples to 424 people (192 in the experimental group and the control group 232), statistical analysis through the pre / post-test questionnaire descriptive of the learning effectiveness and satisfaction differences.

According to the description of the statistical data analysis showed that: In some experimental group pre-test, the relevant scientific knowledge analysis results: (1) which is part of the Arctic ice correct rate of 62%, (2) the Antarctic ice sheet is the kind of answer below rate of 49%, (3) the Arctic ice melting sea-level rise will result in correct rate of 19.8%, (4) whether the Antarctic ice melting will cause sea level rise correct rate of 64.6%. In part to test the experimental group, the relevant scientific knowledge analysis results are: (1) which is part of the Arctic ice correct rate was 91.7%, (2) the Antarctic ice sheet is the correct rate which belong 47.4%, (3) Arctic ice melting will result in rising sea levels correct rate of 83.9%, (4) whether the Antarctic ice melting will cause sea level rise correct rate of 82.3%. (Table.1)

Pre-group portion of the test, the relevant scientific knowledge analysis results: (1) what kind of Arctic ice correct rate below 56%, (2) the Antarctic ice sheet is the correct rate which belong 46.1%, (3) the Arctic ice melting sea-level rise will result in correct rate of 15.1%, (4) whether the Antarctic ice melting will cause sea level rise correct rate of 56.5%. Section, relevant scientific knowledge to analyze the results of the control group tested were: (1) which is part of the Arctic ice correct rate 90.1%, (2) the Antarctic ice sheet is the correct rate which belong 54.3%, (3) the Arctic ice melting sea-level rise will result in correct rate 61.2%, (4) whether the Antarctic ice melting will cause sea level rise correct rate of 79.7%. (Table.2)

Part of the satisfaction of the experimental groups: (1) This type of game the most appropriate time to less than 7 minutes 76%, (2)like the picture of the game 66.1%, (3) Like the game's sound 77.6%, (4) like the game content 46.9%, (5) like during conversations 59.9%, (6) mode of operation like somatosensory 32.8% (7) during the game smoothly 45.3%, (8) the process of running, jumping percent fun 54.7, (9) during the game interesting 52.6%, (10) this game impressed me 52.6%, (11) the same form, different content, but also want to play 53.6%.

Part satisfaction of the control group: (1) This type of game the most appropriate time to less than 7 minutes 80.6%, (2) love the game screen 41.8%, (3) Like the game's sound 20.3%, (4)like the content of the game 64.2%, (5) like during conversations 47.4%, (6)during the game interesting 97.9%,(7) I was impressed by this game 95.2%, (8) the same form, different content, but also want to play 97.4%.

Title	Pre-test	Posttest
What kind of ice belong Arctic	62%	91.7%
What kind of ice belong Antarctic	49%	47.4%
Arctic ice melting will result sea-level rise	19.8%	83.9%
Antarctic ice melting will result sea-level rise	64.6%	82.3%

Table.1. Experiment group scientific knowledge quiz results

Title	Pre-test	Posttest
What kind of ice belong Arctic	56%	90.1%
What kind of ice belong Antarctic	46.1%	54.3%
Arctic ice melting will result sea-level rise	15.1%	61.2%
Antarctic ice melting will result sea-level rise	56.5%	79.7%

Table.2. Control group scientific knowledge quiz results

6. Conclusion

This study developed a combined KINECT somatosensory operation and role-playing game RPG character situational somatosensory type-learning modules, teaching joined the misconceptions of the scientific basis of global warming, through experimental analysis proved that this learning module has good the study results, the results are as follows:

1. Looking at the results of the entire study of scientific knowledge shows that, regardless of the experimental group or a control group in the Antarctic, the Arctic is part of what the ice, rising sea levels will result in melted through measured before and after a significant improvement can be seen. In addition to the South Pole is the effect of the experimental group after learning what kind of ice did not reach the expected results belong, after analysis speculate, because the dialogue knowledge of the contents of long Antarctic ice, causing the participants a chance to fully absorb it into the next chapter of relations.
2. This game is yet another special feature is that it mirrors the concept of cash is the most popular role-playing surface, which allows users to integrate in situations near and this sets learning module allows learners to experience the ice melt layer may have any effect, so that learners learn to play in the process of knowledge.
3. The performance of this study learning modules and then the user satisfaction, the whole matter can be obtained through the analysis of the results in the experimental group or the control group, of which the learners will want to experience the learning mode again.
4. Finally, in terms of scientific knowledge or obtained through the test results that, scientific knowledge that learners are in school and in the media network. So this results also show that school students conducting a correct concept and newspapers, the media, the Internet dial bulk messages must pass rigorous police caution not to cause misunderstanding shot will of the public.

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The Effects of Integrating Metacognitive Scaffolding in Chemistry Educational Computer Games in High School Students' Learning Outcomes and Game-based Learning

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Abstract: In the last decades, many researchers have discussed the potentials of using computer games in education. The use of educational computer games can provide more active involvement, increase motivation and satisfaction. In particular, science education is generally believed that can benefit from the educational computer games due to the ability of presenting abstract concepts. For learning basic chemistry, learners are required understand chemical reactions which are all abstract concepts to them. As a result, learners often experience difficult learning experience and lack of motivation while learning them. In this study, a chemistry educational computer game designed in our previous research was modified and adopted. The modified version of the game integrated metacognitive scaffolding design which could provide promptly assistance. A total of 171 senior high school students in Taiwan participated in this study. They were randomly assigned to control group (common version of ECG without metacognitive scaffolding design) and experimental group (the ECG with metacognitive scaffolding design). Both groups took pre-test/post-test. Meanwhile, both groups were required to take notes while using the game. The digital game-based learning (DGBL) experience of playing the game was also collected through the questionnaire and semi-structure interview. The results showed that both groups made marked progress by using the game ($P<.05$). Regarding the real-time hints, it is helpful for the experimental group to answer chemistry conceptual understanding questions ($P<.05$). It showed no difference of using the note-taking function, suggesting that all participants were willing to use the metacognitive scaffolding design in the game. Results also indicate that both groups had game experience. In particular, the experimental group (MS-ECG) expressed that they were not only playing a game but felt that they were learning. In sum, with metacognitive scaffolding design, it is easier for participants to use the educational computer game. Implications for educational practices are also discussed.

Keywords: Chemistry, educational computer games (ECGs), digital game-based learning (DGBL), metacognition, scaffolding, learning outcomes

1. Introduction

Fast development in information technology has radically influenced the ways of teaching and learning (Knezek & Christensen, 2002). It brought out that computer games are no longer considered merely a form of entertainment, but also a form of edutainment. In the last decades, many researchers have widely discussed the potentials of using computer games in education (e.g., Connolly et al., 2012; Gee, 2003, Kebritchi, 2010; Van Eck, 2006). As revealed in previous studies, the use of educational computer games (ECGs) can provide more active involvement, increase motivation and satisfaction (Kebritchi & Hirumi, 2008). Prensky (2001) also proposed the term "digital game-based learning" (DGBL) to describe learning with games which can be combined with curricular goals and content.

Recently, DGBL has been employed in many subjects and more and more ECGs have been implemented in different learning areas (Paraskeva, Mysirlaki, & Papagianni, 2010; Peterson, 2010). For researchers and educators in science education, it is believed that science learners could benefit from learning with ECGs. For science learners, scientific concepts can be relatively more abstract and difficult compared to other learning subjects. Therefore, science learners would sometimes show anxiety and face difficulties. To help them overcome the dilemmas, the use of ECGs to support science learning could be a vital approach. ECGs could be used to present abstract scientific concepts by using digitalized content, and thus could improve learners' motivation and help them learn science better (Shaffer et al., 2004).

In recent years, the adoption of computer games in science learning has received increasing attention from science educators and researchers (Hwang & Wu, 2012). However, in previous research, the educational computer games adopted in science education mainly concerned on interdisciplinary learning (Baytak & Land, 2011), physics or biology learning (Anderson & Barnett, 2011; Sanchez & Olivares, 2011). However, a subject like chemistry, with more abstract concepts than other subjects in science, is short of relevant educational game research. Therefore, this study aims to explore the effects of an ECG for basic chemistry learning, which is designed in our previous research (i.e. Chen & etc., 2012).

In this study, metacognitive scaffolding was designed in the ECG. Metacognition, a psychological term explains the process of learning has been extensively discussed in learning metacognition literally means cognition about cognition, or more informally, thinking about thinking (Metcalfe & Shimamura, 1994). Flavell (1976) defined metacognition as knowledge about cognition and control of cognition. It is a skill to monitor one's own thinking process such as study skills, memory capabilities. In previous studies, metacognition has been proved to become a key factor helping learners to maximize learning (Flavell, 1976; Metcalfe & Shimamura, 1994; Lysaker & etc., 2011). Scaffolding was also adopted for giving learners support during the learning process (Sawyer, 2006). The ECG used in this study was further developed with the metacognitive scaffold design aiming to help learners better acquire the abstract chemistry knowledge and maximize the learning outcomes. In sum, this study explored the effects of the ECG with metacognitive scaffolding design on junior high school students' chemistry conceptual understanding. Also, their DGBL experience was investigated.

1.1 Research questions

In this study, two versions of ECG were designed and used in this study: C-ECG (i.e., common version of ECG without metacognitive scaffold design) and MS-ECG (i.e., the ECG with metacognitive scaffold design). According to the motivation of this study, research questions are listed below.

1. Did the students learn with the MS-ECG significantly outperform those who learned with the C-ECG in their conceptual understanding regarding basic chemical reactions?
2. Did the students in the two groups (i.e., the C-ECG and the MS-ECG groups) perceive significantly different DGBL experience?

3. Methods

2.1 Participants

The participants of this study consisted of 171 junior high school students (80 males and 91 females). These students were randomly divided into two groups, the C-ECG group and the MS-ECG group. The C-ECG group (i.e., the control group in this study) consisted of 84 students while the MS-ECG group (i.e., the experiment group) consisted of 87 students.

2.2 Materials

This study adopted a chemistry educational computer game, "The adventure of Mr. Dalton", designed in our previous study (Chen & etc., 2012). There were two versions in this study. The first version was C-ECG (common ECG) which only covered junior high school basic chemistry reactions including chemical reaction, decomposition reaction, substitution reaction, and double decomposition reaction. Besides the basic chemistry reactions mentioned above, the second version has added the metacognitive scaffolding (MS-ECG). Figure 1 shows the screenshots of the ECG including the main screen, chemical reaction game, decomposition reaction game, and decomposition reaction game. Figure 2 shows the metacognitive scaffolding functions design (real-time hints and note-taking) in the second version of the game.

Figure 1: Screenshots of “The adventure of Mr. Dalton.”

Figure 2: Screenshots of metacognitive scaffolding design (left: real-time hints and right: note-taking)

2.3 Procedure and data collection

Fig 3 shows the procedure and data collection of the study. The participants enrolled in a one day chemistry course which lasted for 8 hours. The learning goal of the course was to learn four chemical reactions. The procedure of the study had pretest, introduction, learning, posttest, and questionnaire and interview sections. In the pretest section, students were given a chemistry achievement test, including multiple choices and corresponding chemistry concepts. In the introduction and learning sections, students were given a 10 minutes lecture for each chemistry reaction. They were randomly assigned to a control group (i.e. with a C-ECG) and an experiment group (i.e. with a MS-ECG). Both groups had to learn the assigned unit for 50 minutes. They all had the access to use the note-taking function in the game. After learning the 4 reactions, students were given a posttest and a DGBL experience questionnaire. A semi-structure interview was also adopted at the end.

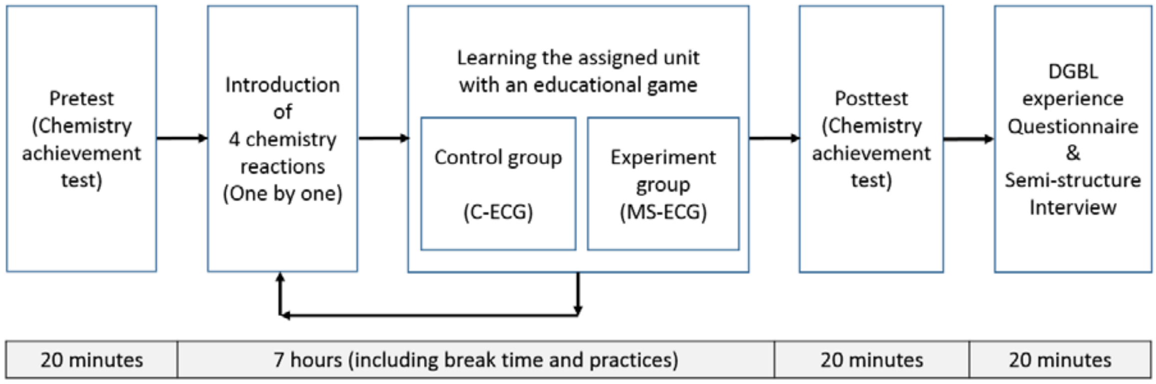

Figure 3. Procedure and data collection

3. Major findings and Conclusions

3.1 Major findings
3.1.1 The effects of using ECG with metacognitive scaffolding function in chemistry conceptual learning

The results showed that both experimental and control groups made marked progress by using the ECG (Table 1) (P<.05). Regarding the metacognitive scaffolding, it is helpful for the experimental group (with real-time hints) to answer chemistry conceptual understanding questions (Table 2) (*P*<.05).

Table 1 Students' learning outcomes of their conceptual understanding regarding basic chemical reactions (n=171)

		Pretest		Posttest	
		Mean	S.D.	Mean	S.D.
Participants	Experimental Group (MS-ECG) (n=87)	19.46	3.84	24.01	3.06
	Control Group (C-ECG) (n=84)	17.81	4.86	22.50	3.63

Table 2 The ANCOVA adjusted means and standard error of variables of students' learning outcomes and the results of ANCOVA (n=171)

		Mean (adjusted)	Standard error	*F*-value
Participants	Experimental Group (MS-ECG) (n=87)	23.79	0.34	4.64*
	Control Group (C-ECG) (n=84)	22.73	0.35	

*p<.05, **p<.01

3.1.2 The effects of using ECG with metacognitive scaffolding in students' perceived DGBL experience

Results also indicate that both groups had game experience. In particular, the experimental group expressed that they were not only playing a game but felt that they were learning (P<.05) (Table 3). In brief, the metacognition scaffolding design, it is easier for participants to use the chemistry educational computer game. From the results of semi-interview, the participants expressed that the metacognitive scaffolding design (real-time hints and note-taking) in the game can facilitate their learning. They liked the game design and especially the note-taking function which helped them to notice their learning process. In addition, the two groups showed no difference of using the note-taking function, suggesting that all participants were willing to use the metacognitive scaffolding design in the game.

Table 3 Metacognitive scaffolding design and DGBL experience *t*-test summary

		mean	S.D.	*t*
Playing games	Experimental Group (MS-ECG)	7.48	1.98	0.99
	Control Group (C-ECG)	7.45	2.05	
Learning Chemistry	Experimental Group (MS-ECG)	7.69	1.77	2.07*
	Control Group (C-ECG)	7.08	2.05	
Note-taking	Experimental Group (MS-ECG)	72.89	0.54	9.75**
	Control Group (C-ECG)	39.17	31.70	
Prompting (seconds)	Experimental Group (MS-ECG)	502.67	478.13	1.86
	Control Group (C-ECG)	380.13	379.41	

*p<.05, **p<.01

3.2 Conclusions

In conclusion, the chemistry educational computer game did help learners acquire the abstract concepts of four basic chemical reactions. With the real-time hints function, learners learned better, suggesting that the metacognitive scaffolding is crucial in the digital game-based learning design. In other words, learners need scaffolding that can provide instant assistance while using ECGs. Regarding the note-taking function, learners had the chance to monitor their own thinking process. This design may help learners to maximize their learning outcomes. From the investigation of DGBL experience, we found out that an educational game with metacognitive scaffolding design also could increase the learning experience in a game. The participants also provided some valuable suggestions for future game design. Based on the findings in this study, the "The adventure of Mr. Dalton" may be improved and applied to the teaching practices.

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A Preliminary Creative Process Exploration of Learners' Behavioral Patterns in a Collaborative Green Building Design Learning Activity Using Minecraft

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Abstract:
In the era of knowledge economy, creativity can be a critical skill to advance the science and technology development. Thus, in science education, researchers emphasize the importance of creativity and have been advocating the importance of teaching creative thinking skills. While previous studies regarded creativity as an internal process or personality attributes; nonetheless, creativity also can be a collaborative product of social and cognitive interaction among knowledgeable individuals. To understand how creativity can be collaboratively produced and thus could provide adequate guidance for creative collaboration, it is important to depict the patterns of interaction during creative process. However, to the authors' best knowledge, relative little attention has been devoted to the process of collaborative creativity. In order to address this literature gap, this preliminary study employed a project-based creativity learning activity, which required students to collaboratively design a green building. To design a green building, students have to comprehend and negotiate on the advantages and disadvantages of various energy sources and come up with creative ideas to efficiently reduce energy consumption of the building. This learning activity was expected to improve students' understanding of the mechanism and cost of various kinds of energy generation by asking students to negotiate on the advantages and disadvantages of varied energy sources when designing the green building. In order to depict the creative process, this study employed a novel approach, which combined quantitative content analysis (QCA) and lag sequential analysis (LSA) to illustrate learners' behavioral patterns exhibited in the creative process. By improving our understanding of the process of collaborative creativity, we could thus provide adequate guidance for students to go through the creative process. Students might not be born with creativity or know how to think creatively, but the instructor can guide them going through creative process and collaboratively work with each other to produce creative ideas of science and technology development. The novel approach to depict the creative process can be employed to subsequent collaborative creativity research for improving our understanding of the creative process.
Keywords: Creativity, green technology, collaborative learning, behavioral analysis.

1. Introduction

Creativity was regarded as a higher order cognitive skill as it can be complex and abstract (DeHaan, 2011). Creativity do not only manifest in fine arts and design, but as well in many practical disciplines. When it comes to science and technology development, there would be multiple solutions. Scientists have to think of the problem in unconventional ways and explore unusual alternatives before new discoveries and innovations could happen. In this manner, creative thinking could be the root of innovation and is considered as a critical ability to advance the science and technology development. To promote creative thinking in science and technology development, researchers have been advocating the importance of teaching creative thinking skills in science education (DeHaan, 2011; Kind & Kind, 2007). Creativity is regarded as the ability to produce novel ideas or apply innovative strategy to solve problem. In addition, the proposed ideas need to be original, useful and feasible for being considered as creative (Amabile, 1983; Sternberg, 2006). Previous creativity research mostly regarded creativity as an internal process or personality attribute of an individual. Besides the internal process, researchers have proposed the idea of collaborative creativity arguing that creativity is the product of cognitive and social interaction among individuals of diverse background and experience (Mamykina, Candy, & Edmonds, 2002). As to collaborative creativity, the development of creative outcomes becomes the result of a creative process among group members that involves varied phases of cognitive and social interaction, such as idea generation, idea selection, and idea validation. In different phases of the creative process, group member have to employ different strategy in order to produce better creative outcomes (Runco & Chand, 1995; Treffinger, 1995). For example, in the phase of idea generation, group members have to propose as many ideas as possible without any judgment or boundary. Associative thinking could be an important cognitive skill to be employed in this phase. However, in the phase of idea evaluation or validation, they need to employ critical thinking to apply criteria and rules to evaluate the ideas for it can be more feasible.

Previous creativity assessments generally assess the individual's personality attribute or evaluate one's idea generating ability from multiple dimensions, such as fluency, cognitive flexibility, and originality (Kirton, 1976; Torrance, 1995). However, these tests could not depict the cognitive and social interactions in the creative process. By observing the patterns of cognitive and social interaction among group members in the creative process and comparing their creative outcomes could help us better understand how the collaborative creativity is formed. In addition, with this knowledge, the instructor would be able to provide adequate guidance to learners in the creative process.

Nonetheless, to the authors' best knowledge, there is quite limited research that explored the patterns shown in the creative process in the context of collaborative creativity. To address this literature gap, this preliminary work designed a project-based creativity learning activity, which required students to work as a team and used asynchronous online discussion board to support their collaboration. The subject of the project-based creativity learning activity is to design a green building for a family with children of around 5 year-old. To design a green building, students have to come up with creative ideas of how to efficiently utilize the natural resources for reducing energy consumption. Also, they have to evaluate the alternatives of the different materials and design they would like to apply in the green building design project. It is an important learning goal for students to comprehend the advantages and disadvantages of various energy sources in green technology. Therefore, in the creativity learning activity, we expected students could collaborate on proposing creative ideas of how to design a building that could efficiently utilizing energies and create a comfortable space for living. The details of the creativity learning activity are delineated in section 2.2. This study then employed a novel analysis approach that integrates the quantitative content analysis (QCA) and lag sequential analysis (LSA) to explore the learners' content structure of and behavioral patterns exhibited in the creativity learning activity, which students used Minecraft to design a green building. The procedure of QCA and LSA will be delineated in section 2.3. Combining the results of QCA and LSA, the purpose of this preliminary work is to propose a novel approach to look into the formation of the collaborative creativity from a process perspective. The initial findings of this preliminary study could improve our understanding of how learners collaborate during the creative process. In addition, suggestions for guiding students' interaction would be proposed based upon the findings.

2. Research method

2.1 Participants

Participants of this study were 57 students from an institute of technology in northern Taiwan. These Students were of department of Multimedia design and were enrolled in a course – The principles and practices of e-learning. This course was to introduce the current status and novel applications of the e-learning. Also, software and skills for developing digital content were also introduced to improve students' ability to produce e-learning content. In the course, students were asked to collaboratively work on the assignments using asynchronous online discussion board for they can experience learning with the support of information technology. The discussion board was also used for students to work on the creative project in this study.

2.2 The project-based creativity learning activity

A project-based creativity learning activity was employed in the course. Students were grouped into 10 groups, each with 5 to 6 students. Each group was asked to design a green building for a family with children of around five years old. With this goal, each group have to take into account of how to efficiently utilize the natural energy resources, such as solar, water or wind, when designing the building. Meanwhile, when they design the interior of the building, they also have to consider the safety issue of the space for children. Students were encouraged to express their creativity when designing the green building. This learning activity was expected to improve students' understanding of the mechanism and cost of energy generation of different kinds by asking them to negotiate on the advantages and disadvantages of varied energy sources. In the end of the creative project, students had to prepare a document explaining their design concept and features of their work.

The tool that students used to design the green building is Minecraft, which is a game that allows players to build structure using blocks. Figure 1 shows a sample screenshot of Minecraft. Unlike conventional video games, Minecraft is more like a sandbox, or an open world. There are no clear objectives, challenges or levels for the gamers to complete (Short, 2012). With the freedom to play, Minecraft has been regarded as a creative tool for building structures (Schifter & Cipollone, 2013). Searching YouTube using keyword – "Minecraft" would return a long list of videos showing the creative structures built using Minecraft. These videos mostly demonstrate a walkthrough of the structures with no particular stories or game plots. In Minecraft, players can build anything they can imagine of in a virtual 3D world. With its freedom of play and ease of use, Minecraft has been used as a teaching tool in various subjects (Al-Washmi et al., 2014; Schifter & Cipollone, 2013; Wendel et al., 2013). While computer-aided design (CAD) tools, such as Sketch or AutoCAD, requires a considerable amount of training before students can use the functions to design structures, Minecraft is relatively simple to use. Moreover, the game-like environment of Minecraft would also promote students' engagement in the creative project of this study. In this manner, students would be able to focus on designing the green building rather than trapped by the complicated functions of CAD software.

Before the start of the creative project, the instructor introduced the green building to give students the basic ideas for they can apply to the project and further collect more information when designing the green building. Students had three weeks to work on the creative project. To document students' interaction, an asynchronous discussion board were setup for each group. Each group had a dedicated discussion board and was asked to discuss the creative project on the discussion board. After three weeks, all the messages on the discussion board were retrieved for further analysis. There were 1109 messages in students' three weeks discussion.

2.2 The assessment of the creative performance

Previous creativity studies usually assess the creativity performance of individuals by asking them to come up with ideas of how one can use rubber bands or bricks. Then, the creative performance would be assessed by several indicators, such as the creative fluency (the number of ideas generated), cognitive flexibility (the extent of the diversity of ideas generated), and the originality (Torrance, 1965). Nonetheless, this approach might not be adequately translated to their creative performance on particular creative tasks. Another approach is to assess the creative performance by evaluating the creative outcome (Amabile, 1983). Echoing this notion, Besemer (1998) proposed Creative product analysis matrix (CPAM) to assess the creative performance of creative products, There are three components of CPAM, namely the *novelty*, which reflects the newness aspects in a product, the *resolution*, which denotes how well the product does what it is supposed to do and the *elaboration and synthesis*, which represents the aesthetic and level of details of a product. This study adapted CPAM as the framework to assess each group's project outcome using conclusive measures for each measure. In the preliminary stage of this study, each group's creative project performance was evaluated by one expert who is knowledgeable of the green building and familiar with Minecraft.

2.3 The procedure of QCA and LSA

This study employed a novel approach to depict the creative process in the learning activity. In specific, this study was to explore the content structure and behavioral patterns of students' interaction on the green building design project. Therefore, quantitative content analysis (QCA) and Lag sequential analysis (LSA) were employed to analyze the retrieved message (Bakeman & Gottman, 1997; Gunawardena, Lowe, & Anderson, 1997). QCA begins with a pre-defined coding scheme. Previous studies have proposed coding schemes, such as Interaction analysis model (IAM), Revised Bloom's Taxonomy (RBT), to analyze learners' online discussion; nonetheless, to the authors' best knowledge, there is no specific coding scheme to depict the creative process. Therefore, we developed a coding scheme to delineate the creative process by reviewing previous creativity literature (Botella et al., 2013; Feldhusen & Ban Eng, 1995; Nemiro, 2002; Treffinger, 1995). In this study, we decomposed the creative process into five phases and assigned a code to each phase. The five phases are (1) Understanding the problem (Cre1); (2). Divergent exploration (Cre2); (3) Idea generation (Cre3); (4) Selective focusing (Cre4); (5) Idea development and evaluation (Cre5), respectively. In addition, we assigned two codes to represent the off-topic discussions. Cre61 denotes off-topic discussion that involves casual social interaction, such as greeting. Cre62 refers to off-topic discussion that involves encouragement, promoting team morale, which is considered a factor that could promote positive teamwork climate (Abedin, Daneshgar, & D'Ambra, 2011). To conduct QCA, we invited two experienced coders jointly coded the retrieved messages using the coding scheme to ensure the reliability of the coding results. Kappa coefficient was calculated to assess the inter-rater reliability. The Kappa coefficient of the coding results is 0.72, suggesting high inter-rater reliability (Rourke & Anderson, 2004). The coding results of each group were arranged to represent the distribution of their discussion on each phase of creative process. With the QCA results, this study further conducted LSA to analyze the behavioral patterns of learners' interaction. LSA can be used to determine the statistical significance of a behavioral sequences, or the sequential order of the appearance of behaviors. In other word, LSA is used to determine an observed sequence, i.e. the appearance of one specific behavior followed by another specific behavior, is not a outcome of random chance. LSA begins with a series of matrix calculations (Bakeman & Gottman, 1997), which are the calculation of (1). sequential frequency transfer matrix; (2). condition probability matrix; (3). expected-value matrix. Next, the significance level of each behavioral sequence would be determined by calculating Z-score using previous matrices. Based on the Z-score table, the last step is to draw a sequential transfer diagram for depicting the significant sequences using the data in the z-score table. Only those behavioral sequences with z-score higher than 1.96 was considered as significant ($p < 0.05$) and depicted in the sequential transfer diagram.

3. Data Analysis and Results

3.1 Results of QCA

The distribution of QCA results of each group is as shown in Table 1. Regarding the level of engagement in the learning creativity, group 4, 6, 8 participated the online discussion more frequent than other groups in terms of the number of message posted. Nonetheless, group 10 is of the lowest level of participation among all groups. In fact, this group didn't work on developing ideas in the discussion board. This study thus excluded group 10 for subsequent analysis. Overall, students' discussions were mostly on 'idea development and evaluation (Cre5)' and 'Off-topic casual social interaction (Cre61)'. In the learning activity of this study, the instructor gave students clear goal, which was to design a green building for a family with children. As the results of QCA showed, these students generally jumped to the idea development phase without seeking references or explore other possibilities. This could limit their creative performance. On the other hand, the large number of casual social interaction is a common phenomenon in asynchronous online discussion (Lin, Hou, Wang, & Chang, 2013). Nonetheless, by giving students clear discussion topic and rubric for grading their performance, student could more focus on meeting the goals of each phase.

Figure 1: The project outcome of the group 1

Figure 2: The project outcome of the group 6

As to the diversity of the distribution of QCA, Group 1 and 3 showed more diversity than other groups. Group 5 to 9 showed quite similar patterns as their discussions were mostly on developing the ideas and off-topic social interaction. In the creative performance assessment, group 1 showed more distinct elements in their project outcome, such as a garden and waterfalls on the roof to reduce the heat from sunlight that would raise the room temperature. Group 1 received high score on the *resolution* dimension. Nonetheless, group 1 didn't get high score on *elaboration and synthesis* dimension. This finding might attribute to their lower amount of discussion in comparison with other groups. Figure 1 showed a screenshot of the project outcome of group 1.

On the other hand, the project outcome of group 6, which has the highest number of 'idea development and evaluation', received the highest score on the elaboration and synthesis dimension as the green building they designed was relatively larger than other groups. And the decoration of the building is more detailed in comparison with the project outcomes of other groups. Figure 2 showed the screenshot of the project outcome of group 6.

Table 1: The results of QCA

	Cre1	Cre2	Cre3	Cre4	Cre5	Cre61	Cre62	Total
G1	1	7	9	1	29	49	2	98
G2	0	0	0	2	60	68	10	140
G3	0	5	4	0	31	31	4	75
G4	0	0	3	1	32	118	3	157
G5	0	0	2	0	38	28	4	72
G6	0	0	0	1	98	73	9	181
G7	0	0	0	0	58	56	2	116
G8	0	0	0	0	85	71	3	159
G9	0	0	0	0	39	58	0	97
G10*	0	6	0	0	0	8	0	14

*: Group 10 was excluded from the further analysis due to low level of participation.

3.2 Results of LSA

In general, all groups showed behavioral continuity patterns of 'idea development and evalution (Cre5)' and 'off-topic discussion (Cre61, Cre62)'. This finding suggested students could focus on developing the idea. Nonetheless, students' discussion could easily go to off-topic. This finding is similar to previous studies, which used online discussion as tool to support students' interaction (Lin et al., 2013).

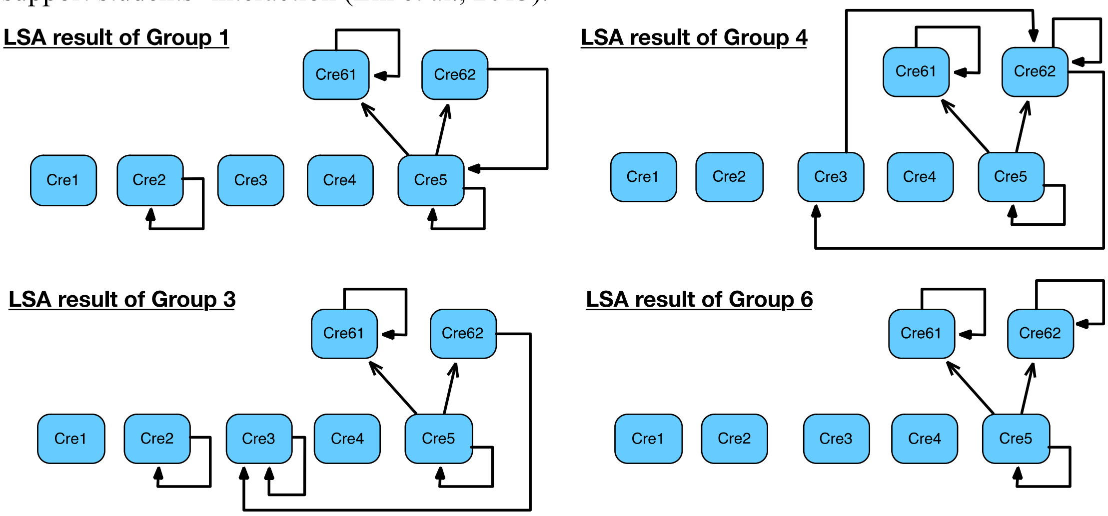

Figure 3: LSA results of selected groups

As for the patterns of particular groups, group 1 showed the most diversified interaction patterns, which is as shown in top-left panel of figure 3. In specific, behavioral continuing patterns were observed in 'divergent exploration (Cre2)', 'idea generation (Cre3)', 'idea development and evolution (Cre5)' as well as 'off-topic discussion (Cre61, Cre62)'. We also observed a behavioral transition pattern from Cre5 to off-topic discussion (both Cre61 and Cre62). It is worth noting that group 1 showed a behavioral transition pattern from Cre62 to Cre5, suggesting when developing the ideas, the group members would give each other positive affirmation of the contributions to the project. Previous studies suggested that this kind of social interaction is helpful to promote the positive teamwork climate, which is considered beneficial to the team performance (Abedin et al., 2011). Similar patterns were also found in the results of LSA of group 3 and 4. As shown in figure 3, we observed a behavioral transition pattern from Cre62 to Cre3. Group 4 in particular, we found a loop from 'idea generation (Cre3)' between 'positive affirmation (Cre62)'.

Similar to the results of QCA, the results of LSA for Group 6 to 9 showed similar patterns. For an example of group 6, which is as shown in Figure 3, behavioral continuity patterns of 'idea development and evaluation (cre5)' and 'off-topic discussion (cre61, cre62)' were observed. Meanwhile, behavioral transition patterns of 'idea development and evaluation (cre5)' to 'off-topic discussion (cre61, cre62)' were observed. These patterns were also found in group 7, 8, 9.

4. Conclusion and subsequent research

The primary purpose of this study was to propose a novel approach to delineate the creative process of a collaborative creativity learning activity. In this study, a learning activity of designing a green building was employed. Students were asked to discuss in the asynchronous discussion board. Afterward, all the messages were retrieved and analyzed using QCA and LSA from a process perspective. This study developed a coding scheme to depict the phases of a creative process as well as off-topic social interaction. Our major findings and its discussions are summarized as following.

First of all, in general, the QCA results of the current study lacked of diversity in terms of the creative phases. Most of the discussions were on 'idea development and evaluation (Cre5)' and 'off-topic discussion (Cre61 and Cre62)'. This finding could be attributed to that this study employed the learning activity in a natural setting without specific instructional strategy as guidance. In specific, the instructor only gave students the project goals and the context to design a green building for. Without adequate creative thinking skills at hand, students could jump to developing the green building immediately in order to achieve the project goal. Nonetheless, previous studies suggested that by giving students creative thinking techniques and adequate guidance to walk through the phases of creative process, students would be more able to produce better creative outcomes. The results of this preliminary work can be compared with those of future research that employs creative thinking instructional strategies, such as creative spiral (Resnick, 2007), or creative problem-solving (CPS) (Treffinger, 1995). In this vein, we would be able to delineate an effective creative collaboration process that thus can be used in science education or technology development. Therefore, students would be able to employ creative thinking to solve the ill-structured problems or technology development. Secondly, we observed a significant amount of off-topic social interaction in students' discussion. This phenomenon was frequently observed in online discussions (Lin et al., 2013). As casual social interaction requires less cognitive effort, student would easily turn to discuss things that are not related to the project. This situation could be alleviated by providing specific rubrics of the learning activity or collaboration script, which could be helpful to keep students on the track (Lin et al., 2013; Weinberger, Kollar, Dimitriadis, Mäkitalo-Siegl, & Fischer, 2009). Lastly, casual social interaction might not necessarily be detrimental to group members' collaboration on the project. On the contrary, casual social interaction could be a facilitator to form a positive knowledge sharing climate (Abedin et al., 2011) and was considered as a key to promote collaborative creativity (Sawyer, 2007). A free and relaxed environment that enables frequent casual social interaction could cultivate the creativity. Despite this preliminary study found a patterns from casual social interaction (Cre61) to idea generations and idea development (Cre5). Nonetheless, how casual social interaction could contribute to the collaborative creativity still requires further exploration. Future study could employ the process-oriented approach that this preliminary study introduced to analyze the relationship between the guided creative collaboration process and its creative outcomes to better understand the creative interaction patterns.

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Non Numerical Aspects of School Mathematics

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Abstract: In this short paper, we describe issues resulting from a lack of clarity in understanding the nomenclature of *numeracy* in mathematics education at the school level and consider some of the underlying foundational structures of mathematical thinking. The purpose of the paper is to open a conversation about shifting the focus from the narrower conceptual boundaries concerning *numeracy* by considering theoretical perspectives that describe mathematical thinking as a form of *intelligence* on the one hand, and as a *skill* within the paradigm of 21st century skills, on the other. We identify a number of questions to be considered in teaching mathematics and specifically in contexts where digital technology is utilised.

Keywords: STEM, mathematics, digital technology, sense-making, 21CC

1. Introduction

> When instructions for a task are too directive, then it may be possible to carry them out without actually encountering the intended ideas behind the task.
> (Mason & Johnston-Wilder, 2006, p. 29)

As opposed to solving an issue or problem using rules, a key purpose of mathematics education is to enhance student cognitive ability to connect the non-numerical aspects of the process and enable application of this learning in other situations. It is this aspect of mathematics, however, that is often not effectively conveyed, either explicitly or implicitly, at the school level of the discipline.

The purpose of this paper is to provoke discussion that could assist in shifting focus from *numeracy* – a term given far too much emphasis as a proxy for basic mathematical ability – to other aspects of cognitive facility associated with mathematics at the school level.

Intended learning may fail to be achieved for many reasons and if the purpose of the mathematical tasks is confined or limited to 'solving', rather than 'learning from solving', it is likely that learners may neither learn nor enjoy engaging with the problem. Focusing merely on the numerical aspects of mathematics and problems does not create opportunities for students to generalize the situation in order to apply the mathematical learning in other contexts. Differences in perceptions between teachers and students regarding the purpose of a task may also exacerbate non-effectiveness in the performance of the tasks.

As Stein (1987) has famously pointed out, the intention to 'teach thinking' can easily turn into a set of instructions so that learners do not have to think.

The main purpose of the paper is to provide an overview of issues resulting from an over emphasis upon numeracy in school mathematics education and to consider some of the underlying foundational structures of mathematical thinking. Conveying a sense of the range of thought processes available when working within a problem can help children engage with the logic and ideas which is arguably more at core of mathematics teaching. Doing so could bring the focus back from the algorithmic processes, numerical memorization, and rote learning aspects to a richer palette of sense-making, abstraction, and inquiry. In the words of Anderson (2001): "In trying to connect mathematics with what is learnable, we have disconnected school mathematics from what is genuinely useful."

Now that we are mid-way through the second decade of the 21st century it is also timely to consider how numeracy and mathematics education relate to the discourse on *21st century skills* or *21st century competencies* (21CC). This discourse has arisen largely as a consequence of ongoing innovation in digital technology and the proliferation of networks (global and local) as an organizing principle of society that cuts across most political configurations. The key question here is: *how do mathematical thinking and numeracy skills fit within the various frameworks of 21st century skills?*

2. Numeracy – a Misnomer?

2.1 Origins

The term *Numeracy* was first used in 1959 in *The Crowther Report* developed by the Central Advisory Council for Education (England) to consider the changing social and industrial needs of society and, in particular, to consider the balance at various levels of general and specialized studies between students aged 15-18, and to examine the inter-relationship of the various stages of education.

Numeracy had been defined as a term with similar utility to that of *Literacy* – as a means of thinking about the world in a quantitative way, to realise problems as problems of the degree even as they appear to be problems of the kind, and to point toward the scientific approach to the study of phenomena: observation, hypothesis, experimentation and verification. Justification for this was articulated by Cockcroft (1982) as: "Statistical ignorance and statistical fallacies are widespread and quite as dangerous as the logical fallacies that come under the heading of illiteracy" (p. 11).

This early definition thus encompasses metacognition and logical understanding. Since then this term has attracted alternative definitions numerous times with several related terms having been devised to replace it, e.g., Mathematical literacy, statistical literacy, mathematical skills, working mathematically etc. (Cavanagh, 2006; Jablonka, 2003; Hoyles, Wolf, Molyneux-Hodgson, & Kent, 2002; Kilpatrick, 2001; Wallman, 1993).

A simple search on Google reveals that a common interpretation of this term is *the ability to understand and work with numbers*. The Australian Curriculum defines Numeracy as "the ability to recognise and understand the role of mathematics in the world and having the dispositions and capacities to use mathematical knowledge and skills purposefully" (Numeracy, 2012). In the United Kingdom being Numerate means having the confidence and skill to use numbers and mathematical approaches in all aspects of life (National Numeracy, 2015).

With the proliferation of different definitions the word Numeracy can become quite subjective. For some people it may mean being able to do number operations, being able to do budgeting, being competent with shopping, or performing practical tasks that involve numbers. Some decades ago Riley (1984) analyzed the term and found that it had been distorted and over-simplified. Penny (1984) also questioned the definitions surrounding and she pondered whether the term might mean a checklist of coping skills. In her view, the term should reflect the ability to understand and use mathematical skills as a means of communication closely linked to individual needs. Castle (1992) also observed that approaches to teaching numeracy tend to place emphasis on coping and survival skills and on the needs to accommodate prevailing social and economic circumstances rather than pursuing social change through questioning and challenging structural inequalities.

It is significant to note that the various frameworks associated with 21st century skills or 21CC do not offer re-conceived notions of *numeracy* for the digital age; however, they do this for *literacy* as "information literacy", "technological literacy", and "ICT literacy" (Griffin, McGraw, & Care, 2012; Voot, et al., 2013; Hanover, 2011). Arguably, however, the presence of *critical thinking* and *problem solving* within this discourse – while not explicitly invoking mathematics – can be seen as foundational aspect of mathematical thinking.

2.2 What numbers mean and what lies beyond?

Several research papers on mathematics include in their title '*Beyond the numbers'* (Greenhalgh, & Taylor, 1997; Yoder, 1994; Slovic, 1991; Marr, & Hagston, 2007). However, this has not been the subject of much research in Mathematics Education at the school level.

On one hand numbers quantify, express and explain a measure of quantities while on the other they are just symbols expressing abstractions of the commonality of objects that have the same count. It is important to see beyond the number symbols and understand the generality they express.

In all school curriculums the aspects of literacy and numeracy are integrated and interlinked and in order to understand the rules and learn to apply them it is necessary that we deconstruct the relationship between language, numbers and literacy so we can then focus on distinctive aspects of mathematics teaching and problem solving.

Thus, even in the simplest of the examples with minimal language and maximum numerical involvement such as 13 + 5 =? or 4 x 7 =? the idea that needs focus and clarity in student minds is the *purpose* of these questions – students need to make sense of mathematical statements and symbols, which is not the same as memorization nor just rote learning of the rules. The purpose may be communicated implicitly by asking:

- What is the meaning of these operations?
- Can these problems be relevant?
- In which situations may these be relevant?
- Why do we need to know this?
- What other ideas can we extract from these? (e.g., 13 + 5 = 5 + 13; or 4 x 7 = (2+2) x 7)

The next level of thinking may begin from questions like: *What if ...?* for example: *what if ... 12 + 1 = 1? In what circumstances might this logic hold true?* Such a problem intentionally collides with conventional common sense yet in mathematics such a problem may lead to ideas such as clock arithmetic which, in turn, may mark modular arithmetic making sense later in the curriculum.

As teachers, we need plan to teach and think: what are the ideas that numbers or numerical data cannot or do not capture in the problem as stated?

From a theoretical perspective, Gardner (1983) offers useful perspective in defining "logical mathematical intelligence" as one of seven types of intelligence and a term to describe the capacity for analyzing and solving problems logically, performing mathematical operations, and to think scientifically while also engaging in activities such as pattern recognition, abstract modeling and computation. By focusing upon *intelligence* as a disposition as well as something to be cultivated Gardner brings to the fore both breadth and depth to mathematical thinking – way beyond numeracy.

3. Context, Connections and Experiences

There could be a range of situations where the development of this behaviour (to see beyond numbers) would enable students to function more effectively. Government policies, taxation, climate change and health issues all need a conscious understanding to discover what lies beyond displayed numbers. A genuine understanding requires a critical view that can only be developed if an explicit training is provided so that we do not get overwhelmed by the amount of tables, graphs and large numbers used to explain as well as persuade. For example, statistics and trend graphs are often presented in political contexts in ways that can prevent us looking beyond, and people believing them as factual without questioning their qualitative nature.

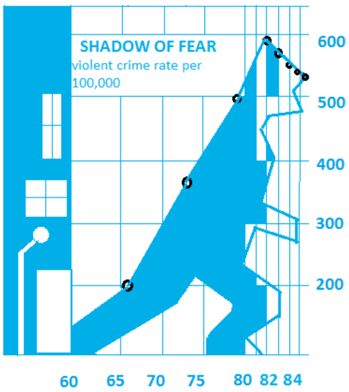

Figure 1. Rising Crimes 1 (OECD, 2009)

A better understanding of the underlying structures and the role of contextual factors can only be arrived at by improved mathematical thinking, along with an understanding of the nature of the situation in which numbers are being applied or drawn from. A good example that depicts this is from the International PISA 2009 Assessment Framework (OECD, 2009, p. 103), as shown in Figure 1 and Figure 2 where the same data is used to convey different messages.

Figure 1 shows the number of reported crimes per 100,000 inhabitants, starting with five-year intervals, then changing to one-year intervals. From this graph the following question is suggested as a task for students to answer: *How many reported crimes per 100,000 were there in 1960?* Using the same data manufacturers of alarm systems produced the graph in Figure 2:

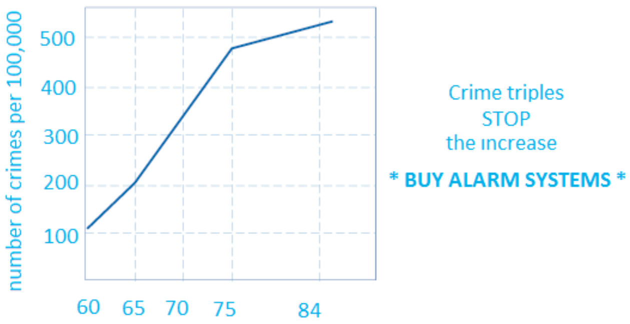

Figure 2: Rising Crimes 2 (OECD, 2009)

A follow-on question is posed: *How did the designers come up with this graph and why?* The police were not too happy with the graph from the alarm systems manufacturers because they wanted to show how successful crime fighting has been. It is then suggested that students be set a task to design a graph to be used by the police to demonstrate that crime has decreased recently. These figures provide an excellent example of the critical relationship between data, context and sense that mathematics in our classrooms needs to provide. It's about making a conscious effort to see what is not shown.

3.1 Conscious questioning - that uses no numbers

Does the articulation and scaffolding of mathematical tasks provide opportunities to students to apprehend vocabulary, definitions, data and numbers and refining these 'seeing' aspects of a problem situation into 'thinking' 'understanding' then 'solving' and then 'connecting' cycle? What questions need be asked to enhance these abilities? Indeed, such questions beg a deeper question concerning the nature of inquiry – *in what ways do or can our students make sense of mathematics?* And, in an era where digital technology is a given, though typically dominated by a "search paradigm" (Mason, 2014), *how can our digital tools be used effectively in ways that promote student questioning?*

3.2 What constitutes mathematical thinking?

Mathematical thinking often begins with some vague questioning to inquire about a situation in order to understand the context. The process of inquiry and answering cycles moves in a particular way in which exact and precise connections within language, symbols and syllogism are maintained. Ideally, no assumptions are made about the unknown and unproven. It is best described in the following tale.

> An Astrophysicist, a physicist, and a mathematician were on a train heading north and had just crossed the border into Scotland. The Astrophysicist looked out of the window, saw a black sheep and said "Look! Scottish sheep are black!" The physicist said, "No, no, you are wrong! At LEAST ONE Scottish sheep is black." The mathematician looked irritated. "Both of you are not right in your observations!! There is at least one field in Scotland, containing at least one sheep, of which at least one side is black." (Anonymous)

This short joke has been used many times to convey that mathematics is a precise branch of science – it cannot proceed without evidence or precision. Computers are likewise precise in the way they operate and they are certainly less forgiving than people are in daily discourse. Yet, for mathematics education, they also need to deal with semantics and syntax in ways that extend beyond daily conventions of sense-making and, in some senses, perhaps be more forgiving.

4. Digital Technology

Technologies in the form of talking drums, pen and paper, or the Internet have all been instrumental to human communication and the evolution of education (Gleick, 2011). In a word, technology has generally made it easier for communication to proceed even though technological innovation has not always been welcome. Debates about the use of digital technology in mathematics education have taken many forms and in recent decades the efficacy or otherwise of slide rules, calculators, laptops and the Internet in developing mathematical skills have all been challenged. Given that technology has made it easier to create illusions and hype through numbers, graphs and animated visuals, it is increasingly more important to consider the skills necessary for our next generation so they will not be misled and misdirected by such innovations. For example, ‘zoom in’ and ‘zoom out’ features may allow a change of perspective and context and if used effectively could assist students develop the power of imagination and seeing the unseen. The ability to translate and rotate may also help this perspective. Conversely, it is important that students realize that data collected and presented is never independent of personal bias and the context in which it is collected.

Generally, all school mathematics curriculums now require use of a range of digital resources and skills. They ask for the creative and effective integration of these tools to produce a challenging and creative mathematics syllabus. But what might the underlying assumptions be concerning digital technology? To what extent can mathematical thinking be scaffolded by technology? Questions concerning the scope of engagement with digital technology and its integration in developing curiosity and critical thinking also require investigation. Computers have the power to test conjectures, produce counter arguments, and execute fast calculations – seeing this power for what it is may enable students to start seeing beyond numbers to visualise the underlying mathematics could be highly motivating.

Thus, as we move through various stages of the digital revolution (from early forms of computer-based training to now include digital games, mobile devices, computer-aided explanation, learning analytics, intelligent computing, and numerous innovations in the design of software and applications) an increasing diversity of options is available for innovative educators to consider. For mathematics education, as well as STEM more broadly, the era of data-intensive computing sometimes described as the “fourth paradigm” of science has arrived – and it brings with it many implications (Hey, Tansley, & Tolle, 2009). In thinking about what might help shift the focus from numbers and numeracy is there a clue here? Given that the visualisation of data principally occurs as a result of mathematical operations do we now need to think of what might constitute “data literacy” within a STEM or mathematics paradigm for the 21st century?

5. Conclusion

One of the challenges for mathematics education concerns effective communication of its scope. While it is arguably the case that in early years of education foundational skill development based upon *numeracy* and *literacy* are essential there are other considerations as we move forward into 21st century teaching and learning – in particular, there many new skills are demanded that extend well beyond notions of numeracy.

In briefly considering theoretical perspectives that describe mathematical thinking as a form of *intelligence* on the one hand and as a *skill* within the paradigm of 21st century skills on the other, this short paper provides some basic parameters for shifting the focus on numeracy in mathematics education. While non-numerical aspects of mathematics can be thought of in terms of a capacity for abstraction, critical thinking, and problem solving, it appears that the scope of mathematics education could extend further. With data ubiquity now characterizing the age we live in what are the questions we must ask in order to precisely determine this scope? Might data literacy emerge as a form of mathematical thinking or an extension of notions of literacy?

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Integration of Reciprocal Teaching-ICT Model To Improve Students' Mathematics Critical Thinking Ability

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Abstract : This research examines the effectiveness on how mathematics teachers have begun to integrate information and communication technology (ICT) with reciprocal teaching model to improve students' mathematics critical thinking ability into seventh junior high school classroom practice. This study was experimental research with a quasi-experimental design. The samples of the study are 36 students for classroom experiments and 36 students for classroom control. The instruments employed in this study were pre-test and post-test. All the instruments are made in essays forms. The data were analyzed by using descriptive statistics. Based on the research findings, it was gotten that (1) the development of teaching instructional multimedia of the seven grade students of junior high school; (2) the improvement of students' mathematics critical thinking ability in experimental class; (3) the aspect of attractiveness shows that the developed instructional multimedia was very interesting; and (4) reciprocal learning has good impact on students' mathematics critical thinking ability.

Keywords: Reciprocal Teaching, mathematics critical thinking ability, ICT.

1. Introduction

Mathematics learning in junior high school especially in suburb Jakarta is still using conventional method. In teaching practice, the teacher only rely on the classical lecture method which most of the students are usually sitting and listening to the lecture. Moreover, the learning resources are limited to the text book and media are rarely used for improving learning quality. According to Syaiful Rohim (2014) that learning methods like this does not fulfill the principles of effective learning and empowering the student's potential. Based on the statements above, mathematics learning in junior high school needs both of the resources and learning practices to be changed in order to integrate ICT to improve the quality of learning.

Education has three objectives, namely cognitive, affective and psychomotor. Cognitive domain is the most important student psychological realm which is simultaneously controlling the source of affective and psychomotor. Jean Piaget underlying on the set of cognitive strategies called metacognitive theory that the skills possessed by students in organizing and controlling the thinking process. Metacognitive includes four types of skills, one of which is of critical thinking skills, individual skill in using his thinking process to analyze the argument and give an interpretation based on the perception that the correct and rational, analytical assumptions and bias argument, and logical interpretation (Sutikno, 2013). With critical thinking will produce right thinking, structured and intelligent in analyzing a problem.

Critical thinking is an important thing to be developed. There are several considerations to develop critical thinking, critical thinking is a mode of thinking about things, substance or matter whatever, where the thinker improve the quality of his thinking by skillfully handling structures inherent in thinking and implementing the standards on intellectual him. Carson (2007) said that the dichotomy implies that thinking and knowledge are mutually exclusive, when in fact critical thinking and problem solving require a great deal of specific content knowledge. Critical thinking is the way how a person uses his brain to think logically, structured and thorough in solving a problem.

Using fun with teaching ca assist students learn effectively in various models of learning. Learning with fun learning model that will encourage students to be more enthusiasm in learning, and teachers also will be easier to teach. Therefore every learning model will be a comparison of the results achieved by the students to measure how big the influence of the learning model used by teachers in teaching. Mathematics is one of the subjects that are considered difficult by most students, but it depends on how teachers can invite students to love math and make the math was easy for them that is by using learning models that are tailored to the material. Learning as a set of measures designed to support the learning process of students, taking into account the internal events that took place in the self-learners. Every source of learning in this world will produce useful knowledge for all those who study it (Sutikno, 2013).

2. Literature

2.1 Students' Mathematics Critical Thinking Ability

Critical thinking is the ability to think in an organized manner reasoning and evaluate the quality of a reason systematically and make decision confidently. Think critically consider and evaluate the information that ultimately enable students to make decisions actively. Critical thinking can be said to be a form of mental activity or human mind activity.

Critical thinking is an important thing to be developed in education in modern times. There are several considerations to develop critical thinking. This is because someone who develop a critical thinking is going to make it ready to face any circumstances to achieve the ideas of right and correct decision.

Krulick and Rudnick (1987) suggest that including critical thinking in mathematics test is thinking, questioning, connecting, and evaluating every aspect of a situation or a mathematical problem. That which include critical thinking in mathematics is thought that test, questioning, connect, and evaluate all aspects that exist in any situation in a problem (Fachrurazi, 2011). Critical thinking mathematical indicators used in this study are as follows:

a. Thinking Test (test) that provides precise results and in accordance with the procedures, find ideas in solving problems.
b. Questioning is finding the root of the problem appropriately, explaining a problem by presenting arguments there.
c. Connecting is that explain the differences / similarities of a problem, linking two objects that have some of the same properties.
d. Evaluation is considering the results and determine the value of the conclusions of the solution to the problems that have been obtained.

2.2 Reciprocal Teaching Model with ICT

Reciprocal Teaching was first described by Palincsar in her dissertation thesis in 1982 (Palincsar and Brown, 1984). The main purposes of Reciprocal Teaching is designed to improve reading comprehension. This teaching practice will be achieved by encouraging a group of students to work together to construct meaning and build understanding from a range of texts. Reciprocal teaching learning model is a model of learning that familiarize students using four independent comprehension. Reciprocal teaching is an activity where students talk with their teachers about the substance and meaning of texts they just read. Students are put in a position where they have to stay focused on what they read, so they are able to explain it to the class by using four strategies (they are listed below). While the teacher begins leading these discussions to show how it is done, they slowly reduce involvement so that students take the lead. They are then not only responsibility for reading the text but also for learning and teaching it.

As mentioned above, there are four main strategies used by students in reciprocal teaching: summarizing, questioning, clarifying and predicting. Students are instructed to go through each action after they read a segment of text. Below is a detailed look at each strategy. The reciprocal teaching strategy described by Palincsar and Brown, (1984), as follows :

a. Summarizing the essence and meaning of students and identifying the main idea of what they read;
b. Inquire means students ask themselves to make questions to ensure they understand their readings, thereby monitoring their understanding so that they are ready to start reading the material;
c. Clarify means students take steps to clarify parts of the text are confusing; and,

d. Predicting means that students anticipate what they might read next based on cues in the text and the ideas that have been presented.

3. Research Method

The research method used is a quasi-experimental design. In the quasi-experimental, the researchers are not allowed to take the subject randomly, however the researchers will be permitted to use the existing subjects who have been formed in the previous class. The main reasons that random group of individuals are not allowed is that it would disturb the Teaching and Learning Activities in schools. This research was conducted in two classes which has the same characteristics. The first class are called experimental class which is given special treatment, using the model of reciprocal learning and teaching – ICT model, while second class are called the control class which is taught by using conventional learning. Population in this study are all students of class VII which is approximately about 216 students of Junior High School 150 Jakarta in the second semester of academic year 2014/2015.

In control class teachers start the lesson by explaining the material of math and the problem of math which is related with their daily life, and the students act as a listener. In this class we called it as teacher oriented because the teaching and learning presented only by the teacher.

In experiment class we devided the class into small groups and the students are given question sheet by the teachers. The students have to read the text carefully and try to understand the text. And to help the students more understand about the problems which are given in the sheet, the teacher explain it by using attractive power point. After that the students make a summarize based on the problems which are given by the teachers. Then the students ask questions to the other group, facilitate by the teacher. Next teacher gives students' work sheet to the groups and they have to present the answers by using power point. The groups who present the power point in front of the class give a chance to the other group to ask questions and develop the problem based on the presentation. To answer the questions students have to examine the questions first and answer the questions by using the mathematical concept and to solve the problem accurately need to connect one concept of mathematical to the other mathematical concept, so the problem can be solved easily. When the students try to answer the questions they need to analyze it and this things are never done in conventional class.

4. Result

4.1 Students' Mathematics Critical Thinking Ability

The descriptive statistics research data shows that students' mathematics critical thinking ability in the experimental class which is taught by using Reciprocal–ICT model is presented in the following data:

Table 2: Descriptive of Students' Mathematics Critical Thinking Ability in Experimental Class

No	Indicators	Question Number	Total Score	the average score Of each number	Total Of each Indicator
1	Test Thinking	2	89	2.47	4.89
		3	87	2.42	
2	Questioning	4	81	2.25	4.72
		8	89	2.47	
3	Connecting	1	101	2.81	5.53
		5	98	2.72	
4	Evaluating	6	94	2.61	4.97
		7	85	2.36	
Total					20.11

The descriptive statistics research data shows that students' mathematics critical thinking ability in the control class which is taught using conventional model is presented in the following data:

Table 3: Descriptive of Students' Mathematics Critical Thinking Ability in Control Class

No	Indicators	Question Number	Total Score	the average score of each number	Total per Indikator
1	Test Thinking	2	65	1,81	3,61
		3	65	1,81	
2	Questioning	4	72	2,00	3,92
		8	69	1,92	
3	Connecting	1	83	2,31	4,08
		5	64	1,78	
4	Evaluating	6	77	2,14	3,72
		7	57	1,58	
Total					15,33

5. Conclusion

Based on above data we can say that the level of students' who are in experiment class by using reciprocal learning and the students who are in control class by using conventional learning are quite different because of several reasons. In experiment class students have a lot of chance to ask questions and develop the problems which are given, this things can make students think more critical. In this class both teacher and students are using attractive power point that can make the learning process more interesting. Thus, the researchers conclude that there was a significant influence on the model of reciprocal learning ICT-assisted teaching to students' critical thinking skills. Whereas the control class which are given the conventional learning make the students more passive and significantly are not shown the ability of ctitical thinking.

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Developing STS Projectile motion Unit for Providing Students' perception of the relationship between Science Technology Engineering and Mathematics

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Abstract: STEM education suggested that students should be enhanced to learn science with integration between Science, Technology, Engineering and Mathematics. To help Thai students make sense of relationship between Science, Technology, Engineering and Mathematics, this paper presents learning activities of STS Projectile Motion Unit. The developing of STS Projectile Motion Unit is a part of research that aimed to enhance students' perception of the relationship between Science Technology Engineering and Mathematics. This paper will discuss how to develop Yuenyong (2006) STS Projectile Motion Unit. The Yuenyong (2006) STS approach provided learning activities in five stages. These included (1) identification of social issues, (2) identification of potential solutions, (3) need for knowledge, (4) decision-making, and (5) socialization stage. The learning activities could be highlighted as following. First stage, we use movie of 'Conan the barbarian (human catapult)'. Second stage, students will need to identification of potential solutions by Create Catapult Model. The need of scientific and other knowledge will be proposed for various alternative solutions. Third stage, students will gain their scientific knowledge through laboratory and simulation of projectile motion. Fourth stage, students have to make decision for the best solution of designing and creating catapult model based on their scientific knowledge and others (e.g. mathematics, economics, art, value, and so on). Finally, students will present and share their catapult model in society (e.g. social media or exhibition) in order to validate their ideas and redesigning.

Keywords: STEM, STS, Projectile motion, Technological Process, Engineering Process Design

1. Introduction

Lifelong learning is a prominent public policy theme for many countries and non-governmental organizations for education, economic, political, social and cultural purposes. Education systems are expected to convey values that will help develop more just and inclusive societies; they must also provide a variety of learning experiences to train a competent and active citizenship, and ensure quality and equity in learning outcomes. The goal and vision of the Thai science education suggests that science teaching and learning should lay emphasis on the relationship between science, technology and society; and life-long learning (IPST, 2002). And, the goal also aims to provide students with the intrigued study in Science, Technology, Engineering and Mathematics. So students can use the knowledge in many subjects to solve the problem, research and improve many things in today world. All learning from all teachers is help to solve real problems and very life problems. All those problems need all the knowledge you have, not individual one. (Bernard, 2012; Siripattrachai, 2013)

Introducing students to learn science regarding the integrated concepts of science, technology, engineering and mathematics is rising across the world (Bernard, 2012). According to 21st century citizen decision making, the issues are related to science, technology, engineering, and mathematics. Therefore, STEM Education was recognized. Science is the subject that study from natural phenomena by scientific inquiry. Technology is the subject that applied all the subject to help solve the problems and also improving and developing to human need. Engineering is the subject that creative innovation and build many things to accommodate human by use the knowledge of Science, Mathematics and Technology to inventive. Mathematics is the subject that about calculation at this subject is very important foundation of education. Mathematics can be further in engineering. (Dejarnette, 2012; Bybee, 2010)

The literature suggested many possible activities of STEM Education. These included 1) Integrate Science, Technology, Engineering and Mathematics Content; 2) Link all the Science, 3) Mathematics and Technology to real world; 4) Engage in inquiry; 5) Project base; Apply Technology Strategically; 6) Focus on the skills of the Twenty first Century; 7) Building an awareness and participation in the community (Lungkhapin, 2013).

According to literature of activities for STEM Education, the authors were suggested how to provide the learning activities for physics in order to enhance students to learn physics on the relationship between science, technology, engineering, and mathematics. The 7 STEM guidelines activities (Integrate Science, Technology, Engineering and Mathematics Content; Link all the Science, Mathematics and Technology to real world; Engage in inquiry; Project base; Apply Technology Strategically; Focus on the skills of the Twenty first Century; Building an awareness and participation in the community) will be taken into account for physics leaning on the relationship between science, technology, engineering, and mathematics (STEM). It indicates that Science, Technology, and Society (STS) approach could support all these 7 STEM guidelines activities to provide physics learning activities on the relation between STEM.

The IPST has enhanced science teachers to teach science through engineering process design with aiming to provide STEM education in Thailand. They expected that scientific inquiry and designing for problem solving through engineering process design may allow students to integrate science technology engineering and mathematics for designing. This program has been launch since early year 2014 (IPST, 2014). The STS approach is another teaching approach that suggested science learning through technological or engineering process design (Soyjak, 2010). Therefore, the STS may provide student chance to learn science and creating some projects, volition, solutions with integration among science, technology, engineering and mathematics.

STS approach is learning that promotes inquiry scientific knowledge of social issues and technology in community, locality and world. (Yuenyong&Narjaikaew,2009; Chantaranima,2013) Therefore student will study the problem and also questioning on society and technology. Student is also self explanation by involvement of evidences in the communication, concept and reason and the way of comparison in the concept by strong of evidences before the determined of which way is important and not important of learning. It’s also integrated in to other study. This is the way of STEM Education work. Beside that the student will do research the science knowledge from the objective in society and technology. Student also make good work and integrated all the knowledge to STEM Education.(Yuenyong, 2006; Klahan & Yuenyong, 2012.)

Beside the knowledge in the Science, Technology and Society also integrated in to other knowledge’s that can be approved by the local expert. Also can letting student making project on open – ended problems by student own interest. This is the learning though the uses of real life and the local expert can be the guideline for student. Science, Technology and Society can help student with research, debate by listen to the expert. (Klahan & Yuenyong, 2012;Chantaranima, 2013)

2. STEM Educationand Engineering Design

The combination of the concept of Engineering Design and learning of Science, Technology and Mathematics is unique to STEM learning organization. As students are trying to learn, understand and practice skills in Science, Technology and Mathematics, they must have an opportunity to apply the knowledge gained to designing a product or a method to meet their daily life problem solving needs(IPST, 2013).

The Engineering Design Process (EDP) is about organizing ideas to improve decision making in order to develop high quality solutions and/or products to problems. The main ideas in successful instruction of the EDP are: students are engineers; teachers need to listen to students; and classroom environments need to change to properly enable learning through the EDP. Skills and abilities associated with engineering design for high school student consists of nine stages including: (1) The Identify need or problem (2) Research the need or problem (3) Develop possible solution(s) (4) Select the Best Possible Solution (5) Construct a prototype (6) Test and Evaluate the Solution(s) (7) Communicate the Solution(s) (8) Redesign (9) Completion decision.(see Figure1)(Hynes et.al., 2011).

Throughout this process, students are constantly evaluating and testing their ideas, repeating steps as necessary and sometimes even restarting from the beginning. Occasionally the original idea will have some initial overlooked flaw or a different approach may become apparent through work on the challenge (Hynes et.al., 2011).

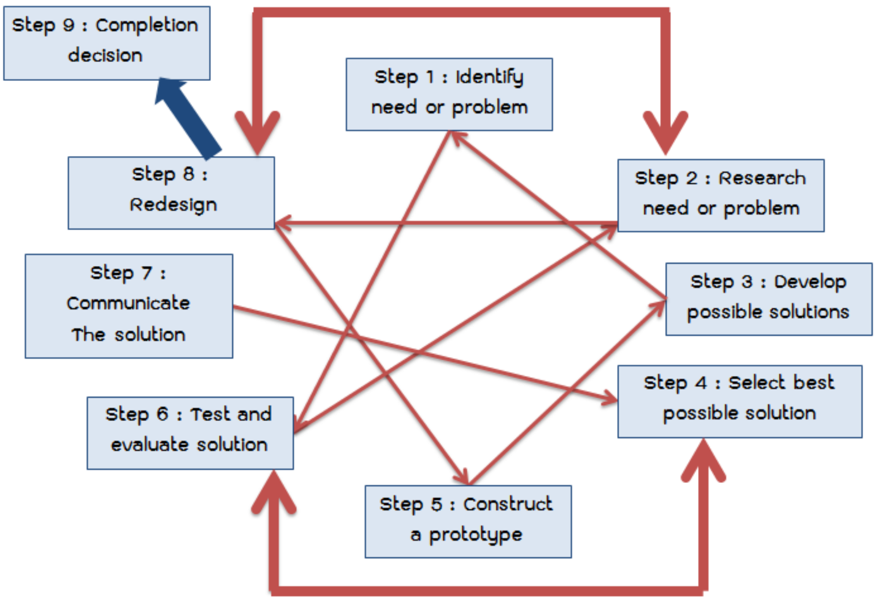

Figure 1: Engineering Design Process (Hynes et.al., 2011).

3. Science Technology and Society (STS) Approach and Yuenyong (2006) STS Projectile Motion Unit

According to the different and goals of STS there are several ways of attaining, objectives (Aikenhead, 1994). In this research, participants developed the STS unit regarding Yuenyong(2006)'s STS approach. Teaching and learning are started from society realm and moved to acquiring technology, science concepts and skills. Finally, students have chance to take action in society. Yuenyong (2006) developed science unit through STS approach that consisted of five stages including identification of social issues, identification of potential solutions, need for knowledge, decision-making, and socialization stage.

(1) **Identification of social issues stage.** This stage is designed to focus on student attention and attitudes also learning about Projectile motion. The STS instruction begins in the realm of society, social issue related to Projectile motion. These questions or problems of social issues need to be solved by citizens. For Projectile motion, the issue of the catapult motion and the social problem related Projectile motion should be brought into classroom by various strategies such as informing situation related these issues by posing on newspaper; posing the social questions related to for students to participate in public decision- making and seeing social problem by taking field trip.

(2) **Identification of potential solutions stage.** Students plan to solve the social problem related to Projectile motion. This stage supports students to concern with technological aspects for find the possible solutions. Technological aspects are skills to support student decision making. Students need to think of what, where, and how ideas, also design, systems, volition of application scientific knowledge work for that social problems. Teaching strategies may be used discussion among students' group, role-play brainstorming, searching information, via internet, and discussion with expert (e.g. engineers or scientists).

(3)**Need for knowledge stage.** This stage involves developing scientific knowledge. Social questions and technological knowledge can create science content. Projectile motion concept was formulated in many strategies to help students to understand the technology and social issues. The strategies, included reflection reading document provided by teacher, and lecture. Students will gain the understanding about projectile motion concept and the short quiz will be taken after class at this stage.

(4) **Decision-making stage.** This stage with student involves in making a decision on how to use Projectile motion knowledge and technology. This aspect public rhetoric about Projectile motion related technological and social issues. It's becomes dominates like 'chances and problem', 'advantages and disadvantages', or uses and abuses'. Student will be given chance to learn and choose between alternatives in a thoughtful way systematically comparing as many relevant pro's and con's as possible. Teaching strategies may be used discussion among students' group, role-play, and brainstorming to allow students designing the possible solutions.

(5) **Socialization stage.** Students need to act as people who are a part of society by reporting their proposal for solving problem. Student might exhibit their solution in public by making poster, write newspaper article or science project(Klahan & Yuenyong, 2012).

Summary; an important learning activities based on the concept of Science, Technology and Society (STS) is help to improve students' learning behavior in self learning. Also, focus on problems in a present situation. The concept of Projectile motion in which the contents are related to the daily life learners. The physics learning about Projectile motion would allow students to learn physics on the relation between concepts of science, technology, engineering, and mathematics. Because human lives each day, are related to the phenomenon of movement and things all around. In the learning subject Projectile motion of physics, are three learning objectives including (1) can describe the phenomenon, (2) solve problems in daily life and (3) apply to subjects of Engineering, Technologies and Mathematics.

3.1 Developing STS Projectile motion Unit

Lesson plans, the concepts based on Projectile motion, Science, Technology and Society of Yuenyong (2006) with aiming to students to learn physics on the relation between concepts of science, technology, engineering, and mathematics. It is a step in creating and developing the following:

1. Study Principles, Goals, Visions, Standard measure and indicator. The Content and documents which are related to create a lesson plan follow science courses in the Basic of Education Core Curriculum 2008, in Projectile motion of ten grader students.

2. Create a Lesson plan on concept of Science, Technology and Society (STS) by using the STS approach of Yuenyong(2006).

-**Identification of social issues stage:** on this stage, students must be aware of the social problems due to science and technology, and also grateful that he got involved to help solve the problem.

- **Identification of potential solutions stage:** students will recognize social problems due to science and technology. At this stage, students will need to answer the problem on planning by the knowledge of their existence and planned to seek additional knowledge that will encourage students to find out the answer.
- **Need for knowledge stage:** At this stage, students will need to study the scientific knowledge related to the problem.
- **Decision-making stage:** on this stage, the students will use classroom knowledge to review the guidelines to solving and hand on the problem.
- **Socialization stage:** Socialization stage, reflected in the students review of concept and valid through social process. At this stage, students will present a scientific exhibition project or campaign.

3. Present the Thesis to advisors.
4. Improve Lesson plans based on the guidance of advisors.
5. Recreated lesson plan, also present the experts for revision.
6. Improve lesson plan based on the recommendations of the experts.
7. Lesson plan use with students who are not the target group.
8. Implement adjust lesson plan for further improving.
9. Implement Lesson plan adjusted to the target group students.

Table 1: Learning management plan of Yuenyong (2006) STS *Projectile motion* Unit

Stage	Activity
Identification of social issues stage.	Students watched movie about "Conan the Barbarian(Human catapult)"It is a social issue which relationship with Projectile Motion. This movie, Catapult will be used to shoot objects to a destination in the Projectile Motion.  **Figure 2**Conan the Barbarian(Human catapult) Questions for Students: 1. In Movie, how does Catapult shoot? 2. If students will create Catapult, how do you create? Teacher will set the activity, and let the student solve this problem on paper. Student will design and create Catapult by used scientific knowledge in Projectile motion.
Identification of potential solutions stage.	Students will need to identification of potential solutions on identification of social issues stage **"Create Catapult"** First, Students will create questions on knowledge **"Create Catapult"** Then each group brainstorm together to review prior knowledge:"What knowledge can be used to solving the problem?".Moreover, Students create an unknown knowledge question and further research.
Need for knowledge stage.	Teacher set exploration activity and explanations to application for **"Create Catapult"** by **Activity 1: Coins' Fall Demonstration.** Teachers demonstrate a Coins' Fall to study about Coin A's motion and Coin B's motion when it was pushed to the ground. For demonstration, teachers set Ruler, Coin A and Coin B follow figure 3. Next, teachers' right hand press center of ruler and teachers' left hand fast push ruler (see figure 2). Teacher and Students observe and discuss together about "What will happen when teacher fast push ruler?"which is related with **Motion in Gravity Field and Projectile Motion.** Moreover, teachers explain knowledge about **Projectile Motion.** The purpose of this demonstration is 1) to study the projectile motion of object. 2) To study relationship between the Motion in Gravity Field and Projectile Motion. And 3) this demonstration is basic for Projectile motion learning to "Create Catapult".

<table>
<tr><th>Stage</th><th>Activity</th></tr>
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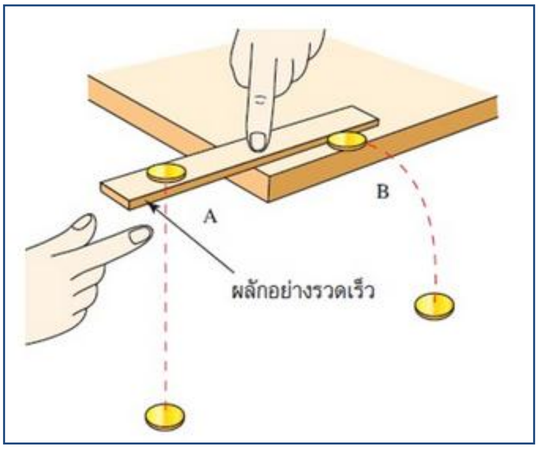

Figure 3 Coins' Fall

Activity 2: Class Discussion I

After students learned in Activity 1. Next step, They will be Class Discussion about projectile motion as flat and horizontal axis, displacement and velocity for each position of projectile motion, and net of velocity in projectile motion. Teacher, then, try to enhance student to apply these knowledge for creating catapult that was raised in the identification of social issues stage.

Activity 3: Projectile Simulation Lab

The purpose of this Lab is 1) to study Velocity and Angle of object in the projectile motion.2) Apply knowledge to create Catapult.

First Step, Teacher asks the following questions in order to engage students to identify the problem of projectile motion experimentation in simulation lab.

1) If you shoot object in projectile motion which have difference of initial velocity, how will displacement change?
2) If you shoot the object in projectile motion which has the same initial velocity but difference of angle of motion, how will displacement change?

Second Step, students start to do simulation lab to find solutions of problems of projectile motion. The simulation lab was provided as shown in figure 3.

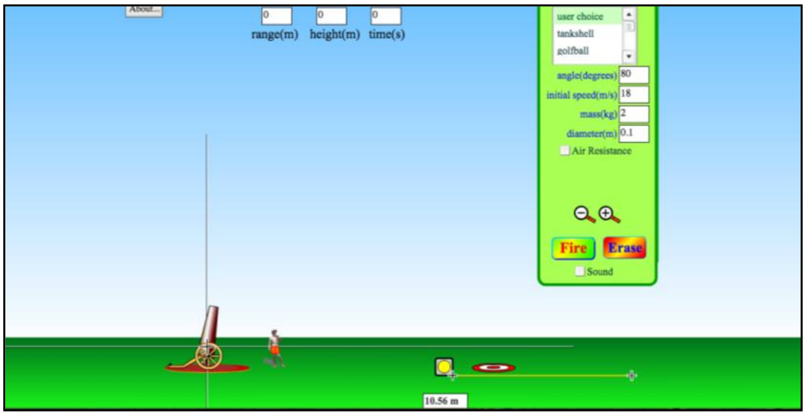

Figure 3 Example Program Projectile Simulation Lab

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Stage	Activity
	Activity 4:Class Discussion II After students learned about Projectile Simulation Lab. Next step, They will discuss about how to explain the projectile motion from the initial to the end of motion at the flat axis. Teacher may enhance students to apply this knowledge for finding some solutions of the problem of creating catapult that was raised in the first stage of Yuenyong (2006) STS – identification of social issues stage. **Activity 5: Mathematical Calculations Problem Solving** Teacher provides activity of calculation about projectile motion. These include: • Exercise about net total of velocity and Instantaneous velocity in projectile motion • Calculation of net total of velocity and Instantaneous velocity in bullet motion when it travels as projectile motion from the Catapult.
Decision-making stage.	Each group work together to make decision on how to use knowledge of Science and Mathematics (Calculation). From Need for knowledge stage to create possible solution(s).Moreover, they work together again to make decision for select the Best Possible Solution. Next, hand on "Create Catapult" by on paper sheets.
Socialization stage.	Each group presents a"How to Create Catapult by step by step". By record it is a Video File and share it on facebook. This video will open for comments and ideas. Comments and Ideas will be revised and developed again to completion.

3.2 STS Projectile motion Unit and guideline of relationship between Science Technology Engineering and Mathematics.

How the STS Projectile motion unit provides students to learn physics on the relationship between Science, Technology, Engineering and Mathematics will be explained. Provided activities in each stage of STS Yuenyong (2006) will be clarified to show possible students learning about concepts of Science and Mathematics and process of technology and Engineering design.

From each stage of STS Yuenyong (2006), Students will use combination of the concept of Engineering Design, Technology (Problem solving) and learning of Science(Projectile motion) and Mathematics. As students are trying to learn, understand and practice skills in Science (Projectile motion)and Calculation in Mathematics, they must have an opportunity to apply the knowledge gained to designing and create a Catapult which are product or a method to meet their daily life problem solving needs through Engineering Design process(IPST, 2013) that consists of nine stages including: (1) The Identify need or problem (2) Research the need or problem (3) Develop possible solution(s) (4) Select the Best Possible Solution (5) Construct a prototype (6) Test and Evaluate the Solution(s) (7) Communicate the Solution(s) (8) Redesign (9) Completion decision.(see Figure 1)(Hynes et.al., 2011).

First, learning of Projectile motion through Yuenyong (2006) Science Technology and Society (STS) began with Identification of social issues stage. The Social issue was raised by the movie of "Conan the Barbarian(Human catapult)".This social issue, teacher set activity to Students will designing and create a Catapult by used scientific knowledge of Projectile motion. In this stage, students will identify problems which has consistent with "Engineering Design Process" on step one: the Identify need or problem.

Second, Identification of potential solutions stage, students will create questions on knowledge how use "Create a Catapult". Next step, each group brainstorm together to review prior knowledge: "What knowledge can be used to solving problem?".Moreover, Students create question to unknown knowledges and need further research.

Third, Need for knowledge stage, students study knowledge of science and mathematics(calculation) involving “Create a Catapult”on a learning resources such as books, magazines, and an internet. Furthermore, Teacher set exploration activity and explanations to apply for“Create a Catapult”.

Activity 1: Coins’ Fall Demonstration.

Activity 2:Class DiscussionI

Activity 3: Projectile Simulation Lab

Activity 4: Class Discussion II

Activity 5: Mathematical Calculations Problem Solving

Identification of potential solutions stage and Need for knowledge stage have relate with knowledge of Science(Projectile motion) and Mathematics(calculation).Moreover, both stage have relate with “Engineering Design Process” on step two: research the need or problem.

Fourth Decision-making stage, each group work together in making a decision on how to use knowledge of Science and Mathematics(calculation) from Need for knowledge stage and create possible solution(s).Moreover, they work together making decision for best possible solution. Next, hand on design Safety Road on paper sheets.

Found that “Decision-making stage” has relate with knowledge of Science (Projectile motion), Mathematics (calculation) and Technology.

Moreover, this stage as relate with “Engineering design” on step 3-5:

- Step three: Develop possible solution(s), each group apply knowledge from Need for knowledge stage to create possible solution(s).
- Step four: Select the Best Possible Solution. This step, each group work together in making a decision on select the best possible solution for “Create a Catapult”.
- Step five: Construct a prototype. After select the best possible solution, each group start“Create a Catapult”on paper sheets.

Fifth, Socialization stage, This stage, Students need to act as people who are a part of society by reporting their solving problem proposal (Klahan & Yuenyong, 2012). Student will exhibit their solution in public that “How to Create a Catapult step by step”. By record it is a Video File and share on Facebook. This video will open for comments and ideas. Comments and Ideas will be revise and develop again to completion.

Found that, this stage as relate with “Engineering design” on step 6-7

- Step six: Test and Evaluate the Solution(s). Students test a Catapult to fin
- Step seven: Communicate the Solution(s). There is a video for share comments and ideas.
- Step eight: Redesign. Comments and ideas will be revise and develop again to completion for “Create a Catapult”.

4. Conclusion

Development of the Yuenyong (2006) STS projectile motion learning unit probably give students chance to learn physics with integration knowledge of science, technology, engineering, and mathematics. Based on the activities of this unit seems to be provided students chance of interaction in the relationship of Science, Technology, Engineering and Mathematics into 2 groups. First, the unit provided activities for developing skills, abilities and knowledge such as projectile motion (scientific knowledge) and mathematics as a tool of physics explanation and observation. Second, the unit provided activities for creating some process or designing such as technological process and engineering process design. This instructional design show that the five stages of Yuenyong (2006) STS allow teachers to organize the activities as scientific inquiry with engineering process design when students try to find possible solutions of the social issues and then make decision to do their best solution.

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Revisit: Wide Field of View in Visualization

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Abstract: Science museums provide learning opportunities through exhibits using various kinds of media, but they also require providing a space and time environment that differs from that in daily life. Immersive displays have been used to exhibit virtual reality content in such learning facilities, and they can provide users with a sense of presence by incorporating a wide field of view. We created an immersive projection display for visualizing the Yatsu tideland, an area registered under the Ramsar Convention on Wetlands. We conducted an empirical study to compare different fields of view when a user moves around in the virtual world. The results of the subjective evaluation suggested that a field of view of 90 degrees would sufficiently provide a sense of presence in a non-stereoscopic view.

Keywords: Visualization, wide field of view, immersive projection display, subjective evaluation, tideland, science museum

1. Introduction

Learning facilities such as science museums provide visitors with learning opportunities that are enjoyable as well as informative. Exhibits based on real objects are typically displayed in science museums, and multimedia presentations with computers have been used for visualizing various types of content from digital archives (Hawkey, 2004; Clough, 2013). However, simply providing visitors with information on the exhibits is not enough, because museums are considered to be unique places where space and time differ from that in daily life (Bell, 2002). Museums have also tried to make learning compatible with enjoyment by creating learning environments that increase the visitor's interaction with exhibits. Interactive experiments have been found to be particularly effective ways for children to enjoy learning (Falk & Dierking, 2000; Adams, et al., 2004). However, experimental exhibits consisting primarily of play equipment result in environments that are only *fun*. A dilemma exists because such exhibits should not only be fun; they should also convey knowledge to visitors.

Many studies on educational technology have claimed that the learner's performance when using new media or systems is gained in the initial period of time when they were introduced for learning (Clark, 1983). Evidence on the learning effectiveness of new media or systems is typically obtained from a comparison with existing ones, and the opinions on the performance of new media or systems are often biased. Although the novelty effect has been treated as an artifact that should be removed in determining the learning effectiveness of new media or systems, it may work as a factor in increasing visitors' motivation to learn in museums. We believe that large displays such as tiled displays and immersive projection displays are capable of creating space and time environments that differ from those in daily life. Although much work has been done on immersive experiences in large displays, it has not yet been clarified what elements of the large displays affect the user's experiences.

One of the significant factors in achieving a *sense of presence* is considered to be the field of view. It is generally accepted that a wide field of view produces a feeling of immersion in a virtual environment (Patrick, et al., 2000; Lin, et al., 2002). Large displays covering a wide field of view have been introduced in many industries where the objective is to entertain the user, for example, in video arcade games and amusement park rides, so that users get a higher feeling of involvement in the activity they are taking part in. The individual gains on large displays have been measured in terms of task performance, for example, improving multi-window tasks, rich information tasks, and awareness of peripheral applications (Bi & Balakrishnan, 2009). Three-dimensional (3D) navigation experiments showed that a large projection display outperformed a normal-sized desktop monitor in task performance (Tan, et al., 2004). In the experiments, unfortunately, the large projection display had a projection area with a horizontal visual angle of less than 35 degrees, which was insufficient as a large display.

The performance of 3D interaction tasks involving elements such as travel and manipulation was measured by comparing a large display with a desktop monitor (Tyndiuk, et al., 2005). The results indicated that not all users benefited similarly from large displays, and the performance strongly depended on the interaction task. In task performance involving travel, it was found that the travel techniques dominate the task performance according to their appropriateness for the applications and depending on the combinations of techniques that are used (Bowman, et al., 2001). Although much research has focused on task performance, more work needs to be done to determine the individual gains in the sense of presence of large displays, because the sense of presence is not obtained from the task performance.

Since the development of the immersive projection display known as a cave automatic virtual environment (CAVE) (Cruz-Neira, et al., 1993), many systems have been applied as a visualization environment for research work. The typical CAVE system consists of four screens, in which three walls and a floor form a cubic screen. Stereoscopic images are projected onto each screen so as to be seamlessly seen from a user's point of view, achieving a wide viewing angle. In this paper, we describe our subjective evaluation of field of view in an immersive projection display, in which we compared a wide field of view using four screens with a narrow field of view using only the front screen. We developed an original application enabling users to move around in a virtual environment in the Yatsu tideland, an area registered under the Ramsar Convention on Wetlands (Ramsar), so they could learn about various kinds of migratory birds.

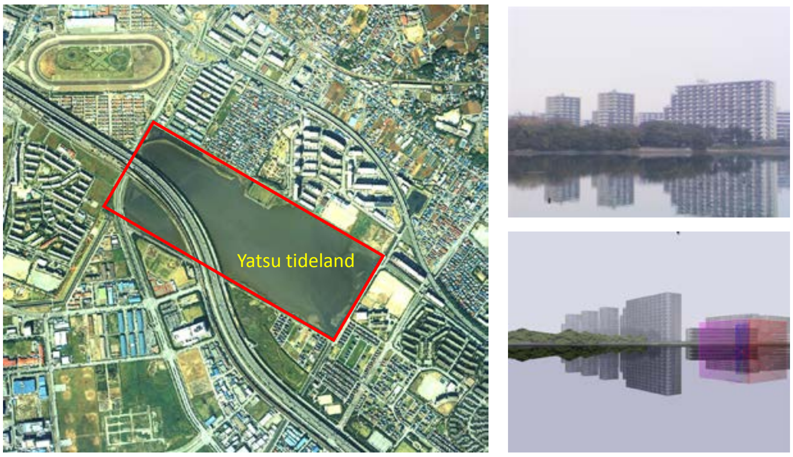
2. System

2.1 Yatsu Tideland

The Yatsu tideland is a 40-ha area located in Chiba, Japan. Chiba is adjacent to Tokyo bay, which had a huge tideland area in the years prior to 1960, when most of the tidelands were reclaimed for development to build industrial and residential districts. The rectangular area, shown in Figure 1 (a), was reserved due to the scarce habitat for migratory birds. The Yatsu tideland was registered under the Ramsar Convention on Wetlands in 1993.

Many kinds of waterfowl such as herons, ducks, and seagulls can be seen throughout the year in the Yatsu tideland. In recent years, large outbreaks of sea lettuce, a kind of green algae, have occurred because of water pollution. After the sea lettuce dies in summer, it decays. The decayed sea lettuce lowers the oxygen concentration of the water and mud, and this kills native animals and plants such as Japanese littleneck clams, hermit crabs, and ragworms. In addition, urbanization around the Yatsu tideland has drastically reduced the number of migratory birds. For example, in 1976, more than 1500 Kentish plovers were observed, whereas the number had plummeted to around 150 in 1996 (Ishikawa, 2001).

We believe that this environment would be useful material for learning about an ecological system. Because the Yatsu tideland still exists, students can actually observe migratory birds and other small creatures. Visualization of the Yatsu tideland in a virtual environment would enable students to learn more about its ecological system. That in turn would lead to deeper insights into the relationships between the food chain, urban development, climate change, and other factors through the virtual environment that could only previously be experienced in the real world. Consequently, we have been developing a virtual reproduction of the Yatsu tideland in recent years to enable observation of migratory birds in a virtual world. Figure 1 (b) shows a photo (upper) and a synthesized model (lower) of some of the buildings around the Yatsu tideland.



(a) Top view of Yatsu tideland* (b) Nearby buildings

Figure 1. Yatsu tideland.

2.2 Configuration

Our immersive projection display was constructed as a CAVE-like system with a four-surface cubic screen (Asai, et al., 2013). Our objective was to build the virtual environment system so that it would not require costly maintenance or advanced technical skills. An overview of the projection screen display is shown in Figure 2.


Figure 2. Overview of projection screen display.

The cubic screen is composed of three walls and a floor. Stereoscopic images are projected by LCD projectors that separate the left-eye and right-eye images through circular polarization. Each screen is 3 m × 3 m, and the projection resolution is 1000 × 1000 pixels. The stereoscopic images are generated by four PCs equipped with a GPU, which form a PC cluster through a gigabit Ethernet LAN.

* Made based on National Land Image Information, Ministry of Land, Infrastructure, Transport and Tourism, Japan

Two input devices are implemented into the immersive virtual environment system. A wired game pad (Sony PlayStation2) is used as a joystick for controlling the viewpoint in the 3D virtual space. A wireless game controller with an accelerometer (Nintendo Wii Remote) is also used as a wand for interacting with 3D virtual objects. These interface devices are controlled by the device PC, and the interaction data are sent to the management PC through the gigabit Ethernet LAN.

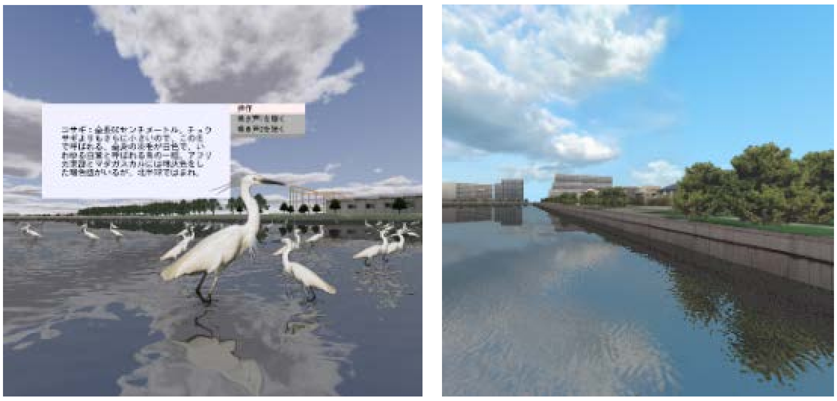
2.3 Software

VR Juggler (Bierbaum, et al., 2001) was installed as a set of libraries for parallel 3D rendering in cluster computing. The VRPN (Virtual Reality Peripheral Network; Taylor, et al., 2001) was used as a set of libraries and servers for implementing various interface devices into virtual reality (VR) applications over a network.

Applications and content data are stored in the management PC. Each rendering PC refers to these data through the network file system (NFS). Although VR Juggler supports a framework to transfer the data from the management PC to the rendering PCs, the NFS enables the programmer to omit the data transfer process in the application development.

We used OpenSceneGraph as an object-oriented framework on OpenGL for describing virtual environments based on scene graphs. That is, the visualization applications were implemented with OpenSceneGraph. Therefore, the Yatsu tideland application and the OSG (OpenSceneGraph) viewer must be used with VR Juggler and OpenSceneGraph. Using OpenSceneGraph makes it easy to install applications in different platforms by setting different parameters.

We developed our own application for demonstration, which involved visualizing the Yatsu tideland. The visualization application enables the user to view the landscape of the tideland and virtually walk through it. Figure 3 shows synthetic images generated by one of the rendering PCs, including (a) an explanation of a kind of egret and (b) the landscape of a shore in the virtual tideland.



(a) Explanation of egret (b) Shore of the tideland

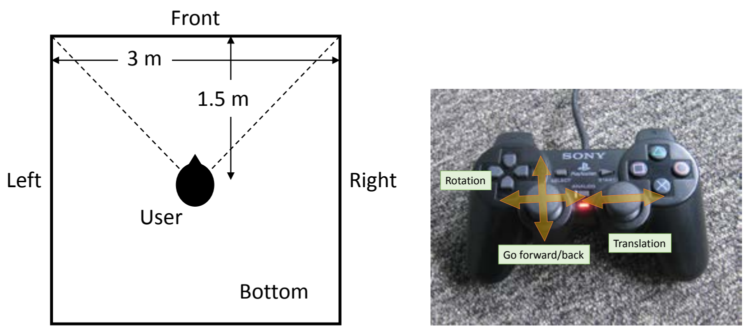
Figure 3. Screenshots of virtual tideland world.

3. Experiment

We conducted an experiment that involved viewing scenes of the virtual tideland. We set the condition to compare a wide field of view and a narrow field of view. No sound was generated during the experiment.

3.1 Methods

Nine students (five males and four females) from different universities participated in the experiment. The participants used the system for roughly 10 minutes in both field-of-view conditions. The experimental settings and the input device are shown in Figure 4. The participants were instructed to move around in the virtual tideland world and to find some migratory birds. They were told to read the explanations of at least two migratory birds. When they finished, they were given a preference test.



(a) Top view (b) Joystick

Figure 4. Experimental setting and input device.

The preference test had nine questions items, as listed in Table 1. A five-point Likert scale was used in the preference test. The scale ranged from 1=definitely disagree to 5=definitely agree. The students were also requested to provide open-ended comments about their opinions on using the immersive projection display for viewing the virtual tideland.

Table 1: Questions in preference test.

No.	Question items
1	You could see the surroundings.
2	The objects close to you looked three-dimensional.
3	You were able to distinguish the objects placed near and far.
4	The scenes were viewed with a feeling of depth.
5	You were immersed in the virtual world.
6	The experience of viewing scenes was interesting.
7	You felt uncomfortable when viewing scenes.
8	The setup was suitable for viewing scenes for a long time.
9	You felt tired when viewing scenes.

3.2 Results and Discussion

The results of the preference test for the wide field of view and the narrow field of view are shown in Figure 5. The numbers along the horizontal axis correspond to each question item, and the symbols a and b respectively indicate the wide and narrow fields of view. The vertical axis indicates the average scores among participants. The thin bar on each black and white column is the standard deviation. The average scores for questions 3, 4, 5, and 6 exceeded 4 in both conditions, which means that the participants had positive feelings. However, the average scores for questions 2 and 8 were below 3 for both stereoscopic and normal views, which means that the participants did not have positive feelings.

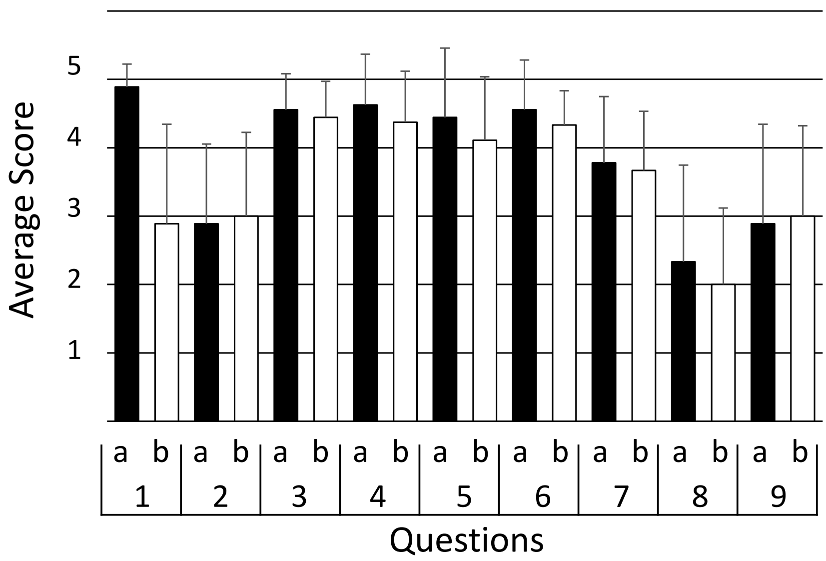


Figure 5. Scores for wide field of view vs. narrow field of view

A large difference was found in the average scores between the conditions for question 1, whereas there was no difference between the conditions for question 5. This result suggests that the field of view of 90 deg. is sufficient for providing a sense of presence because the field of view is considered to be significant to achieving a sense of presence. Although further investigation is needed to clarify the details of the result, it coincides with the earlier studies that visually induced self-motion or vection starts to be perceived at a horizontal field of view over 20 deg. (Allison, et al., 1999). This means that roughly 32 deg. in the horizontal field of view gives us the self-motion perception, but it is not sufficient for achieving a sense of presence, where a normal display with 17 inch (34 cm in horizontal wide) is placed at a distance of 60 cm from a user.

We conducted a subjective evaluation of stereoscopic views in our previous experiments (Asai, 2014). The results showed that virtual objects placed near a user looked more three-dimensional in the stereoscopic views, and a sufficient sense of presence was provided even in the normal views. These results lead us to expect that a field of view of 90 deg. would sufficiently provide a sense of presence in non-stereoscopic views.

4. Conclusion

We performed a subjective evaluation of the field of view in an immersive projection display where the task involved moving around a virtual tideland. The results of comparing a wide field of view with a narrow field of view suggested that a 90-degree field of view is sufficient for providing a sense of presence.

Acknowledgements

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Investigating a Scientist's Use of a Visualization Tool to Visualize the Concepts of Carbon Cycling

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Abstract: Teaching students learn to think like scientists is one of the purposes of science education and the premise of this study is to understand the processes of scientists' visualization. In order to understand the involved aspects while scientists visualizing the complex concepts, this study interviewed one scientist and explored his thinking processes while he constructed visualizations of the concept of carbon cycling in the ecosystem. The interview consisted of visualization tasks with think-aloud and the follow-up retrospective. By the analysis of the information of interview of a scientist, this study found that cognitive skills, metacognitive skills, visualization skills, conceptual knowledge, metacognitive knowledge, and meta-level visualization knowledge were interactively used by a scientist. We identified six strategies demonstrated by the scientist constructing visualizations. Moreover, two critical points influenced the visualization task were identified. By the cross-case comparison and revealing the gap between scientists and novices in the future, this study spurs discussion to propose concrete scaffolding in instruction and curriculum design for students.

Keywords: Visualization, thinking process, strategy, critical point

1. Introduction

The processes of visualization are important core activities in the development of science and science education. Visualization, in its broad sense, means the making of meaning for internal and external representations which are mentally available to oneself and physically available to others (Gilbert, 2008). In respect of the development of science, scientists try to provide explanations of natural phenomena, form visualizations of what is happening at the macro level from exemplar phenomena, and build models of this complex world (Gilbert, 2005; National Research Council [NRC], 2012). In respect of the development of science education, students should have competence in developing and using visualizations, which involves being able to construct drawings or diagrams as representations of events or systems, represent and explain phenomena with multiple types of models, and discuss the limitations and precision of a model (NRC, 2012). Teaching students to learn to think like scientists and develop models for the complex phenomena is one of the purposes of science education. As diSessa (2004) mentioned that technology is changing the representational basis of science, using visualization tools as a scientific modeling vehicle can bring innovation in science, technology, engineering and mathematics (STEM) education. The latest science education framework integrated both science inquiry and engineering design and emphasized on the practices of science which is based on the understanding of how scientists and engineers work (NRC, 2012). Equally important and worth exploring about the scientists' work is how scientists use visualization tools, or specifically, what strategies scientists employ, to create their visualization of complex phenomena such as the concept of carbon cycling which involves multiple scales (Mohan, Chen, & Anderson, 2009). This study focuses on one scientist. By understanding the scientist's strategies and the critical points in thinking processes of visualization, it can be used as a reference when designing meaningful learning activities which integrated visualization tools. Strategies mean a planned series of actions for achieving some goals; critical points mean a key point of time, a crisis or a turning point important to the success of an operation in this study. This study analyzed one biological scientist's thinking process while he used a visualization tool to visualize the concepts of carbon cycling. The research questions addressed in this study are:

1. What strategies did a scientist use to facilitate his constructing visualization process of the concept of carbon cycling?
2. What were the critical points while the scientist successfully constructing visualization of the concept of carbon cycling?

2. Theoretical Background

2.1 Studies of Scientists' Modeling or Visualization Processes and Their Implications for STEM education

Scientists form visualization and build model to develop illustrations, explanations, and predictions about natural phenomena (Gilbert & Buckley, 2000; NRC, 2012). Some studies have already examined the differences between chemists and novices in terms of their representational skills and their use of representations. For example, Kozma and Russell (1997) found that chemists represent their understanding of the chemical phenomena, not merely using surface elements, but making connections between diverse representations to underlying chemical concepts and principles. In another study, Kozma (2003) found that chemists are skillfully making transitions between different levels of representation or to transform a given representation into another form of representation. He also found that different representations can be used flexibly by chemists for different purposes such as supporting one's own thinking, social interactions and discourse. Some studies focused on the metacognitive and cognitive aspects of visualization and modeling. DiSessa (2004) and Gilbert (2005) point out that the fluent use of visualization or representation entails metacognition. Chiu and Linn (2012) pointed out that both cognitive skills to interpret the scientific information and metacognitive skills to monitor their progress were needed while engaging in complex tasks such as inquiry with technology tools. Schwarz and White (2005) stressed the importance of knowledge about the nature and purpose of science model while modeling. Justi and Gilbert (2002) concerned about the knowledge and skills that necessary in the successful modeling process and emphasize on the intermediate mechanism of mental model. From the above can be seen that it attaches great importance to successful modeling or visualization in STEM education. Relative studies have been explored such as comparison of differences between experts and novices' modeling and skills or knowledge involved in modeling and visualization. A further question, for example, how a scientist use these skills and knowledge to successfully visualize, would be more constructive and instructive for STEM education. In order to teach students to think like a scientist, one premise is identifying how scientists think. Therefore, this study tried to analyze a scientist's thinking process while visualizing.

2.2 Visualization Tools and Related Studies

Computer technologies provide opportunities for creating flexible and diverse learning environments (Donovan, Bransford, & Pellegrino, 2000). In addition to the typical media such as video, animations, and simulations, several interactive environments of multiple-representations have been developed. For example, Ainsworth (2008) introduced a number of integrated multiple-representations environments such as SMV-Chem, Connect Chemistry, and DEMIST which contained the real experiment videos, molecular models, chemical equations, simulations, or dynamic graphs of chemistry and population dynamics. Ainsworth also introduced that SimQuest and PAKMA are interactive simulations which employed dynamic visualizations. Additionally, encouraging learners to construct their own representation start a number of learning such as knowing how to select appropriate representations and lead better understanding than interpreting a given representation (Ainsworth, 2008). MultiMedia and Mental Models (4M:CHEM) (Kozma & Russell, 1997) and ChemSense (Schank & Kozma, 2002) help students developing and constructing an integrated understanding of chemical concepts. Considering the flexibility of instructional space, the program on handheld devices was developed such as Chemation (Holt et al., 2005). Plenty visualization tools have been developed to connect molecular representations and phenomena representations. Equally important but still need to develop is the visualization tools of complex phenomenon across multiple scales such as the concept of carbon cycling in ecosystems. The concept of carbon cycling, an important topic of life science and earth science, encompasses biological, physical, human social and economic systems, and interactions across these systems; it also involves multiple scales included atomic-molecular, cellular, organismal, and ecological process (Mohan, Chen, & Anderson, 2009). It is difficult for students to learn because of the properties of both macroscopic and microscopic scales and also both concrete and abstract of carbon cycling (Lazarowitz & Penso, 1992). Moreover, the lack of existing proper visualization tools makes the construction of complex phenomenon across multiple scales more difficult. DrawScience (Chang et al., 2014) was developed for the above purpose and used by the case in this study, which the visualization tasks were designed regarding the topic of carbon cycling in ecosystems, to construct the complex concept involved symbolic, systematic and macroscopic level.

3. Methods

3.1 Participant

The case is a scientist who has developed expertise and is able to think and solve problems effectively specializing in the field of biological science. He was a postdoctoral researcher and has been studied on flora and fauna for more than 10 years. This study adopted purposeful sampling to select the information-rich case to illuminate the questions under study. The first author served in the role of researcher-interviewer.

3.2 Procedures and Interview Questions

The whole interview process consisted of two parts, think-aloud tasks and follow-up retrospective tasks. The interview draft questions were developed based on the literature review, and underwent several rounds of revisions by a science educator and a science teacher to reach agreement on the interview questions. At the beginning of the interview, the interviewee performed one practice task to practice thinking aloud. Then the interviewee was asked to perform a series of visualization tasks about carbon cycling and to think aloud as the interviewee did them. For the main task, the topic of the visualization tasks was carbon cycling and consisted of two subtopics including the processes of carbon cycling among the hydrosphere, biosphere, geosphere and atmosphere and the growth of a tree. There were 3 questions for the think-aloud tasks of construction of visualization such as "Please draw a picture to present the transformation processes and the formation of the carbon element among the hydrosphere, biosphere, geosphere and atmosphere."

The interviewee was asked to use a mobile application named DrawScience to construct his visualization (Chang et al., 2014). DrawScience allows users to visualize their ideas at the particulate, symbolic, systematic, and macroscopic levels on Android tablets. DrawScience was used as a formative assessment tool to obtain the case's ideas while visualizing. After the think-aloud task, this scientist was interviewed according to the follow-up retrospective to probe and confirm his thinking. There are 9 retrospective questions about the reflection of resources, understanding of purposes and limitations, and reflection of visualization criteria. The interview of the main task and the follow-up retrospective took about 60 minutes and was videotaped to facilitate the subsequent transcripts and analysis.

3.3 Data Analysis

The interview was transcribed with annotation to include the case's nonverbal gestures. The software package, NVivo, was used to aid the coding and analysis procedure. The interview transcripts were coded based on the coding scheme that we proposed in a previous study which included several categories of skills and knowledge (Hung, Chang & Hung, 2014). The scientist's performance was analyzed in the chronological order. From the comparison and integration of the scientist's thinking aloud and follow-up retrospective, strategies that the scientist used while constructing visualization were proposed in this study.

4. Findings

4.1 Strategies a Scientist Used to Facilitate Constructing Visualization Processes of Carbon Cycling

Based on the performance of think-aloud tasks of construction of visualization, the thinking process of a scientist while constructing visualization was listed in the chronological order and shown in Figure 1.

Through the inductive analysis of the case's data, it is found in this study that the scientist used at least three kinds of skills and three kinds of knowledge to perform the construction of visualization tasks: cognitive skills, metacognitive skills, visualization skills, conceptual knowledge, metacognitive knowledge, and meta-level visualization knowledge. From the perspective of the chronological order point of view, the following discussed strategies the scientist used to successfully complete the visualization task.

Strategy 1: Using cognitive skills to comprehend the task at the beginning of the visualization task.

At the beginning of the visualization task, the scientist reads the question to understand the information about the task. As the first block in Figure 1, he knew the topic of the visualization task is carbon cycling, which involved hydrosphere, biosphere, geosphere and atmosphere.

Strategy 2: Using metacognitive skills to plan the drawing framework.

After understanding the task, the scientist used the metacognitive skill to plan the drawing framework. In this study, the scientist decided to start drawing from the part he was familiar with, the biosphere, as the second block in Figure 1.

Strategy 3: Dividing the complex concept into several sub-concepts, then constructing visualization in accordance with the relevance between sub-concepts one by one.

The topic of constructing visualization task in this study is carbon cycling in ecosystems. Carbon cycling is a complex conception which involved several different forms of compounds of carbon and several physical and chemical reactions within and among the hydrosphere, biosphere, geosphere and atmosphere. The scientist divided concepts of carbon cycling into at least 7 sub-concepts, such as photosynthesis and its reactant and product, food chains and webs, respiration and its reactant and product, the dissolution of carbon dioxide, the formation of calcium carbonate, and sediment formation and the release of carbon dioxide (See the block no.3-1 to 20. Blocks with the same area of gray background belong one sub-concept). Based on the relationships of those sub-concepts, the scientists sequentially draw each sub-concepts.

Strategy 4: Retrieving relevant conceptual knowledge to explain the sub-concept, then using visualization skills and meta-level visualization knowledge to represent the details of the sub-concept.

Before actual drawing, the scientist used cognitive skills to apply own conceptual resources which were related to the task. Then he considered the purpose, functions and conventions of visualization and the advantage and limitation of software, and he used visualization skills, such as using different colors for different marking or symbolic representation for interpretation, to convey the meaning and thinking of images. For example, see the block no. 11 to 12-2, the scientist explained that carbohydrates are transferred into CO_2 by respiration, then he used an arrow to represent the process of respiration and used texts to indicate respiration.

Strategy 5: Monitoring the drawing progress with metacognitive skills after constructing one or several sub-concepts.

After the primary drawing, the scientist used metacognitive skills again to monitor and check whether the drawing task was complete or not (See the gray block no. 10, 13, and 14). If incomplete, he returned back to use cognitive and visualization skills to add to the lack or revise his drawing. This process was repeated several rounds until passed the monitoring and checking. At last, the scientist compeleted the constructing visualization task.

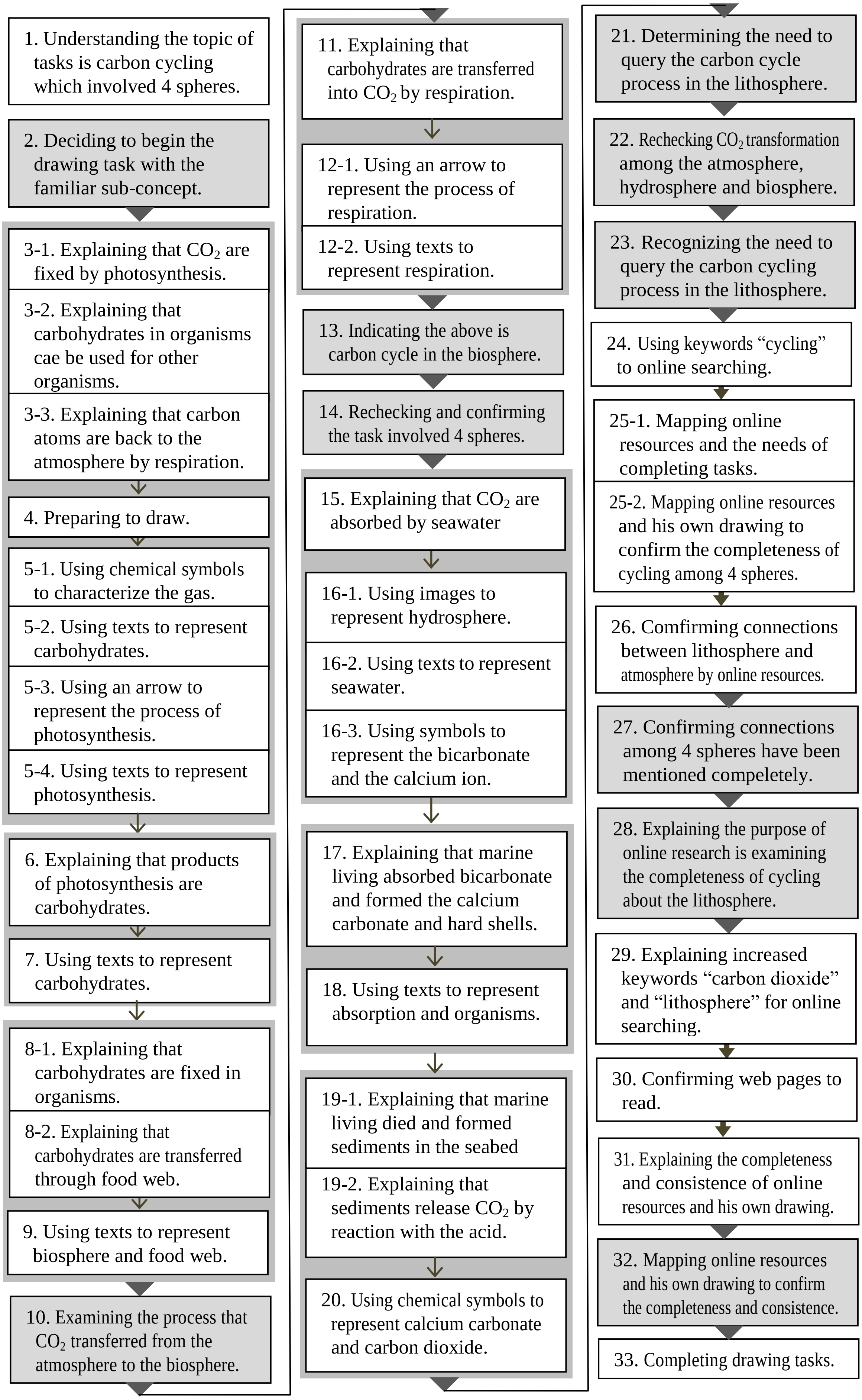

Figure 1. The Thinking Process of a Scientist while Constructing Visualization.

Strategy 6: Switching on the action of searching resources while identifying the knowledge about completing visualization tasks is insufficient.

Continuation of the previous monitoring strategy, if the scientist perceived and confirmed that relevant knowledge is not enough, he switched on the action to search for other resources. The scientist was limited to use Internet queries in this study and he selected some keywords to online researching. With several rounds of mapping online resources, the needs of completing tasks, and his own drawing (See the block no. 21 to 31), and with confirming the completeness and consistence between new resources and his own drawing, the scientist would determine the task was completed.

4.2 Critical Points While a Scientist Successfully Constructing Visualization of the Concept of Carbon Cycling

The analysis of strategies appeared that the scientist interactively used cognitive skills, metacognitive skills, visualization skills, conceptual knowledge, metacognitive knowledge, and meta-level visualization knowledge to complete the visualization task. In the thinking process of a scientist while constructing visualization (See Figure 1), there were two critical points while the scientist successfully constructing visualization of the concept of carbon cycling. The critical point 1 is in the occasion of the conversion of cognitive skills and visualization skills. For example, when the scientist explained that CO_2 are absorbed by seawater (See the block no.15), he needed to simultaneously use his meta-level visualization knowledge and visualization skills to choose the suitable representation and prepared to make the idea visible; then he used images to represent hydrosphere, texts to represent seawater, and symbols to represent the bicarbonate and the calcium ion (See the block no.16-1 to 16-3). If this conversion is not smooth, the sub-concept cannot be constructed.

The critical point 2 is the monitoring of metacognitive skills, such as the block no. 2, 10, 13, 14, 21 to 23, 27 to 28, and 32. In these monitoring stages, the scientist planned the drawing framework, recognized conceptual limitations, determined the need to search for the more resources. In addition, he mapped the new resources, original conceptions, and own drawing, reflected the purpose of the drawing task, evaluated and confirmed the completeness of the visualization progress. For the delicately converting, the scientist constructed visualization smoothly. Although whether there is still another critical point existed in visualization processes may need the more investigate, it is certain that the sufficient conceptual resources are needed in doing visualization task.

5. Concluding Remarks

By the analysis of the information of interview of a scientist, this study used a scientist's thinking process to illustrate the process that skills and knowledge used in constructing visualization. This study found that cognitive skills, metacognitive skills, visualization skills, conceptual knowledge, metacognitive knowledge, and meta-level visualization knowledge were used by a scientist while constructing visualization. Moreover, this research found at least six strategies that the scientist used to facilitate the visualization task and the two critical points influenced on the visualization task. Based on these strategies and critical points to interactively use of skills and knowledge, concrete scaffolding in instruction and curriculum design for students can be proposed, such as integrated some steps or functions in visualization instruction or designing visualization tools to prompt the use of conceptual resources, the transformation of cognitive skills to visualization skills, and the planning and monitoring of metacognitive skills.

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Motivation is Important When They Learn Chemical Equilibrium with Computer-simulated Experimentation: A Pilot Study

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Abstract: Chemical equilibrium is important and fundamental chemistry concept for studying advance chemistry topics. A numerous researches reported that students often hold alternative conceptions of science and encounter learning difficulty because of complexity and abstraction of scientific concepts. Researchers seek to discover effective way to assist students learning of science concepts meaningfully. This paper presents an examination of relationship between students' motivation toward chemistry and their perceptions toward the chemistry learning of chemical equilibrium through interacting with a computer-simulated experimentation, called Chemical Equilibrium Simulation (CE-SIM). Thirty males and forty females 11th grade students participated in this study. The result of study indicated that intrinsic motivation was significantly correlated to all constructs of perception toward computer-simulated experimentation of chemical equilibrium. Based on this finding, science teachers should concern and consider students' career motivation, self-determination, self-efficacy, and grade motivation before using CE-SIM in chemistry learning of chemical equilibrium. This implied that chemistry motivation is important for chemistry learning of chemical equilibrium through the use of computer-simulated experimentation.

Keywords: simulation, chemical equilibrium, perception, chemistry motivation

1. Introduction

In recent year, the increasing use of computer and technology is rapidly growth in science education (Vreman-de Olde, 2013). Technologies were used to be effective tools in the classroom teaching process and they become a commonplace in science-based education (Srisawasdi and Sornkhatha, 2014; Pyatt and Sims, 2011). Due to features of technology, the support of students' visualization and imagination skill is important for science learning in school science level. Moreover, technological tools could promote learning motivation and inspiration for students. Educational researchers mentioned that implementing technology-based learning environment could raise students' cognitive engagement and learning performance. (Wartella and Robb, 2007). A numerous research has found that technology can improve students' conceptual understanding of science and impacts the transformation of teaching and learning in school science classroom as being a powerful pedagogic tool in science education.

In science-based education, chemistry is an important discipline in science that nature of chemistry content is abstract and complex. As such nature, students need to use imagination for learning of chemistry (Eilam, 2004; Leite, Mendoza and Borsese, 2007). In chemistry education, the concept of chemical equilibrium is very important for studying advance chemistry topics, such as acid-base interaction, electrochemistry, and so on. However, in Thai context a numerous researches show that students often hold alternative conceptions of science and encounter learning difficulty because of complexity and abstraction of scientific concepts (Chaiyen, 2007). Because of its abstraction and complexity, enhancing of chemistry learning has an inter-relationship among three chemistry representations, including macro-, micro- and symbolic representations. Another reason is difficulty about incomplete reaction, reversibility and dynamics. (Quilez, 2004)

Currently, computer animation and simulation are powerful tools which can make unobservable phenomena being visible representation and could support students' conceptual learning in chemistry. Researches indicated that computer animation and simulation can help student reducing alternative- or misconceptions, and revise and improve conceptual understanding of scientific concepts (Srisawasdi and Kroothkeaw, 2014; Suits and Srisawasdi, 2013). Moreover, Suits and Srisawasdi (2013) mentioned that instructional computer simulation could support students; favorable perceptions of science learning through visualizing scientific phenomena both macroscopic, microscopic, and symbolic levels of chemistry representation.

Accordingly, this pilot study aims to investigate correlation between students' motivation toward chemistry, before interact with an computer-simulated experimentation, called Chemical Equilibrium Simulation (CE-SIM), and students' perception toward computer-simulated experimentation, after interacting with the CE-SIM of eleventh-grade students To address the aim of this study, the following specific question will be answered: Is there a significant correlation between students' motivation toward chemistry and students' perception toward the CE-SIM among eleventh-grade Thai students?

2. Literature review

According to the rapid growth of computers and technologies in the practice and progression of science education community, computer simulation offers students to learning of science through inquiry-based process (Rutten, 2012; Srisawasdi and anjaburee, 2015; Vreman-de Olde, 2013). Many attributes of computer simulation are potentially useful for promoting conceptual development in science and inducing cognitive mechanism of conceptual change (Srisawasdi and Kroothkeaw, 2014; Srisawasdi and Panjaburee, 2015; Srisawasdi and Sornkhatha, 2014). Currently, inquiry-based learning with computer simulations is generally seen as a promising area for conceptual change in science (Smetana and Bell, 2012). Suits and Srisawasdi (2013) mentioned the advantage of computer simulations that they could support positive perceptions and visualize scientific phenomena both macroscopic, microscopic, and symbolic level of chemistry representation. Based on visual-aids learning with simulations, its visualize features facilitate the integrated cognitive process of new knowledge and existing knowledge framework, which are important components of learning from the constructivist perspective, and improve conceptual understanding in scientific phenomena (Cook 2006; Wu and Shah 2004). With regarding benefits of computer simulation in science learning, inquiry-based learning with simulations is, currently, a promising area for science-based instruction to foster learners' mental interaction with the physical and social world in order to develop science literacy.

To address conceptual learning problems in chemistry outlined in the previous section, simulation-based inquiry learning has been becoming a pedagogical approach for enhancing students' conceptual learning and development in school science (Srisawasdi and Kroothkeaw 2014; Srisawasdi and Sornkhatha 2014). Researchers found that simulation-based inquiry learning works with remedial by producing change to the alternative conceptions held by learners, improving the performance of gaining intuitive domain knowledge, promoting more qualitative knowledge than formalized knowledge, and achieving a more theoretical focus and coherent understanding of the concepts (Srisawasdi and Panjaburee, 2015).

3. Method

3.1 Study Participants

In this pilot study, 71 eleventh-grade students (31 males and 40 females), aging 15-17 years old, in a secondary public school at northeastern region of Thailand participated the use of computer-simulated experimentation of chemical equilibrium for chemistry learning. All of them have basic skills in using information and communication technology. They were served in basic chemistry course about chemical equilibrium and they had no experience with the use of computer-simulated experimentation in science before. In additions, they had no learning experience in chemistry of chemical equilibrium yet.

3.2 Learning Material

Table 1: The goals of the sub-topics in chemical equilibrium in this study.

sub-topics	Description of main chemistry concepts
Chemical Equilibrium	This concept refers to incomplete, reversibility, dynamics reaction and definition of chemical equilibrium.
Lechateliers' Principle : Change in concentration	This concept refers to effect of disturbing equilibrium by changing concentration of substance or product in reaction on equilibrium state.
Lechateliers' Principle : Change in temperature	This concept refers to effect of disturbing equilibrium by changing temperature of reaction on equilibrium state.
Lechateliers' Principle : Change in pressure	This concept refers to effect of disturbing equilibrium by changing pressure of reaction on equilibrium state.

The Chemical Equilibrium Simulation (CE-SIM) is computer-simulated experimentation on chemistry concept of chemical equilibrium. This simulation comprises 4 main chemistry concepts: chemical equilibrium; Lechateliers' principle — change in concentration; Lechateliers' principle — change in temperature; and Lechateliers' principle — change in pressure. Table 1 describes the goals of each main chemistry concept used in this study.

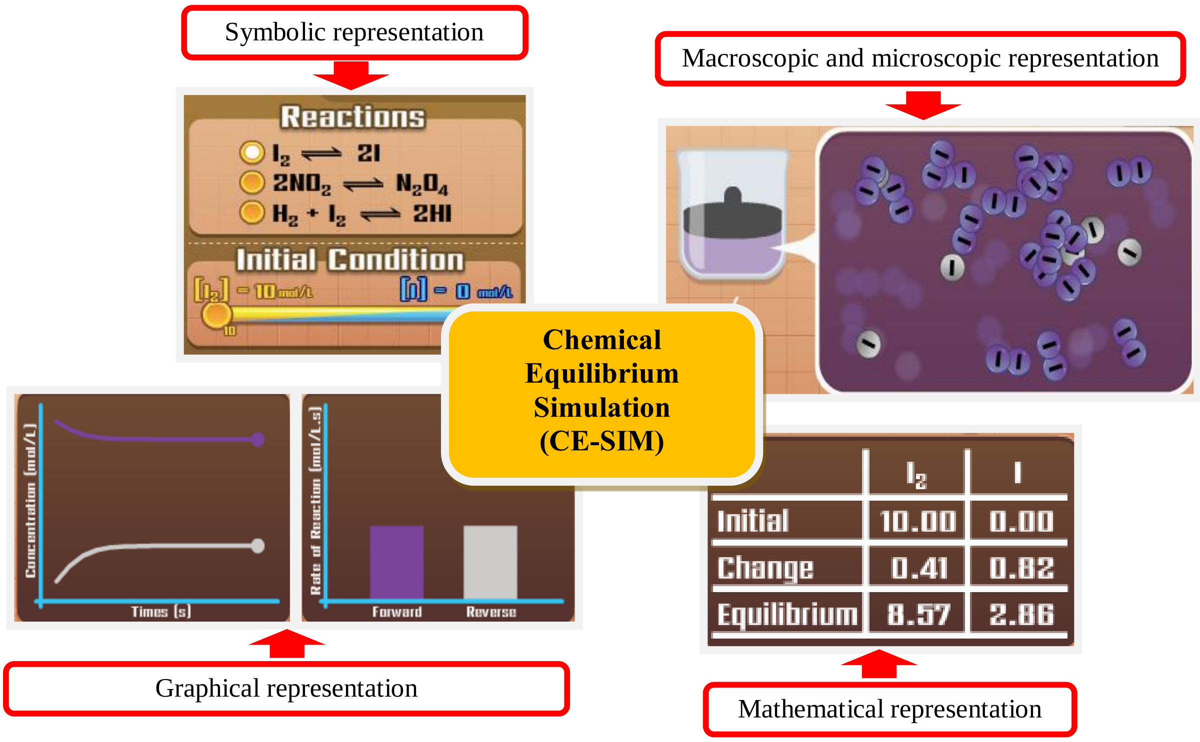

Figure 1. Representational components of the Chemical Equilibrium Simulation (CE-SIM)

To enhance chemistry learning of chemical equilibrium, the CE-SIM has been designed and created to include: (a) macroscopic level of chemical representation which presents color of observable phenomena that varies follow concentrations of substance and product in solution; (b) microscopic level of chemical representation which presents movement, collision and reaction of molecules; (c) symbolic level of chemical representation which presents chemical equations and models of molecules; (d) graphical representation which simplifies experimental data, trend line of graph between concentrations of substance and product with time, and bar graph between rate of reactions (forward and revers reaction); and (e) mathematical representation which displays amount of initial substance and products at the same time for supporting the construction of chemistry understanding related the target scientific phenomena. In additions, the CE-SIM was designed data table of substance concentration and product concentration in each step of reactions that can be used for engaging in calculation part such as equilibrium constant. Figure 1 illustrates representational components of CE-SIM

3.3 Instruments

In this study, two instruments were used to examine the relationship between students' motivation toward chemistry learning and perception toward computer-simulated experimentation. First, A 25-item chemistry motivation questionnaire (Glynn et al., 2011), developed in Thai version by Srisawasdi (2015), was used in this study. According to Glynn et al. (2011)'s suggestion, the Nanoscience Motivation Questionnaire (Srisawasdi, 2015) was revised by changing the word "nanoscience" to "chemistry" for using as a discipline-specific version of the questionnaire, and was used in this study to explore secondary school students' motivation to learn chemistry. The questionnaire consists of five subscales: Intrinsic Motivation (IM), Career Motivation (CM), Self-determination (SDT), Self-efficacy (SEC), and Grade Motivation (GM), as shows the sample items of each subscales in Table 2. Another, 18-item perception questionnaire (Tao and et al., 2009), developed in Thai by Pinatuwong and Srisawasdi (2014), separated into six subscales, consisting Perceived Learning (PL) (3 items), Perceived Ease of Use (PEU) (2 items), Flow (3 items), Perceived Usefulness (PU) (3 items), Enjoyment (2 items), and Perceived Satisfaction (PS) (5 items). The sample items and description of each subscale are shown in Table 3. For both questionnaire, all of items were rated on 5-point Likert scale ranging from 1 = strongly disagree to 5 = strongly agree. Table 2 and 3 illustrates sample items of the questionnaires used in this study and its reliability.

Table 2: Sample items of the motivation toward chemistry learning questionnaires and its reliability.

Sub-scales	Sample items	α
Intrinsic Motivation	• Learning chemistry is interesting. • Learning chemistry coherent with my diary life.	0.79
Career Motivation	• I would like to work about chemistry. • I think that is chemical knowledge useful for career progression in the future.	0.81
Self-Determination	• I use many strategies for learning chemistry. • I spend a long time to learning chemistry.	0.81
Self-Efficacy	• I am confident about understanding difficult chemical concepts. • I am confident I can pass chemistry test.	0.89
Grade Motivation	• I can get a good grade in chemistry courses. • I participate in chemistry courses to perform better than other students.	0.85

Table 3: Sample items of the perception toward computer simulation questionnaires and its reliability.

Sub-scales	Sample items	α
Perceived learning	• The Simulation allow me to complete my studies faster. • The Simulation will help me remember the things I learned.	0.80
Perceived ease of use	• The Simulation are easy to use. • Interacting with the Simulation is unambiguous and easy to understand.	0.82
Flow	• I really got into the Simulation. • I was very involved in the Simulation.	0.75
Perceived playfulness	• It is interesting to use Simulation. • I was totally immersed in the Simulation.	0.74
Enjoyment	• I had fun playing the Simulation. • Interaction with the Simulation was pleasant.	0.84
Satisfaction	• I like to learn with the simulation. • I would like to learn with the Simulation in the future	0.77

3.4 Data Collection and Analysis

Before the participants interact with CE-SIM, the motivation toward chemistry learning questionnaire was used to measure their pre-motivation toward chemistry learning for 10 minutes. Then, they interact with CE-SIM and answer three questions about chemical equilibrium: How do molecules behave when reaction reach equilibrium?, How do rate of reactions (forward and revers reaction) when reaction reach equilibrium? and How do concentrations of substance and product when reaction reach equilibrium? Total time to complete for this step was approximate 30 minutes. After interacting the CE-SIM, their post-perception toward computer simulation were examined by the perception toward computer simulation questionnaire for 10 minutes. The correlation between pre-motivation toward chemistry learning and post-perception toward computer simulation were investigated by Pearson's coefficient. Figure 2 illustrates a flow step of data collection.

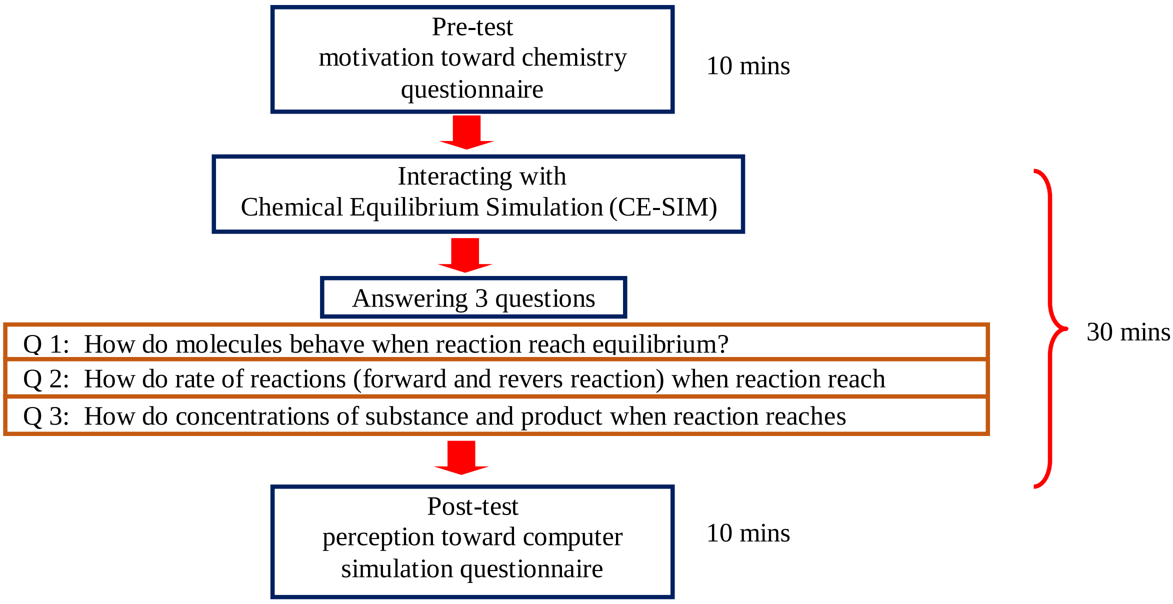

Figure 2. A flow steps of data collection in this study

4. Results and Discussion

Pearson's correlation was used to analyze relationship between motivation toward chemistry (IM, CM, SDT, SEC, and GM) before student interact with CE-SIM and perception toward computer simulation (PL, PE, F, PP, EJ, and S) after student interact with CE-SIM as shown in Table 4. Result showed that (1) Intrinsic Motivation (IM) relate together sub-scale of perception toward computer simulation, (2) Career Motivation (CM) relate together sub-scale of perception toward computer simulation except that do not relate to Perceived Learning (PL) and Satisfaction (S), (3)Self-Determination (SDT) that do not relate to 3 sub-scale were Perceived Playfulness (PP), Enjoy (EJ) and Satisfaction (S), (4)Self-Efficacy (SEC) showed no relation with Perceived Learning (PL), Enjoy (EJ) and Satisfaction (S), (5)Grade Motivation relate together sub-scale of perception toward computer simulation except do not relate to Enjoy (EJ). Table 4 illustrates correlation between motivation toward chemistry before students interact with simulation and perception toward computer simulation.

Table 4: Correlation between motivation toward chemistry before student interact with CE-SIM and perception toward CE-SIM.

Scale	IM	CM	SD	SE	GM	PL	PE	F	PP	E	S
IM	1										
CM	.645**	1									
SD	.498**	.485**	1								
SE	.612**	.513**	.448**	1							
GM	.315**	.274*	.235*	.532**	1						
PL	.345**	.227	.268	.184	.078	1					
PE	.545**	.429**	.258*	.383**	.181	.724**	1				
F	.398**	.343**	.263*	.300*	.133	.780**	.748**	1			
PP	.276*	.246*	.209	.180	.126	.791**	.712**	.733**	1		
EJ	.430**	.358**	.195	.278*	.334**	.736**	.777**	.769**	.731**	1	
S	.309**	.212	.192	.174	.158	.768**	.691**	.742**	.848**	.802**	1
Mean	18.49	19.07	16.59	16.38	18.17	15.03	11.44	14.79	11.15	11.55	15.56
SD	3.125	3.357	3.036	3.457	3.939	2.863	2.260	2.792	1.990	2.190	2.844

**$p < 0.01$,*$p < 0.05$

The findings from this study were as followings:

- Students' intrinsic motivation has effect to perception from learning by computer simulation.
- Students who have high or low motivation toward chemistry (except in intrinsic motivation sub-scale) could perceive learning from computer simulation. For example, students' answers in Frist question: When the reaction reached to equilibrium, reaction of iodine I_2 (g) still forward react to I (g) and iodide I also backward react to I_2 (g). Then the amount of I_2 (g) and I (g) stayed the same. Considering to the color of the reaction, it looked like the reaction was not change. (Student ID#8) It indicated student could observe and understood incomplete, reversibility of chemical equilibrium. In addition, student showed that he could integrated between microscopic level and macroscopic. In Second question: When the reaction reached to equilibrium, the concentration of I_2 (g) and I (g) have no tendency to change. According to the amount of I_2 (g) and I (g) molecules in the model still remained the same and it related to the constant concentration graph. (Student ID#24) It indicated student could descript a part of definition of chemical equilibrium and related between microscopic representation with the concentration graph.
- Students who have high or low motivation toward chemistry (except in Intrinsic Motivation sub-scale) could satisfaction from computer simulation.

5. Conclusion

The result of this study provided understanding correlation between student's motivation toward chemistry before interacting with CE-SIM and student's perception after interacting with CE-SIM. The finding indicated that Intrinsic Motivation (IM) relate together sub-scale of perception after interacting with computer simulation. Thus, we should consider students' intrinsic motivation before using CE-SIM in teaching and correlation between student's motivation toward chemistry with student's perception learning and Satisfaction is no significant. It mean student who have high or low motivation toward chemistry (except in intrinsic motivation sub-scale) could perceive learning and satisfaction from CE-SIM.

A previous study by Srisawasdi and Kroothkeaw (2014) used simulation-based open inquiry and they found that the students could develop student's conceptual learning in science inquiry. Based on the findings of this study, researcher will design next study for improving conceptual understanding and integrating knowledge by using Chemical Equilibrium Simulation-based open inquiry in quasi-experimental design that includes two different-intervention groups of students. One group will provide simulation-based open inquiry instruction and another acquire traditional instruction (5E). The mixed research methodology combined quantitative method of non-equivalent control group design with qualitative method of phenomenological research design will carry out in future research.

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Using Mobile Augmented Reality for Chemistry Learning of Acid-base Titration: Correlation between Motivation and Perception

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Abstract: The comprehension of micro-worlds has always been focused and challenged in chemistry learning. High school students' imaginative abilities are not yet mature. As a result, they could able to visualize in microscopic level correctly during the beginning stage of chemistry learning. This study was targeted to support students' imagination by visualized the composition and behavior of substances in microscopic (molecular) level. Moreover, the study involved the pedagogical design and development of a series of mobile augmented reality (AR) application for enhancing chemistry learning of Acid-Base. This study examined influence of motivation toward chemistry on perception toward the mobile AR. In interacting with the AR, students could visualize a set of 3D model of molecular substance using smartphone scanning markers. The result showed that intrinsic and career motivation significant correlated with flow and enjoyment of learning experience with the AR. As such, this implied that chemistry learning activity with the use of mobile AR should consider ways to promote students' motivation before implementing the activity. In additions, this paper suggests how to use this finding for designing an ebook of Acid-base and titration experimentation for chemistry learning in school science.

Keywords: Ebook, augmented reality, motivation, perception

1. Introduction

From past to present, chemistry still be a difficulty subject which is abstract and complex by its nature. For students' perspective, they perceive to chemistry which is not relate in daily life, that chemistry is chemical substance, toxic, smoke, pollution, e.g. Thus, it is reason to cause students' question that "Why do I have to learn chemistry?" This is just students' perspective to chemistry. For the nature of chemistry which is rather abstract and invisible. This is a barrier to learn and cause to tell that it is difficult subject. Although, the chemistry learning activities attempted to link the subject matter with how the world works, the students still have numerous learning difficulties and misconceptions on the subject. Moreover, they only link their own existing conception to the new concepts leading to fragmented and fractured understanding (Gilbert & Boulter, 2000). Because of high school students' imaginative abilities are not yet mature. As a result, they could not able to visualize micro-particles correctly during the beginning stage of chemistry learning. Students could not distinguish between macroscopic and sub-microscopic level. The students have also difficulty linking observable phenomena (macroscopic level) to molecular level (microscopic level) interaction (Chang & Linn, 2013). Especially, these students are often required to envision across micro-and macro-worlds, which can be extremely challenging. Both the composition and the behavior of substances are a critical concept in chemistry learning, as it is the foundation of further learning about chemistry. This problem necessitates improving in the learning strategies and tools used in chemistry learning.

In the current, there are many technologies which could support students' visualization and imagination skill which are necessary skills for chemistry learning. Not only supporting learning but also technology could play a huge part in motivating, involving, inspiring. Today, students are highly visual, preferring pictures and video to words and speech. Merging in visual learning tools rise students' engagement, by adding variety to the learning environment with technology. Each new technology is introduced with the potential to utility children's learning (Wartella & Robb, 2007). In 2010, the U.S. Department of Education released the National Education Technology Plan to promote student-centered learning with technology as a way to improve students' achievement (Moeller & Reitzes, 2011). Many research indicate that technology enhance students' comprehensive in science learning and impacts in school classroom as being a powerful cognitive tool.

In science learning, many researcher have been investigated the impact of using various technologies to support students' conceptual understanding, visualization and to promote instructional competency of the 21st century teacher. A research in Thailand revealed that the intervention of simulation-based inquiry with DSLM can be effective in fostering radical conceptual change in students. The results from this study conclude that the simulation-based inquiry learning environment based on DSLM could be an alternative method for developing conceptual understanding of light refraction (Srisawasdi & Kroothkaew, 2014). For example international context show that The Microcomputer-based Laboratory (MBL) is an example of a student-centered learning environment that provides new opportunities to engage secondary-level chemistry students in meaningful learning and higher-order thinking through inquiry. MBL promotes student discussion, planning, measuring and taking responsibility for their learning processes (Aksela, 2011).

The interesting technology which could simulates quite naturalistic about the composition and the behavior of the substances is augmented reality (AR). AR is an extension of Real-world to Virtual-world which provides a seamless interface for users that combine both the real world and the virtual world. AR is a new technology which could simulate 2D and 3D object in macroscopic level, microscopic level and symbolic. Although, there are many research indicate that the AR could improve and support students' learning and motivation. For example, Cai and Xu (2014) were investigated about the impact of the AR on students' achievement, experience meaningful and interesting in chemistry which they found that The AR tool is beneficial in improving middle school students' cognitive test performance on corresponding content, and has relatively larger influence on low-achieving students. Additionally, students generally hold a positive attitude toward the AR tool and enjoyed the exploration experience. With the application and instruction form, teachers could apply this AR tool in inquiry-based learning in their own classes. However, we did not know that student (Both positive and negative motivation toward chemistry) will perceive from learning with the AR. Therefore, we want to investigate the influence of motivation toward chemistry on perception toward augmented reality after interacted with the AR and the correlation between motivation toward chemistry and perception toward augmented reality within educational augmented reality learning.

So, this research was aim to develop the AR technology to support students' comprehension and visualization skill with investigating correlation between motivation toward chemistry and perception toward augmented reality within educational augmented reality learning. This study is pilot study which was goal to investigate that how students perceive toward augmented reality within educational augmented reality learning.

2. Literature Review

2.1 Augmented Reality (AR)

Augmented Reality (AR) is an extension of Real-world to Virtual-world which provides a seamless interface for users that combine both the real world and the virtual world. In the past two decades, the applications of augmented reality (AR) have been increasingly receiving attention. Moreover, according to the 2011 Horizon Report, AR, with its layering of information over 3D space, creates new experiences of the world. With these new prospects of information access, the prevalent employment of AR has been in marketing, social engagement, or entertainment (Johnson et al. 2011). In addition to these consumer uses, the 2011 Horizon Report also suggested that AR should be adopted in the next 2–3 years to provide new opportunities for teaching, learning, research, or creative inquiry. By examining article publications on Google Scholar, Martin et al. (2011) reported that AR is in its initial stage according to its publication impact, and they have proposed that it will probably have significant influences on education in the future.

2.2 *Motivation toward chemistry*

Scientific motivation refers to the motivation of students to learn science within their emotional which stimulate, control and support in science learning behavior. Thus, Scientific motivation could be achieved to learners when activate their behaviors with asking the questions, doing experiments, and collaborative learning (Schunk, Pintrich & Meece, 2008; Glynn et al., 2011). Researchers stated that Scientific motivation consists of five motivational constructs: intrinsic motivation, an internal state of satisfaction to learn science because it will be good or beneficial thing for itself; self-determination, the controlling of students' belief that they have when learning science; self-efficacy, students could bring their belief connect and manage to achieve learning science; career motivation, students learn science to get a good work in the future; and grade motivation, learning science to have a good score (Glynn et al., 2011). The following research hypothesis was another one which the researchers expected to examine in this study.

2.3 *Perception toward augmented reality*

2.3.1 *Perceived Learning*

Perceived learning relates to a retrospective evaluation of the learning experience and can be defined as a set of beliefs and feelings one has regarding the learning that has occurred (Caspi & Blau, 2011). The perceived learning is about the new information was obtained and person can get the new understanding, subjective evaluation of learning by learners themselves. Researchers mentioned that perceived learning is connected to emotion as flow, enjoyable, and satisfaction (Chu & Hwang, 2010).

2.3.2 *Perceived Ease of Use*

Perceived ease of use refers to the degree to which a person believes that using a particular system would be free of effort. This follows from the definition of "ease" which is freedom from difficulty or great effort. Effort is a finite resource that a person may allocate to the various activities for which learner is responsible (Radner & Rothschild, 1975). All else being equal, we claim, an application perceived to be easier to use than another is more likely to be accepted by users.

2.3.3 *Flow*

Flow is a state of deep concentration in which thoughts, intentions, feelings, and all of the senses are focused on the same goal (Csikszentmihalyi, 1990; Barzilai & Blau, 2014). The experience of flow would happen when person who take part in challenge situations or activities that need skills. Flow depends on a chance to concentrate, an immediate feedback, a sense of control, and a clarify goal (Barzilai & Blau, 2014).

2.3.4 *Perceived playfulness*

Perceived Playfulness is the extent to which the individual perceives that learner's attention is focused on the interaction with the global. It is curiosity during the interaction and the interaction intrinsically enjoyable or interesting (Moon & Kim, 2001).

2.3.5 *Enjoyment*

Enjoyment is the condition of having and using technology, e.g. educational computer game that is good or pleasant. The enjoyment of player is a key goal, related with an easy to use of game and enjoyment was found to have valuable in explaining objective to use applications (Giannakos, 2013).

When learners which act as players of game fail to pass the game task, they would get disappointment and attempt to replay again.

2.3.6 Satisfaction

Satisfaction is the individual awareness of how well a learning environment supports academic success (Lo, 2010). It is relevant to instructional method that learners can think and learn, so their satisfaction can help to get how academic success. At the moment to learn with educational computer game, if it gets positive response from learners that means they reach to positive learning experience with also. In an addition, satisfaction can yield positive of learning performance and can improve learning outcome (Giannakos, 2013).

3. Purpose

In this study, the researchers conducted an exploration to investigate correlation between students' motivation toward chemistry and perception toward augmented reality after interaction with augmented reality in the topic of acid-base reaction. Especially, the research questions were answer:

- How were the influences of motivation toward chemistry on perception toward augmented reality after interaction with augmented reality?
- Is it suitable to implement the augmented reality in a Thai school?

4. Method

4.1 Participants

This study was conducted with participation of 77 high school students (17 years of aged) in a local public school at northeastern region of Thailand. Participant in this study have not experienced yet facing augmented reality in Science learning but they have good experience with mobile device. They already completed a regular chemistry class but they have not taught about acid-base reaction yet before participated in this study.

4.2 Instruments

This research used two instruments for determining students' motivation toward chemistry and perception toward augmented reality via the AR. First, the motivation toward chemistry is the questionnaire developed from Scientific Motivation Questionnaire (SMQ) consisting of 25 items. All items were classified into five scales, including intrinsic motivation (five items), career motivation (five items), self-determination (five items), self-efficacy (five items) and grade motivation (five items). The sample items and description of each scale are provided in table 1. Second, the perception toward augmented reality is questionnaire developed from Technology Perception Questionnaire (TPQ) which was developed to use only in this study consisting of 18 items which are divided into six scales, including perceived learning (three items), perceived ease of use (two items), flow (three items), perceived playfulness (three items), enjoyment (two items) and satisfaction (five items). To develop a Thai version of the questionnaire, the original English version was translated identically in Thai language. The sample items and description of students' perception questionnaire are provided in table 2. One expert was recruited to identify communication validity of the items. On each item of chemistry motivation questionnaire and students' perception questionnaire, respondents were assigned to rate how much the respondent agree with into five scale, from 1-strongly disagree to 5-strongly agree.

Table 1: Subscale description and sample items of the Chemistry Motivation Questionnaire

Subscale	Description	Sample items
IM	Which involves learning chemistry for its own sakes	Learning chemistry is interesting.
CM	Which involves learning chemistry as a means to an end	Understanding chemistry will benefit me in my career.
SD	Which refers to the power or ability to make a decision for oneself without influence from outside	I put enough effort into learning chemistry.
SE	Which refers to students' confidence that they can achieve well in chemistry	I believe I can master chemistry knowledge.
GM	Which refers to the debilitating tension some students experience in association with grading in chemistry	I like to do better than other students on chemistry tests.

4.3 Learning Material

In this study, the design and development of the technology material which will bring it to support learning, called "the augmented reality (AR)" was related to content of acid-base. 3D model of molecule will be shown if smart phone detect on AR marker The AR provides secondary information which represents the animation of 3D model of molecule in microscopic and symbolic levels to support students' visualization and linked to macroscopic level which in this learning will shows a solution in the beaker before students observe the micro-particle via the AR. Figure 1 illustrates the 3D structure and behavior of the molecule.

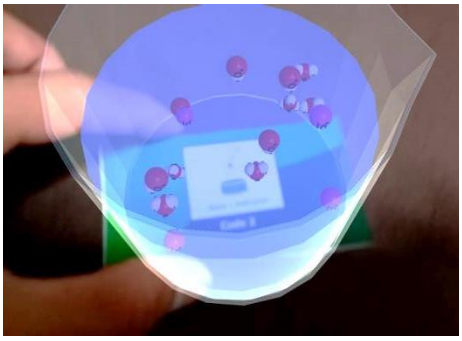

Figure 1 illustrates the 3D structure and behavior of the molecule. (Left shows viewpoint from observer which we will see both the marker and display in mobile phone. Right shows 3D structure and behavior of the molecule in mobile phone which we could move both mobile phone and marker to adjust.)

Table 2: Subscale description and sample items of the students' perception questionnaire

Subscale	Description	Sample items
PL	Extent to which students can get the new understanding, subjective evaluation of learning by learners themselves.	The AR allows me to complete my studies faster. The AR increases my learning efficiency. The AR will help me understand the things I learned.

PEU	Extent to which using to easy and help to science easier.	The AR is easy to use. Using the AR to complete course related tasks are easy.
F	Extent to which a state of deep concentration in which thoughts, intentions, feelings, and all of the senses are focused on the same goal	I was very involved in the AR. I lost track of time when I interacted. When I interacted I did not think of anything else.
PP	Extent to which students feel happy and attentiveness.	It is interesting to use AR. I feel like exploring more information when I use AR. I was totally immersed in the AR.
E	Extent to feeling of students when used game-like simulation.	I had fun playing the AR for learning science. I feel relaxed to use AR for learning science.
S	Extent to which the individual awareness of how well a learning environment supports academic success.	The use of the system makes this learning activity more interesting. I would like to learn with the system in the future. I would like to know if the innovative approach can be applied to other courses to improve my learning performance.

4.4 Data Collection and Analysis

The intervention class consists of 77 students. Before providing the augmented reality, students was surveyed the motivation toward chemistry. The technology perception questionnaire survey was provided to the students after they interacted with the augmented reality material. The data from two scales was analyzed the relation in each variable with Pearson's correlation in SPSS. The result of analytic with Pearson's correlation illustrate the relation of motivation toward chemistry (intrinsic motivation, career motivation, self-determination, self-efficacy and grade motivation) and perception toward augmented reality (perceived learning, perceived ease of use, flow, perceived playfulness, enjoyment and satisfaction). The influent of motivation toward chemistry on perception toward augmented reality via interaction with the augmented reality (AR) was analyzed to investigate. Figure 2 illustrates students' interaction with the mobile AR of acid-base.

Figure 2. An illustrations of students' interaction with acid-base AR using mobile phone

Figure 3 shows the procedure of the experiment. Before the interaction with the augmented reality, the students took the pre-test questionnaire (the motivation toward chemistry is the questionnaire). During the learning activity, stage 1 teacher shows two solutions in a beaker which labels as "Beaker 1 and Beaker 2" and provides the first question "What do you see in Beaker 1 and Beaker 2?" that students will answer in macroscopic level. After that, teacher guides students to visualize and imagine micro-particles and provides the second question "What is in Beaker 1 and Beaker 2?" and then, teacher mixes two solutions from Beaker 1 and Beaker 2 into Beaker 3 as a mixed-solution together with provides the third question "What will happen in Beaker 3 in microscopic level?". Students will imagine and predict the model and behavior of the micro-particle from demonstration in each group (15 minutes). Then stage 2, students observe by material learning (the augmented reality) in each group to find what is a model of molecule in microscopic level and to be able to understand how solution molecules behave in the beaker. 3D model of molecule will be shown if smart phone detect on AR marker (30 minutes). Stage 3, after observed with AR material they discuss in their group, compare the micro-particle from prediction step with observation step and explain the model and behavior of the molecule in microscopic level (30 minutes). After finished the learning activity, the students took the perception toward augmented reality questionnaire to investigate the correlation between motivation toward chemistry and perception toward augmented reality (15 minutes).

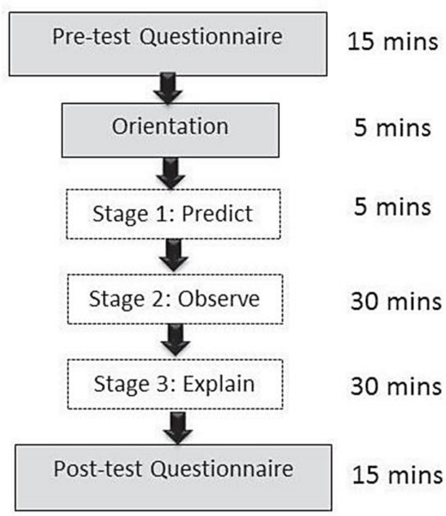

Figure 3 shows the procedure of the learning activity

The statistical data analysis techniques selected for this study were Pearson's correlation. The Pearson's correlation in SPSS was used to investigate the correlation between motivation toward chemistry and perception toward augmented reality.

5. Results and Discussion

5.1 Correlation between Motivation and Perception

In order to investigate correlation between motivation toward chemistry and perception toward augmented reality, Table 1 shows Pearson's correlation of Intrinsic Motivation (IM), Career Motivation (CM), Self-determination (SD), Self-Efficacy (SE) and Grade Motivation (GM) in the motivation toward chemistry Questionnaire (MTCQ) and Perceived Learning (PL), Perceived Ease of Use (PEU), Flow (F), Perceived playfulness (PPF), Enjoyment (E) and Satisfaction (S) in the perception toward augmented reality questionnaire (PTARQ). Mean and standard deviation are also presented in table 3.

Table 3 : Descriptive and correlation motivation toward chemistry and perception toward augmented reality.

Scale	IM	CM	SD	SE	GM	PL	PEU	F	PPF	E	S
IM	1										
CM	.709**	1									
SD	.466**	.472**	1								
SE	.324**	.249*	.492**	1							
GM	.392**	.441**	.472**	.504**	1						
PL	.067	.070	.094	.121	-.158	1					
PEU	.212	.169	.134	.173	.111	.590**	1				
F	.282*	.238*	.282*	.197	.070	.593**	.596**	1			
PPF	.183	.071	-.061	.147	-.001	.246*	.307**	.380**	1		
E	.229*	.229*	.095	.217	-.045	.473**	.602**	.522**	.373**	1	
S	.111	.175	.164	.210	-.014	.708**	.663**	.597**	.287*	.716**	1
Mean	16.56	16.87	16.91	15.35	18.12	13.00	8.61	11.90	12.97	8.55	21.60
SD	3.504	3.618	3.499	4.167	3.433	2.084	1.359	2.257	3.727	1.535	3.388

$^{**}p < 0.01$

$^{*}p < 0.05$

Regarding Pearson's correlation analysis of each scale from MTCQ, Intrinsic Motivation (IM) was positively related to Career Motivation, Self-determination, Self-Efficacy, and Grade Motivation. Career Motivation was positively related to Self-determination, Self-Efficacy and Grade Motivation. Self-determination was positively related to Self-Efficacy and Grade Motivation. Self-Efficacy was positively related to Grade Motivation. All scale positively related together, this result indicate that students have motivation to learn chemistry.

The result of PTARQ, Perceived Learning, Perceived Ease of Use, Flow, Perceived playfulness, Enjoyment, and Satisfaction were related together. From the pronouncement, it suggests that if students have only one scale of Perceived Learning, Perceived Ease of Use, Flow, Perceived playfulness, Enjoyment, and Satisfaction. They have motivation to learn via the mobile AR application. Considering Table 2, Intrinsic Motivation and Career Motivation were related to Flow and Enjoyment, but there were no significantly related to Perceived Learning, Perceived Ease of Use, Perceived playfulness, and Satisfaction, when students learned via the mobile AR. Self-determination was related to Flow but was no related to Perceived Learning, Perceived Ease of Use, Perceived playfulness, Enjoyment, and Satisfaction, when students learned via the mobile AR. Self-Efficacy and Grade Motivation were related to Perceived Learning, Perceived Ease of Use, Flow, Perceived playfulness, Enjoyment, and Satisfaction, when students learned via the mobile augmented reality. Thus, the AR could use for all students even if they have a negative or positive motivation toward chemistry.

The findings from this result indicated that perception toward augmented reality does not depend on motivation toward chemistry. Although students negative or positive motivation toward chemistry, they could learn chemistry by augmented reality.

6. Conclusions and limitations

6.1 Conclusions

The result of this study indicated the influence of motivation toward chemistry on students' perception to learn in setting of inquiry-based augmented reality learning environment that students' motivation toward chemistry has a partial impact on their perception toward mobile augmented reality. There are two dimensions, i.e. Flow and Enjoyment, which were significant related to Intrinsic Motivation, Career Motivation and Self-determination. That is, students' feeling of enjoyment and perceiving of flow of learning experience depend on the feeling of learning science for its own sake, and as a means to an end. Thus, we could use the AR for participants who have both positive and negative effect. Although they like or dislike to learn chemistry, they still have a positive perception toward augmented reality after learning with the AR. Finally, it is suitable to implement the augmented reality in a Thai school. But instructor has to design and develop correctly material to elimination of students' misconception.

6.2 Limitations

Besides providing the result of using the AR for chemistry learning in the present paper, the results investigated about the correlation between motivation and perception from the intervention with using the AR in some parts of acid-base. However, due to well-implemented investigations of AR in science learning is still a little number used in chemistry learning and Thai context. So, it may be a limitation about the articles reviewed from scholar database. Some model of the AR might be copyrights about technical graphic or business demonstrations of the AR in science learning which might limit the representation of state-of-the-art AR applications. Although, the AR could support students' visualization and imagination skills, but it is not suitable on complex mechanism or many steps of reaction in science learning. In addition, this is just some content with using the AR in science learning. In the future, it deserves to explore the possibilities of using the AR with others content or others perspective which suitable applied in science education to elaborate the efficiency of this contemporary technology.

Although there are many researchers indicated that teaching and learning with AR technology can improve students' motivation, visualization, and imagination skills, but a few study implemented the combination of AR technology and hands-on microcomputer-based laboratory. In additions, the challenge is how to immerse the AR into classroom instruction or into text book. Moreover, the most challenge which researcher is interested to design and develop the AR to support students' learning is how to immerse the AR into e-book. Based on the finding of this study, we will design and develop the AR in ebook about acid-base content use model-based inquiry (MBI) approach for improving chemistry learning in quasi-experimental design that include different-intervention groups of students. One group will provide the AR in ebook with MBI instruction and another gain traditional instruction. The mixed research methodology quantitative method of non-equivalent control group design with method of phenomenological research design will carry out in future research.

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An Integrated Environmental Monitor

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Abstract: More and more pollutions have been made since the Industrial Revolution occurred in the late 18th century, and these environmental problems are not confronted seriously until the previous century. In recent years, people face these problems and start to pay attention on monitoring our living environment by self. Simple and practical instruments are required in measuring environmental parameters and pollutions. In this purpose, we developed an integrated environmental monitor (IEM), based on Arduino platform. This monitor is composed by several sensors, includes measurement of temperature, humidity, atmospheric pressure, air quality, sound strength, solar ultraviolet (UV) radiation, etc. All sensors are modular, which means these sensors could be added/removed depending on different requirements. A GPS receiver is also build-in to get real time and position, and all the observed data are recorded on a SD card. The advantages of this monitor are low-cost, low-power consumption, high accuracy, and multi-function. It's suitable for education and can be a good household environmental monitor in the future.

Keywords: environmental monitor, air quality, automatic weather station, Arduino.

1. Introduction

In the last century, scientific and industrial advancement changed human life dramatically. Accompanies with the progression of technology, a huge amount of natural resources, fossil fuels, and energy are consumed, environmental pollution and toxic chemicals become a major issue in the world at this situation. Therefore, people turn to attend to their living environments and try to protect the health and living quality. However, observing temperature and humidity is effortless by using a dry- and wet-bulb thermometer, but measuring other environmental parameters, such like noise and air quality, is much more difficult. Unattended and automatic recording is also required to help people monitor their living environment whole day.

In recent years, light, low-cost, and high-performance electronic devices have been developed, people can use these portable and beneficial devices to improve their living quality. The revolution in electronic device also provides a good opportunity for people to measure environmental parameters. Nowadays, it's possible to attend and try to protect our environment by using consumer electronics products.

In this paper, we present an environmental monitoring system with several advantages, include low-cost, low-power consumption, high accuracy, etc. This monitor is a modular system, it's able to customize for any purpose and also suitable for environmental education.

2. System Configuration and Operation

The present integrated environmental monitor (IEM) is based on Arduino electronics platform, which is an open-source micro-controller with high performance and low-power consumption. Environmental sensors, data storage, and display units could be integrated into Arduino platform. All sensors and units are self-governing and modular, customized designs are available by adding or removing sensors/units depending on different requirements. The programmable micro-controller provides customized sampling and data rate, and some calculations and unit conversions could be done immediately.

Most of sensors which follow one of the protocols, such like 1-wire, I^2C (Inter-Integrated Circuit), SPI (Serial Peripheral Interface), are compatible with Arduino and could be stacked/attached to the present IEM. This system uses a 5 volts DC power via USB port, in other word the power can supply from the USB port of a computer or an AC/DC adapter. External battery or power bank are also acceptable to power this system.

The dimension of the present IEM is quite small and can be contained in a 20 * 10 *10 cm^3 box, and the total weight does not exceed 500 grams (includes battery which could power this IEM more than 1 day). This portable size fits for hand-held box, handbag, backpack, etc., and could be transported to any place to observe environmental parameters. An illustration of this system is shown in Figure 1.

Figure 1. The present IEM could be stored in a hand-held box. Two fans are installed to maintain airy condition.

In the following sections, we show two applications of the present IEM. These two applications have different configurations both in hardware and firmware, i.e., the sensors and program codes used in these two are different. Three sets of the present IEM have been tested. The IEM (#1) in the first application is constructed by a universal air quality sensor to measure air quality, and we set a sampling rate of 1 sample per minute. In the second application, some meteorological sensors are attached to the IEMs (#1, #2, and #3) to observe meteorological parameters during a rainy day and the influence of a typhoon, sampling rate is set to 1 sample per 10 seconds to record both short- and long-period variations. GPS receiver has also been build-in to get real time and position information. All the observed data were recorded on SD cards.

The present IEM is an easy-to-use system, two university students who have no experience in electronics and micro-controllers participated in the test of this system. Two IEMs (#1 and #2) were placed in students' dormitory rooms at National Central University (NCU), and the other one (#3) was placed at Changhua, about 150 km away from NCU. All the instruments were installed indoor with airy condition, and kept powered on 24 hours.

3. Applied Example 1 – Air Quality

In this case, an air quality sensor is attached to IEM to measure pernicious gases. The output of this sensor is a numerical air quality index (AQI), indicates how polluted the air is. Higher/lower index indicates worse/better air quality.

Figure 2 shows an example of air quality measurement, which the IEM was sited in a university dormitory influenced by biogas from neighbor drains. Biogas is a mixture of different gases, such like methane (CH_4), carbon dioxide (CO_2), Nitrogen N_2, and toxic gas as hydrogen sulfide (H_2S). Hydrogen sulfide is very poisonous and corrosive (World Health Organization, 2003), which may harm health and safety.

In Figure 2, the AQI remains higher values during nighttime, and trends to lower values during daytime. After sunrise, the atmosphere becomes unstable as solar heating increase, strong and gusty winds are more likely to occur (Ahrens and Henson, 2015). The hydrogen sulfide produced from drains will be blown away from its source region while the weather is windy. Therefore, the AQI lowers as the concentration of hydrogen sulfide decreases during daytime, and then heightens during nighttime.

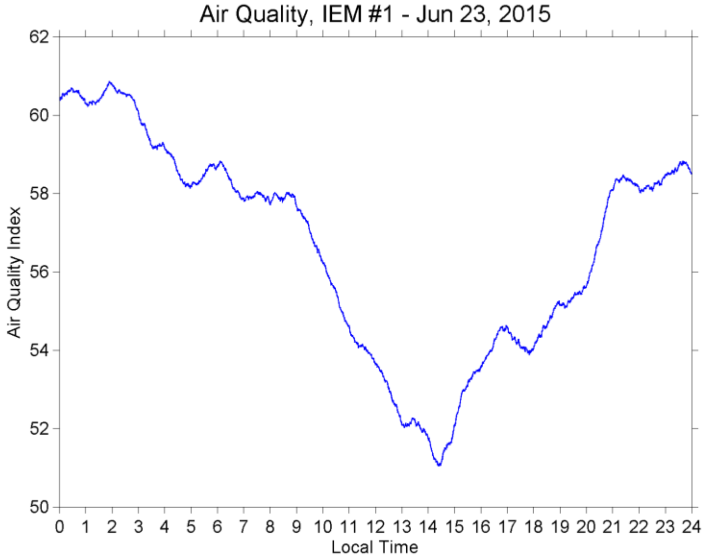

Figure 2. The measurement of air quality.

4. Applied Example 2 – Automatic Weather Station (AWS)

The present IEM is also sufficient for weather observations. In this section, we show two examinations of meteorological behavior. The attached sensors are thermometer, hygrometer, barometer, etc.

4.1 Humidity

People feels most comfortable while the relative humidity (RH) is in the range of 50% – 60% ("Relative humidity," n.d.). In this section, we try to find a quite uncomfortable room which was reported by residents in a university dormitory, and the IEM (#2) was prepared as an AWS and installed during rainy days.

Figure 3 shows the observed temperature, RH, and corresponding mixing ratio (which means the mass ratio of water vapor in day air) on May 24, when the weather was influenced by Mei-yu front whole day. Since the indoor temperature is nearly the same as outdoor temperature (figure is not shown here), and the air was moist because of raining, the indoor RH maintained very high values, exceed 90%. The residents in the dormitory reported that it was a humid day, consistent with the high humidity observed by the IEM.

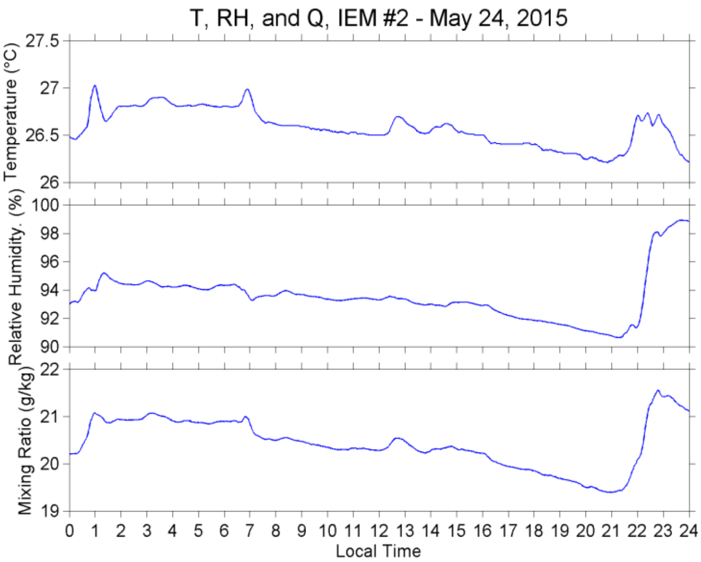

Figure 3. The observed temperature (top), relative humidity (middle), and corresponding mixing ratio (bottom), respectively.

4.2 Atmospheric Pressure

Figure 4 shows the examples of barometric pressure measurement. The Typhoon SOUDELOR influenced Taiwan from August 6 – 9. Two IEMs were set at different positions to observe the barometric variations during the passage of this typhoon.

IEM #3 was sited at Changhua during typhoon. The observed lowest mean sea level pressure (MSLP) is about 959 hPa while the center of typhoon is located 20 km away from this site in the morning of Aug 8 (blue line in Figure 4a). The surface observations at Taichung Weather Station operated by Central Weather Bureau, Taiwan are used to validate the data observed by the IEM (red line in Figure 4a). Although Taichung Weather Station is 20 km farther from the center of Typhoon than Changhua is, the barometric trends of these two are similar within 4 hPa difference in values.

Another comparison is shown in Figure 4b. The second set of the IEMs (#1) was sited at NCU, and the observed data at Sinwu Weather Station, Taoyuan are used to validate the IEM data. These two locations are neighbor and much farther away from the center of typhoon, and the MSLP measurements are almost the same.

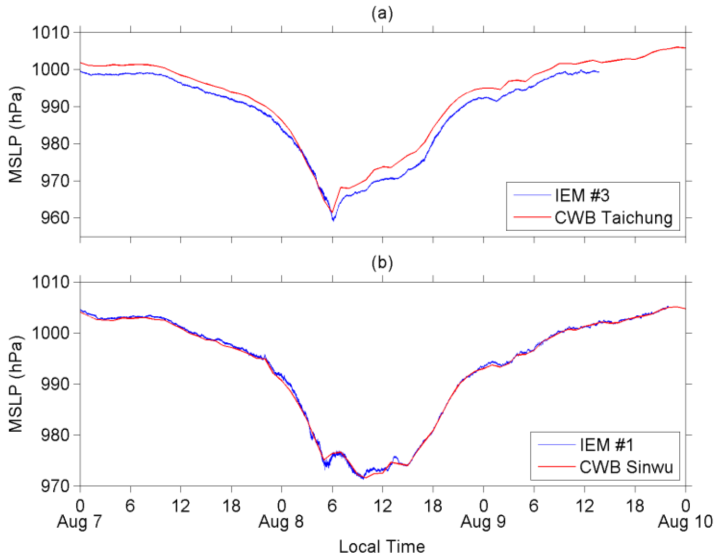

Figure 4. (a) The barometric pressure observed by the IEM at Changhua (blue) and the comparison observed by neighbor weather station at Taichung (red). (b) Similar to (a) but the IEM placed at NCU and compared with weather station at Sinwu.

5. Summary

In this paper, we present an integrated environmental monitor (IEM) used to measure environmental parameters, include temperature, humidity, atmospheric pressure, and some factors of pollution, such like air quality. The present IEM is quite stable for continuous observation, and the performance and observational results are satisfied, as discussed in Sections 3 and 4. This system is suitable for people who have no experience in electronics and could be used in environmental education.

Acknowledgement

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Online Student-Constructed Tests with Citing Capability: Perceived Uses, Usage, and Considerations

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Abstract: Students' perceived uses, usage, and considerations with regard to citing versus no citing peers' work during online student-constructed tests (SCT) activities were examined. A total of 84 fifth-grade students from three classes (N=84) were invited to participate in an online SCT activity during their regular science class. One online system was adopted to support the associated learning activities, where students experienced SCT with both citing (i.e., SCT based on both self- and peer-generated questions) and no citing conditions (i.e., SCT based on entirely self-generated questions). Three major findings were obtained. First, predominate percentage of the participants rooted for 'citing' for promoting learning over 'no citing' during online SCT. Second, data from perceived uses and revealed citing usage both supported the potential of citing for providing an observational learning space for imitation, comparison-making, and learning from peers, despite that a handful of the participants casted doubts upon the worth of the effort and work involved in locating and editing items. Third, the quality and the author of the item are the two determining factors affecting citing decisions. Suggestions for system developers and instructors were provided.

Keywords: online learning activities, perceived uses, revealed usage, selection considerations, student-constructed tests

1. Introduction

Engaging students in reflecting back on what they view as relevant and important in the study material and generating question items around the identified areas has attracted an increasing number of researchers' and practitioners' attention since the turn of the century (Yu, 2012). This approach, known widely as student-generated questions (hereafter called SGQ), has been applied in different domains at various educational levels as alternative learning and assessment approach (Yu, Wu and Hung, 2014).

With SGQ's prevalent learning effects for facilitating cognitive and affective development, recently, efforts to further promote the fluidity, flexibility, and effects of SGQ via different arrangements and designs have been the focus of a network of researchers. Some features examined include: the provision of online procedural prompts during SGQ by Yu, Tsai and Wu (2013) and Yu and Pan (2014), different identity during SGQ (Yu and Liu, 2009; Yu and Wu, 2011), online access to peer-generated questions during SGQ by Yu and Yang (2014), and student-constructed tests (SCT) based on SGQ activities by Yu and Su (in press). Along this line of work, this study explored the potential of citing peers' work during online SCT process. Specifically, students' perceived uses, revealed usage, and considerations with regard to citing versus no citing peers' work during online SCT were examined.

2. Methods

Three fifth-grade classes (N=84) participated in this study during their regular science class in the participating school's science lab. Two units were covered during the study—Unit 3: properties of an aqueous solution (e.g., PH, conductivity), and Unit 4: forces and motion. Three 40-minute instructional sessions were allocated for science each week. The online learning activities (both SGQ and SCT) were introduced to support students' science learning. As yes/no and multiple-choice question types are most frequently used by primary school science teachers, they were chosen as the question types to be generated for SGQ and included in SCT.

Prior to the actual study, a training session was reserved to equip the participants with the needed knowledge and skills to prepare them for the following online SGQ and SCT activities. Four instructional sessions, each with a different focus, were arranged in two weeks. They are: locating the main ideas of the study material and generating questions around the identified target in conformance with a set of criteria; generating yes/no questions in the adopted system with reference to the set criteria; generating multiple-choice questions in the adopted system with reference to the set criteria; constructing a test based on generated questions in the adopted system with reference to the set criteria.

Afterwards, for the following nine weeks, as a routine, students were directed to use I-pad mini to individually generate five yes/no and multiple-choice question items according to the learned science material covered in the current week and keyed in the adopted SGQ online system at the last 20 minutes of the instructional time on a weekly basis. Then, after the last instructional session on each unit (i.e., Units 3 and 4), students were requested to construct a test for each respective unit with reference to already generated questions stored in the system in 40 minutes. Students could also generate new question items at this stage if deemed beneficial. In order for the participants to experience and compare SCT with and without the capability of citing peers' work, students were set to work on SCT based entirely on their own generated questions for Unit 3, following by constructing a test based on one's own and peers' generated questions for Unit 4.

An online system to support the associated activities (SGQ and SCT) was adopted. Simply explained, to access peers' work during SCT, students click on / icon, which are only accessible when the citing function is activated by the instructor to switch between self-generated and peer-generated questions spaces. Students must edit peer's work before it can be included in one's test. To include any work in a test, students simply drag the targeted item from the SGQ space to the SCT space. For a complete description on the design of SGQ and SCT, please refer to Yu (2009) and Yu and Su (in press).

At the conclusion of this study, each student was asked to complete a questionnaire. Three questions were designed to solicit students' views regarding their perceived uses, revealed usage, and considerations with regard to citing versus no citing peers' work during SCT. They are:

(1) Which of the two approaches for SCT do you think better promote your learning (no citing, citing, no difference)?
(2) Under citing condition, your frequency of citing peers' work was (very high, high, slightly high, slightly low, low, very low). Please justify your answer.
(3) What are the determining factors when deciding whether and which peer's work to cite?

3. Results

3.1 Uses

Results from Q1 found that nearly two-thirds of the participants (n=54, 65.85%) expressed their support for 'citing' function for promoting learning over 'no citing.' The rest of the participants split between 'no citing' and 'no difference' options (17.07%, n=14). A X^2 test indicated that the proportion among the three options was statistically significant (X^2=39.02, $p < .001$).

Three salient themes emerged from the constant comparative data analysis method (Lincoln & Guba, 1985) done on students' written responses supporting citing. First, among those, 50% (n=27) highlighted citing's enabling effects for observing and learning various ways of creating questions around the study content. Second, more than 20% of those (n=11, 20.37%) mentioned directly that via viewing peers' generated questions, it served well for reviewing purpose. Finally, five students appreciated that 'citing' allowed them to recognize areas deemed important by their peers but missed by them.

On the other hand, more than half of those supporting ‘no citing’ (57.14%, eight out of the fourteen) referred explicitly to the importance of relying on oneself to reflect and figure out what’s important, what’s not yet understood, the answer to the posed question, and so on, which resulted in better comprehension, learning, and sense of accomplishment. Three respondents directly downplayed the effects ‘citing’ may have due to its merely requiring preliminary editing work from the part of the user, and was less challenging, less effort-demanding, and thus not beneficial for learning.

Finally, for those feeling no difference between ‘citing’ and ‘no citing’ (n=14), most noticed the benefits that respective approaches offered, that is, ‘citing’ for allowing one to observe and learn from peers’ versatile ways of generating questions and reviewing, and ‘not citing’ for directing students to review and think hard about test-worthy content by themselves.

3.2 Usage

As for Q2, as shown in Table 1, substantially more participants (32.10%) selected the ‘slightly high’ option than the rest of the options, which ranges between 9.88% (very low) and 16.05% (high). Clustering the participants into the high citing (i.e., those selecting 1+2+3) and low citing frequency use groups (i.e., those selecting 4+5+6) revealed that more participants fell on the high citing group (61.73%) than the low citing group (38.27%).

One main theme emerged from the constant comparative method done on reasons for frequently citing peers’ work—to increase the quality of SCT (32 out of the 50, 64%). Among those, eight respondents pointed out specifically that they tended to cite items that appear interesting or creative (i.e., style-wise), five mentioned that they chose to cite items at different difficulty levels or covering different areas of the study material to increase versatility (i.e., content-wise).

On the other hand, data analysis conducted for not frequently citing peers’ work (n=31) revealed two major reasons—no need, and the editing work imposed by citing peers’ work. For the former, fourteen respondents explained that it is because they felt that the quantity and quality of their own work is good enough, and it is hard to locate questions of a better quality than theirs. Eight respondents simply stated that the hassle involved in editing peers’ work surpassed what was needed for generating one’s own questions.

Table 1. Descriptive statistics on students’ responses regarding their frequency of citing peers’ work (N=81)

	1* f (%)	2* f (%)	3* f (%)	4* f (%)	5* f (%)	6 f (%)	1+2+3 f (%)	4+5+6 f (%)
Q2. Reported frequency of citing peers’ work	11 (13.58)	13 (16.05)	26 (32.10)	12 (14.81)	11 (13.58)	8 (9.88)	50 (61.73)	31 (38.27)

*1: very high; 2: high; 3: slightly high; 4: slightly low; 5: low; 6: very low

3.3 Selection consideration

Constant comparative method done on students’ responses as to the determining factors for their deciding whether and which peer’s work to cite (n=80) fell into two main categories—the quality of the item itself (n=68, 85%) and who the author is (n=13).

While some respondents simply stated that “items of good quality” without providing further explanation about what qualities those are (n=11), most respondents did. Three main features were identified. First, the interestingness, creativity and funniness of the item were mentioned by most respondents (n=44). Relating to main ideas of the study material was also pinpointed by many (n=35) as their main consideration during the citing process, followed up by item difficulty (n=12).

Another group of respondents clearly stated that items generated by their good friends (n=11), or by those generally performing well in class (n=4) were their main targets for citing.

4. Discussion and Conclusion

Several important findings were obtained. First, significantly predominate percentage of the participants rooted for 'citing' for promoting learning over 'no citing' during SCT.

Second, data from the perceived uses and revealed citing frequency both supported the potential of citing for providing an observational learning space for the participants to imitate, compare, and learn from each other regarding question-generation and main ideas identification. This provided space, as suggested by Bandura's social learning theory (1977, 1986), would be beneficial for personal cognitive growth and task development in the focal domain.

Third, the quality and the author of the item are the two determining factors affecting students' citing decision. About the quality of the item, the interestingness/creativity/funniness of the item, relating to main ideas of the study material, and item difficulty were the three considerations offered by most respondents. This obtained results resembled what was found in Yu and Sung's study (in press) where the features/content of the work was the determining factor when it came to deciding the target for online peer assessment. However, unlike Yu and Sung's findings, in this study the author of an item did have an effect on citing for a handful of students.

In view of the positive responses obtained from the participants about SCT with citing, system developers are advised to include this design in SCT to allow students to benefit from the process. By including citing feature in online SCT, the power of the web 2.0 technology is better tapped on for the realization of collective wisdom (Abramovich and Brouwer, 2008; O'Reilly, 2005) and peer-assisted learning in a fluid way (Topping and Ehly, 1998). Likewise, it is suggested that instructors consider adopting systems equipped with this affordance for added learning support.

Finally, as reflected in respondents' comments, requirements for citing peers' work (i.e., editing) affected usage. System developers as well as instructors can incorporate this requirement/design to help mitigate unethical copying behavior, which negatively affect deep cognitive processing on the part of the user.

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A learning environment for externalizing procedural knowledge in problem solving:

A preliminary trial for tutoring problem posing skills

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Abstract: Problem posing is a challenging task for naive students. For problem posing, students must identify knowledge and procedures for solving problems. We suppose that understanding of procedural knowledge for problem solving enhances problem-posing activities. We developed a learning environment wherein students find and formally describe various types of procedural knowledge while problem-solving. The system comprises two modules: the knowledge editor and the problem-solving simulator. Students externalize a procedural knowledge set for solving crypt-arithmetic tasks using the knowledge editor. With the problem-solving simulator, they also simulate the behavior of the model comprising the knowledge set. The practice in class confirmed that two-thirds of the participants constructed reasonable models with our system. They appeared to succeed in identifying and externalizing procedural knowledge for solving a relatively complex arithmetic task.

Keywords: Problem posing, Cognitive model, Procedural knowledge, Crypt-arithmetic task.

1. Introduction

Problem posing is a crucial educational method for facilitating the students understanding on the nature and structure of problems. However, students also encounter challenges while posing problems. Many studies have reported that when students are required to pose problems, they merely replicate a familiar example problem, not employing effective styles of problem posing (Kojima, Miwa, & Matsui, 2015). To enhance students' problem-posing activities, we must investigate the processes that underlie problem-posing activities.

Initially, we have to understand how to solve problems for posing problems. In other words, we need to identify the knowledge and mental procedures required to solve problems. For example, when we pose an arithmetic problem, we must possess the procedural knowledge required to solve that problem. One effective strategy for doing so is to focus and monitor our own problem-solving processes to understand how we, by ourselves, solve the problem. Such cognitive capability is known as meta-cognitive skills. Numerous studies have reported that meta-cognitive activities, such as self-explanation, improve students' learning processes and create positive learning effects (Chi et al., 1989; Aleven & Koedinger, 2002). These findings imply that meta-cognitive activities also provide beneficial advantages in problem posing. However, it is also challenging for naive students to engage in meta-cognitive activities because such activities' involve significant cognitive load.

The authors have developed the "learning by building cognitive models paradigm," wherein students construct computational cognitive models that solve cognitive tasks (Miwa et al., 2014a). We have confirmed three advantages of this learning paradigm: (1) theory-based thinking in which students learn to interpret and explain experimental results based on a theory (Saito et al., 2013); (2) mental simulations in which students learn to predict experimental results by performing mental simulations (Miwa et al., 2014b); and (3) externalization of cognitive processing in which students learn to identify the procedural knowledge required to perform a cognitive task (Miwa et al., 2015).

The final feature in the aforementioned advantages, drawn from learning by building cognitive models, may generate beneficial resources in teaching problem posing. Our preceding study included two class practices for undergraduates and graduates: Participants were required to construct a computational running model for solving subtraction problems and then develop a bug model that simulated students' arithmetic errors. Analyses indicated that by creating cognitive models, participants learned to identify buggy procedures that produce systematic errors and to predict expected erroneous answers by mentally simulating the mental model. Such learning skills for identifying procedural knowledge should provide students with the significant foundation for acquiring capabilities in sophisticated problem posing.

We believe that acquisition of this type of skill causes acquisition of problem-posing abilities. Our strategy is to promote students to learn skills that enable them to identify procedural knowledge necessary for problem-solving. Thus, we present a preliminary trial for developing a learning system for teaching problem-posing skills. We report here the construction of a learning environment and a preliminary evaluation performed with class practice that examines the extent to which participants could accurately externalize relatively complex procedural knowledge used in solving a crypt-arithmetic task.

2. Task

The task used in our study is a crypt-arithmetic task. In this study, we propose an environment wherein students learn to understand their procedural knowledge to perform the task while building a computational model. The following is an example problem:

```
 DONALD
+GERALD
 ROBERT  D=5 is given
```

The problem is prima facie simple; however, cognitive information processing for its solution is relatively complex. In fact, multiple types of procedural knowledge are used during solution processes. The following are some examples.

- <u>Numeral processing</u>
  If a column is x + y = z, and both x and y are known, then infer z by adding x and y. For example, in the rightmost column, we know D equals 5; therefore, 0 is assigned to letter T by applying this procedure.
- <u>Specific numeral processing</u>
  If a column is x + y = x, then infer that y equals 0 or 9. For example, in the fifth column, we obtain that E equals 0 or 9 independently, without any other information.
- <u>Parity processing</u>
  If a column is x + x = y, and we have a carry from the right column, then infer that y is an odd numeral. For example, in the second column, we obtained a carry by the inference in the first (i.e., right) column; therefore, we conclude that R is an odd numeral.
- <u>Inequality processing</u>
  If a column is x + y = z, and no carry is sent to the left column, then infer that z is greater than x (or y). For example, in the sixth column, we know that D equals 5, and no carry is sent to the left column; therefore, R is greater than 5.

University students easily understand such procedural knowledge sets if they are given; however, they may face challenges finding the knowledge by themselves and externalizing it while solving the problem.

3. Learning System

We developed a learning environment to enable students to find and formally describe various types of procedural knowledge while solving problems. The system comprises two modules: the knowledge editor and the problem-solving simulator.

3. 1 Knowledge editor

Students externalize a set of procedural knowledge for solving crypt-arithmetic tasks with the knowledge editor.

Figure 1 demonstrates an example screenshot of the knowledge editor wherein the procedural knowledge of inequality processing such as, “If a column is x + y = z, and no carry is sent to the left column (b==0 in the figure), then infer that z is greater than x,” is described.

A list of procedural knowledge installed for the problem solver is presented at the right side of the window. If we delete the check from each item of the list, we can simulate the behavior of the problem solver from whom the knowledge is excluded.

<u>Figure 1</u>: Knowledge editor for helping students externalize a procedural knowledge set for solving crypt-arithmetic tasks

3. 2 Problem solving simulator

The problem-solving simulator is mounted on the learning system. The problem solver that simulates behavior has the potential to perform an exhaustive search for assignments of digits to letters. Specifically, it selects one of the letters that has not been determined and systematically assigns each digit to a letter. If a contradiction is found in the process of inference, another assignment is tested. If the problem solver has no procedural knowledge, it is impossible to derive the solution because the problem space spreads exhaustively. Students are required to give the problem solver adequate procedural knowledge with the knowledge editor.

(a) Problem-solving simulator (b) Example search tree

<u>Figure 2</u>: The problem-solving simulator, which simulates behavior, can perform an exhaustive search for assignments of digits to letters.

Figure 2 (a) indicates an example screenshot of the problem-solving simulator, which presents the assignment status of digits to letters (left side) and further presents a series for information processing step by step (right window). The system also presents the problem solver's behavior, represented as a search tree of problem-solving processes (see Figure 2 (b)). Students can confirm inference steps one by one, forwarding the inference by clicking the inference button. At any point of the problem-solving process, students can install, delete, or revise knowledge using the editor and restart the inference from the problem-solving point.

The system can simulate a variety of problem-solving processes (Newell & Simon, 1972; Miwa, 2008). For example, the complete problem solver arrives at the solution within approximately 21 to 42 steps. However, if the specific numeral processing, such as: "If a column is x + y = x (see the fifth column), then infer that y equals 0 or 9," is excluded from the knowledge set, and the problem solver requires more than 100 steps for a solution using the trial-and-error method.

4. Preliminary evaluation

4. 1 Participants and Procedures

Participants in the practice included 45 undergraduates of Nagoya University. In the first class, they learned how to manage the knowledge editor and operate the problem-solving simulator. Specifically, participants were given an example problem: MEST + BADE = MASER; they installed seven pieces of procedural knowledge for solving the given problem with tutor's guidance, and they simulated behavior at each stage of the construction process.

In the second class (1 week after the first class), participants were given a problem: DONALD + GERALD = ROBERT, and they, by themselves, were required to find a procedural knowledge set for the solution, install it into the problem solver with the knowledge editor, and construct a model—these processes were to be completed within 70 minutes.

4. 2 Result

The following was a representative model construction process. During the simulation process, participants encountered a crucial stage of problem solving and hypothesized a part of procedural knowledge required for processing the specific stage of problem solving. They tried to provide the problem solver with the procedural knowledge, but usually, they initially failed in the installation. They noticed the failure by forwarding the problem solving one step and confirming that the expected result was not obtained. Through the trial-and-error processes, once they accurately installed the knowledge set and passed through the crucial problem-solving stage, then they forwarded the inference process and faced another specific stage of problem solving. They again tried to identify knowledge for the stage.

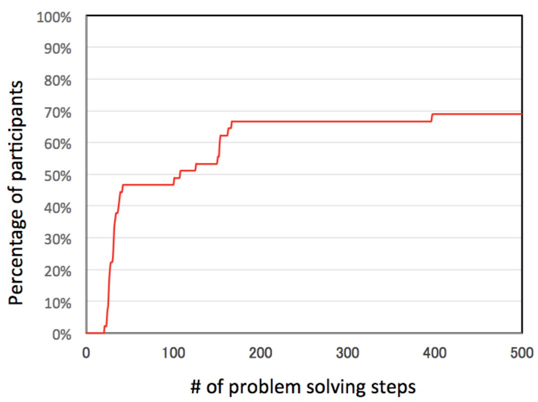

Figure 3: Percentage of undergraduate participants who constructed successful models for problem solving.

Our primary concern is to what rate and to what degree the participants accurately identified the procedural knowledge set for problem solving and successfully had the problem solver achieve the solution. Figure 3 indicates the class practice's results: The horizontal axis indicates problem-solving steps, and the vertical axis indicates the rate of participants who constructed the model that reached the solution by the problem-solving steps indicated in the horizontal axis.

Figure 3 indicates that 46.7% of participants constructed models that solved the problem within 42 steps. The second group comprised 20% of participants who solved it within 167 steps. The other 34.3% of participants failed to successfully construct the model.

5. Conclusions

We developed a learning environment to enable students to find and formally describe various types of procedural knowledge applied when solving crypt-arithmetic tasks. Our class practice confirmed that two-thirds of participants constructed reasonable models with our system. They appeared to succeed in identifying and externalizing procedural knowledge for solving such a relatively complex arithmetic task.

Our report here is limited to the first half of the project. The next crucial step is to examine whether developing such externalization of procedural knowledge actually enhances problem-posing activities. Our preceding study confirmed that following generative steps of problem posing positively impacts students' ability to pose a variety of problems (Kojima, Miwa, & Matsui, 2013). Similarly, we expect to improve problem posing through the development of such monitoring activities for mental processing.

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Scoping Research with a Focus on Questioning

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Abstract: This conceptual paper outlines a cross-disciplinary research agenda focused on situating questioning while engaging with the digital environment. It builds upon earlier research focused primarily in the area of *why*-questioning that identified significant difference between *information* and *explanation* as distinct goals of inquiry. Consequences of this distinction point to limitations of current digital technology, particularly from the perspective of an individual researcher engaging in prolonged, reflective inquiry. The digital environment offers numerous options to support inquiry but is dominated by the *search paradigm* in which the *informational* bias of search engines abbreviate inquiry, and therefore, questioning. While other digital options such as scholarly collection services, social media, and question-answering services also support inquiry there are limits to which these services can provide targeted support for sense-making activities such as in-session questioning, reasoning, interpreting, identifying connections, discerning relationships and implications, evaluating competing explanations, as well as development and validation of understanding. Within the research agenda outlined here the relationship between sense-making and questioning has emerged as a pivotal area to investigate. In a very reflexive way many questions arise – as the scope of this inquiry includes inquiry itself. What can be learned from a focus on *questions as data*? How might question formulation be supported online? What digital technologies are successfully used to support sense-making? In what ways might human-computer interfaces be further developed in order to scaffold deep and prolonged in-session questioning? In what ways might ontologies of questioning support such an endeavour? While situated at the nexus of educational research and information science, this research agenda is both informed by, and positioned to inform, other domains of research and innovation, including human-computer interaction, knowledge management, and communications design. Of particular interest is how application of the Question Formulation Technique and recent innovations in automated Question Generation might be utilized.

Keywords: questioning, inquiry, question formulation, sense-making, digital technology

1. Introduction

For a researcher, particularly at an early career stage, it can be important to articulate and make explicit a *research agenda* (the scope of research interest). Through doing so, a clear focus is established that can be communicated to colleagues as well as providing an overall coherent framework for a range of research projects to be situated within. This paper represents an outline of my own work-in-progress aimed at achieving this. Its focus is on questioning and sense-making within the digital environment, and this presents a reflexive dimension. Thus, while questioning represents a focus of inquiry, this paper does not set out to answer or report upon a primary research question as such.

Questioning has been integral to education for many centuries. The art of asking questions was most famously developed by Socrates as a pedagogical technique nearly twenty five hundred years ago. For Socrates, dialogue involving questioning was the principal means for uncovering the truth, revealing misconceptions and assumptions, exposing poor argumentation and prejudice, or discovering wider perspectives through clear reasoning (Guthrie, 1989; Stumpf, 1983). Socratic questioning can also be seen as a key foundation of the critical thinking movement and scaffolding techniques within constructivist literature (Mason, 2011; Paul & Elder, 2007; Paul, 1990; Wood, Bruner, & Ross, 1976).

Despite questioning having a long history within education, the actual *ability* to question is surprisingly under-researched given its complexity. The act of questioning is complex because it can seek or invite a range of very different responses – answers, facts, data, information, advice, explanations, understanding, reasons and dialogue. Indeed, a question often generates other, deeper questions. In digital environments, however, close analysis reveals that support for question formulation and refinement, as well as prolonged in-session questioning, is under-developed. The frontier that this research therefore aims to explore is the rich variation in human sense-making during questioning and how analysis of questions might inform development of digital scaffolds.

Conceptually, this research agenda builds upon the cross-disciplinary foundations and findings from my PhD dissertation (Mason, 2014a), a study that investigated the "*why* dimension – asking, learning, understanding, knowing, and explaining *why*" in the context of digital learning. Specifically, the research agenda going forward is focused more broadly on questioning – in particular, question formulation and generation that can be supported by digital technology and extends beyond the *search paradigm*, a construct used to describe the informational bias of search engines in abbreviating inquiry as keywords, and therefore, also abbreviating questioning (Mason, 2012b). In doing so it aims to examine the implications for digital services development arising from two key categorical distinctions within knowledge discovery and construction that were identified in my PhD dissertation:

- *Informational* versus *explanatory* content (see Figure 1)
- *Meaning-making* versus *sense-making*

It is typically the case that for inquiry instigated with informational goals the search paradigm is likely to be the most effective strategy. While it is the case that *browsing* is sometimes considered to be complementary (though distinct) from *searching*, it can also be considered as a subset in the context of this paper. Thus, searching for the nearest pizza shop is a simple example that would likely return clear and direct information to a query and would not normally require ongoing sense-making. Conversely, for inquiry that seeks an explanation, the content of a response might require extended reflection and sense-making – such as, *why is it so difficult to end the violent conflict in the Middle East?*

The distinction between *meaning-making* and *sense-making* is made for a number of reasons and dealt with at length in my PhD dissertation. Within this research agenda, it is important because "[sense-making] does not necessarily invoke meaning-making and is an activity that has a prominent role in human-computer interaction" (Mason, 2014c, p. 206). Moreover, questioning can proceed with or without meaning-making. Through dialogue, however, these distinct activities can be seen to converge for the simple reason that dialogue cannot proceed without some form of meaning-making..

In this short paper extensive use is made of conceptual representations. The rationale for doing so is in presenting complementary visualizations of the range of topics of interest and their relationships with each other. Significantly, artefacts such as concept maps are an example of an output of sense-making (Mason, 2014a). While concept mapping tools can also invoke meaning-making based upon semantic content their utility is not defined in such terms (Mason, 2014c).

Three figures are thus presented that indicate the scope and focus of this research agenda: Figure 1 presents a concept map used in my PhD dissertation to show a distinction between information and explanation which arises particularly in the case of why-questioning; Figure 2 presents a concept map of the key topics and how they are perceived to relate to each other; and, Figure 3 represents where the research is theoretically situated, from a disciplinary perspective. While these figures have been developed to be sufficiently expressive to communicate the scope of the research agenda this paper first provides some background discussion on sense-making and why it has been chosen as a pivotal construct. This is then followed by discussion on questioning and why it is pivotal to inquiry. Finally – given that the evolution of the digital environment has facilitated a shift toward student-centred pedagogies, self-regulated learning, and inquiry-based learning – the discussion focuses on tools that have been developed to facilitate this: automated question generation within the field of intelligent tutoring systems (Olney, Graesser, & Person, 2012) and the Question Formulation Technique (QFT), a teaching tool aimed at teaching students how to ask their own questions (Rothstein & Santana, 2011).

2. Sense-Making and Questioning

2.1 Sense-Making

Making sense of things is a fundamental need and disposition of human beings and probably predates the invention of language (Mason, 2014c). The term sense-making (also sensemaking), however, has only appeared as a construct within academic discourse in recent decades – across a broad range of disciplines (Dervin, 1998, 2005; Russell, et. al., 1993, 2008; Klein, et. al., 2006; Weick, 1995; Snowden, 2002). Digital environments bring expanded scope to this construct through providing novel and extended ways for sense-making to be expressed, explored, supported, and scaffolded.

This topic has been of particular interest to me for some years, initially in the context of modelling the various facets of knowing (*knowing-that, knowing-how, knowing-why*) given the convergence of digital systems designed for learning management, knowledge management, and performance support (Mason, 2008; Mooney, 2011). It is also a topic within information science that is essential for understanding of the structure and content of various metadata schemas and modelling of knowledge within educational contexts (Mason, 2009).

As my research agenda evolves it is expected that numerous discrete research projects focused on sense-making within the digital environment will be initiated – projects that will be positioned to have implications for both human-computer interface development and pedagogical practice.

2.2 Questioning

Questioning is a key foundation of all inquiry and research. It can also be considered to be a subset of inquiry and an activity broader in scope to search. Within the digital environment, however, there are significant constraints that limit natural questioning to dialogic rather than single user contexts. Despite this, the intrinsic extensibility of the Web also provides opportunities for development and deployment of novel tools that can support questioning (Graesser, et al., 2010; Graesser, et al., 2008; Lauer, et al., 2013; Mason, 2014a; Mason 2014b; Mason, 2014c; Mason, 2011).

Questions can be formulated in a rich diversity of ways, from the trivial to the complex, and research does not take place without them. This research will investigate questions classified according to user-assigned topics, their situational or conditional provenance, and collected at various scales of aggregation. The underlying assumption is that questions can function as data, whether as discrete elements of inquiry or within larger collections. Such data has potential to reveal aspects of human sense-making through analysis of their formulation, structural composition, situational relatedness, and semantic content. Data can also be collected when on-screen options for question formulation and refinement are presented. Through closer analysis of the form and function of questions, this research is positioned to inform the design of digital scaffolds and services that directly support – and advance – online inquiry.

Mainstream search engines do not facilitate or encourage deep thinking or prolonged inquiry. Their power and prevalence is embedded in contemporary digital devices and lies in abbreviating inquiry through keywords. In this *search paradigm* questioning becomes a casualty and is cut short. Within the broader digital environment, however, it is well supported through dialogue enabled by social media. The large subscriber bases of community question-answering services like Quora and Research Gate also testify to this function and their utility. Despite such options, the scaffolding of individual reflective inquiry through digital tools remains limited and is dominated by the search paradigm and the parsing of simple semantics. Arguably, this is at odds with trends in flexible education that place emphasis upon inquiry-based and self-regulated approaches to learning.

Recent developments in search technologies are also significant in their exploitation of developments in natural language processing – for example, the Watson DeepQA project (Ferrucci, et al., 2010, 2013; Fan, et al., 2012), which is now a cloud-based machine learning service. However, such projects are focused on improving the precision and efficacy of *answers* to questions in online systems. In this research, however, *answers are not within scope*. Understanding this limitation is critical as it enables a sharper focus upon question structure, function, nature of formulation, and intent.

From an inquiry-based learning perspective Rothstein and Santana (2011) have developed the Question Formulation Technique (QFT) as a method that stimulates student inquiry and questioning skills. As a pedagogical approach its underlying aim is to shift the role of the teacher away from the instigator of questioning. It follows a simple sequence of activities that begins with open brainstorming of all possible questions relevant to an agreed question focus. A key characteristic is a disciplined approach to limiting the activity to question generation – in other words, considering answers is not pursued. As a teaching academic, I have successfully used this technique on numerous occasions with my own students. It is also consistent with the vision of a "new culture of learning" outlined by Thomas and Seely Brown (2011, p. 81):

We propose reversing the order of things. What if, for example, questions were more important than answers? What if the key to learning were not the application of techniques but their invention? What if students were asking questions about things that really mattered to them?

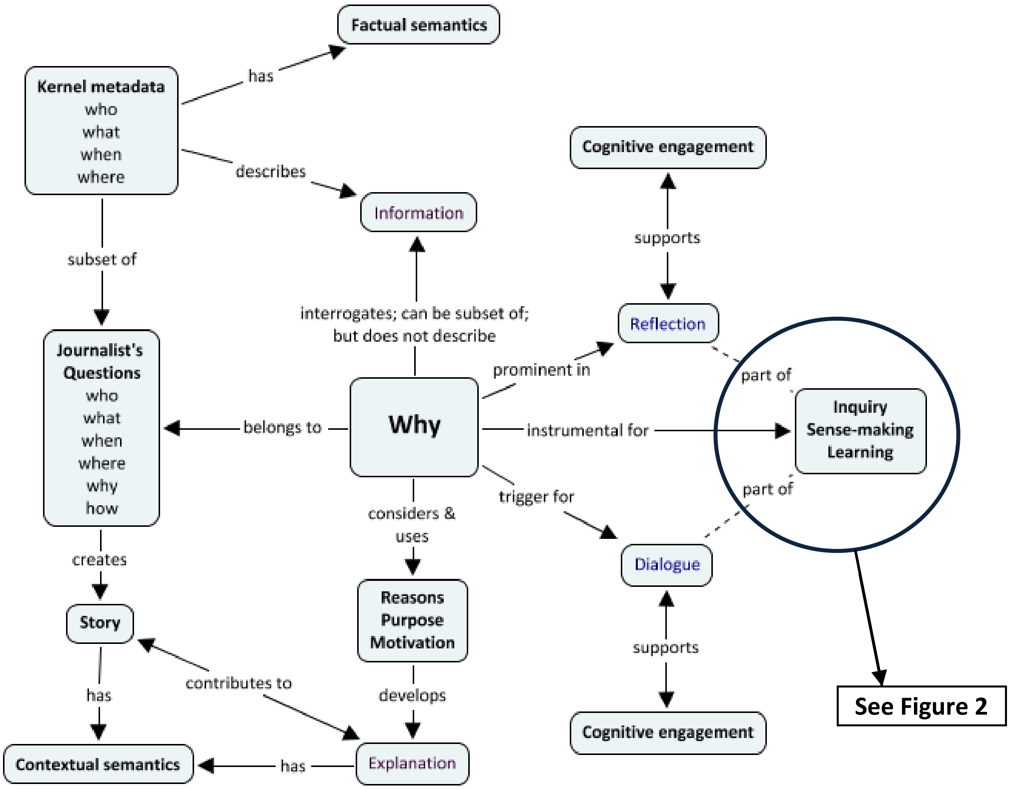

Figure 1. Conceptual domain of topics and semantics associated with *Why* (Mason, 2014a).

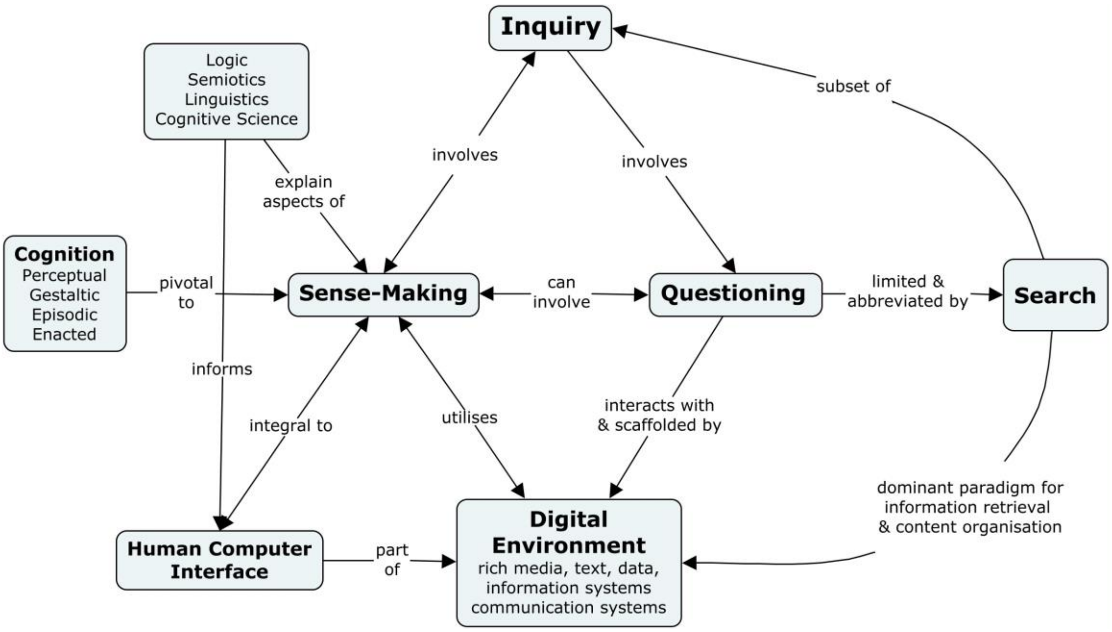

Figure 2. Conceptual map of emerging research agenda.

Figure 3. Cross-disciplinary focus.

3. Concluding Remarks

This paper has been developed with the intention of inviting comment at the workshop on *Technology Enhanced Learning by Posing/Solving Problems/Questions* to be held at ICCE2015 in Hangzhou in China in late 2015. It is a feature of this paper that it *does not* report on a research question as is typically the case at research-based conferences; rather, it presents the context from which a number of research questions emerge, such as: *What can be learned from research that has a focus on questions as data? What can be learned from the structure, function, formulation, and intent of questions? What digital technologies are successfully used to support sense-making? In what ways might human-computer interfaces be further developed in order to scaffold deep and prolonged in-session questioning? In what ways might ontologies of questioning be utilised?* In pursuing these and other related questions it is assumed that there are numerous ways in which digital technology can be harnessed to enhance learning and facilitate research. Through focusing on questioning as a sense-making activity – and *questions as data* – the expected outputs of activities resulting from the research agenda as outlined are novel strategies and services that could be used to support questioning within the digital environment.

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Using Problem-based Gaming Environment supported Conceptual Physics of Electric Current: A Result on Students' Perceptions

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Abstract: Educational problem-based gaming, which is one of emerging pedagogies, could promote students' perception. In this study, the educational digital game was specially designed for learning physics based on problem situation. To investigate the effect of perception toward physics lesson and to evaluate the developed problem-based gaming, 82 eleventh grade student were recruited to participate in the developed problem-based gaming. A Likert-scale perception questionnaire was administered to the students before starting learning activity as pre-test. After completing the learning activity, the students were asked to response the perception questionnaire as post-test. The repeated-measures MANOVA results indicated that there was no significant main effect on gender and interaction effect between gender and time (pre-test/post-test), but there were significant main effect on time. That is, there was no effect of gender difference on students' perception towards physics learning through the developed problem-based gaming

Keywords: Problem-based gaming, digital game-based learning, physics learning, interactive experience

1. Introduction

Nowadays, innovative technologies in learning and science teaching are growing continuously. Game is one of technologies that are important to promote science learning. In recent years, several researchers have paid attention to a new research trend that focused on using digital game for teaching physics concepts and other science concepts. There were several studies revealed that the use of game-based learning technology in the instruction could promote motivation and perception of students. For example, Farrokhnia and Esmailpour (2010) showed that the game have significant effect in fostering the students' perceptions. Meesuk and Srisawasdi (2014), Natthida & Srisawasdi (2014), Lokayuth & Srisawasdi (2014) implemented the student-associated game-based open inquiry in chemistry education and found that the students' perceptions and motivations were triggered. Generally, to study about the impact of real, virtual and comprehensive experimenting on students' conceptual understanding of DC electric circuits and their skill in undergraduate electricity laboratory, it has used computer simulations in learning. It was found that the computer simulations could promote students' learning. With technological features, the development of interactive computer-based learning materials for science teaching and learning provides opportunities to help students understand the concepts better by visualizing abstract science concepts into concrete experience to change students' alternative conceptions to scientific conceptual understanding (Srisawasdi, Kerdcharooen, and Suits, 2008; Suits and Srisawasdi, 2013). Moreover, teaching-learning process by integrating computer technologies such as digital game, simulation and others could be a novel pedagogy to promote meaningful learning and students' motivation better than traditional teaching-learning process. Physics, which is the one of most important discipline, explains daily life natural phenomena. Physics concept related to other concepts in science such as the biology, chemistry and materials science. However, it is difficult to understanding and learning when teaching by textbook led to low motivation in learning. Because the nature of Physics is abstract content which need to use imagination for connecting to real life situation (Turgut, 2011).

Therefore, with the abovementioned reasons, the digital game attributes may be help students increase learning interest in physics, motivation and attitude towards physics learning. Therefore, this study aims to create educational computer game as an inquiry tool to learn physics in concepts of electric current. Consequently, the goals of this study were to investigate students' perceptions towards Problem-based gaming in physics after interacting with the Problem-based gaming in physics. Specifically, the following questions were answered:

1) Do the student engaged in the developed problem-based gaming in physics perform significantly better by perceive learning, perceive ease of use, flow, perceived playfulness, enjoyment, and satisfaction?
2) Do genders effect on students' perceptions through the developed game?

2. Literature Review

2.1 Digital game-based Learning

Currently, digital technology and digital gaming are all around. Digital games consist of dazzling and sophisticated images and sounds, alongside textual communication. Players get engagement, which is both pleasurable and challenging. The educational digital games keep players immersed in digital worlds, knowledge, information, and skill development become increasingly accessible outside confines of formal education (Castell, Jenson and Taylor, 2007). In recent years, educators employed digital game combined with content of subject matter or information for educational purpose. Several researches presented empirical evidences that the educational digital games have positive effect on student learning (Farrokhnia & Esmailpour, 2010; Meesuk & Srisawasdi, 2014; Dorji, Panjaburee, & Srisawasdi, 2014).

In the past, game was produced only for entertainment but recently educational researchers have attempted to adapt games for learning which call educational games or serious game and use to study in classroom (Sorensen and Meyer 2007; Stone 2009). The game that composed of challenge, control, curiosity and fantasy can motivate persistence and enjoyment (Toro-Troconis and Partridge, 2010). The educators have developed games for three goals including : (i) student can learn from playing the game; (ii) the component of game can support learning; (ii) the component of game can support learning; and (iii) students have motivation to learn when they learning by playing the game (McNamara, Jackson, & Graesser, 2010). Game-based learning is a king of constructivist-based active learning. Based on the learning research, Watson, Mong and Harris (2011) found that using game in classroom made a shift of teaching from teacher-centered learning environment to student-centered learning environment.

2.2 Problem-based Gaming (PBG)

Problem-based gaming focuses on the meaning of authentic learning tasks, experiential learning and collaboration. Because games usually allow players to creatively test their hypotheses and reflect on outcomes in the game world, experiential learning theory provides an appropriate basis for PBG. In fact, a game includes a major problem, which is caused minor problem (Kiili, 2005). On the other hand, the authenticity of learning situations and tasks is assumed to be a very important factor in facilitating higher order learning (Brown, Collins & Duguid, 1989), at least in higher education. The basic idea is to anchor the learning of knowledge and skills into meaningful problem-solving situations encountered in everyday life. The situated learning theory supports this view by stressing that learning is a context-dependent activity (Brown et al, 1989). Such approach supports the transferability of learned knowledge and skills into the practice (Savery & Duffy, 1995). In games, the storyline and the game world can be used to contextualize the provided problems. Furthermore, the collaborative nature of problem solving is emphasized.

2.3 Problem solving

Problem-solving is a 21st century skill that is essential for learning, work, and daily life (Anneta, 2008). Problem solving can be defined as the ability to find causes, find solutions, and avoid problem (Chan & Wu, 2007). In evaluating problem solving ability, both flexibility and effectiveness should be considered. Whereas flexibility results in a variety of unique responses to a problem, effectiveness ensures that the solutions are practical and thoroughly considered.

3. Method

3.1 Participants

A total of 82 eleventh-grade student (female = 58, male =24), age ranging from 16-17 years, in a local public school at the northeastern region of Thailand participated in this study. They were attending a physics course for basic education level. Regarding to prior learning experience, they have no experience yet using problem-based gaming learning in physics.

3.2 Instructional materials

This section describes the design of problem-based gaming in conceptual physics of electric current. The researcher designed the game as a model problem situation in order to improve problem-solving skill in physics about electric current solution. When the player starts the game, they will assume themselves as characters in the game in order to perform various missions as shown in Figure 1. Figure 1 shows problem-situation about electricity shortages in kingdom: The leader of kingdom say that "How will kingdom have electricity?".

Figure 1. An example of screen interface of the digital game

Moreover, Figure 3 and 4 show problem-based gaming about electricity how to electrons move to the positive pole. Player can use left and right arrow to control electrons through possible obstacles in order to move on to positive pole.

Figure2. An example of a problematic situation in the digital game

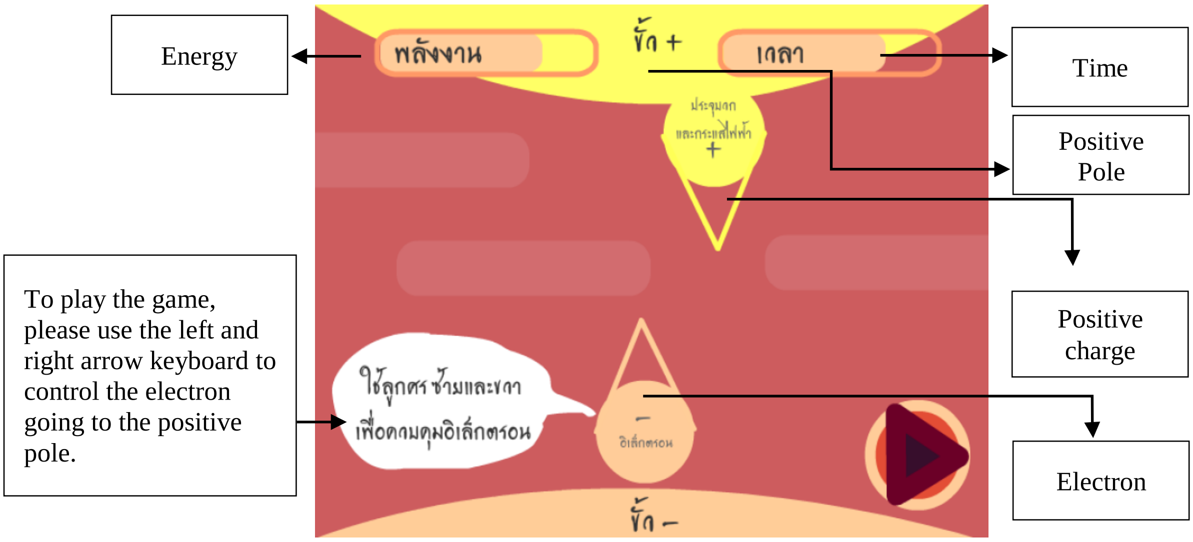

Figure3. An illustration of components in the game

3.3 Research instrument

A 18-item Likert-scale questionnaire was adapted to employ in this study for examining students' perceptions towards the developed game-based learning in physics on six subscales: perceived learning, Perceive ease of use, Flow, Perceived playfulness, Enjoyment, Perceived Satisfaction as shown in Table 1. All of these 5-point Likert-scale item obtained from (Cheng, 2014). From the English version, an identical version in Thai was constructed, and one expert was recruited to identify communication validity of the items.

3.4 Data Collection and Analysis

The participants were asked to complete the perception questionnaire, to measure their pre-perceptions towards the problem-based gaming on electric current for 15 minutes. After completing the instrument, they were exposed to interact dependently with the experiment for 25 minutes. After completing the experiment, the students' post-perceptions were examined by the same questionnaire for 10 minutes. The statistical data techniques selected for analyzing students' science motivation was repeated-measures MANOVA in SPSS to compare effect of intervention considering gender (female/male) and time(pre-test/post-test).

Table1: Example items of perception questionnaire for each construct.

Dimension	Sample items
Perceive learning	The game will help me understand the things I learned. The games increase my learning efficiency. The games allow me to complete my studies faster.
Perceived ease of use	The games are easy to use. Using the games to complete course related tasks are easy.
Flow	I was very involved in the game. I lost track of time when I played. When I played I did not think of anything else.
Perceived playfulness	It is interesting to use games. I feel like exploring more information when I use games. I was totally immersed in the game.
Enjoyment	I had fun playing the game for learning science. I feel relaxed to use games for learning science.
Perceived Satisfaction	The use of the system makes this learning activity more interesting I like to learn new skills by using business simulation games. I would like to learn with the system in the future. I would like to know if the innovative approach could be applied to other courses to improve my learning performance. I would recommend this learning system to others.

Table 2: The students' subscale means of perceptions by time and univariate MANOVA

Dimension	Gender	Time		*F* (Total)	Sig. (Total)	$\eta 2$ (Total)
		Pre-test Mean (SD)	Post-test Mean (SD)			
Perceive learning (PL)	Male	9.92 (2.977)	11.79 (2.654)	20.856	$.000^{***}$	0.995
	Female	10.91 (2.452)	12.71 (2.209)			
	Total	10.62 (2.637)	12.44 (2.368)			
Perceive eased of use (PE)	Male	7.50 (1.719)	8.00 (1.615)	10.743	$.002^{**}$	0.899
	Female	7.57 (1.798)	8.76 (1.329)			
	Total	7.55 (1.765)	8.54 (1.450)			
Flow (Fl)	Male	9.88 (2.542)	11.54 (2.604)	19.009	$.000^{***}$	0.991
	Female	10.67 (2.612)	12.52 (2.234)			
	Total	10.44 (2.602)	12.23 (2.374)			
Perceive of playfulness (PP)	Male	10.33 (2.408)	11.79 (2.322)	14.098	$.000^{***}$	0.960
	Female	11.21 (2.419)	12.64 (2.330)			
	Total	10.95 (2.434)	12.39 (2.345)			
Enjoyment (Ej)	Male	7.54 (1.587)	7.96 (1.706)	6.622	$.012^{*}$	0.720
	Female	7.98 (1.681)	8.79 (1.448)			
	Total	7.85 (1.656)	8.55 (1.565)			
Perceive satisfaction (PS)	Male	18.04 (4.123)	20.08 (3.623)	16.336	$.000^{***}$	0.979
	Female	18.90 (4.012)	21.66 (3.343)			
	Total	18.65 (4.038)	21.20 (3.480)			

Note. $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$

4. Results

The results for the repeated-measures MANOVA was conducted to determine students' perceptions scores. The assumption of homogeneity of variance-covariance was tested with Box's M Test which was not significant and indicated that homogeneity of variance-covariance was fulfilled (p = .110). The results for the repeated-measures MANOVA indicated significant main effect for gender (Wilks' lambda =0.933, $F_{(6, 75)}$ = .903, p = .497, η^2=0.067) and time (Wilks' lambda = .708, $F_{(6, 75)}$ = 5.160, p = .000, η^2=0.292). Also, there was significant interaction effect between time and genders (Wilks' lambda = .942, $F_{(6, 75)}$ = .774, p = .593, η^2=0.058). Univariate analyses of variances (ANOVA) on each subscale were conducted as follow-up tests to the one-way MANOVA. The results of the univariate test for groups are summarized in Table 2.

Moreover, Figure 5 shows that pre-test and post-test of six perception dimension consist of (1) perceived learning, (2) Perceive ease of use, (3) Flow, (4) Perceived playfulness, (5) Enjoyment, (6) Perceived Satisfaction.

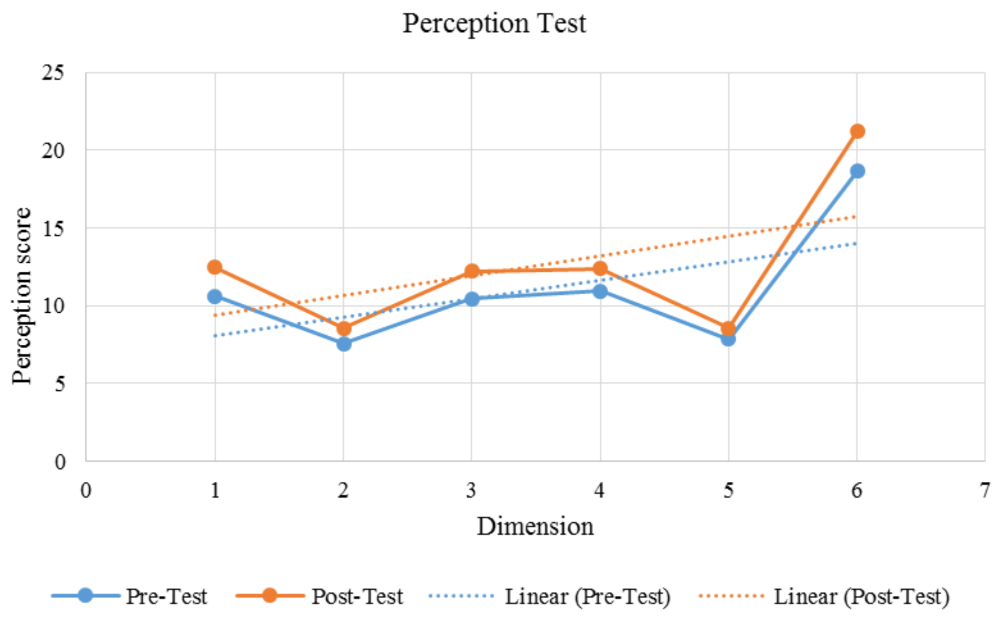

Figure 4. display about perception test score and trend pre-test and post-test of six perception dimension

The trend of this graph indicated that student have positive perception in physics learning by playing the game more than usual after pre-test. As shown in Table 2, the univariate MANOVA on the six dimension scores of perceived towards learning science through the developed problem-based gaming were significant differences across time, from pre-test to post-test. The univariate results revealed a significant effect on PL(F(1,80) = 20.856, p < .05, partial η2 = .995), PE(F(1,80) = 10.743, p < .05, partial η2 = .899), Fl(F(1,80) = 19.009, p < .05, partial η2 = .991), PP(F(1,80) = 14.098, p < .05, partial η2 = .960), Ej(F(1,80) = 6.622, p < .05, partial η2 = .720) and PS(F(1,80) = 16.336, p < .05, partial η2 = .979). According to aforementioned results, the overall result suggested that the increase of perceived towards learning science through the developed problem-based gaming regarding perceive learning, perceive ease of use, flow, perceive of playfulness, enjoyment and perceive satisfaction from the pre-test to post-test was homogeneous both females and males after participating with the developed problem-based gaming. That is, there was no effect of gender difference on perceived towards learning physics, through the developed problem-based gaming.

5. A Proposed Instructional Strategy of Open-Inquiry with problem-based gaming for Promoting problem-based Learning

In pilot study, the researcher aim to explore the effect of gender difference with problem-based gaming and the next study researcher will be using the game to improve problem-solving skill with 11^{th} graders' conceptual understanding, learning attitude, and problem-solving skill, The table 3 shows the example of learning process with Open-inquiry by using the problem-based gaming.

Table 3. An example of open-inquiry learning process using in the next study

Open-Inquiry Process	Description of learning process
1. Open-ended inquiry question	At the beginning of the lesson, teacher will give a question about electric current, such as "How does the electric current travel?"
2. Scientific background	Teacher induces collaborative discussion toward the definitions and pictorial diagram of electric flow; positive charge; negative charge or electron and potential difference.
3. Procedure	Student play the problem-based gaming about electric current to explore the travel of electric flow in the wire; positive charge; negative charge or electron.
4. Data and Result analysis	Student saved the score when they finished the game and bring to analysis "Why they get the score?" and shared with other students.
5. Result Communication	Student have to select the way to present, communicate and discuss the meaning of problem in the game and how to solve the problem to get high score in the game.
6. Conclusion	Teacher using the question to summarized conception about electric current such as "How does the electron move?"; "How does the positive charge move?"

6. Conclusion and implementation

The result of this study provided a more understand on students' perceptions about the problem-based gaming. The finding revealed successful of improving students' perceptions in context of digital game-based learning experience. In addition, gender difference has no effect on students' perceptions towards learning of physics through the developed problem-based gaming. As such, it is obviously found that both females and males increased their perceptions on perceive learning, perceive ease of use, flow, perceived playfulness, enjoyment, and satisfaction.

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Analysis of Problem-Posing Activity Sequences toward Modeling Thinking Process and Detection of Trap States

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Abstract: Problem-posing is well known as an effective activity to learn problem-solving methods. Although the activity is considered to contribute to understanding of the structure of problems, it is not clear how learners could understand it through the activity. The goal of this study is to make it possible to analyze problem-posing activity sequence for enhancing the effectiveness in learning. This paper proposes visualizations of problem-posing activity sequence in MONSAKUN, a learning environment for problem-posing of arithmetic word problems as sentence integration. This system requires that users pose problems not freely but as combinations of given simple sentences and logs problem-posing activity as sequences of them. The sequences are considered to represent the thinking process of learners and reflect their understanding and misunderstanding about the structure of problems. This study expects visualization of the sequences to be helpful to infer learners' bottlenecks in thinking and misunderstanding behind them. As an example, this paper proposes detection of "trap state" that is a combination of simple sentences many learners tend to make in problem-posing assignments.

Keywords: problem posing process, problem state space, visualizations

1. Introduction

Problem posing is one of the key components of mathematical exploration. The development of problem posing skills for students is one of the important aims of mathematics learning and it should occupy the center space in mathematical activities (Crespo, 2003). Moreover, problem-posing activities could provide us with important insights into children's understanding of mathematical concepts and processes, as well as their perceptions of, and attitudes towards, problem solving and mathematics in general (Brown and Walter, 1993). In order to improve students' learning in problem posing, it is important to develop an understanding about the developmental status of students' thinking and reasoning. The more information we can obtain about what students know and how they think, the more opportunities would be possible to create for student success (Cai, 2003).

Educational Data Mining (EDM) is concerned with developing methods for exploring the unique types of data that come from educational settings, and using those methods to better understand students, and the settings in which they learn. Learning Analytics (LA) consists of measuring, collecting, analyzing, and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs. EDM and LA both reflect the emergence of data-intensive approaches to education and improve the quality of analysis of large-scale educational data, to support both basic research and practice in education (Siemens and Baker, 2012). EDM focuses on the technical challenge, deals with the development of methods to extract value from data originating in an educational context (Romero and Ventura, 2010). LA focuses on the educational challenge, deals with the development of analytics for learning which focused on the perspectives of institutions needs such as grades and persistence, and this is a challenge to focus on the perspectives of learners related to their needs (Ferguson, 2012). In many cases, the analytics process would need to be transparent to enable learners to respond with feedback that could be used to refine their thinking. Learners who used problem-posing learning environment changed their approach to pose problems after they had experienced posing the same type of story (Hasanah, Hayashi and Hirashima, 2015). Although the activity is considered to contribute to understanding of the structure of problems, it is not clear how learners could understand it through the activity. Therefore, this is important to generate inferences of learners' thinking from their behavior in learning environments when they receive feedback. Visualization is one approach which could be used to interpret the student's behavior.

The purpose of visualization is to "amplify cognition" about data (Card et al., 1999). Visualization could be fully leveraged to get better understanding from step-by-step data logs generated by learning environments. Anscombe (1973) suggested both calculations and graphs should be used by a computer, both sorts of output should be studied due to each of them would contribute to understanding. Visualization could help to avoid misinterpretation of data. Shneiderman (2002) claimed that integration of both data mining and information visualization to invent discovery tools could enable more effective exploration and promote responsibility. In this research, we present the design and evaluation of a set of visualizations that infer the learners' thinking from their behavior to detect the important actions. By this detection, we would be able to provide individualized feedback based on learners' understanding and offer adaptive learning.

2. Related Works

Many researchers have studied and used practically interactive learning environments for the problem-posing. A new design of problem-posing learning environment using computer-based method is proposed as sentence-integration, named MONSAKUN (Hirashima et al., 2007). The use of sentence-integration method was proven to support learning by problem-posing in the lower grades of elementary schools. A long-term evaluation with the system was carried out and confirmed that it was interesting and useful for learning (Hirashima et al., 2008a). Moreover, the system also improved the problem solving ability of low performance students (Hirashima et al., 2008b). In 2011, a task model of problem-posing that dealt with not only the forward thinking problem but also the reverse thinking problem was proposed (Hirashima and Kurayama, 2011). Practical use of the environment focused on the first grade students was reported (Yamamoto et al., 2012) and developed with online connected media tablets (Yamamoto et al., 2013). The results showed that the practice to pose problems improved learners' ability not only in problem-posing but also in problem-solving. Finally, an interactive learning environment for learning by problem-posing based on the "triplet structure model" was developed and practically used (Hirashima, Yamamoto and Hayashi, 2014). In the practical use, it was confirmed that learning by problem-posing with MONSAKUN was a useful learning method.

Several researches have specifically addressed the analysis of learning activities in MONSAKUN. (Hirashima et al., 2007) have analyzed whether learners could pose problem based on the logs of the system. The number of posed problems and correct problems was shown and discussed. (Hirashima et al., 2008a) and (Hirashima and Kurayama, 2011) have analyzed the learning effect of MONSAKUN comparing with the score of pre-test and post-test on problem solving and posing. Further analysis has been conducted by (Hasanah, Hayashi and Hirashima, 2015), this study examines the way of learners' thinking based on the first selected sentence in assignments on MONSAKUN. Binomial test to the amount of each card being firstly chosen or not in each assignment was implemented to analyze the result, and found that the selection changed based on different type of approach, type of story and students' exercise experience. Even though many studies have analyzed the logs data from MONSAKUN, there are few studies using visualization to exploit the potential learning of activities in that environment.

There has also been considerable work exploring the importance of visualizations to externalize the activity of learners. Some of them have conducted design and visualize learning process in a computer supported collaborative learning environment (Janssen, Erkens and Kanselaar, 2007; Tan et al., 2008), visualize and externalize the activity of groups working together on collaborative learning participation (Janssen et al., 2007; Rabbany, Takaffoli and Zaïane, 2011), and visualize the learning interaction with respect to collaborative and learning attitudes of each participant (Hayashi, Ogawa and Nakano, 2013). On individual learning, systems which collect detailed real-time data on learner behavior and interpret those data by drawing on behavioral research have been developed (Macfadyen and Sorenson, 2010). In 2011, the adaptive learning environment has been developed (Anjewierden et al., 2011). This system could monitor learner behavior through the actions they perform and identify patterns that point to systematic behavior using visual representation. Moreover, the visualization uses a tree structure to provide an overview of class performance also have been developed to allow easy navigation and exploration of student behavior (Johnson et al., 2011).

3. Recording Learners' Problem-Posing Activity in MONSAKUN

3.1 Problem-Posing Activity on MONSAKUN

MONSAKUN was designed as an interactive learning environment for problem posing as sentence integration based on "triplet structure" model (Hirashima, Tamamoto and Hayashi, 2014). This model defines an arithmetic word problem as a composition of three simple sentences with two known numbers and one unknown number and problem posing as ensuring consistency among a story composed from three simple sentences and numerical relation of known and unknown numbers. Based on this model, MONSAKUN interface consists of three components: problem-composition area, sentence cards, and diagnosis button as shown in Figure 1.

The problem composition area consists of calculation expression and three card slots, the area in the left side of the interface. Here, calculation expression is an arithmetic expression that becomes reference to pose a problem using sentence card by learner. The three card slots in the area are the ones to set sentence cards. Sentence cards are presented at right side of the interface. A learner can move the card by dragging and dropping it to a slot in the interface. MONSAKUN provides more than three cards. This means the cards include ones not necessary to pose the required problem. We call such cards "dummy cards". These cards are included intentionally and used by learners with supposed types of overlooking, misunderstanding and so on, for example, careless of story types or confusion of formulas for representing stories and for calculation to solve problems.

The last component is a button located under the problem composition area called diagnosis button. Diagnosis button is used to check the answer of the combination of sentences cards posed by learner. The learner selects several sentence cards and arranges them to pose a problem in a proper order. Putting a sentence card into a card slot and removing out a sentence card from a card slot are basic actions of learner on MONSAKUN. MONSAKUN records learners' problem posing activity as the results that are combinations of cards set in the card slots.

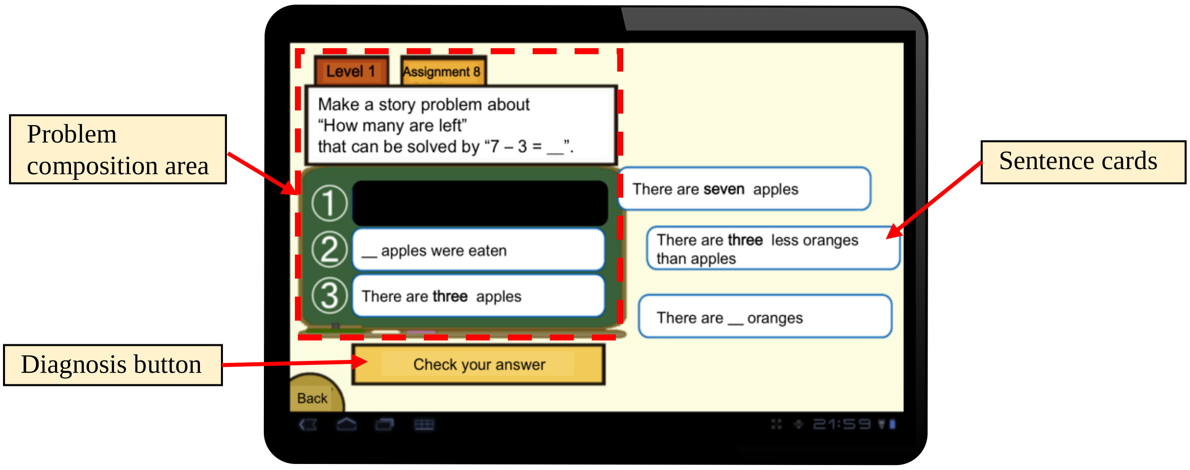

Figure 1. Interface of MONSAKUN.

3.2 Formulation of Problem Posing Process

MONSAKUN records learners' problem-posing activity as combinations of cards set in the card slots. An activity is a resultant combination of cards, which is called "state" of the problem learner try to make, shown in Table 1. Type 1 represents incomplete states as there are still empty card slots that are represented as zero. This type consist of card number and at least one zero number (state with brown color). Type 2 represents complete states before the student submitted the solution by pushing the diagnosis button. This type is coded by three combination of card number and followed by string '[u]' (state with black color). Type 3 represents an incorrect solution: the learner specified all three cards, but the solution is wrong. This type is coded by three combination of card number and followed by string '[f]' (state with red color). The last one (Type 4) represents correct solutions, the completed state and gets correct answer when pushed the diagnosis button. This type is coded by three combination of card number without followed by any other string code.

Table 1: The example of each state type.

Type	Definition	Example	Description
1	incomplete state	010	Slot 1 is empty, slot 2 is occupied by card 1, slot 3 is empty
2	complete state	413 [u]	Slot 1 is occupied by card 4, slot 2 is occupied by card 1, slot 3 is occupied by card 3, and without check the answer
3	wrong solution	315 [f]	Slot 1 is occupied by card 3, slot 2 is occupied by card 1, slot 3 is occupied by card 5, and check the answer then gets fail
4	correct solution	312	Slot 1 is occupied by card 3, slot 2 is occupied by card 1, slot 3 is occupied by card 2, and check the answer then gets success

Based on the model, all possible states can be defined (including state never performed by learners). All learners' action can be mapped to one defined state. All possible state obtained from combining all the available sentence cards, including the empty slot. We refer to all possible states as the "Problem State Space". The problem state space means range of basic unit of thinking.

The example of all possible states from 6 available cards is shown in Figure 2. The possible combinations starting from state 000 which means that all empty slots (root state), then proceed with the state 100, 200, 300... 010, 020, 030... 001, 002, 003, and so on. Since the order of cards in the state is not important, we then combine state that has the same composition with different order into one state. For instance, state 013 is a combination of state 013, 031, 103, 130, 301, and 310. There is a constraint that must be satisfied to generate all possible states. The card could only be used one time. For example, it is impossible to create the state 121, which means that the first card is used twice, at the first slot and the third slot. However, it becomes possible to make a combination of empty slot by appearing more than once. The result of combining states, we get total state is 42 states.

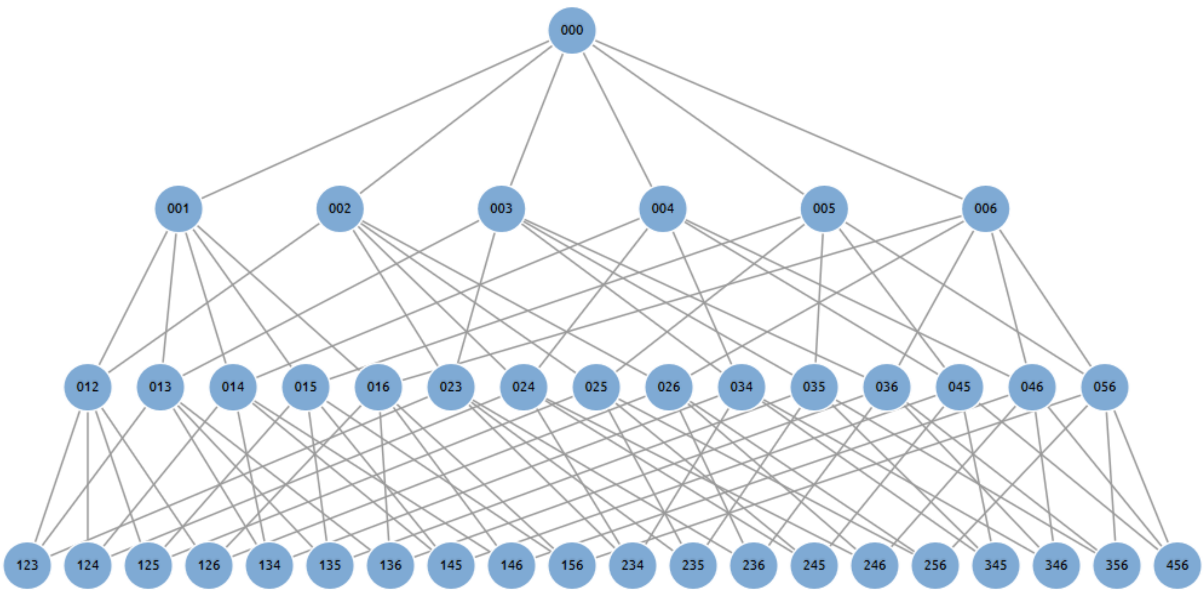

Figure 2. The graph of problem state space.

The next step, we connect each state in accordance with the proper conditions. The proper condition is a condition where there is a relation between the situation before and after an action. For example, we connect a situation where all slots are empty with a situation where one card slot is filled. It was impossible to connect a situation where all slot is empty with a situation in which two slots filled with cards, because there is one situation that elapsed. As a concrete example, we could not connect state 000 to state 014, because there is one step that elapsed before the state 014. The state that may be done before state 014 is state 001 or state 004.

3.3 *Tracing the Way of Thinking: Sequence of States*

In order to complete an assignment, the learner tried various compositions of cards to generate a particular state according to what they thought. They continue to change the composition of cards until they reach the correct card composition. Every state that occurs on learners is stored by the system. Thus, we had an order of each state called "Sequences of States". A sequence of states is a collection of states arranged in the order of the learner's activities. This sequence reflects the way of learners' thinking. Figure 3 shows three example sequences.

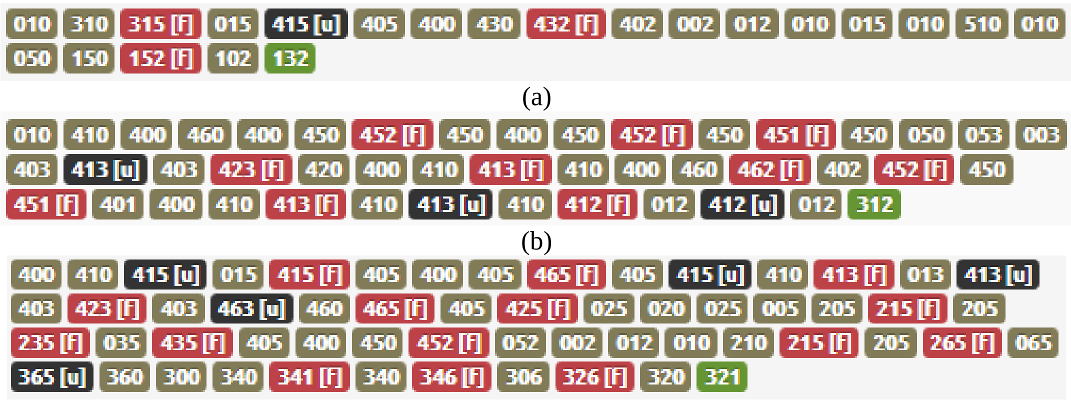

Figure 3. Sequence of states.

The first sequence has 22 states shown in Figure 3(a); which means that the sequence comprises 22 steps to reach the correct answer. The second and third sequences had 45 steps shown in Figure 3(b) and 57 steps shown in Figure 3(c) respectively. Four example steps in the first sequence are shown in Figure 4. In the second sequence begins with the state 010; this means that the learner put the first card in the second slot. State 010 is shown in Figure 4(a). The next state is the state 310 shown in Figure 4(b). In this state, learner put a third card into the first slot. The next state is learner put the fifth card in the third slot, followed by pressing the diagnosis button and learner get an error. Representation of the state is 315[f] shown in Figure 4(c). Due to an error found, then the learner tried to correct it by taking the third card from the first slot, this condition makes the state turned into state 015. The condition of the state 015 is shown in Figure 4(d). The complete steps of the first sequence shown in Figure 3(a) could be mapped on the problem state space shown in Figure 5. The blue nodes show visited states. The yellow links show relation between the states and the thickness represents how many steps the link is followed. On the other hand, the gray nodes mean states that never be arranged by learner. This represents what the learner consider before he get to the correct answer.

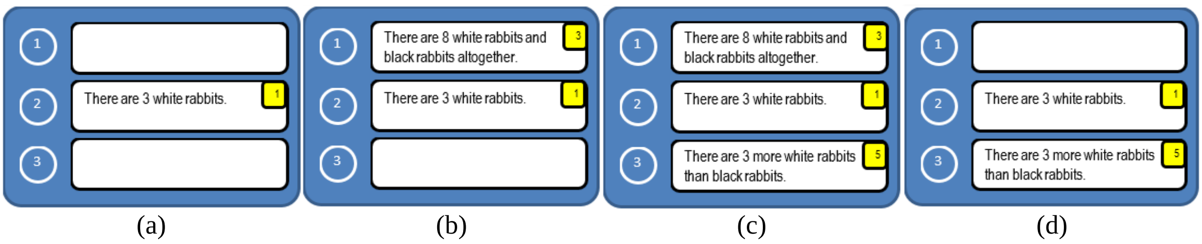

Figure 4. Part of a sequence. (a) State 010. (b) State 310. (c) State 315[f]. (d) State 015.

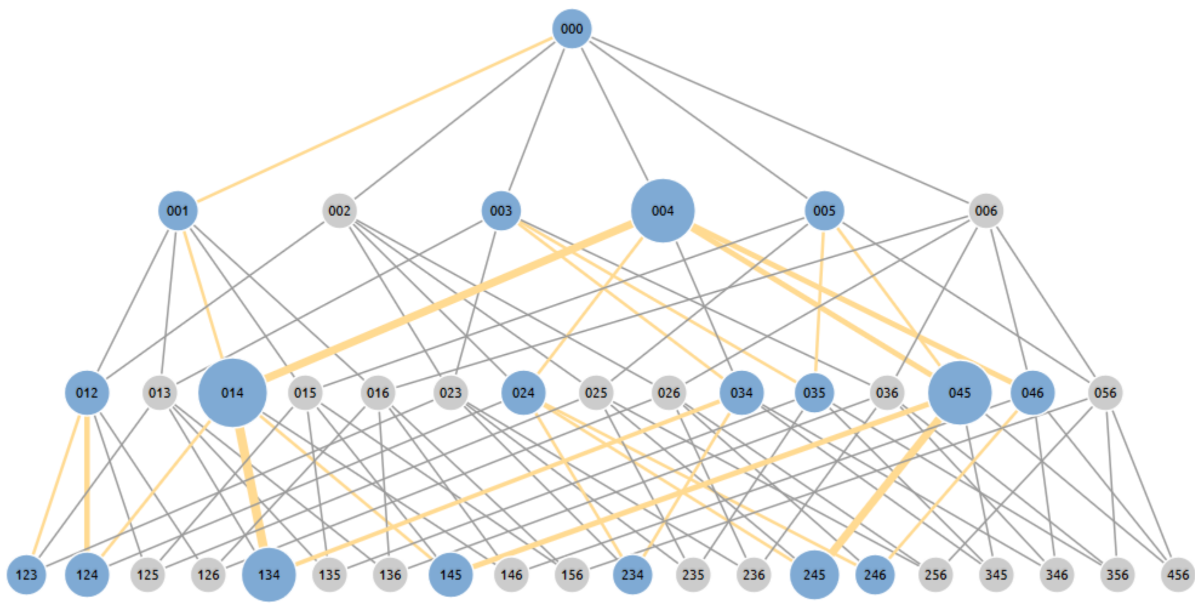

Figure 5. An example of mapped a sequence to the problem state space.

4. Visualizations of Problem-Posing Process

4.1 Data Logged in MONSAKUN

The participants were Japanese students of first grade of elementary school which aged 6 years old. Basically, the learners have already learned problem structure on the black board by using several sentence cards that are parts of problems (Yamamoto et al., 2012). These cards are provided to the learners as a request of problem posing. In order to promote learning deeper, MONSAKUN used as interactive learning environment to exercise and receive lectures of problem structure as usual classes. Every learner's action on MONSAKUN was logged into database. Each student was asked to create story problems using sentence card based on calculation expression. They had to select sentence card, move to the available slot, and complete all three slots. There are five or six cards provided by system. When learners finished posing the problem, they could push a diagnosis button under the problem-composition area. Then the system diagnoses the combination of sentences, and shows the results of the diagnosis and message to help the learner's problem-posing on another window.

This study collected data from learners' activity on MONSAKUN who involve 39 participants, and we focus on the first assignment in the fifth level. There are four story types: combination problem, comparison problem, increase problem, and decrease problem. The first assignment is about combination problem. The learners are asked to combine three sentence cards in order to pose a problem. Requirement of the first assignment is: *Make a word problem about "How many are there overall" that can be solved by "8-3"*. There are 6 sentence cards that could be used by learner. The sentences for each card from the first card to the sixth card are:

① **There are 3 white rabbits**.
② **There are _ black rabbits**.
③ **There are 8 white rabbits and black rabbit's altogether**.
④ There are 8 white rabbits.
⑤ There are 3 more white rabbits than black rabbits.
⑥ There are 3 brown rabbits.

At this assignment, the correct state is consisted of card 1, card 2 and card 3 (sentence card with printed bold).

This assignment consists of 1818 actions. The raw data was coded as a series of Events, where Event= {id, lv, asg, stp, slt1, slt2, slt3, jdg}. "id" shows learner ID. "lv" is difficulty of problem-posing task and "asg" is number of assignment. "stp" shows sequence number of actions. slt1 "," slt2 and "slt3" is location of sentence card of first place, second place, and third place respectively. The last code is "jdg" which shows type of action, for example incomplete slot action, failed action, or successful action. We present a sample of log data from learners' action shown in Figure 6.

id	lv	asg	stp	slt1	slt2	slt3	jdg
1	5	1	1	0	1	0	n
1	5	1	2	4	1	0	n
1	5	1	3	4	0	0	n
1	5	1	4	4	6	0	n
1	5	1	5	4	0	0	n
1	5	1	6	4	5	0	n
1	5	1	7	4	5	2	f
1	5	1	8	4	5	0	n
1	5	1	9	4	0	0	n

Figure 6. Example of log data from learners' action.

4.2 Support Graph and Distance Graph

A sequence has several states as objects representing the learner's steps. The first step linked to the second step, the second step linked to the third one, and so on. For this reason, we propose the graph visualization, which shows the states and its relations. In addition, information visualization is best represented in graph structures which act as bridge between the visualization and graph drawing field (Gröller, 2002). Rabbany et al. (2011) use graphs to visualize overall snapshots of the students' participation in the discussion forums and gives the instructor a quick view of what is under discussion in online courses. In this study, such in Johnson et al. (2011), we design a graph where each node represents a state and each link an action that takes learner from one state to the next. The graph gives an overview visualization of all relations between the previous state and the next state in a sequence.

We describe two kinds of graphs: Support Graph and Distance Graph. A Support Graph displays the frequency of states appearing in learners' problem posing process. Figure 7 and Figure 8 show an example of Support Graph and Distance Graph respectively. Support Graph is a graph where size of each node is determined by how many times a state arranged by learners. This graph aimed to visualize states which have number of support shown by the size of the node. The node with a larger size has a number of supports more than the node with smaller sizes. A distance graph is a graph where size of nodes based on the far-close of the current state to the correct state; it is called distance of states. This graph aimed to visualize the average number of steps of a state to correct state indicated by the size of the node. The node with a larger size has an average number of steps more than node with a smaller size. It is means that a large-sized node has a long distance to the correct state.

The value of each state in the both types of graph is normalized by scaling 0 to 1. We discard the node that has a value of zero, which means the state has never been done by the learners. We want to focus on the state that ever made by learners. We also implement two different colors for nodes. The first color is red, it is for nodes that have a value greater than or equal to 0.3 on the scale normalization. The second one is blue; it is for nodes that have a value of less than 0.3. We did it on the ground that the node which has a value greater than or equal to 30% are: (1) states that have high value support as shown in Figure 7, and (2) states that have long distances from the correct answer as shown in Figure 8. For that reason, we would like to focus on the red states to be further analyzed. We argue that using these two graphs, we could detect trap states based on large-sized node in Support Graph and Distance Graph.

5. Trap State: A Finding about Characteristic State in Problem-Posing

5.1 Characteristic Behavior of Learners

A state that happens to learners is the result of their thinking. When students choose to put one card into one of the empty slot, it has a consequence. Similarly, when students tried to take out a card that has been installed in one slot, it will lead consequences too. The consequences could cause learners difficult to get the correct answer. In this case, the learners are stuck in a condition where they would do more steps to reach the correct answer. In other words, the learners trapped in the state that distanced them from the correct state. In addition, there are many learners who perform such state. Thus, we defined a state where it could lead learners do a lot of steps to the correct state and supported by many learners as "Trap State".

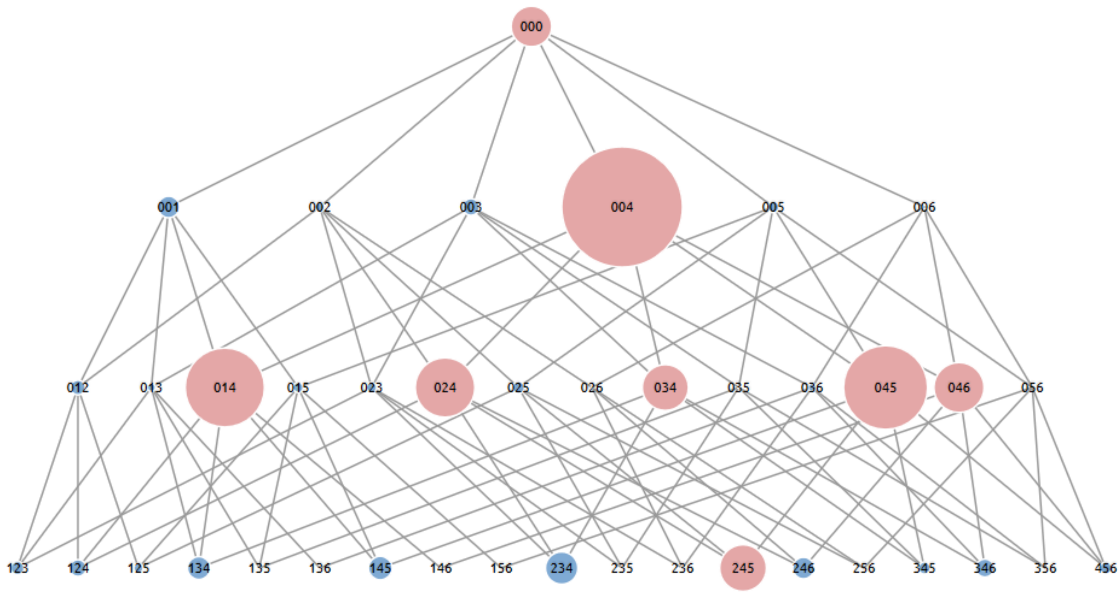

Figure 7. Support Graph of an assignment.

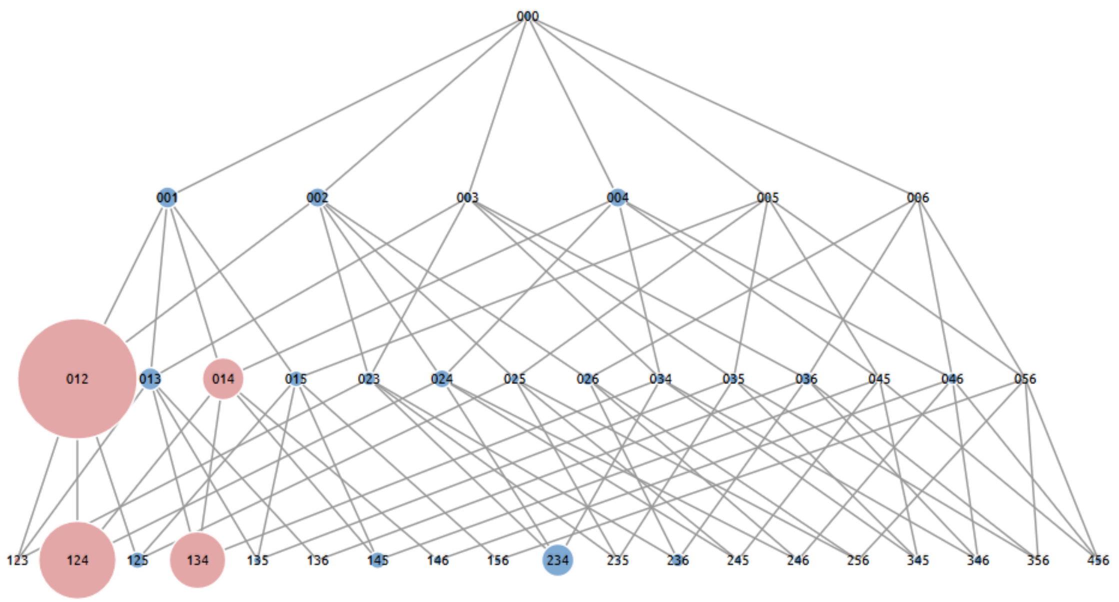

Figure 8. Distance Graph of an assignment.

5.2 An Example of Trap State

The support graph shown in Figure 7 has 8 red states. Based on the value of its support, the states are 004, 045, 014, 024, 034, 046, 245, and 000 which have a value of support 179, 125, 118, 89, 69, 75, 70, and 61 respectively. This means that the state 004 made by learners 179 times, state 045 made 125 times, and so on. On the other graph, distance graph shown in Figure 8 has four red states. The states are 012, 124, 134, and 014 which have the average distance to the correct state 63, 41, 30, and 22 respectively. This means that when learners were on state 012, they took 63 steps to reach the correct answer on average. Similarly with state 124 that required 41 steps, state 134 required 30 steps and state 014 required 22 steps. Basically, highlighted states on distance graph are strong candidate of trap states.

However, this is not enough to identify that a state is a trap state. Combining distance graph with support graph, general trap states are revealed.

The most distinct state in the distance graph is state 012 (the largest node shown in Figure 8). This situation makes the state 012 could potentially be a trap state for many learners. However, when we look at the support value, this state is only supported by a few learners (a little blue node shown in Figure 7). Although state 012 is a state that has required a lot of steps to reach the correct answer in this data, but there are not many learners' action arrange this state. In this situation, this state is not a trap state in general. The same thing occurred on state 124 and state 134. Both of them are also not supported by many learners.

The rest state with red color shown in Figure 8 is a state 014. When learners were in this state, they were required 22 steps to reach the correct answer on average. Moreover, this state is also supported by many actions with colored red in Figure 7. It is means that, for many learners, they tend to do more steps and further away from the correct answer when they are on state 014. Thus, this could be said as a general trap state. In other words, by using visualization we could say that a general trap state is a colored red state in Support and Distance Graph.

The difficulty in this assignment is that learners are confused about the gap between the required story type of combination and the numerical expression of subtraction (8-3). Although subtraction generally implies story type of decrease and comparison, in this case learners must pose a problem of combination. In addition, before this assignment, learners have done assignments in which learners could make the correct answers by arranging cards according to the order of numbers in the numerical expression. However, this is not valid to this assignment because the numerical expression expresses a solution rather than a story to evaluate to evaluate unknown number. Even if they make a strategy to arrange cards according to the numerical expression from previous assignments, it doesn't work on this assignment. Actually learners tend to make such a strategy (Hasanah, Hayashi and Hirashima, 2015). In order to complete this assignment, for example, learners need to transform the numerical expression, "8-3", into the numerical expression representing a combination story, "3+?=8". And then, learners could assign cards of existence sentences to "3" and "?". State 014 consists of sentence card 1 (*There are 3 white rabbits*) and sentence card 4 (*There are 8 white rabbits*). This is supposed that learners try to directly use the given numerical expression, "8-3", and to assign card 1 and 4 to "3" and "8", respectively. Based on available cards, it was reasonable that card 1 and card 4 had chosen instead of card 2 containing unknown number (*There are _ black rabbits*) and card 6 contains different story with others (*There are 3 brown rabbits*). In this situation, most of them have confused and stuck due to the correct answer was number 8 on the calculation expression should be number in relational sentence (*There are 8 white rabbits and black rabbit's altogether*). Thus, state 014 could also be explained as a trap state based on "triplet structure" model. We will confirm that by using these visualizations, trap state for learners could be detected.

6. Conclusion and Future Work

We have presented visualizations that externalize the activity of learners at problem-posing learning environment to pose the problem based on requirement of an assignment. The Support Graph illustrates the number of states visited by learners. The Distance Graph depicts the number of steps to the correct answer. These visualizations trace different aspects of learners' activity, and combination of both visualizations could detect trap situation for learners. By this detection, the system could give support to learners during the learning process, especially when they are confused due to errors in choosing the sentence card. Thus, learners could learn adaptively.

The ultimate goal of this line of research is placed in the context of exploring and mining data in problem-posing learning environment to get useful information for supporting learners. This research still preliminary and we believe that this research promises many further analysis such evaluating these visualizations for all assignments to detect trap state. We also would like to explore ways to identify the other significant actions. We also plan to include data mining method for discovering learners' activities, for example, sequential data mining and clustering method for grouping learners.

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An Integrated Model of Flipped Classrooms and M-Learning in Workplace English

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Abstract: The Flipped Learning Model, an innovative model of instruction, was proposed to focus on student learning needs as the driver of instruction. To benefit from this emerging learning/teaching trend, several studies have examined the efficiency of flipping classrooms in terms of improving student performance and engagement. However, none of the previous studies have explored the viability of integrating M-Learning in flipped classrooms, especially in the discipline of workplace English. English language proficiency in the workplace continues to be a top concern among employers in Taiwan who have become increasingly dissatisfied with the English language standards of the university graduates they employ. The aim of the current study is to fill this gap by designing an integrated model for flipped classrooms and M-Learning in workplace English and to investigate the viability of the model. The participants are 48 college students enrolled in Workplace English course. Data collection consists of pre- and post-tests, questionnaire, and in-depth interviews. It is noted that this study is currently ongoing. The preliminary findings reveal that students had positive perceptions of the integrated model which enhanced their communicative competence. Based on the comparison of students' pre- and post- tests, it is found that the given technological resources helped students improve their English skills for workplace. In addition, those who were more engaged in the instructional design tended to have better improvement than those who were less active. More detailed description will be addressed upon the completion of the study.

Keywords: Flipped classrooms, mobile learning, workplace English, college students, Taiwan

1. Introduction

Technological advances have contributed to the changing face of education. The use of technology in school education has increasingly been the object of study in recent years. As technologies become widely available, alternative approaches are proposed to integrate technology into language learning. The Flipped Learning Model, an innovative model of instruction, was proposed to focus on student learning needs as the driver of instruction. In a flipped classroom, students watch online instructional videos before class, and devote class time to active and collaborative learning. To benefit from this emerging learning/teaching trend, several studies in various disciplines have examined the efficiency of flipping classrooms for improving student performance (Day & Foley, 2006; Deslauriers & Wieman, 2011) and student engagement (Clark, 2013). The findings indicate that students in the flipped environment have a significant increase in learning performance and engagement. Other studies have investigated how flipped classrooms could foster active learning (Hung, 2015) and critical thinking skills (Kong, 2014). It has been found that the students had a statistically significant growth in their learning outcomes and critical thinking skills.

Recently, several attempts have been made to understand the benefits of mobile learning (M-Learning) and mobile-assisted language learning (MALL). These studies demonstrate the potential of mobile devices and applications in enhancing language learning. In view of mobile learning's characteristics such as mobility, reachability, personalization, spontaneity, and ubiquity, and its promises for education (Saran & Seferoglu, 2012), integrating M-Learning in a flipped classroom may enhance student learning outcomes and learning motivation.

It should be noted, however, that none of the previous studies have explored the viability of integrating M-Learning in flipped classrooms, especially in the discipline of workplace English.

Employers in Taiwan have become increasingly dissatisfied with the English language standards of the university graduates they employ. As the Educational Testing Service's (ETS) Taiwan office pointed out in a 2012 survey, 95.9% of Taiwan's top 1,000 companies state that employees need to use English in their jobs, but only 2.4% of them are satisfied with the English communication skills of their employees. Obviously, issues regarding the teaching of English for Specific Business Purposes (ESBP) demand immediate attention. English as a foreign language (EFL) teachers must be creative in identifying and maximizing opportunities for practical training and linguistic expression in workplace settings.

Flipped classrooms and M-Learning might provide solutions for the lack of actual training and preparation for using English in the workplace, particularly when working with students who face additional adversities, such as low motivation and English proficiency. Therefore, this paper aims to investigate the possibilities of integrating M-Learning in a flipped classroom in a college EFL Workplace English course in Taiwan. The following research questions guided this study:

(1) How does the integrated model of flipped classrooms and M-Learning influence students' English skills for workplace?
(2) What are the students' perceptions of the integrated model?

2. Background

2.1 Flipped Classrooms

The Flipped Learning Network and Pearson's School Achievement Services (2013) identified the four key features, or pillars, of flipped classrooms. The four pillars of F-L-I-P™ are Flexible Environment, Learning Culture, Intentional Content, and Professional Educator. They maintain that the environment of a flipped classroom has to be flexible, allowing students to choose when and where they learn. Additionally, teachers who adopt the flipped classroom framework will shift the learning culture from teacher-centered to student-centered. Finally, to allow flipped learning to occur, intentional content and professional educators are necessary in order to help students gain conceptual understanding and procedural fluency (Hamdan, 2013). Addressing the deficiencies in the four pillars of F-L-I-P™, Chen, Wang, Kinshuk, and Chen (2014) proposed the "FLIPPED" model. Three additional components were added in order to better suit a higher education context: Progressive Networking Activities, Engaging and Effective Learning Experiences, and Diversified and Seamless Learning Platforms. They have proved the proposed model to be effective.

Researchers have put efforts into empirical studies in an attempt to implement the flipped learning model in school education. For example, Clark (2013) have conducted related empirical studies with students in K-12; whereas Day and Foley (2006), Deslauriers and Wieman (2011) and McLaughlin et al. (2014) have conducted empirical studies in higher education. These researchers such as Day and Foley (2006) have compared student performance and perceptions in traditional and flipped college courses over a semester. Day and Foley (2006) flipped a Human-Computer Interaction course where students watched online video lectures outside of class and spent time engaged in hands-on learning activities such as group discussions, presentations, and design critiques during the remaining class meetings. Compared to students in a traditional lecture course, Day and Foley (2006) found that students in the flipped course performed significantly better on the semester project and final grades. It was also found that the students were generally satisfied with the format. In the empirical studies by Deslauriers and Wieman (2011) and McLaughlin et al. (2014), student performance in flipped classes with that of students taught using a traditional approach the year before was compared. The findings suggested that the flipped learning model had a positive impact on student learning. These past studies found that the flipped classroom can, in general, lead to a significant increase in learning effectiveness at both basic and higher education levels.

As mentioned earlier, the flipped learning model has been implemented in elementary, high school, and college levels in various disciplines such as math (Clark, 2013), pharmacy (McLaughlin et al., 2014)), physics (Deslauriers & Wieman, 2011), and more. However, the flipped model is still underutilized and underexplored in the discipline of English for Specific Business Purposes (ESBP).

2.2 Mobile-assisted language learning (MALL)

Mobile learning (M-Learning) is defined as the acquisition of knowledge with the aid of any service or facility regardless of time and space (Lehner & Nosekabel, 2002). The utilization of M-Learning has gained importance in the field of English language teaching. One of the devices used in mobile learning is the smart phone which has great potential for educational purposes. Common features of a smart phone include the short messaging service (SMS), the multimedia messaging service (MMS), Internet access, cameras, bluetooth, etc. An increasing number of young users in Taiwan are communicating with each other through mobile messaging applications, such as Whatsapp, LINE, Viber, and WeChat. Some scholars have pointed out the prominent roles of mobile messaging services in learning environments. For instance, Saran and Seferoglu (2010) examined students' opinions of using MMS via mobile phones to learn English vocabulary. They found that the students were motivated in the educational settings and were able to make use of their previously wasted time (on the bus or waiting for something/someone) for learning English vocabulary.

Currently, LINE is one of the most popular MMS applications among young students in Taiwan. Launched in Japan in 2011, LINE is an app for instant messaging on smart phones and PCs. LINE is more of a social entertainment network, in addition to a messaging app. It provides free voice calls, instant text messages, games, and a built-in camera. The cartoon characters and stickers serve as emoticons to make communication more interesting. It has become the most popular mobile messenger app in Taiwan, according to the market research of InsightXplorer Limited, as of May 2013. The official website of LINE pointed out that, as at the end of November 2013, the app had 300 million users worldwide; Taiwanese users of LINE had reached 17 million, second only to Japan (50 million) and Thailand (20 million), and most of the registered users are the younger generation. Due to the popularity of LINE, it is hoped that such technology can be leveraged to support English language learning.

3 Method

3.1 The Research Site and Participants

This study is conducted at a university located in northern Taiwan. The participants involved in the study are 48 students who enrolled in Workplace English course. The 18-week course is a required course with two credits for non-English majors and is scheduled two class hours per week.

3.2 Instructional Design

3.2.1 Phase 1: Online video lectures

Each week, before introducing a new lesson, the students watch a self-developed online instructional video prior the class. The self-made videos introduce the meanings and usage of useful vocabulary and language expressions of a chosen topic in workplace settings. The main goal is to guide students to gain knowledge of the content to be introduced in the form of self-study via E-learning.

3.2.2 Phase 2: Online communication via LINE

After viewing the video, the students are assigned a task to assess their understanding of the video lecture. The participants pair up and establish a personal LINE group with their respective partners. The researcher join the participants' LINE groups to monitor the progress and to give feedback. The participants complete the task through LINE with a partner. Timely feedback are given by the instructor. This practice help the students reinforce what they have learned in the video lectures as well as helping the instructor evaluate their engagement and comprehension of the lectures.

3.2.3 Phase 3: In-class activities

When students are in class, they already have a basic understanding of the topic to be introduced. Therefore, the instructor can shift from teacher-driven instruction to student-centered learning. That is, the students can have more practice, interaction and individual attention in class. The purpose of the in-class activities is to maximize learning efficiency through cooperative and active learning. Table 1 demonstrates details of the three phases of the flipped classroom design in the workplace English class.

Table 1: The Flipped Classroom Design in the Workplace English Course

Phase	Approach	Goal	Channel
Phase 1 (Online video lectures)	Self-study via E-Learning 	Knowledge acquisition	Recorded video lectures
Phase 2 (Online communication)	Peer-collaborative M-Learning 	Assessment and reinforcement of knowledge gained in video lectures	Mobile apps: LINE (dialogue making; problem-solving; discussions; timely teacher feedback)
Phase 3 (In-class activities)	Face-to-face interaction 	Maximum learning efficiency through cooperative and active learning	Role-play; games; group discussions; presentations; teacher feedback; reflection

3.2 *Design of Experiment*

This study applies a mixed-method research design to the investigation. Specifically, the pre- and post-test, survey design and interview methodology are employed to quantitatively and qualitatively understand college students' experiences and challenges encountered in the flipped classrooms. The experiment is implemented in the Workplace English course of freshmen. The duration is about two months. Data collection consists of three sources: pre- and post-test, questionnaire, and in-depth interview. The quantitative data will be processed with the statistical software, Statistical Package for Social Science (SPSS), including descriptive statistics, t-test, and correlation. In addition, content analysis will be utilized to analyze qualitative data. Students' interview transcripts and responses to the open-ended questions will be analyzed using category construction (Erlandson et al., 1993) to code the data into emergent categories.

4 Preliminary Findings

As mentioned, this study is currently ongoing. The preliminary findings indicate that the students, overall had positive perceptions of the integrated model of flipped classrooms and M-Learning; many of them reported that the designed activities helped foster their English communicative competence for workplace. Based on the comparison of students' pre- and post- tests, it is found that the given technological resources helped students improve their English skills for workplace. In addition, those who were more engaged in the instructional design tended to have better improvement than those who were less active. More detailed description will be addressed upon the completion of the study.

5 Conclusion

The self-developed instructional design can provide a set of guidelines, directions, and activities for instructors who intend to develop flipped classrooms and LINE-based learning materials for EFL instruction in workplace English. It is hoped that administrators and educators may be able to redesign their English programs and facilities to improve them and to meet the learners' needs as well.

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Impact of Misplaced Words in Reading Comprehension of Chinese Sentences: Evidences from Eye Movement and Electroencephalography

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Abstract: This pilot study aimed to investigate the impact of misplaced words in Chinese sentences by using eye-tracker and electroencephalography (EEG) technology. There were 5 participants. Four of which were graduate students and one was a college student. Their average age was 24.4 years old. The participants were asked to read text with and without misplaced words. After reading, they were asked to answer a question that determined whether they understood the content of the stimulus previously displayed. Eye movement data and attention levels were recorded using an eye tracker and an EEG device. The data were saved in the background system automatically and synchronously while the experiment was performed. The findings suggest that: 1.) The number of misplaced words do not affect the reading comprehension of participants. Instead, wrong answers resulted from the question that evaluated the reading comprehension on one stimulus that contained too many information 2.) In increasing the number of misplaced words in a stimulus, participants did not spend more time gazing at them in comparison to other stimuli that had lesser or no misplaced words 3.) When asked to read a stimulus as quickly as possible, the analysis showed that most of the participants did not gaze longer at the regions of the misplaced words. They spent less than 5% of the time gazing at these regions of interest 4.) EEG data analysis yielded mixed results since some participants that gazed at misplaced words had high attention levels and some did not show an increase in their attention levels.

Keywords: misplaced words in Chinese, eye-tracker, electroencephalography (EEG)

1. Introduction

Cambridge University Effect claims that people can read a word even when the interior letters are jumbled. It is saying that people do not look at all characters in reading a word. Hence, if the first and last letter are in the right place, people can still read it and comprehend its meaning. However, a formally published paper is not available to reference it to researchers of Cambridge University. Apparently, the earliest demonstration of this effect belongs to Rawlinson. His study showed that randomization of letters in a middle of a word have minimal effect on the skilled reader's ability to comprehend a printed text (Rawlinson, 1976). Interestingly, in recent years there has been a circulating concept on the internet which is almost the same with the Cambridge University Effect. It implies that misplaced words in a sentence do not affect the reader's understanding of the content. Nation mentions in his study that although having no knowledge on the meanings of individual words hinders understanding, humans are capable of deriving meanings from text even if some of the words makes no sense (Nation, 2009). This also occurs in Chinese text that is why authors have become interested in studying this phenomenon. In account of this, researchers that have been investigating this topic use the eye tracking technology to analyze reading behaviors. However, using both the eye-tracker and EEG have not been done yet. This lead the researchers of this study to investigate whether there are obvious differences in the eye movement and electroencephalography data in reading and comprehending sentences with misplaced words versus sentences without misplaced words. We aimed to deduce the participants' reading behavior more objectively by using the mentioned technologies.

2. Literature Review

Researchers which aimed to find methods on studying thinking processes that are invisible to human observation used eye-tracking to determine factors such as gaze points and dwell times on the locations of interest on a stimulus. This is mainly because when people get or process information through vision, eyesight is often more directed and attracted to texts, pictures, and animation (Jaušovec, 2000). Because it presents these advantages, eye-tracking technology has been used to conduct various studies on visual and content design (Chwo, Ho, Liu, & Chiu Lin, 2013) and on cognitive psychology and reading strategies (Thang, Jaafar, Ho, Chen, & Soh, 2015). For this study, we used eye gaze data to analyze reading behavior on Chinese sentences with misplaced words in order to find out whether or not they have direct effects on reading comprehension of texts presented. Reading comprehension is a focal point on this research since it is vital in understanding meanings of text which is essential in learning (National Reading Panel, 2000). In line with this, a research work conducted by Qian et al about the effects of the transposed morpheme on reading Chinese sentences used an eye-tracker to gather and analyze participant's reading behavior. Result showed that there was a significant difference between reading sentences in transposed and not transposed sentences (Qian, Cui, & Yan, 2010). However, in another study, results showed that the order of the word, both in English or in Chinese, did not affect the reading comprehension of participants. The important factor that should be present among participants is that they have language skills that are the same with the native speakers of the language used in the content of stimuli used in experiments (Ye, 2014). Also another investigation on reading comprehension was conducted by using both eye-tracking and event-related potential (ERP) in conducting experiments. Recording of how participants read required the coordination of two complex systems namely the word recognition and Eye-Movement (EM) control (Kliegl, Dambacher, Dimigen, Jacobs, & Sommer, 2012). In another study done by Baretta et al, electroencephalography (EEG) was utilized to investigate reading comprehension. Results showed that the type of text and word have different influences on cognitive load (Baretta, Tomitch, Lim, & Waldie, 2012).

Review of experiments previously conducted on reading comprehension has lead the researchers of this study in choosing an experiment design that involved both eye-tracking and electroencephalography. This has given us the ability to get data and investigate details on the eye-behavior and emotional index of participants while reading.

3. Research Questions and Hypotheses

According to the literature reviews presented in the previous section, research questions and hypotheses are as follows,
Q1: Is there a difference in the reading comprehension when there are misplaced words in a stimulus?
Q2: Is there a difference in the reading speed when there are misplaced words in a stimulus?
Q3: Is there a difference in the variables of electroencephalography data when there are misplaced words in a stimulus?

Works of Qian and Ye stated that the order of the word either in English or in Chinese does not affect the participants' reading comprehension (Qian et al., 2010; Ye, 2014). They just need more time to figure out the meaning of the misplaced words. Basing from this, the hypotheses of this study are as follows,
H1: There is a difference in the reading comprehension when there are misplaced words in a stimulus versus a stimulus that does not have misplaced words.
H2: Participants reading a stimulus with the misplaced word need much more time to understand the information. Hence, the reading speed will be slower in comparison to a stimulus without any misplaced words.

H3: In reading a stimulus with the misplaced word, the participants need to be more concentrated in understanding a content. The participant emotional index of attention might be higher in comparison to reading a stimulus which do not have misplaced words present.

4. .Methodology

4.1 Participants

The participants were randomly selected from Department of Electrical Engineering, National Taiwan Normal University. They were all male students. Their average age was 24.4 years old.

4.2 Materials

Two groups of stimuli were used in conducting the experiment. One was for the short essays and the other was for the reading comprehension questions answerable by yes or no. There were eight stimuli for the short essays. To prevent influencing the experimental result with participants' background knowledge, each stimulus was written in Mandarin (Chinese) for easy understanding. All of them were extracted from the news which described a certain condition. For the reading comprehension questions, eight stimuli were also used. The reading comprehensive question was displayed after the participant read the stimulus with an essay. The question assessed the reading comprehension to determine whether or not the participant understood the short essay. Questions were designed to ask about the concept or implication of the previous content read instead of asking participants to remember a certain detail.

4.3 Design

A 2x2x2 quasi-experimental within-subject and between-subject design was used in this study. What we manipulated were the independent variables that included the existence of the misplaced words (Yes, No), the number of the misplaced words (1, 3) and the type of the misplaced words (noun or verb). All of the misplaced words have a high frequency of usage in Chinese. In addition, all of the stimuli were displayed randomly so that the display order did not influence any data analysis. Comparison of time spent in reading the stimulus, the number of correctly answered questions, and changes of attention level were taken into account in analyzing participant data.

4.4 Instruments

For the eye movement data:
EyeNTNU-120 eye tacker was used in this study. The sampling rate is 120Hz. The stimuli were displayed in an ASUS X53S laptop (CPU: Core i7-27600, Memory: 8GB, Size of the screen: 15.6 inches). The participants can gaze at the stimulus using both of their eyes, but the camera data recording of the eye movement was only directed to the right eye of the participants. The features of the EyeNTNU-120 are as follows:

1. Given that the distance between the screen and the participant is under 60 cm, the error rate is less than 0.3∘
2. A chin-rest is used in experiments to reduce the occurrence of invalid or inaccurate data.
3. It supports various analysis tool for data collected so that it returns report on Hot Zone, Scan Path, Total Contact Time (TCT), Number of Fixations (NOF), Duration of the First Fixation (DFF), and Latency of the First Fixation (LFF).

For the EEG data:
Neurosky MindWave Mobile was the apparatus used to gather EEG data from participants. Its sampling rate is 512Hz. A single channel of a none-invasive electrode was placed on the participant's left forehead. The apparatus records eight bands of brainwaves which are the delta(0.5-2.75Hz), theta(3.5-6.75Hz), low alpha(7.5-9.25Hz), high alpha(10-11.75Hz), low beta(13-16.75), high

beta(18-29.75), low gamma(31-39.75Hz) and mid gamma(41-49.75). The eye movement data and electroencephalography data were recorded automatically and synchronously.

4.5 Procedure

In order for the participants to be familiar with the software, the researcher gave them a short orientation and overview of the experiment. The participants were assisted in wearing the Neurosky MindWave Mobile and were asked to rest their chin on the chin rest while the EyeNTNU120 eye tracker camera was directed to their right eye. Participants have gone through a nine-point calibration process to ensure data accuracy. After the calibration, the experiment started by letting the participants view the randomly arranged stimuli. They were asked to read the content of a stimulus as quickly as possible. The next stimulus was then displayed which contained a reading comprehension question about what was previously read and it was answerable by Yes or No using designated keyboard buttons. The eye movement data, electroencephalography data and answers to the comprehensive questions were recorded by the system all throughout the experiment.

5. Results And Discussions

Discussions of results are arranged according to the order of the research questions presented earlier in this study. This will cover the analysis and interpretation of the eye movement data and of the electroencephalography data.

5.1 The relationship between the number of participants that had wrong answers in the reading comprehension questions and the number of misplaced words.

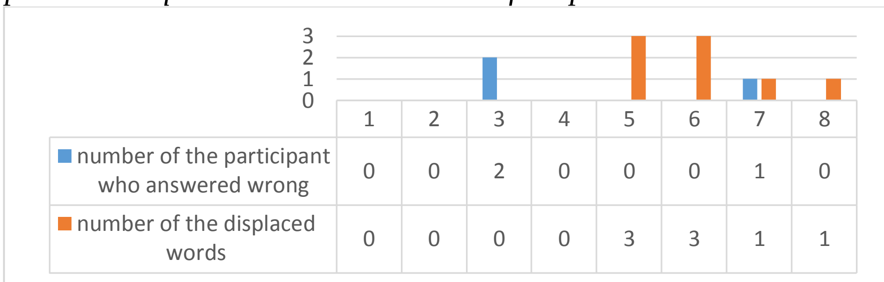


Figure 1. The relationship between the number of participants that had wrong answers and the number of misplaced words.

Fig. 1 shows that stimulus 3 had the highest number of participants who gave the wrong answer in the reading comprehension question. It is interesting to note that misplaced words were not present in stimulus 3. The researchers suspect that this is because of the too many information mentioned in the stimulus leading to the difficulty of participants in understanding the content correctly. While stimuli 5 and 6 had the highest number of misplaced words, which is three, all the participants answered the reading comprehension questions correctly. On the other hand, while stimuli 7 and 8 had only one misplaced word in their content, only one participant gave the wrong answer on the reading comprehension question for stimulus 7. The result suggests that the number of misplaced words does not directly affect the difficulty of participants in comprehending the content of the stimulus.

5.2 Reading Speed

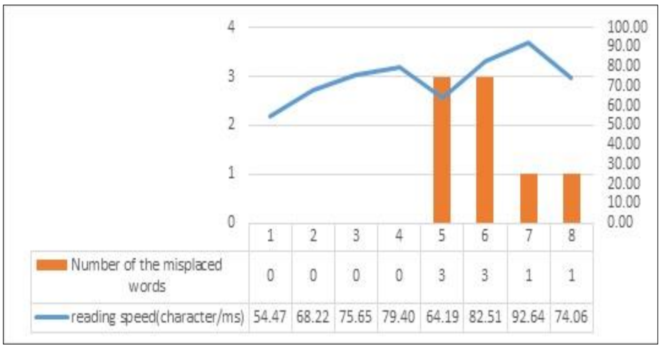


Figure 2. The analysis of the reading speed

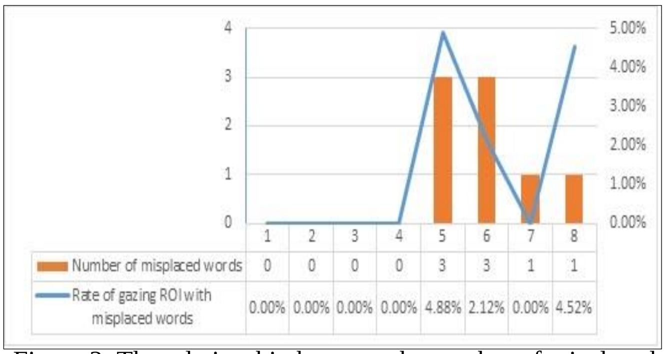


Figure 3. The relationship between the number of misplaced words and the average of gazing percentage on the ROIs which were the misplaced words.

Calculation on the reading speed of participants have been done based on the number of character parsed per second. Fig. 2 then shows the average character reading speed of participants on stimuli 5 and 6 were 64.19 and 82.51 characters per second. While the average character reading speed of participants on stimuli 7 and 8 were 92.64 and 74.06 characters per second. Hence, results suggest that increased number of misplaced words does not directly indicate an increased character reading time. In addition, Fig. 3 shows that average rate of gazing at the misplaced words was less than 5%. Therefore, average total contact time on the regions of interest was very small. As the participants were asked to read stimulus quickly, results suggest the majority of them did not necessarily notice the misplaced words.

5.3 The variation of the emotional index

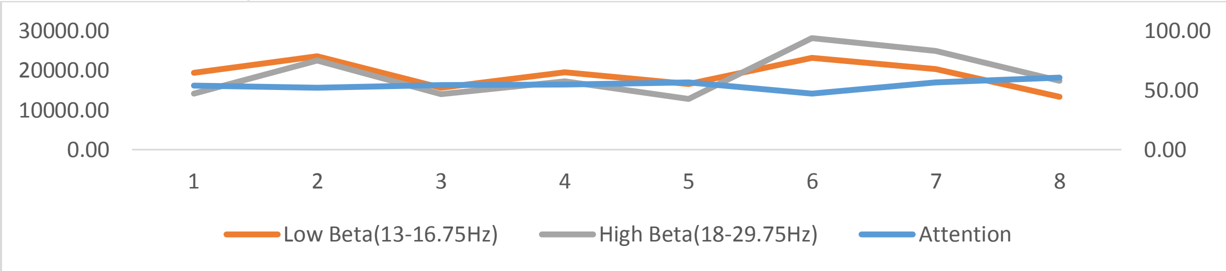


Figure 4. The variation of the Attention

Neurosky Mindwave Mobile records the changes of emotions the participants are experiencing during an experiment. Recordings include data on participant attention and meditation levels(Crowley, Sliney, Pitt, & Murphy, 2010). These factors have been included to be a third point of interest in our research question. Fig. 4 shows that the average attention level was generally the same whether there were misplaced words in the stimulus or not. To look at the results more closely, an analysis and comparison of the attention levels of each participant are presented in the following graphs.

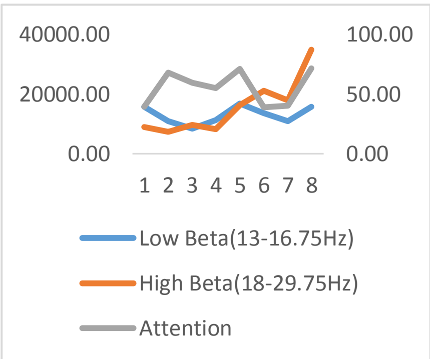


Figure5. Average change of the attention level of the participant No.1

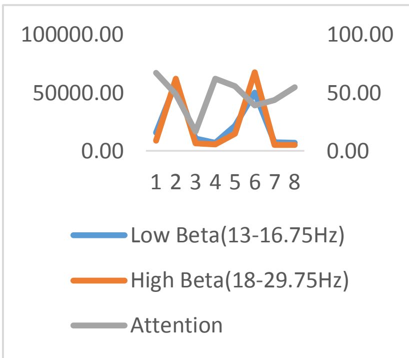


Figure 6. Average change of the attention level of the participant No.2

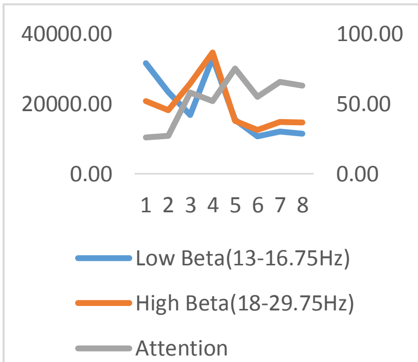
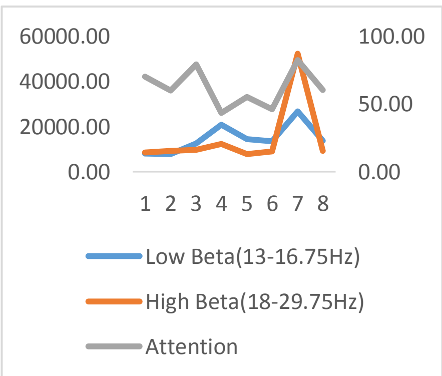


Figure 7. Average change of the attention level of the participant No.3



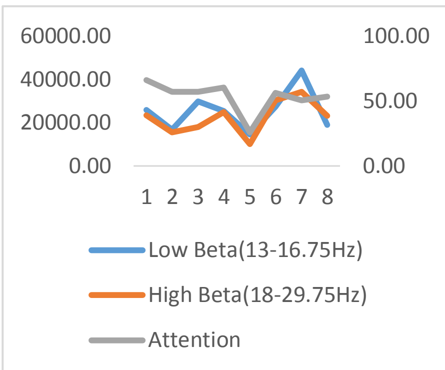


Figure 8. Average change of the attention level of the participant No.4

Figure 9. Average change of the attention level of the participant No.5

Although Fig. 5 to Fig. 9 show that to some participants that gazed at the stimuli with misplaced words have average attention levels found to be higher than on a stimulus with no misplaced words, one participant that also gazed at misplaced words showed no increase in attention levels (Fig. 7). EEG data analysis yielded mixed results since some participants gazed at misplaced words had high attention levels and some did not show an increase in their attention levels. As this is a pilot study, the sample size was limited. Therefore, findings may not generally apply to all population.

6. Conclusion and Future Work

Reading comprehension assessments result suggests that misplaced words in a stimulus do not necessarily contribute to difficulty in understanding the content. Analysis of data from this study is different from the findings of Qian that there is a significant difference in understanding transposed and not transposed sentences (Qian et al., 2010). We suspect that this can be attributed to the different backgrounds of participants and the materials used. This difference in results is another interesting point of study for a future research. Furthermore, as this is also a pilot study, the sample size might not be enough to find a difference in the analysis of electroencephalography data among students that noticed the misplace words and those who did not. The researchers plan to conduct a formal study with a bigger population to investigate further the findings of this pilot study.

Acknowledgements

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Identifying Context Familiarity for Incidental Word Learning Task Recommendations

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Abstract: Incidental word learning tasks are widely adopted in pedagogical activities and self-paced learning processes, given their advantages of providing rich contexts and training on other language skills. While these tasks, diverse learners are often provided with the same contexts. For example, a cloze test with the same essay may be offered to all users in an e-learning system for learning target words. However, different learners may have varied expertise on and subjective preferences of many topics. Hence the provided unified learning context may be unfamiliar to some learners. The learning effectiveness is therefore likely to be negatively influenced. In response to a call to solve this problem, we propose in this paper a framework for word learning systems to automatically identify the context familiarity of individual learners based on their logs. A personalized approach to accurate recommendations of incidental word learning tasks is also devised according to the individual context familiarity. The results of our experimental studies on real participants show that the proposed framework and method promote significantly more effective word learning and increase the learning enjoyment greatly than conventional approaches with unified learning contexts.

Keywords: Incidental word learning, context familiarity, task recommendation, learner profile, e-learning

1. Introduction

Incidental word learning tasks are widely adopted in pedagogical activities and self-paced learning processes. This is mainly because incidental word learning provides not only richer contexts but also more opportunities of practicing on other language skills such as reading, listening, speaking and writing, compared with intentional word learning (Zou et al., 2014). While doing incidental word learning tasks, diverse learners are often provided with the same contexts. For example, a cloze test with the same essay may be offered to all users in an e-learning system for learning target words.

However, the provided unified learning context is perhaps unfamiliar to some learners, the reasons of which can be categorized as follows.

- ***Diverse expertise*:** learners (or students) may have varied levels of pre-knowledge and skills stemmed from their distinguished educational backgrounds and individual experiences. A typical example is that students from different departments surely have diverse expertise and domain knowledge.
- ***Subjective preferences*:** learners are likely to have subjective interests and preferences, which influence their desirable learning contexts to a great extent, e.g., some may prefer sport news while others enjoy science fictions.

The learning effectiveness therefore can be negatively influenced if the unified learning contexts are offered to all users. To tackle this problem, we therefore propose (i) a framework for word learning systems to automatically obtain the context familiarity of each learner based on their logs, including their historical learning materials, testing results as well as the their writing assignments; and (ii) design a personalized approach to recommendations of incidental word learning tasks according to the individual context familiarity. Our hypothesis is that those tasks with contexts that are more familiar and/or engaging promote significantly more effective word learning. This is partially supported by a study on topic familiarity and incidental word learning (Pulido, 2003). To further explore the effectiveness of the proposed framework and approach in e-learning systems, we invite some subjects to participate in the experiment. The results of our research show that the proposed framework and method can promote significantly more effective word learning compared to conventional approaches with unified learning contexts.

The reminder of this paper is organized as follows. In Section 2, we review the related work and findings from past research. The framework which is designed to automatically identify context familiarity of each learner based on their logs is introduced in Section 3. In Section 4, we present the personalized approach to recommendations of incidental word learning task according to the individual context familiarity. The experimental settings, procedures as well as the results are reported in Section 5. Finally, we summarize this research and discuss potential issues to be further explored.

2. Related Work

In this section, we mainly review the related work and existing findings in two relevant areas: incidental word learning and e-learning systems for language learning.

2.1 Incidental Word Learning

Research in incidental word learning can be generally summarized in two categories. One of them focuses mainly on word knowledge. It is commonly acknowledged that word knowledge is a continuum of one unique system containing both productive and receptive knowledge (Webb, 2005). Some researchers (Read & Chapelle 2001; Nassaji, 2006) argue that there is a distinction to be made between the breadth dimension and depth dimension of word knowledge, which is a model for measuring word knowledge. Particularly, the breadth dimension (a.k.a. vocabulary size) is the quantity of words acquired by learners at a specific level of language proficiency (Mehrpour et al., 2011), while the depth dimension refers to the quality of words known by a learner (Schmitt, 2008). The other category concentrates on word learning process and facilitative factors for it. Fraser (1999) believes that word learning naturally is a cumulative process in an incremental way. Laufer and Hulstijn (2001) propose the involvement load hypothesis (ILH) to evaluate the effectiveness of diverse tasks in promoting incidental word learning. There are also many other studies (Hulstijn and Laufer, 2001; Williams 2012; Godfroid et al. 2013) which attempt to verify the validity and reliability of this hypothesis.

2.2 E-Learning Systems for Language Learning

The era of big data witnesses rapid development and great popularity of e-learning systems (Li et al., 2009; Li et al., 2013). Existing research basically follows the paradigm of intentional word learning rather than incidental word learning models (Zou et al., 2014). Loucky (2012) presents a task-based distance learning to optimize the vocabulary development of language learners. A blended learning environment named 'ArabCAVL' is developed by Essam (2010) to facilitate vocabulary acquisition of Arab students. Marc et al. (2014) exploits the augmented reality (AR) techniques to enhance vocabulary learning and compare learning performance of various AR-based systems. The popularity of mobile devices in recent years results in the ubiquitous word learning systems for learners. Through tracking users' learning logs in mobile phone, Chen and Chung (2008) proposed a personalized ubiquitous system for English word learning according to the item response theory. Chen et al., (2010) further improves their ubiquitous learning system by integrating the context-aware techniques which enable systems to be adapted according to learning contexts.

3. The Framework of Identifying Context Familiarity

3.1 Problem Formulation

The overall framework of identifying context familiarity can be interpreted as the problem of measuring degrees of familiarity of each word for diverse learners from a collection of documents such as historical learning articles and testing results related to the learner. Formally, we model the overall framework of identifying context familiarity as a mapping function θ between the set of documents *D* and the set of learner profiles *L* as follows.

$$\theta\text{:}\ \ \mathrm{D} \rightarrow \mathrm{L} \tag{1}$$

where *L* is in the form of word-weight values to indicate the familiarity of each word for learners, and each element $d \in D$ is essentially a document that can be modeled as a set of words $d = \{w \mid w \in d\}$.

3.2 Learner Profile with Familiarity

In this subsection, the definition of the learner profile is introduced. As we believe that the degree of familiarity of learning contexts have positively effects on vocabulary learning, the degree of familiarity for various learning contexts is included in the learner profile. However, it is impossible to include all contexts in a learner profile because the learning contexts are naturally permutation of all words. The quantity of learning contexts are $\sum_{i=1}^{n} \mathrm{P}_i^{|V|}$, where *P* is the permutation, |*V*| is the vocabulary size, and *i* is the length of the context. To address this issue, we include the familiarity of each word rather than all possible learning contexts in the learner profile.

Definition 1: Let {w_1, w_2,…w_n}∈*V* and { ε_1^i, ε_2^i,… ε_n^i } be the corpus of all words and the corresponding degree of familiarity of each word for learner l_i, the learner profile of l_i is denoted by a vector $\vec{l_i}$ as:

$$\vec{l_i} = (w_1, \varepsilon_1^i; w_2, \varepsilon_2^i; \ldots w_n, \varepsilon_n^i)$$

As learning contexts are basically consisted of words, the degree of familiarity of a learning context can be regarded as the expectation (i.e., the weighted mean) of the familiarity degrees of all words that form this context. Given a learning context *c* = { $w_1^{'}$, $w_2^{'}$,… $w_m^{'}$ }, the degree of familiarity for learner l_i therefore can be calculated as follows.

$$f(c, \vec{l}_i) = \sum_{j=1}^{m} r(w_j^{'}) \cdot \varepsilon_j^i \tag{2}$$

where $f(c, \vec{l}_i)$ is the function of calculating familiarity degree of a learning context for a learner, and $r(w_j^{'})$ is the ratio of $w_j^{'}$ appearing in the context *c*. Note that words in the context c is a sequence may contain duplicated words. To eliminate the negative influence of useless high frequency words (e.g., "the", "an") we pre-process learner profiles, learning contexts as well as other relevant documents by deleting all words that are in the stop-words list created by Google (Google, 2014).

3.3 Objective Vocabulary Familiarity

The objective context familiarity refers to the context familiarity obtaining from objective documents (i.e., learning documents D^o). Specifically speaking, we mainly use three kinds of learning documents: learning articles for reading comprehension (denoted as D^r), writing assignments for short essays (denoted as D^e) and test papers for word learning practice in form of multiple choices (denoted as D^t).

Learning Essays. For each article ($d^r \in D^r$), it can be represented by a bag-of-words. We hypothesize that the degree of familiarity is positively correlated with frequencies of all words in an essay. Therefore, we employ the model of term frequency and inverse document frequency (TF-IDF) to calculate the familiarity (Manning, 2008).

$$f_r(\mathrm{d}_i^r, w_x) = (1 + \log n(w_x)) \times \log(1 + N_i / N_i(w_x)) \tag{3}$$

where $n(t)$ denotes the frequency of word w_x appearing in an essay d_i^r learnt by learner *i*, 1+log$n(w_x)$ is the log normalization, N_i is the total number of essays learnt by this learner, and $N_i(w_x)$ is the total number of essays containing word w_x. The sum of degrees of familiarity for each word to a learner is the cumulation of all learning essays with an upper limit "1".

Writing assignments. For writing essays, it can also be denoted by a bag-of-words. However, in addition to the pre-process step of deleting all stop-words, the words with errors and typos should not be taken into account while meaning the degree of familiarity. Therefore, we parse each word with

WordNet and check whether the word exists in the WordNet or not (WordNet, 2014). Rather than employing the TF-IDF model, we believe that writing process involves using words that have been already stored in a learner's memory. The ratio of the use of words reflects the degree of familiarity. Therefore, the quantity of writing essays is a significant factor, and we adopt the ratio to represent the degree of familiarity.

$$f_e(\mathrm{D}_i^e, w_x) = n(w_x) / N(\mathrm{D}_i^e) \tag{4}$$

where $n(w_x)$ is the total frequencies of word w_x among all writing essays, and $N(\mathrm{D}_i^e)$ is the total number of words in all writing essays.

Test papers. As the main purpose of a test paper is to exam whether a student acquires the knowledge of target words or not, we can interpret the ratio of correct answers of a target word among all tests as the degree of familiarity.

$$f_t(\mathrm{D}_i^t, w_x) = c(w_x) / N(w_x) \tag{5}$$

where $c(w_x)$ is the number of correct answers for the target word w_x, $N(w_x)$ is the total number of tests of the word w_x. Note that for those test papers which do not show detail test results for each target words, we take the overall test score as the degree of familiarity. To assign weights to three kinds of familiarity from three data sources during the aggregation, we adopt the ILH theory (Laufer and Hulstijn 2001). As suggested by the ILH theory (Laufer and Hulstijn 2001), we can assign the essay writing task with two involvement loads, while assign one to the task of reading comprehension and cloze. Therefore, we adopt the following aggregation method to obtain the overall objective context familiarity:

$$f_o = \alpha_1 \cdot f_r + \alpha_2 \cdot f_e + \alpha_3 \cdot f_t \tag{6}$$

where α_1=α_3=1/4, α_2= 1/2 to indicate their loads suggested by the ILH theory during their aggregation process. Note that f_o is a simplified notation of $f_o(w_x^i)$.

3.4 Subjective Vocabulary Familiarity

We also believe that individual preferences for the contexts may also positively facilitate word learning. Thus, we invite learners to complete questionnaires to indicate their subjective preferences to contexts (topics) for learning. The questionnaire includes all pre-defined topics associated with some typical words (e.g., topic: food, words: bread, chip, steak, etc). The learners are required to give a score from "strongly dislike" to "strongly like" (ranging from "1" to "5") for each topic.

A problem here is how to assign the subjective familiarity to each word when you know the individual preferences for a topic. The solution is that we adopt the latent dirichlet allocation (LDA) to identify topics and the associated typical words (Blei et al., 2003). For each word, we have probability distribution $p(w|t)$ over all topics. Next, we use the expectation to denote the subjective familiarity as follows.

$$f_s(w_x^i) = \sum_j s_i(t_j) \times p(w_x \mid t_j) \tag{7}$$

where $s_i(t_j)$ is a score given by learner i to topic t (note that the score is normalized to the scale of [0, 1]), $p(w_x|t_i)$ is the probability distribution of w_x for a topic t_j, and $f_s(w_x^i)$ denotes the subjective familiarity for word w_x to learner l_i.

Therefore, we can obtain the final familiarity of each word in learner profile (as defined in Definition 1) by aggregating the objective and subjective familiarity as follows.

$$\varepsilon_x^i = \beta_1 f_o(w_x^i) + \beta_2 f_s(w_x^i) \tag{8}$$

where two parameters β_1 and β_2 are to adjust the weight of two kinds of familiarity, and we adopt the optimal combinations (β_1 = 0.6 and β_2 = 0.4) suggested by Cai et al. (2010).

4. Personalized Task Recommendation

In this section, we introduce how to recommend incidental word learning tasks based on the familiarity-based learner profile obtained in Section 3. The learning context associated with a task can also be represented by a bag-of-words paradigm. Formally, we define the task profile to denote the learning context as follows.

Definition 2: Let $\{w_1, w_2,\ldots w_n\}\in V$ and $\{\delta_1^a, \delta_2^a, \ldots \delta_1^a\}$ be the corpus of all words and the corresponding degree of relevance to a learning context of task t_a. The task profile of t_a is denoted by a vector $\vec{t}_a$ as:

$$\vec{t}_a = (w_1, \delta_1^a; w_2, \delta_2^a; \ldots w_n, \delta_n^a)$$

where the degree of relevance is the ratio of the word appearing in the learning context of the learning task t_a.

To recommend incidental word learning tasks with more familiar contexts to learners, it is essential to employ a reasonable measurement to estimate how familiar the learning context is to the learner when the task profile and the learner profile are provided. Research on profile-based information retrieval (IR) has found that the conventional measurement in IR, for instance cosine similarity, may be unsuitable due to the fact that the nature of the problem is to find the most familiar task profile rather than the most similar one (Cai et al. 2010; Xie et al., 2012). Therefore, in this research, we adopt the projection operation from the learner profile and the task profile as the measurement of the degree of familiarity.

$$s(\vec{t}_a, \vec{l}_i) = \|\vec{l}_i\| \cdot \cos\alpha \quad (9)$$

where $\|\vec{l}_i\|$ is the Euclidean length of vector $\vec{l}_i = <\varepsilon_1^i, \varepsilon_2^i, \ldots \varepsilon_n^i>$, α is the angle between two vectors. Essentially speaking, the function *s* here is to project learner profile to the task profile.

The motivation of using projection is that the degree of familiarity can be interpreted as the question of how familiar each word in the learning context is to a learner. To answer the question, the learner profile is therefore projected to the task profile (i.e., the learning context) to measure the holistic degree of familiarity. In sum, we recommend the task with the highest degree of familiarity to the learner.

$$t^* = \arg\max_{t_a \in T} s(\vec{t}_a, \vec{l}_i) \quad (10)$$

where *T* is a set of tasks available in the system for the same target words, yet the task *t** with the highest degree of familiarity is recommended to the learner.

5. Experiments

In this section, we describe the experiment conducted to evaluate the proposed approach to personalized recommendations. After introducing the details of the materials and subjects in the experiment, we then report the experimental results.

5.1 Materials and Subjects

A pilot study was conducted to determine the set of target words for our experiment. As the participants were freshmen from a university in Hong Kong, their language proficiency levels are normally in the range of level 3 to 5 in the HKDSE English Language Subject, which are corresponded to scores from 5.48 to 6.99 in the International English Language Testing System (HKDSE, 2015). Results of the standard vocabulary tests (Vocabulary Size Test, 2015), which was conducted in the pilot study, show that the vocabulary sizes of our participants are in the range of 6000 to 8000 words.

Therefore, we selected 10 words from with the vocabulary levels of 9000 to 14000 and further verified that these words were not acquainted with participants in the experiment. These words were embedded into three categories of learning contexts, namely information technology, science and literature. Adapted from fictions, academic articles and news reports, the learning contexts were further polished or re-written by three native speakers so that all participants can understand their general ideas literally. As mentioned, the participants are freshmen from a university in Hong Kong. There are totally 82 subjects who are further divided into 3 groups in the experiments.

5.2 Experimental Results

The results of immediate and delayed post-tests for the three groups are shown in Figure 1. Group C achieves the best performance in both immediate and delayed post-tests among all groups, while Group

B and A are the first and second runner-up in the two post-tests. The differences among groups reach at significance level according to t-test analysis ($p<0.05$). Such results support the rationale of the proposed framework. That is, the more varied kinds of vocabulary familiarity proposed in our framework been consider, the more effective the learning contexts being recommended would be. Note that the differences among three groups in the immediate post-tests (61.4, 64.2 and 68.7) were smaller in the delayed post-tests (43.7, 44.8 and 45.4). However, the differences were still significant as shown by the results of the independent sample t-tests. This is consistent with the findings of previous work (Wixted and Ebbesen, 1997) that the word retention rate would drop to a similar level without any review after a certain period.

Table 4: Three groups of 82 subjects in the experiments

Group	N	Descriptions
A	27	Control group without providing any familiarity-based contexts.
B	27	Contexts are recommended based on objective vocabulary familiarity (Eq. (6)).
C	28	Contexts are recommended based on aggregated vocabulary familiarity (Eq. (8)).

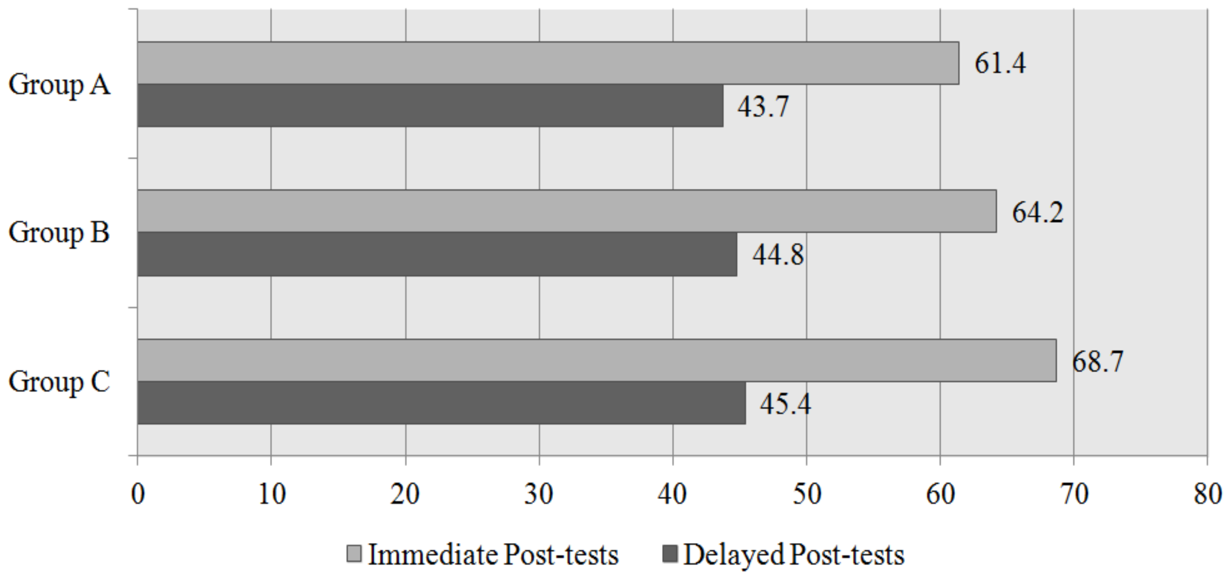

Figure 1. The results of immediate and delayed post-tests of three groups.

6. Conclusion and Future Work

In this research, we studied issues concerning how to identify the context familiarity from historical learning documents of learners, how to model the subjective and objective context (vocabulary) familiarity, as well as how to exploit the context familiarity and recommend preferable learning contexts to assist learners' vocabulary acquisition. We have also conducted an extensive experiment involving 82 subjects, the results of which verify the rationale of the proposed framework of context familiarity and personalized approach to recommendations of incidental word learning tasks according to the individual context familiarity. Furthermore, we discussed the implications for both the design of pedagogical activities and e-learning systems for vocabulary acquisition. For our future study, we plan to integrate those words that have been learnt recently into the upcoming learning contexts is another interesting topic as highlighted in the above systematical implications.

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Wikis: the effects of corrective feedback on EFL learners' written accuracy

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Abstract: This pilot study aims to explore the effect of corrective feedback on learners' written productions by looking at two types of feedback on verb and preposition errors taking place on wikis. Corrective feedback types include recasts (reformulations of incorrect forms) and metalinguistic clues (explanations for linguistic errors). Thirteen English as a foreign language (EFL) learners participated in this study. They were randomly assigned into the three conditions, namely, recasts, metalinguistic clues, and no feedback. The preliminary results derived from the posttest writing suggest that those who received corrective feedback outperformed those who did not; the metalinguistic clues group had a greater number of correct targeted items than did the recast group. Furthermore, all participants of the three groups agreed that corrective feedback was necessary to enhance writing abilities in English. This study concludes with the pedagogical implications and suggestions for future studies.

Keywords: Recasts, metalinguistic clues, corrective feedback, computer mediated communication (CMC), second or foreign language (L2/FL)

1. Introduction

Corrective feedback refers to "any feedback provided to a learner, from any source, that contains evidence to learner error of language form" (Russell & Spada, 2006: 134) assuming that corrective feedback on errors may improve and acquire the linguistic forms in their L2 writing (Bitchener & Knoch, 2009). It has been well documented that group or pair learners working on written assignments collaboratively scaffold each other's knowledge in the target language (Wigglesworth & Storch, 2012). Therefore, corrective feedback has resulted in a substantial body of research in both face-to-face and computer- or technology-assisted learning environments (e.g., Lyster, 1998, Yang & Meng, 2013, Yang & Lyster, 2010, Yeh & Lo, 2009, and Bower & Kawaguchi, 2011).

A central notion of corrective feedback is that it facilitates awareness of how learners pay attention to their verbal or written errors so that they then process the information in L2 (Schmidt, 2010). One important characteristic of noticing states that attention directed to focused rather than unfocused linguistic input is likely to improve the knowledge of the focused linguistic input (Schmidt, 2010). Such a notion applied to L2 writing can mean focusing on a certain linguistic element, say, the simple past tense in a given piece of writing. Because levels of attention differ from individual to individual, some may be more capable than others of noticing the errors occurring in their output, and this highlights the collaborative efforts with their peers, who provide the learners with feedback to resolve communication breakdowns that are triggered by their linguistic errors. That is, the socially modified negotiation plays an important role in the cognitive developmental process (e.g., memorizing new words), which places an emphasis on the sociocultural theory (Vygotsky, 1978; Lantolf & Thorne, 2006).

Various types of corrective feedback can be distinguished, including direct and indirect feedback, recasts, and metalinguistic clues. In this current study, the types of metalinguistic clues and recasts were adopted in accordance with Shintani and Ellis (2013); the former provides learners with metalinguistic explanations for errors, whereas recasts, or as termed by those researchers, direct corrective feedback, refers to the provision of correct forms of errors. Whether the type of corrective feedback has an impact on learning outcomes (e.g., learner responses or uptake) has been increasingly investigated. The results of such studies suggest that compared to recasts, metalinguistic clues, which require learners to self-initiate repair moves on their errors, are more effective for their learning outcomes. AbuSeileek and Abualsha'r (2014) attempted to determine the effectiveness of corrective feedback types on L2 learners' corrective written output in English via the use of Microsoft Office 2010. Four conditions were examined, namely, recasts (the provision of the correct form), metalinguistic clues (giving comments, such as subject-verb agreement), track changes (e.g., marking added and deleted text), and no feedback. Their findings suggest that all the experimental groups performed significantly better than the control group in the posttest essay; the track changes group outperformed the other three groups and the recasts group performed better than the metalinguistic group in terms of the linguistic aspects, such as grammatical accuracy and spelling.

Lee (2004) found that both teachers and learners in a classroom setting had preference for all the errors rather than just some errors being corrected. On the other hand, the majority of teachers believed that how the students' errors were corrected affected their writing; indirect corrective feedback rather than direct feedback might result in more effective writing development. Interestingly, in that study, more than half of the teachers considered that some students had made progress regarding the accuracy of their writing due to the corrective feedback, whilst less than half of the students thought that they had made an improvement in their writing. The teachers were found to prefer direct feedback to indirect feedback.

Kessler, Bikowski, and Boggs (2012) investigated collaborative writing using Google Docs and found that their participants were likely to engage in meaning-focused rather than form-focused interaction and to make changes in spelling or punctuation rather than in grammatical errors (e.g., verb tenses). Their results suggest that using the web-based tool not only improved the accuracy in the writing but also demonstrated a willingness to engage in collaborative writing.

This pilot study extended the attempts of previous research to investigate particular sets of linguistic features, namely, verb tenses and preposition errors, by employing wikis, whereby EFL learners are allowed to provide corrective feedback to their peers. In particular, it examined the effects of recasts and metalinguistic clues on the knowledge gain in L2 and the collaborators' perception of corrective feedback.

2. Research Questions

Three research questions are explored in this study:
1. Does the corrective feedback have an impact on the accurate uses of the targeted linguistic items?
2. Do types of corrective feedback (recasts and metalinguistic clues) influence the accurate uses of the targeted linguistic items (verbs and prepositions)?
3. What is the learners' perception of corrective feedback taking place on the wikis?

3. Methodology

3.1 Participants

Participants in this pilot study were thirteen EFL learners, all of whom spoke Mandarin Chinese or Taiwanese as their first language and who were studying at the chosen university. They had previously studied English as a school subject for more than seven years. All the participants were randomly assigned into three conditions, namely, recasts, metalinguistic clues, and no corrective feedback; this resulted in five learners in the recast group, four in the metalinguistic group, and four in the control group.

3.2 Instruments

There were six writing topics in total. Of these, two were chosen for further analysis and were reported in this pilot study. In order to compare the differences in an increase of form accuracy, one was taken from the learners' initial compositions and used as the pretest whereas the other was taken from their final compositions and utilized as the posttest. The pretest, consisting of picture compositions, was administered to the participants. The posttest contained a set of six pictures derived from Heaton (1975); the pictures illustrate two boys playing ping pong, who found that the ping pong table was much taller than one of them, and so they decided to make the table shorter by sawing off the table legs. Similarly, in the posttest, there was a picture composition comprising four pictures taken from Hsieh (2014, p. 74) describing a careless mother who went shopping with her baby sitting in a pushchair, which rolled away because she forgot to apply the pushchair's parking brake when she came cross a top that she liked.

3.3 Online interviews

The online interviews were conducted individually via text chat on Facebook. The purpose of the interviews was to elicit how the individuals perceived the corrective feedback on their linguistic errors. There were four questions for the online interviews regarding learners' perception of corrective feedback, such as "Is corrective feedback useful to improve your writing in English?" and "Do you notice errors occurring in other members' writing on wikis?"

3.4 Coding

A coding scheme based on the two types of corrective feedback adopted in this study focused mainly on the errors of tenses and prepositions in English. A recast normally used by the teacher in a classroom setting refers to the reformulation of students' erroneous utterances that contain past tense errors (Sheen, 2007; Yang & Lyster, 2010). However, in this study, corrective feedback was initiated by peers or group members on wikis where a recast was an explicit correction or a correct form supplied by others. Unlike recast corrective feedback, a metalinguistic clue provides a learner with an explanation of an error without supplying a correct form of the error (Shintani & Ellis, 2013) as this encourages learners to self-repair their own errors (Yang & Lyster, 2010). Examples of those are illustrated as follows:

Verbs
Tom a good boy.
Recasts: Tom [is] a good boy.
Metalinguistic clues: this sentence requires a singular verb

Prepositions
She moved out on July.
Recasts: She moved out [in] July.
Metalinguistic clues: The preposition is incorrect. You should use the one for during a certain period of time.

3.5 Procedure

Two weeks prior to the data collection, the first researcher of this study invited 50 students online via the text chat on Facebook, but only 13 learners agreed to participate in this study. In order to obtain their permission to conduct this research, the participants were informed about the brief remit and duration of this research; however, they were not told whether they were in the recasts, metalinguistic clues, or control group. In the second week, introductory sessions were set up whereby all the participants were contacted individually online and instructed to sign up for wiki accounts and to familiarize themselves with the tools provided on wikis, such as sending and replying to a message. Immediately after this, the participants were taught how to provide feedback to their peers. The recasts group was introduced to the basic principles in providing their peers with the correct forms without explaining the rules of the forms, the metalinguistic clues group was told not to give their peers correct forms but only explanations of the incorrect forms, and the control group was not given any instructions regarding feedback. Importantly, the researcher drew learners' attention to the forms of verbs and prepositions in the feedback groups of the recasts and metalinguistic clues. All group members were told to complete each composition using 300 words in no more than 20 minutes; they were allowed to use dictionaries or to ask the researcher about vocabulary they did not know. It is worth noting that the collaborative corrective feedback took place in an asynchronous manner, which means that the students worked on the wikis at different times. Apart from the control group, the students in the other two groups accessed the platform three or four times a week to provide their comments on their peers' written work. During the third and sixth weeks, the students completed a piece of written work and revised their work based on the corrective feedback or without feedback each week. In the final week, each participant was asked to compose the final written text and was then interviewed online, which took about 40 minutes.

4. Results and Discussion

This pilot study aimed to explore whether the corrective feedback influenced the accurate use of verbs and prepositions in English and how learners perceived the corrective feedback provided by their peers when collaborating with others on wikis. Three research questions are answered in this section. The first addressed the issue of whether the corrective feedback had an impact on the accurate uses of the targeted linguistic items. The results obtained from the Wilcoxon Signed Rank test as shown in Table 1 suggest that the mean scores of the accuracy in verbs and prepositions differed significantly in the pretest/posttests between the feedback and the control groups. In the feedback groups, the mean scores of verbs demonstrated a statistical significance between the pretest (M=24.11, SD=3.26) and the posttest [M=35.00, SD=5.98, $p < .011$]. Likewise, the mean scores of prepositions reached a significant level between the pretest [M=17.78, SD=3.27] and the posttest [M=17.78, SD=3.27, $p < .018$]. Noticeably, the impact of corrective feedback on the increase of verb accuracy was greater than that on the prepositions. In contrast, the mean scores of accurate verbs and prepositions for the control groups did not differ significantly, as the *p* values were greater than .05.

Table 1. Differences in the pretest and posttest between feedback and control groups

		Feedback groups			Control group		
		Mean	SD	*p*	Mean	SD	*p*
Verbs	Pretest	24.11	3.26	.011	24.00	1.16	.257
	Posttest	35.00	5.98		25.25	2.99	
Prepositions	Pretest	17.78	3.27	.018	19.75	2.99	.458
	Posttest	22.11	2.76		19.25	2.63	

The above results indicate the effect of written corrective feedback on accuracy in the targeted forms (verbs and prepositions) is in line with that of written feedback studies, e.g., AbuSeileek and Abualsha'r (2013).

The second research question asked whether types of corrective feedback influenced the accurate use of the targeted items. In Table 2, the pretest and posttest were measured in terms of the accuracy in the use of verbs and prepositions by using the Mann-Whitney U test. Results indicate that there was no significant difference in the accuracy of verbs and prepositions in the pretest between the recasts and the metalinguistic clues group ($p > .05$). In the posttest, the mean scores of the verbs differed significantly between the recasts (M=30.60, SD=3.98) and the metalinguistic clues group [M=40.50, SD=1.29, $p < .016$]. However, there was no significant difference between the mean scores of accurate prepositions in the posttest of the groups, as the *p* value was greater than .05. Thus, the metalinguistic clues had a greater impact on accuracy than did the recasts.

Table 2. Summary of Mann-Whitney U test

	Recasts group (N=5)	Metalinguistic clues group (N=4)

		Mean	SD	Mean	SD	*p*
Pretest	Verbs	24.40	2.70	23.75	4.27	.712
	Prepositions	17.40	3.36	18.25	3.59	.459
Posttest	Verbs	30.60	3.98	40.50	1.29	.016
	Prepositions	20.60	1.14	24.00	3.16	.111

To some extent, our study, which investigated peer-peer collaborative feedback, provided consistent results with studies investigating teacher-students corrective feedback to suggest that metalinguistic clues are more likely than recasts to influence accuracy in the targeted items; such studies include Shintani and Ellis (2013), who investigated accurate use of the indefinite article (a/an) in revised written work. Such results assumed that feedback such as metalinguistic clues is more likely to push learners' output or self-repair than recasts feedback.

The last research question was regarding the extent to which the participants perceived corrective feedback on their written work taking place on wikis. All the participants (N=13, 100%) agreed that corrective feedback would not only enhance their writing skills but would also improve their overall English abilities. They wished all of their linguistic errors could be corrected in order to write competently. Most of them (N=10, 77%) stated that they were unable to focus on grammar when they were concentrating on composing their written work. More than half of them (N=8, 62%) recounted that, although they could notice the errors that their peers had made, they did not feel comfortable giving comments or feedback on the errors due to their own lack of ability to apply metalinguistic knowledge (e.g., explaining particular forms).

Several limitations to this study need to be addressed, as they may affect the interpretation of the research results. First, there were only 13 learners participating in this study, and thus the sample size was too small to represent other learners in the target population. Second, written rather than oral corrective feedback was closely examined in this study. Hence, it is suggested that oral corrective feedback is needed, particularly for those who are low proficiency learners due to their difficulty in reading metalinguistic clues provided by high proficiency learners. Finally, this study focused only on the accuracy in verbs and prepositions irrespective of some other forms, such as indefinite articles. The pedagogical implications are that teachers should foster learners' metalinguistic knowledge by collaborating with others to comment on others' language use.

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Analysis of Preview Behavior in E-Book System

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Abstract: This paper proposes a method to analyze preview behaviors of students using a learning management system (LMS) and an e-book system. We collected a large number of operation logs from e-books to analyze the process of learning. In addition, we conducted a quiz to test the level of understanding. This study especially focuses on an analysis of the relationship between learning behavior in preview and its effectiveness in the corresponding quiz. We apply a machine learning and classification methodology for behavior analysis. Experimental results report that students who undertake good preview achieve better scores in quizzes.

Keywords: Preview, learning behavior analysis, action logs, slide features

1. Introduction

The growth of information and communication technology (ICT) has produced great changes in education. For instance, ubiquitous learning or mobile learning is a well-known new learning paradigm that enables people to learn anytime and anywhere they want, using electronic devices such as PCs, tablets, smartphones, and so on. Furthermore, the use of learning management system (LMS) has become widespread in academic institutions. These ICT-based learning systems provide not only convenient and effective educational environments, but also various kinds of learning logs for students, such as when and where they use the system, what they learn, and so on.

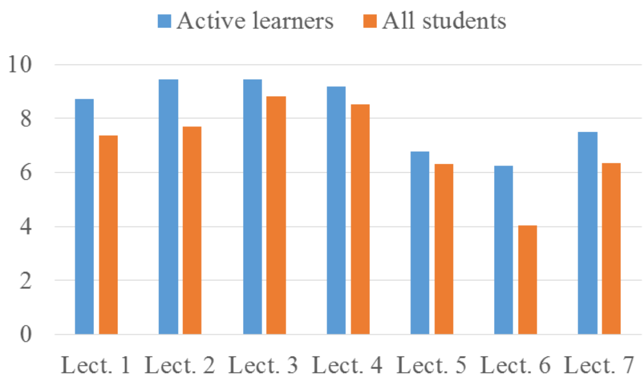


Figure 1. Average quiz scores

These learning logs are very useful for enabling educators to understand the learning activities of students (Yin et al., 2014). For example, teachers can observe a relationship between learning activities and examination scores through the analysis of logs of an e-book system and LMS. We preliminarily investigated the relationship between learning behavior acquired by the e-book system and quiz scores on LMS. Figure 1 presents the scores for several quizzes. Each quiz contained three to five questions related to information science, and was conducted prior to the beginning of the lecture. In the figure, the label of "active learners" indicates students who prepared for the lecture. In all quizzes, the average scores of active learners were higher than the average scores of all students.

In addition, learning logs offer great potential for analyzing the process of learning activities. In other words, it is also possible to analyze how a student learns new things, i.e. learning behavior, quality of learning, etc. Teachers would like to know the learning behavior of students, especially in informal education (Wu et al., 2012) and/or flipped education (Ronchetti, 2010, Foertsch et al., 2002) where a self-activity is required to the student off-site a classroom. If teachers perceive students' learning behavior, they can provide detailed assistance to individual student, reflect on their own educational style and so on. As part of learning behavior analysis, we focus on the learning style of students who use e-books. In this paper, we propose a methodology to analyze how active learners browse lecture materials during their preview.

We utilized learning logs from a LMS and e-book. Analysis of the learning logs revealed a trend whereby students who undertook good preview achieved better scores on the quizzes. Conversely, students whose preview was poor achieved worse scores on the quizzes.

The paper is organized as follows. Section 2 gives a brief overview of our idea and strategy. The details of our proposed strategy and methodologies are explained in Section 3. Section 4 presents the results of our learning behavior analysis and Section 5 concludes.

2. Overview of Proposed Approach

The aim of this study is to analyze learning behaviors in preview, and to investigate the effectiveness of preview in helping students to understand the contents of lecture materials. We utilize an e-book system and a LMS to collect various kinds of logs such as action logs from e-books, quiz scores, etc. The e-book system contains slide materials that are used for lectures. Students may use the e-book system to browse the materials anytime they want. Teachers encourage students to utilize the materials for preview before the lecture starts. We can therefore acquire an understanding of learning behavior, such as how much time each student spends on preview, how much time is spent browsing each page of slides, and so on, from the action logs of the e-books,. The outcomes of this preview are then investigated by the LMS, wherein students take a brief quiz prior to the beginning of the lecture.

We also focus on the process of preview. More precisely, we analyze whether or not a student

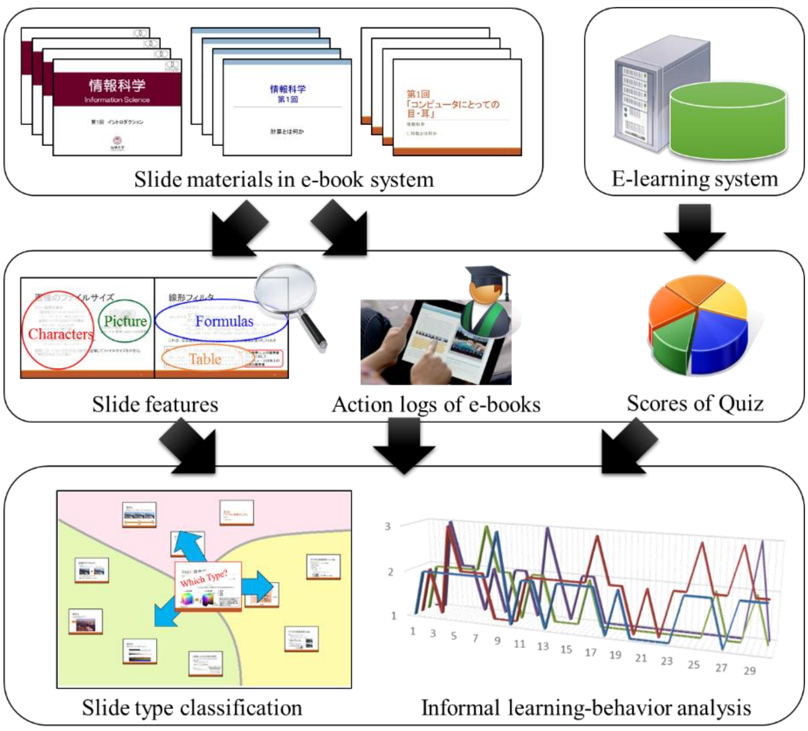


Figure 2. Overview of the proposed approach

spends an appropriate amount of time browsing each page of slides during the preview period. Our assumption is that students who get better scores in the quizzes (i.e., active learners) spend an appropriate amount of time on each page of slides. In other words, each page of slides has a predetermined preview time, and active learners spend the anticipated amount of time browsing the page. To do this, we have to estimate the expected viewing time for each page of slides. Therefore, we extract slide features from each page to measure the contents.

Figure 2 shows the overview of our strategy. Preview processes are collected via action logs from e-books. In addition, the outcomes of preview are collected via the quiz scores using the LMS. Slide contents, such as characters, pictures, mathematical formulas, tables, and so on, are extracted and represented as slide features by visual image processing. Generally, a presentation slide set contains not only text (e.g., slide title, main slide text/bullets), but also other contents such as mathematical formulas, colorful figures, tables, and so on. Therefore, extracting textual features is not sufficiently informative, and we must consider other features that represent this additional content. That's why we focus on visual features, in which even the text regions are considered as visual information. Finally, these logs and features are applied to slide classification and analysis of learning behavior.

3. Visual Feature Extraction and Classification

Liew et al. proposed a slide image retrieval system in which slide features are extracted by image processing (Min et al., 2008). A similar system was also proposed by Boer et al. They regarded a Web page as an image, and utilized image analysis features for Web page classification (Boer et al., 2010). Our idea was inspired by these related works.

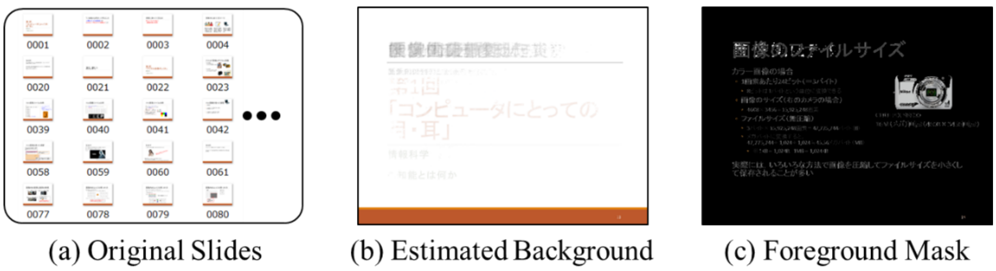


Figure 3. Background estimation and foreground mask

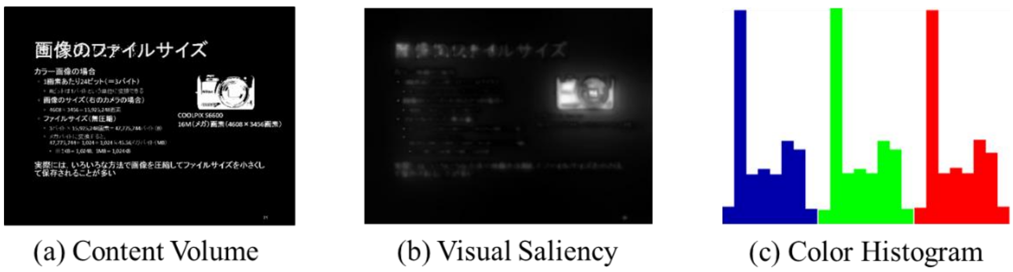


Figure 4. Slide features

3.1 Background Separation and Foreground Mask

Before extracting the slide contents, the background used in the slides has to be estimated. Usually, we can take advantage of the fact that presentation slides have a consistent background throughout the presentation set. Therefore, we apply a background modeling strategy (Zivkovic et al., 2006), which is often used for video surveillance, by using the slide set shown in Figure 3(a).

This background modeling provides an estimate of the dominant RGB value for the background color (see Figure 3(b)). Consequently, we can acquire a foreground mask slide by subtracting the background from the original slide, as shown in Figure 3(c).

3.2 Slide Attributes

Once background separation is complete, we have a set of foreground mask slide images I from which we can extract representative features. We assume that the volume and visibility of a slide affects the learning time of the students, and extract the following three kinds of visual features related to our assumption.

3.2.1 Content Volume

The foreground mask (Figure 3(c)) of each slide image is first binarized by thresholding the color intensity values. As shown in Figure 4(a), the contents of the slide are extracted as white pixels. We calculate the content volume by counting the number of white pixels. We then divide the slide image into 5×5 nonoverlapping subregions to preserve rough content location information.

3.2.2 Visual Saliency

A "Saliency Map" was proposed to find a topographically arranged map that represents the visual saliency of a corresponding visual image (Itti et al., 1998). The saliency map is acquired by combining inputs from several feature maps, intensity, orientation, and color, which display substantial local contrast at several spatial scales in the area.
We apply the strategy to each slide image and acquire salient regions as shown in Figure 4(b). Then, we divide the slide image into 5×5 nonoverlapping subregions and calculate the content volume, and then binarize the map and count the number of white pixels.

3.2.3 Color Histogram

An RGB color histogram is produced from each slide image. Each color channel is discretized into eight bins and concatenated as a 24-bin color histogram (Figure 4(c)). A bin corresponds to part of the color intensity spectrum.

For each slide, we acquire a (25 + 25 + 24 =) 74-dimensional feature vector that characterizes the slide image.

3.3 Slide Classification

A classifier is designed to classify a slide into a corresponding group (class). The slide features extracted from each slide are first trained by a machine learning methodology. In our study, we defined three groups as follows.

- Group 1 Short browsing, less than 5 sec.
- Group 2 Normal browsing, between 5 sec and 20 sec.
- Group 3 Long browsing, more than 20 sec.

Before the training process, all the training samples, i.e., slide images used for training, are categorized into one of these groups according to the e-book learning logs. For further details, see the Experimental Results section. We use a support vector machine (SVM) (Cortes et al., 1995), which is a well-known machine learning method, to generate a classifier.

4. Experimental Results

4.1 E-books and Action Logs

We analyzed the learning logs from an "information science" class. In total, 135 students attended the class, which commenced in October 2014. All the lecture materials were prepared as digital textbooks using the BookLooper system (KCCS, url). Students browsed the materials using their PCs, tablets, and/or smartphones. The materials consisted of three item groups: A (A-01, …, A-11), B (B-01, …, B-

15), and C (C-01, …, C-08). Each item contained several pages of slides. The total number of slides is summarized in Table 1.

Table 1: The total number of slides in each item group.

Item Group	A	B	C	Total
# of slides	452	538	231	1221

Students use their e-books not only while attending a class but also outside of class hours. In our study, we focus on analyzing the effectiveness of preview, especially in learning behavior before the classroom lecture. In other words, we wish to analyze how effectively students learn the materials before the lecture. The target logs for our experiments were collected from the beginning of October to the end of November (All students agreed to our privacy policy for utilizing the logs. The privacy policy was approved by the ethics committee of our university.). We obtained about 187,000 action logs with time stamps such as "go forward", "go backward", "put memos", and so on. Then, we calculated the time spent browsing each slide from these logs. Note that we analyzed action logs that were collected during the week before each lecture, although logs for all learning materials were available over the entire period. Figure 5 illustrates the analysis of the target logs.

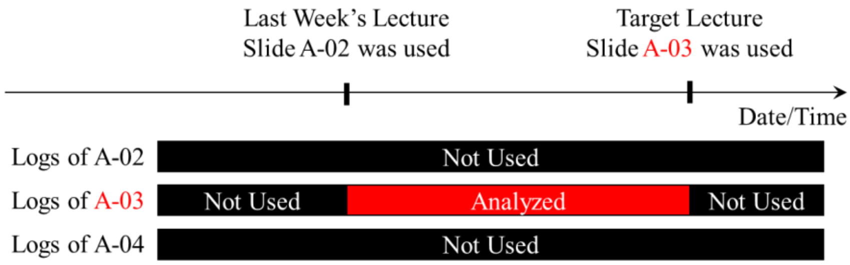


Figure 5. An example of the analysis of an action log period

4.2 *Training and Classification of Slide Type*

First, an SVM was trained to classify the slides into three groups as explained in Section 3.3. The browsing time of each group was based on the actual browsing times calculated from the action logs. To account for the diversity of students, we selected the action logs of high-grade students whose quiz scores were ranked in the top 25% in the class (Prior to the beginning of each lecture, we conducted a quiz to test the effectiveness of preview.). A total of 263 slides with action logs (average 87 slides for each group) were acquired from the high-grade students.

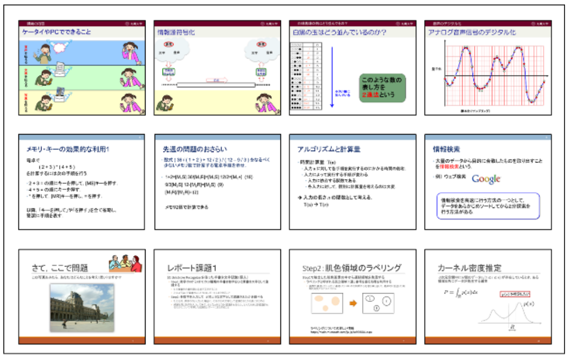
Then, we classified all 1221 slides into one of the three groups using the trained SVM. Figure 6 shows examples of slides classified into "Short browsing", "Normal browsing", and "Long Browsing", respectively. It can be seen that Figure 6(a), contains slides with relatively simple contents, e.g., title slide, introduction, etc., while Figure 6(c) contains slides that have more visual contents, including colorful figures, tables, mathematical formulas, and so on, than the other groups.

4.3 *Estimation of Browsing Time*

Slide classification results can be utilized to estimate the browsing time for each item, i.e., A-01,…, C-08. For example, Figure 7 shows the classification results for three items, which contain about 30 pages of slides. The classification results are different for each of the three items. In this study, we assumed that each group requires an adequate browsing time per page as follows.

- Group 1 5 sec/slide.
- Group 2 20 sec/slide.
- Group 3 60 sec/slide.

(a) Slides classified into Group 1



(b) Slides classified into Group 2

(c) Slides classified into Group 3

Figure 6. Classification results

Based on these assumptions, we can easily calculate the estimated browsing time for each item, as summarized in Table 2. We can see that the browsing time differs even if the items contain the same number of slides. This is because browsing time is affected by the contents of the slides.

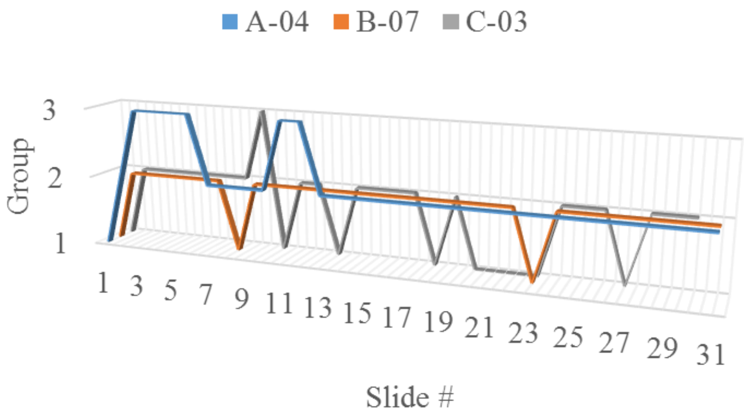


Figure 7. Classification results for three items containing about 30 pages of slides.

Table 2: Estimated browsing time for three items, A-04, B-07, and C-03. We assumed that 5 sec, 20 sec, and 60 sec, respectively, were required for browsing the slides in each group.

Item	Group 1	Group 2	Group 3	Estimated browsing time
A-04	1	24	6	14 min 05 sec
B-07	3	28	0	11 min 10 sec
C-03	9	20	1	8 min 25 sec

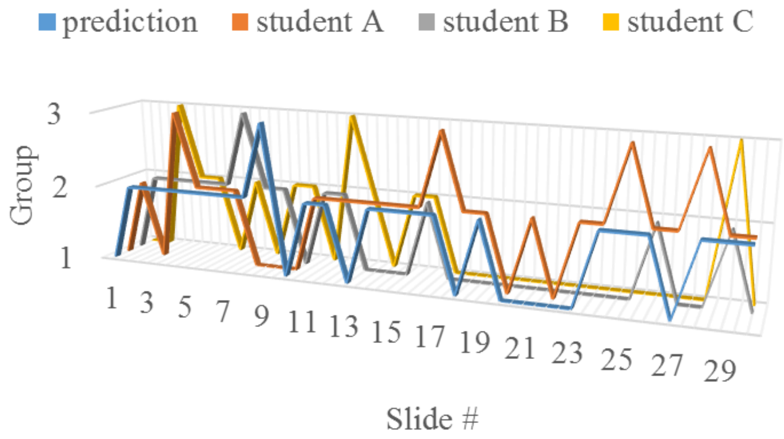


Figure 8. Browsing time for item "C-03". The sequence labeled "prediction" represents the classification result for C-03 slides. The other three sequences are based on the action logs acquired from e-books.

Table 3: Relationships among quiz scores, preview time, and poor browsing.

Item	Score	Learning time	# of poor browsing
Student A	7.5	10 min 45 sec	12/30
Student B	8.75	12 min 24 sec	10/30
Student C	0	5 min 43 sec	18/30

4.4 Analysis of Preview Efficiency

We analyzed the effectiveness of preview. First, we compared the estimated browsing time and actual browsing time of several students for each slide. Figure 8 illustrates the case for item C-03. The sequence labeled "prediction" represents the estimated time using our proposed method, which is the same as that for "C-03" in Figure 7. The other sequences represent the actual browsing time of three students. Their browsing time was calculated from the logs of their e-books. Therefore, the three sequences reflect the time actually spent on preview before the lecture.

Prior to the beginning of the lecture, the teacher conducted a quiz based on the contents of item C-03. Scores were scaled from 0 to 10 points. The average scores of all students and of students who undertook preview were 4.03 points and 6.25 points, respectively. Overall, the scores of active learners were superior to those of the other students, as would be expected. However, there were some students whose scores were poor, even though they undertook preview. Table 3 shows the quiz scores, preview time, and instances of poor browsing of the three students whose browsing performance is shown in Figure 8. "Student A" and "Student B" achieved better than average scores, but "Student C" failed the quiz (scoring 0 points), even though he undertook preview before the lecture.

We analyzed the learning behavior of "Student C" and found that he spent about 6 min on preview (i.e., browsing the material). Meanwhile, the expected time as predicted by our proposed method was about 8 min. Not only was the preview time of "Student C" shorter than that of other two students, it was shorter than the expected time (i.e., 8 min). We investigated the time spent on each page of slides, and whether it met the expected time. Slides were counted as "poor browsing" if the learning time spent on the slide was less than the expected time defined in Section 3.3. The right-hand column in Table 3 denotes the number of instances of poor browsing by the three students. Compared with "Student A" and "Student B", "Student C" had a larger number of instances of poor browsing, which might have caused the worse quiz score. Conversely, the other two students spent the appropriate amount of time on their preview, which led to better quiz scores.

In this way, the proposed analysis strategy enables us to investigate the effect of preview behavior more precisely than by just comparing the students' quiz scores or learning time.

5. Conclusion

We proposed a learning behavior analysis strategy using learning logs collected by a LMS and an e-book system. We focused on a lecture in which a teacher used slide-based materials. Students had free access to the slides anytime and anywhere. Our hypothesis was that a student who spent an appropriate amount of time on preview would achieve better quiz scores. To investigate the hypothesis, we analyze the contents of the slides and learning logs using image processing and machine learning approaches.

In our approach, each page of slides was regarded as an image, and several features were extracted to represent slide features. Then, a machine learning-based classification was performed to arrive at an estimated time for preview. As a result of our experiments, we found that students who did not spend an appropriate amount of time on preview tended to obtain worse quiz scores. It was difficult to reach any definite conclusions simply by using the logs to check whether the student had done any preview. Meaningful findings were enabled by analysis of the learning activity process, how much time the student spent browsing each slide, and whether the time spent was deemed sufficient, based on estimated times.

In this study, we utilized slide classification results to predict the time spent on preview. In future work, we will explore other possible methods of slide classification. For example, we could develop a support system that tells students how much time they should spend browsing a slide. Another possibility is slide summarization based on browsing time. If a student has little time for preview, some important slides will automatically be selected according to the predicted browsing time required for each slide. The entire strategy is also applicable to other learning behavior analyses, such as mobile learning, flipped education, and so on.

Acknowledgements

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An interactive e-book approach to supporting flipped learning in an elementary school math course

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Abstract: In this paper, interactive e-books were developed to enable students to learn at home in the flipped learning mode. Using the interactive e-books, students can learn by themselves before the class and apply what they have learned to the classroom activities later in schools. Moreover, the teachers can monitor the students' learning status based on the e-book learning logs recorded in a cloud system. To evaluate the effectiveness of the proposed approach, an experiment was conducted in an elementary school math course. A total of 45 students participating in the experiment were assigned to an experimental group and a control group. The students in the experimental group learned with the proposed approach, while those in the control group learned with the conventional technology-enhanced learning. From the experimental results, it was found that the proposed approach significantly improved the students' learning achievement.

Keywords: interactive e-books, flipped classroom, flipped learning, cloud system

1. Introduction

Recently, scholars have emphasized the importance of conducting students-centered activities in school settings (Hwang, 2014); moreover, they have pointed out the importance of fostering students' active learning and problem-solving competences in developing the student-centered learning activities (Agbatogun, 2014; Kamarainen et al., 2013). It is apparent that nowadays teachers play the role of a learning promoter rather than a knowledge provider; that is, they play the role of encouraging students to construct knowledge during the learning process. Among various learning modes, flipped classroom has been considered as an effective learning mode for helping students engage in active learning as well as meaningful peer-to-peer and peer-to-teacher interactions during the in-class learning process (Forsey, Low, & Glance, 2013). This can overthrow the direct instruction in the traditional instruction and focus on leading students to apply knowledge to practical applications and engaging them in higher-order thinking.

However, researchers have also pointed out several challenges of conducting the flipped classroom in school settings. For example, teachers need to make lot of efforts in designing learning activities for helping students learn effectively and meaningfully whether in the class or out of the class (Schultz, Duffield, Rasmussen, & Wageman, 2014). In addition, in the out-of-class learning stage, students need to learn by themselves which might cause them high cognitive load when facing too much online information at the same time (Kim, Kim, Khera, & Getman, 2014). More importantly, teachers are unable to know individual students' learning status before the class without any assistance.

Consequently, more and more discussions about the lead-in of technologies for improving the quality of flipped classroom have been made in recent years (Galway, Corbett, Takaro, Tairyan, & Frank, 2014; Kong, 2014). With the help of computer and communication technologies, teachers can manage learning activities online and monitor students' learning status in an efficient way. On the other hand, students can browse learning materials (e.g., videos and web pages) by themselves in a systematically way with the learning guidance provided by the learning system. For instance, some learning management system can assist teachers to schedule the learning plan of individual students and monitor their learning situations (LaRue, 2012). Several studies have further demonstrated that the appliance of technology can engage students to learn effectively and assist teachers to control their students' learning pace and performance, whether students in the class or out-of-class (Mason, Shuman, & Cook, 2013; Teo et al., 2014).

In this study, interactive e-books were developed for assisting students' flipped classroom learning; in particular, guiding them to learn at home in an effective way. In the meantime, the e-book system can automatically record students learning status for helping teachers monitor students' performance and provide assistance in the class accordingly. To evaluate the effectiveness of the proposed approach, an experiment was conducted to investigate whether the interactive e-book in flipped classroom improved the students' learning achievements in comparison with the conventional technology-enhanced learning approach.

2. Literature Review

2.1 Flipped Classroom

In recent years, the educational paradigm has greatly shifted into students-centered learning mode. At the meantime, more technologies have been integrated into the educational scenes, which leading multiple learning modes provided for students to have various learning ways (Li, Verma, Skevi, Zufferey, Blom, & Dillenbourg, 2014). Among various learning modes, "flipped classroom" has been regarded as an extraordinary learning method that engages students in applying their learning knowledge and conducting higher order thinking, rather than receiving direct teaching instruction (Davies, Dean, & Ball, 2013; Flumerfelt & Green, 2013).

The concept of the flipped classroom was proposed by Jonathan Bergmann and Aaron Sams (2012). They proposed that in this learning mode, students could prepare for classes by watching the videos, and could thus form the basic knowledge before class. In the in-class activities, more discussions or practices could be conducted to engage students in more in-depth learning and help them clarify any misconceptions (Bergmann & Sams, 2012).

There are many examples adopting the flipped classroom in courses (Hung, 2015; Teo et al., 2014). For instance, Gilboy, Heinerichs, and Pazzaglia (2015) used the flipped classroom in nutrition course. In this activity, students needed to preview the learning contents and write down the questions they encounter before the class. In the in-class stage, the teacher and students have face-to-face interaction and discussion of these questions. The results showed not only students' learning results are increased but both the students' and teachers' satisfaction with the course tended to be high. Another example in the USA is applied in a chemistry course, which students needed to watch the video and answer the designated questions before class. On the other hand, in the in-class activity, the teacher guided the students to discuss any high-error-rate questions. Through flipped learning, students' academic performance and learning confidence were increased (Fautch, 2015).

Stone (2012) stressed that educators need to make extra efforts in order to meet the expected outcomes of the flipped classroom. Although teachers do not have to prepare the traditional teaching contents, they still have to prepare the content for individualized learning and teaching. Therefore, teachers have to consider the educational value of flipped classroom to lead their students applying learning knowledge with the teachers' guidance (Spencer et al., 2011; Francl, 2014). Certainly, teachers can use technology and teaching strategies to successfully adopt flipped learning for students to achieve the expected outcomes (Bergmann, Overmyer, & Wilie, 2011).

2.2 The challenge of flipped classroom

Previous studies have discussed the technology supported in the flipped classroom, and demonstrated that the enhancement of technologies can effectively present the learning content for students, whether in-class or out-of-class activities (Hung, 2015; Kim et al., 2014). Moreover, teachers can apply some technology in organizing their teaching materials and video (Hwang, Lai, & Wang, 2015). For instance, Bergmann and Sams (2012) applied teaching video in their chemistry courses to solve students learning problems. On the other hand, Teo et al. (2014) also provided a chemistry learning platform for students to understand the basic concept of chemistry and the complex practical procedures through those demonstration videos.

However, some researchers still pointed out the shortcomings of the flipped classroom duo to the lack of learning guidance (Li et al., 2013). Without proper guidance, students might get lost in the out-of-class learning activities. In the out-of-class learning environments, there is plenty of information on the Internet; some of them can force students learning, while others might influence students' concentration. At this circumstance, the guidance and assistance of sustaining students' out-of-class learning become important.

In the past decade, Electronic books (e-books) have been regarded as an alternative media of introductory-level textbooks in educational scenes. One potential advantage of e-books is the flexibility and accessibility to conduct in regular courses; others include more visually appealing content, such as animation and video clips (Woody, Daniel, & Baker, 2010). Moreover, it is a proper technology that assists teachers to organize their teaching materials and guidance effectively. Based on the assistance, e-books can guide students to learn in a well-constructed learning procedure and become good partners with students in their out-of-class learning activities.

For instance, Korat (2010) integrated e-books into students' language and literacy learning courses, and found that students who read the e-books performed better in word reading than students who did not read the e-books. On the other hand, Li, Chen, and Yang (2013) have applied cognitive maps in e-books for improving students' reading comprehensive abilities. The results showed this learning mode can help students gain better reading performance.

Therefore, in this study, an interactive e-book approach was proposed for helping students to learn at home. With the help of the e-books, students read the learning materials following the guidance provided by the teacher and take quiz to evaluate their learning performance at home; moreover, their learning logs are recorded by the e-book system for teachers' reference in conducting classroom activities.

3. An interactive e-books in math courses

To boost students to have active learning, the interactive e-book approach was developed and integrated into a flipped classroom. The system consists of an e-book reading system, a teacher management system, and a cloud system, as shown in Figure 1. The e-book reading system provides the e-books for students to read before their class. The cloud system stores the e-books and students' learning logs. The teacher management system provides the functions for teachers to upload e-books, monitor students learning performance and analyze their learning behaviors

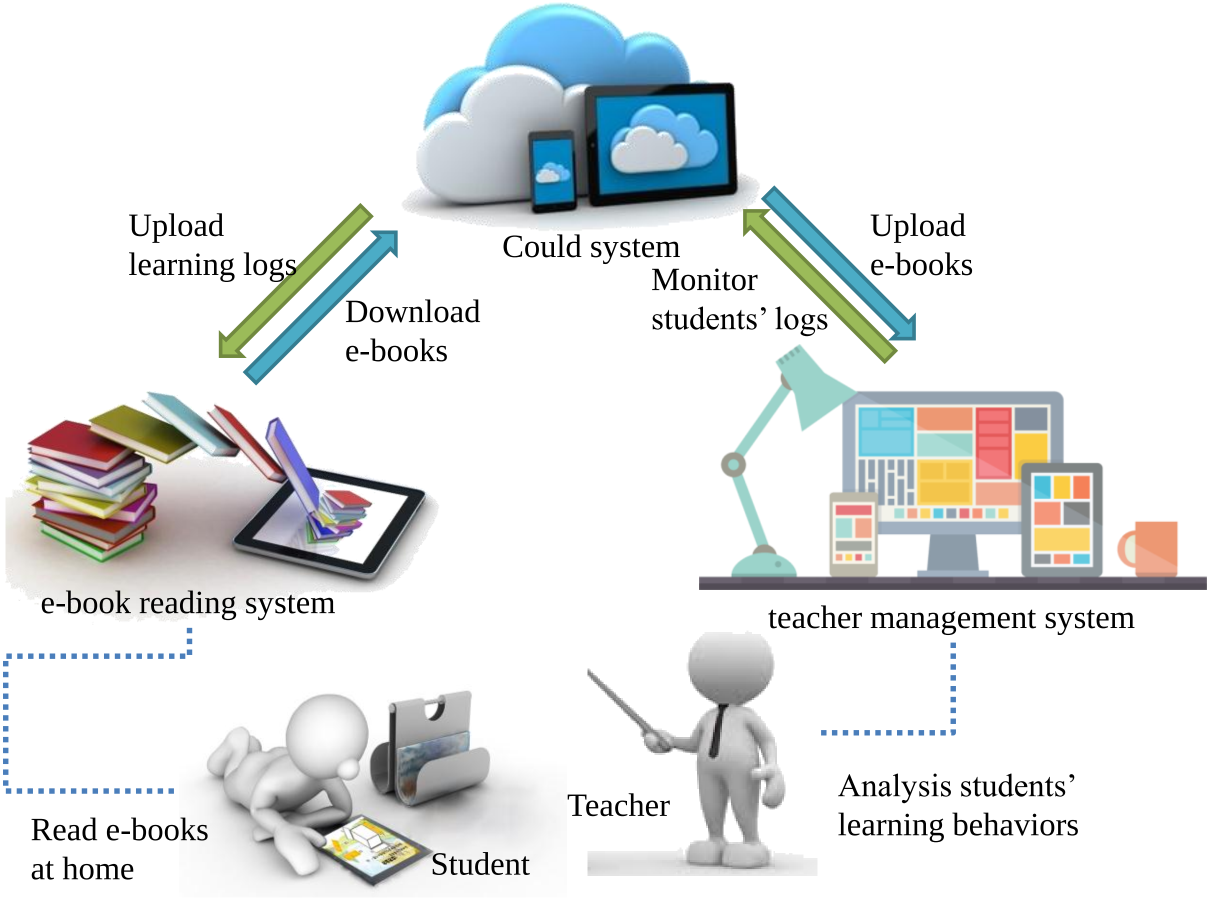

Figure 1. Structure of the interactive e-book approach

After logging in the interactive e-book, students can start the self-learning process. They can read learning materials, which could be in the form of text, photo, graph, or videos with various interactive interfaces. In addition, there are several quiz mechanisms provided by the e-book system, including multiple choices, matching, dragging, and fill-in-the-blank. Figure 2 shows the interface of dragging quiz.

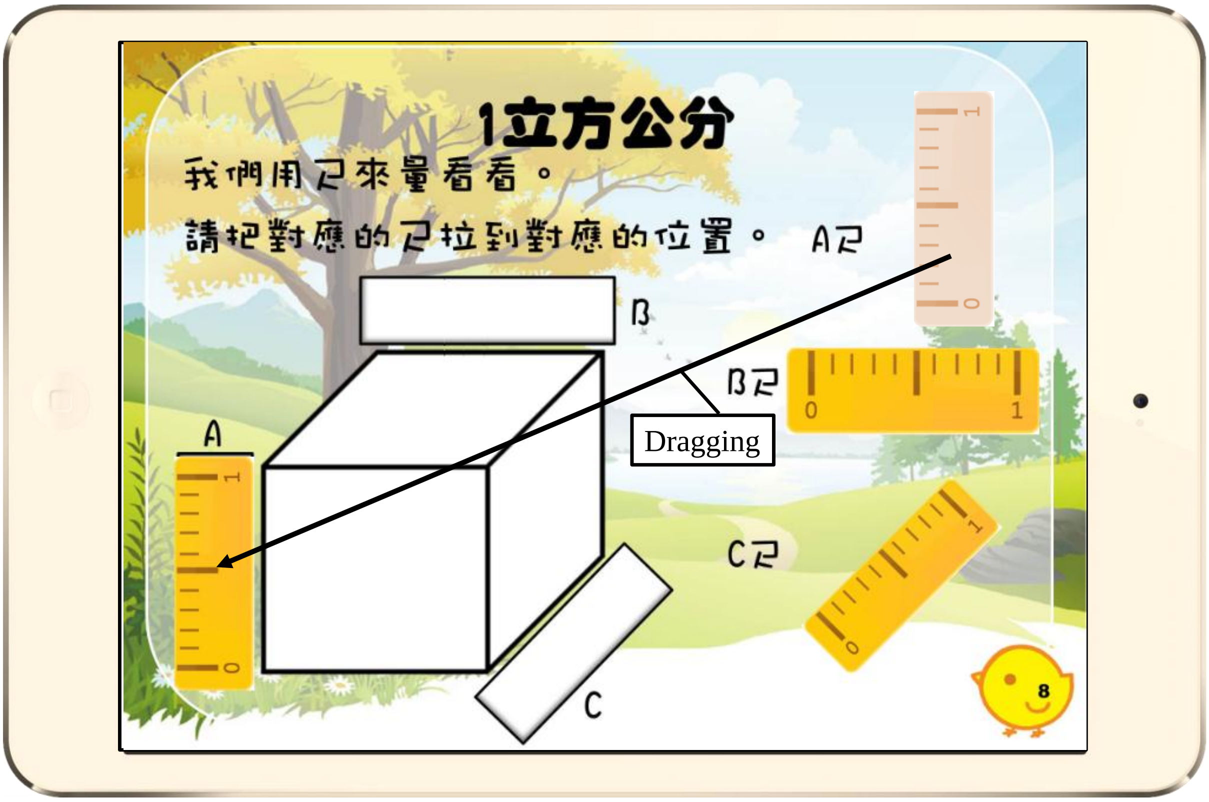

Figure 2. Interface of the interactive e-books, dragging

The interactive e-books can guide students to learn the correct concept by providing appropriate feedback. For instance, if students fail to answer a quiz, the interactive e-book immediately provides relevant feedback and asks them to answer the quiz again. Moreover, if the students fail to answer the quiz for the second time, the system provides some hints or supplementary materials to them before asking them to answer the quiz again, as shown in Figure 3.

Figure 3. The interactive feedback provided through the e-books

After the students finish reading the e-books, the e-book system calculates students' learning scores and uploads the scores to the cloud system, as shown in Figure 4. The system also records the learning logs of individual students, including the time and operations, in the cloud system. Therefore, teacher can check students' learning logs and performance in the cloud system, as shown in Figure 4.

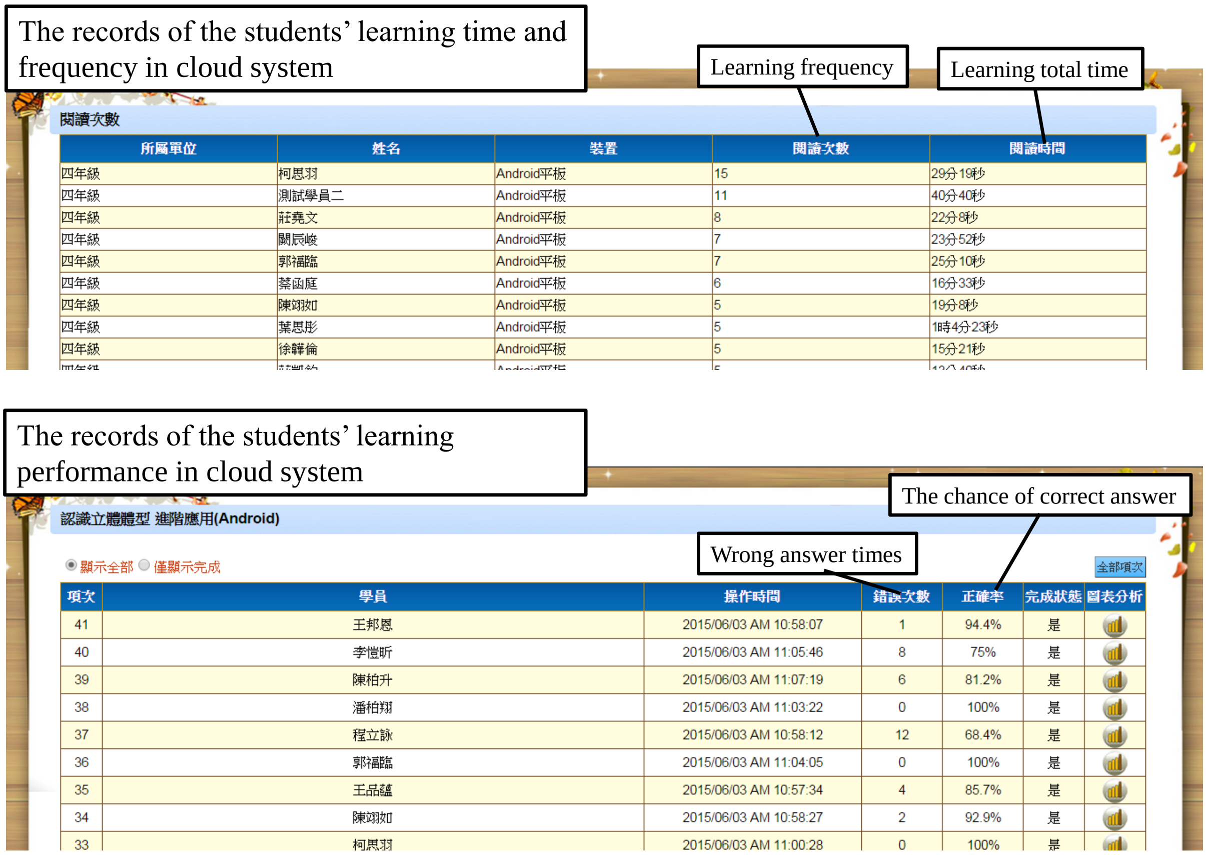

Figure 4. The learning log and performance of the interactive e-books in the database

4. Methodology

4.1 Participants

In this study, the students included two classes of fourth graders in an elementary school. All the students have the basic math concept of area and perimeter. One class was randomly assigned to be the experimental group and the other class was the control group.

The experimental group, including 24 students, learned with the interactive e-book approach in the flipped classroom. On the other hand, the control group with 21 students learned with the conventional flipped learning, that is, the students watched some videos and read some learning material before they went into the class. Both group conducted conventional technology-enhanced learning in in-class activities.

4.2 Measurement

The measuring tools of this study included the pre-test, post-test, and the questionnaires of meta-cognitive awareness. The test sheets were developed by three experienced teachers. The pre-test aimed to evaluate the students' prior knowledge of the math course in the "Area and perimeter" unit. It contained five multiple-choice items (10%), 2 matching items (16%), 17 fill-in-blank items (34%), and 10 question-and-answer items (40%), with a perfect score of 100. The post-test contained ten multiple-choice items (50%), five matching items (25%) and five question-and-answer items (25%) to assess the students' competence in identifying various volume and calculate those complex volume. The perfect score of the post-test was 100. The KR20 coefficient was 0.66, indicating an acceptable internal consistency reliability of the post-test (Kuder & Richardson, 1937).

The meta-cognitive awareness questionnaire originated from the questionnaire developed by Schraw and Dennison (1994). It consists of 10 items with a five-point Likert rating scheme. The Cronbach's alpha value of the questionnaire was 0.91.

4.3 Experimental procedure

The experimental procedure is shown as Figure 5. The learning materials for both groups were identical, while their learning approaches were different. At the beginning of the learning activity, all the students in two groups took the pre-test and the pre-questionnaire. After completing the pre-test, the teachers in both classes introduced the syllabus and the learning goal for the students. The learning course was divided into two units, which students learn the unit 1 in the first week and unit 2 in the second week. During the out-of-class learning activities, the students in the experimental group read the learning materials (videos, photos, graphics, and text) and took the quiz related to the learning content via the e-books. On the other hand, the students in the control group learned with the conventional flipped learning approach; that is, they read the same content (i.e., learning sheets and learning guidance in the printed materials and videos on the web). According to the learning logs, both groups of students spent one hour per week on average for the out-of-class learning tasks.

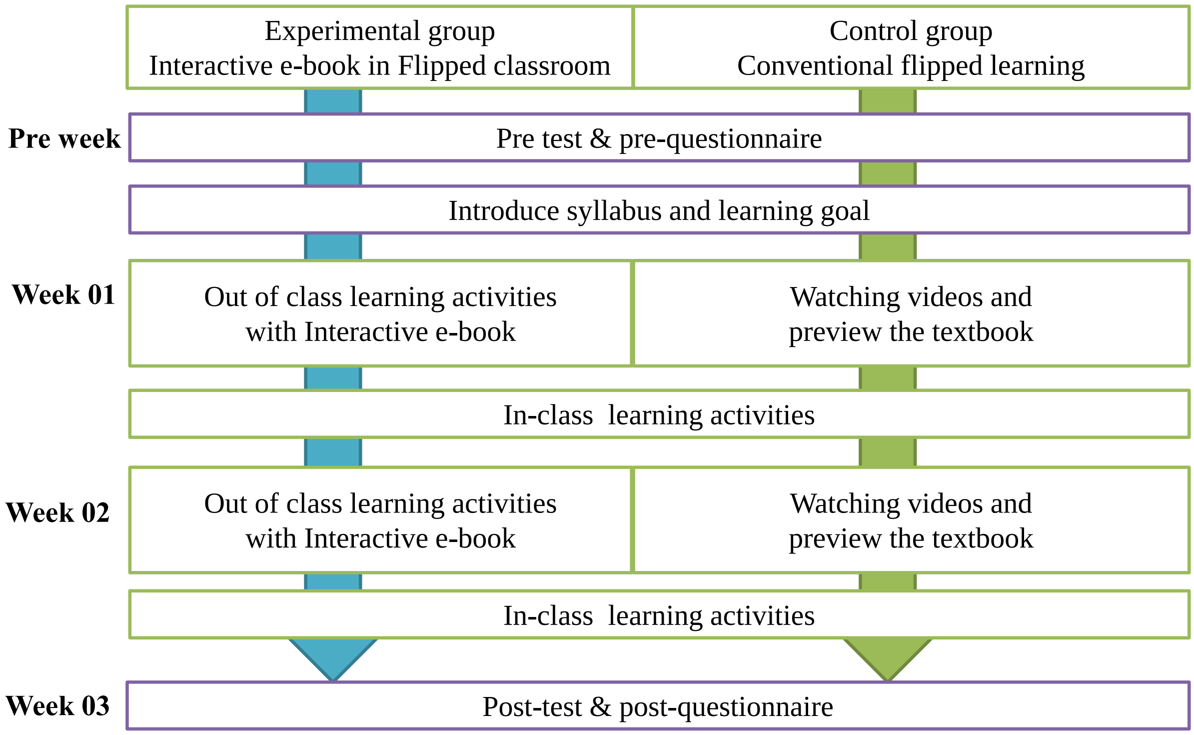

Figure 5. Diagram of the experiment design

During the in-class activities, both group of students learned with the technology-enhanced learning activities, in which the teacher provided remedial instructions based on concepts related to the high-error-rate questions in the out-of-class learning activities and interacted with the students via the electronic whiteboards, as shown in Figure 6. The students' high-error-rate questions were automatically records in the learning system. After the learning activity, all of the students completed the post-test and the post-questionnaire. It should be noted that the post-test items were different from the quiz in the interactive e-books or the questions provided in the learning sheets in the out-of-class stage.

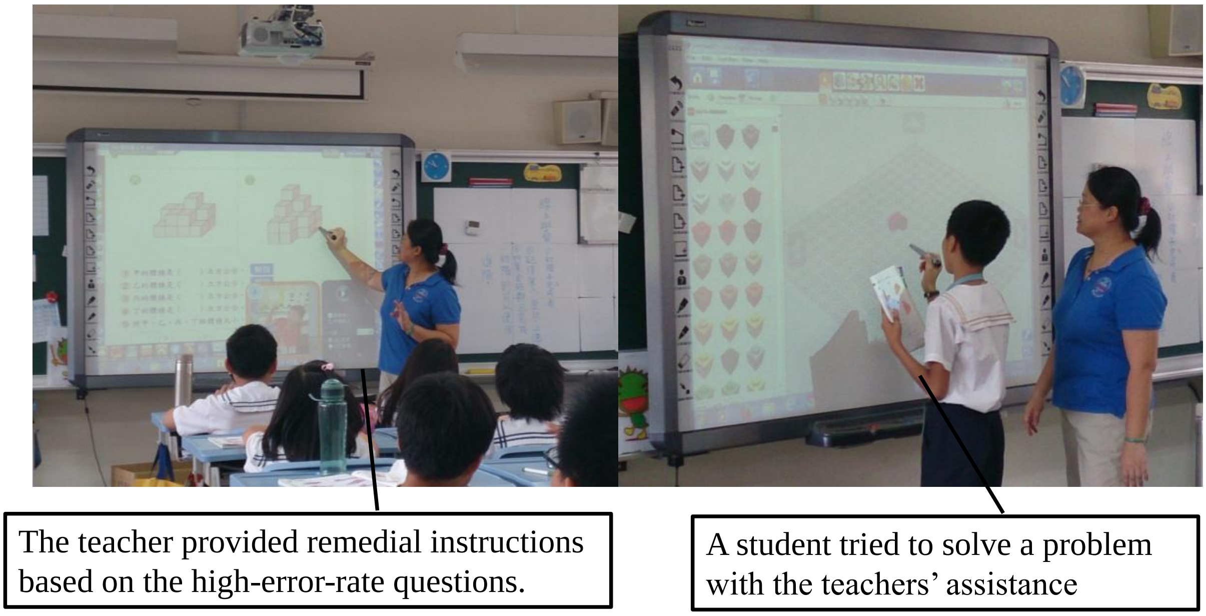

Figure 6. Scenario of the in-class activities

5. Results

5.1 Analysis of Learning achievement

In order to examine the different of learning achievement in two groups, an analysis of covariance (ANCOVA) was conducted. The ANCOVA can be used to adjust for preexisting different in nonequivalent groups, which made the prior knowledge of the two groups more similar (Miller & Chapman, 2001). Table 1 shows the ANCOVA result of the post-test scores of the two groups. The adjusted means and standard error of the ratings were 80.11 and 2.46 for the experimental group, and 71.87 and 2.63 for the control group. It is found that the learning achievement of the two groups are significantly different (F=5.24, p<.05). As the adjusted mean of the experimental group (80.11) was significantly higher than that of the control group (71.87), it is concluded that the interactive e-books supporting in flipped classroom had a significant impact on improving the students' learning achievement regarding the math course.

Table 1. ANCOVA result of the learning achievement post-test of the two groups

Group	N	Mean	S.D.	Adjusted Mean	Std. Error.	F
Experimental group	24	80.50	7.16	80.11	2.46	5.24*
Control group	21	71.43	17.63	71.87	2.63	

* p<.05

5.2 Analysis of meta-cognitive awareness

During the out-of-class learning, the students were engaged in such self-learning activities as learning the concept without teacher's assistance, solving quizzed themselves, and clarifying their misunderstood, and making reflection. Those activities are highly relevant to meta-cognitive awareness, which refers to what individuals know about the cognitive process and status of themselves and others (Schraw & Dennison, 1994).

In this study, the means and standard deviations of the meta-cognitive awareness pre-questionnaire ratings were 3.96 and 0.91 for the experimental group, and 3.63 and 0.80 for the control group. The t-test result shows no significant difference between the pre-questionnaire ratings of the two groups (t=1.28, p > .05), showing that the two groups of students had equivalent meta-cognitive awareness before participating in the learning activity.

Table 2 shows the t-test result of the meta-cognitive awareness post-questionnaire ratings of the two groups. The means and standard errors of the ratings were 3.83 and 0.64 for the experimental group, and 3.38 and 0.80 for the control group. It is found that the post-questionnaire ratings of the two groups are significantly different (t=0.99, p<.05), suggesting that the interactive e-book approach had a significant impact on improving the students' meta-cognitive awareness in the math course.

Table 2. *t*-test result of the meta-cognitive awareness of the two groups

Group	N	Mean	S.D.	*t*
Experimental group	24	3.83	0.64	0.99*
Control group	21	3.38	0.80	

* p<.05

6. Discussion and Conclusion

In order to improve the students' learning performance in the context of the flipped classroom, this study conducted the interactive e-books approach in the flipped learning into students' regular math courses. In order to examine the performance of this study, a quasi-experimental design is adopted and one class is assigned to the experimental group and the other class to the control group. The students in the experimental group learn with this learning approach; while students in the control group learn with the conventional technology-enhanced learning mode. Moreover, some achievement exams were adopted in this study for analyzing students learning performance before and after this experiment.

According to the result, the students' learning achievement in the experimental group has significantly higher than the students in the control group. This result was consisted with Smeets and Bus (2012) that the interactive e-books can promote students learning performance. Moreover, it was consisted with Kong's research (2014) that technology-enhanced flipped classroom can improve the quality of flipped classroom. In sum, it is expected that the future learning mode can be developed in accordance with this learning approach.

On the other hand, the experimental results also show that the proposed approach significantly improved the students' meta-cognitive awareness. It is consisted with some researchers, who have pointed out that engaging students in constructing knowledge by themselves could provide them with more opportunities for self-reflection and deeper thinking in their learning (Akinoglu, 2013; Hwang, Hung, & Chen, 2014).

To sum up, the major contribution of this study is to propose and implement an interactive e-book approach in flipped classroom. In future studies, it is worth recommend that providing more personal and adaptive learning approach to fulfill students' learning in the flipped classroom.

Acknowledgements

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A Proposal of e-Book Based Seamless Learning System

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Abstract: Seamless learning is an approach in which learners can create relationships between their formal and informal learning. To support seamless learning, some seamless learning systems have been proposed. However, conventional systems are mainly based on the relationships and contexts for learners, such as location and time, while their teaching materials are not mentioned in detail. Because most of learners use some textbooks when they learn both inside and outside of the class, textbooks have an important part to support seamless learning. This paper describes a seamless learning system that based on the learners' textbooks (teaching materials) and creates relationships between their formal and informal learning. Through this system, improvement of the learning environment using a wider range of information is expected.

Keywords: mobile learning, ubiquitous learning, seamless learning, e-Book

1. Introduction

With the mobile and wireless technology advances, a new learning environment called "seamless learning" has been gaining many researchers' attention. Wong et al. (2011) identified ten salient features of seamless learning, (1) Encompassing formal and informal learning, (2) Encompassing personalized and social learning, (3) Across time, (4) Across locations, (5) Ubiquitous knowledge access, (6) Encompassing physical and digital worlds, (7) Combined use of multiple device types, (8) Seamless switching between multiple learning tasks, (9) Knowledge synthesis, (10) Encompassing multiple pedagogical or learning activity models.

For example, Uosaki et al. (2010) proposed a seamless learning system called the SMALL System (Seamless Mobile-Assisted Language Learning Support System). Using SMALL, learners can create relationships between what they have learned from their e-textbook inside the class and what they have learned outside the class. For example, when a learner learns the word "credit" at the bank, SMALL provides e-textbook information − such as the book's name, chapter and page − to the learner. Meanwhile, Wong et al. (2014) proposed ubiquitous learning system, MyCloud, allows learners to record what they have learned from the e-textbook.

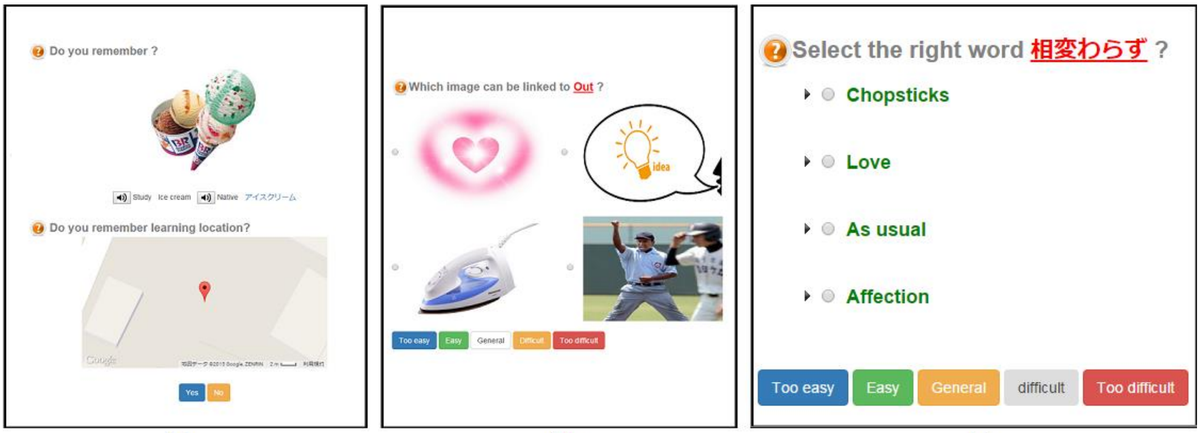
However, while these systems consider learners' contexts − such as learners' location and time − , they do not consider learners' actions to e-book − such as opening/closing books, changing the rate of magnification, changing colors and writing in the e-book (e.g., labels) − . As an example of usage of these information, if many learners open same page again and again, publishers can be noticed that the page may be unreadable. Thus, with these information, improvement of the learning environment is highly expected. For learners' information as described above, an e-book-based ubiquitous learning system that can obtain learners' information is required.

Therefore, this paper proposes a seamless learning system with EPUB (Electronic PUBlication; one of the e-book formats). EPUB does not specify hardware; therefore, it is available on various mobile terminals including general smartphones, and it is easy to obtain information, such as location, acceleration and rotation of the terminal via sensors while learners read the books. Thus, EPUB enables the inspection of learners' actions and obtains much information of not only what learners have learned, but also each learner's state and actions in detail. Therefore, improvement of the learning environment via wider range of information is expected when using this system.

2. Previous works

2.1 SCROLL

Ogata et al. (2010) proposed a ubiquitous learning system called SCROLL (System for Capturing and Reusing Of Learning Log), which supports learners to record, organize, recall, and evaluate Ubiquitous Learning Logs (ULLs). Using SCROLL, learners can log their experiences with information − such as photos, videos, location, QR-code, RFID tag − and sensor data, and they can also receive personalized quizzes about what they have learned. Learners can also navigate and be aware of their past logs.



(a) (b) (c)

Figure 1. SCROLL's quiz function

Figure 1 shows the user interface of SCROLL's quiz system. As shown in Figure 1, SCROLL has 3 kinds of quizzes – "yes/no" quiz (Figure 1 - a), "four-choice of images" quiz (Figure 1 - b), and "four-choice of texts" quiz (Figure 1 - c). Learners can receive these quizzes based on their contexts; for example, when a learner learns the word "ice cream" at a restaurant, the word "ice cream" is recorded in SCROLL with some contextual information, such as the learner's location, restaurant. When the learner visits the restaurant again, SCROLL gives a quiz about chopsticks to the learner to help them recall ice cream. Thus, SCROLL can support learning based on the context. Since SCROLL runs even on mobile phones, learners can access the SCROLL system wherever they are.

2.2 SCROLL problems and proposed solutions

SCROLL presents quizzes about what learners have learned and lets learners recall these. SCROLL's quizzes are based on what the learner learned and what someone who have a relationships with the learner learned. Thus, SCROLL's quiz function is originally implemented for knowledge sharing between each learner. Li et al. (2013) proposed a context-aware ubiquitous learning system to provide quizzes in accordance with learners' contexts in an informal setting. Therefore, the current SCROLL provides quizzes based on not only each learner's relationships, but also their contexts − such as location, and time − .

However, because SCROLL does not mention learners' classroom teaching materials, SCROLL is still insufficient in relating what was learned inside and outside of the classroom. For the better seamless learning environment, the system needs to let learners create relationships between the formal learning − such as the class content − and informal learning − such as actual experiences − by mentioning not only learners' contexts, but also their teaching materials.

In the proposed system, when learners actually experience or learn something out of class and they open a page about it on EPUB later, learners can relate the actual experience and knowledge from EPUB via a quiz. Similarly, learners can obtain e-book information through the proposed system when they experience or learn something outside of class.

3. Seamless learning system based on e-Book

We propose seamless learning system with EPUB consists of the EPUB reader and SCROLL.

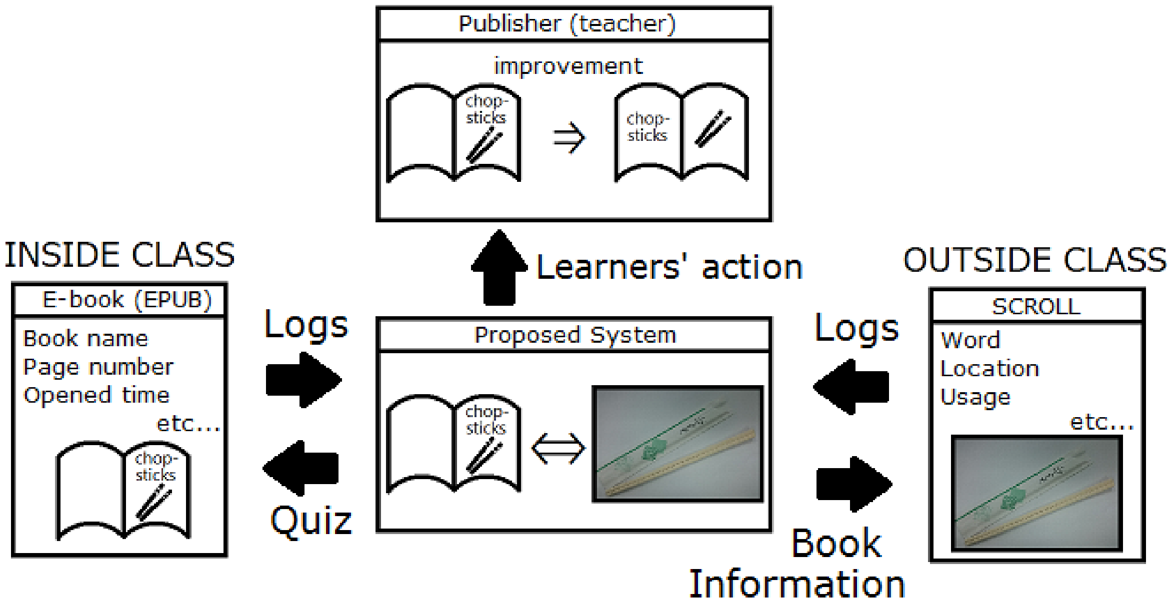
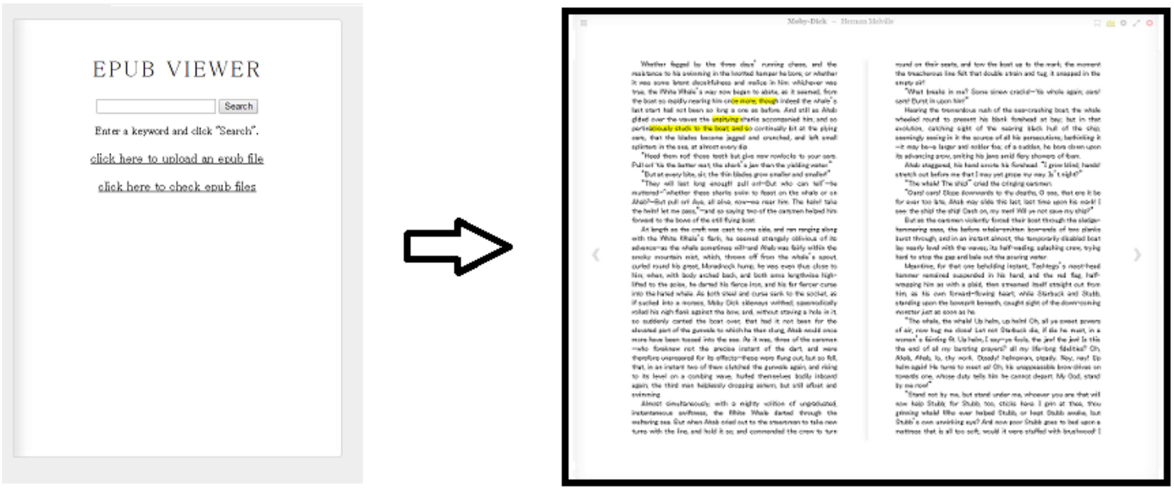


Figure 2. System design

Figure 2 shows the system design of the proposed system. Learners use the EPUB reader in class, and they learn with SCROLL outside the class. Learners' actions − such as opening a book, zooming, and page turning − are recorded into SCROLL's server. The proposed system would provide quizzes or e-book information through SCROLL when learners complete specific actions, such as opening a page that the word the learner has learned outside the class is written, or the learner records something s/he has learned in class. Logs are analyzed and fed back to learners. In addition, publishers (teachers in most of cases) can receive learners' action to e-Book (to be exact, result of analysis) to improve their publications.



(a) (b)

Figure3. User Interface

Figure 3 shows the user interface of EPUB viewer. Learners choose a textbook (Figure 3-a), and read it (Figure 3-b). In Figure 3-b, learners can do not only page turning, but also highlighting, bookmarking, and writing in e-Book. This system is available on both PCs and mobile phones. Figure 3 shows an example of UI on PCs.

4. Logs

4.1 Contents of Logs

Modern tablet PCs equip many types of sensors, such as GPS, acceleration sensor, gyroscope, etc. Therefore, various kind of information can be collected while learners are reading their textbooks. Tamura (2014) proposed data items which to be collected with use of Digital Textbooks, (1) Subject, (2) Date & Time, (3) Place and (4) Object. Object can be divided into (1) Class, (2) Page of e-textbook or reference, (3) Highlight / underline, (4) Note (annotation), (5) Link, (6) Quiz, (7) Assignment, (8) Feedback, (9) Message, (10) Group, (11) Shared whiteboard and (12) Shared file. In addition, Tamura also mentioned following data items which have some issues, (13) Face expression of a learner, (14) Attitude of a learner, (15) Voice of a learner and environmental sound, (16) Acceleration data, (17) Digital compass data and (18) Gyroscope data, (19) Temperature of learner's body and environment, (20) Humidity of environment, (21) Body sweat of a learner, (22) Heart race of a learner, (23) Blood pressure of a learner, (24) Eye-tracking data of a learner and (25) Brain waves of a learner.

Tamura mentioned it is not clear that second half of objects (13 - 25) are useful to identify learner's status or not. In addition, second half of objects have issues, such as risk of privacy violation. Therefore, in this paper, the system deals Subject, Data& Time, Place and some of first half of stated objects (1 - 12). However, information of location is sometimes unavailable on PCs. Therefore, location is not recorded when it is not gettable.

4.2 State of Logs

Histories of learners' actions to EPUB are temporally recorded in a log, and would be sent to SCROLL's database when all necessary data are written. Specifically, the recorded information are not only about EPUB or what the learner has learned from EPUB, but also the learners' actions, such as page turning, book opening/closing, highlighting, and so on. This information is recorded in a log when learners undertake some specific actions, such as opening/closing EPUB, zooming-in, zooming-out, and turning pages.

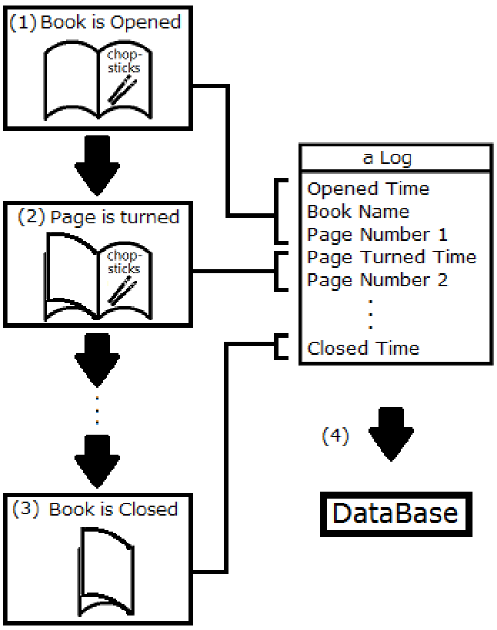


Figure 3. Relation of a learner's actions and a log (example)

Figure 3 shows an example of a log recording.

In Figure 3:

(1) The time the book is opened, book name, and page number are recorded in a log when a learner first opens an e-book (on the EPUB reader).

(2) The time the page was turned and the page number are recorded in the log when the learner turns a page.
(3) Finally, the time the book was closed is recorded in the log when the learner closes the book.
(4) After the closed time is recorded, the log is sent to the database.

4.3 Log usage

This system records not only what learners have learned from EPUB, but also some other information − such as the order of opening and closing pages, learners' actions (e.g., zooming in or zooming out, changing of font color or background color, writing in the EPUB, and highlighting of a specific sentence) in detail.

Logs have some usages. For example, (1) logs are fed back to learners as quizzes (described above), (2) e-books are improvable using the logs of learners' actions (via analyzing the logs).

5. Conclusions and future work

This paper proposes a seamless learning system with EPUB. This system runs on both PCs and mobile phones. Learners' record their learning from EPUB in class and their experiences outside of class through this system. Then, the system allows learners to relate what they have learned in class and what they have experienced outside of class by providing quizzes or book information.

In future work, this seamless learning system needs to be evaluated regarding its efficacy and usability through learners' actual use. In addition, the verification of the effectiveness of this system will help improve e-books and the system itself is expected to improve through an analysis of the logs recorded within the system. Also, we will consider analyzing various methods such as social network analysis and visualization of graph theory (Mouri et al., 2014; 2015).

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Analyzing the Features of Learning Behaviors of Students using e-Books

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Abstract: The analysis of learning behavior and identification of learning style from learning logs are expected to benefit instructors and learners. This study describes methods for processing learning logs, such as data collection, integration, and cleansing, developed in Kyushu University. The research aims to analyze learning behavior and identify students' learning style using student's learning logs. Students were clustered into four groups using k-means clustering, and features of their learning behavior were analyzed in detail. We found that Digital Backtrack Learning style is better than Digital Sequential Learning style.

Keywords: Learning analytics, Learning behavior, Learning log, E-books, Data mining for learning

1. Introduction

E-learning may be subsumed under digital learning, which is a more recent term and arguably has a broader long-term utility (Mason and Pillay, 2014). Many imported digital learning systems have been developed, including Blackboard, Virtual-U, WebCT, and TopClass. These systems accumulate large log data on students' activities. The log data record learning practices, such as reading, writing, taking tests, and performing various tasks in real or virtual environments with peers (Mostow, 2004). An analysis of these log data could help improve the education practice for both instructors and students. For example, by analyzing the features of students' activities, instructors can improve their teaching methods. Meanwhile, students can master learning techniques and learn others' learning style.

Recently, researchers have examined open educational resources (OERs), such as OCW and MOOCs. Compared with OERs, traditional educational resources, such as books, textbooks, or their learning contents, cannot be easily accessed online, and data on students' learning activities are unavailable. Therefore, verifying the educational effectiveness of traditional educational resources remains challenging. Despite the variety in types of traditional learning resources, research on the measurement of their educational effects is limited.

A possible solution is the use of e-books in traditional classrooms, which will enable recording of learning logs that can be used to analyze students' learning behaviors (Ogata et al., 2011; Li et al., 2012; Mouri et al., 2013). Analyzing educational data could yield fruitful results in determining how a pedagogical strategy impacts different types of students, how students study subtopics, and what pages/topics students skip, among others (Romero, 2007).

By 2020, the Ministry of Education, Culture, Sports, Science and Technology (MEXT) of Japan is scheduled to replace all of the textbooks for elementary, middle, and high schools with e-books[1]. Such a move will usher "Educational Big Data," which will comprise learning logs. As a forerunner to this institutional effort, Kyushu University has supported this work in using BookLooper for e-books beginning in April 2014. BookLooper is a document viewer system provided by a partner to this research, Kyocera Communication Systems Co., Ltd., and can be used on personal computers and smart phones. Thus, students can use it as desired, and their learning log will be collected continuously.

[1] http://www.mext.go.jp/

Instructors' lecture materials, such as slides or other notes, can be posted to BookLooper, which can record students' learning behaviors when they use e-books to read their learning contents. Instead of traditional textbooks, traditional classrooms in Kyushu University use BookLooper. Kyushu University implemented the "Bring Your Own PC" program in 2012.

Students can use BookLooper to preview their lessons before class, such as writing questions. They can also take note and mark part of a page as important content during class. After classes, they can review the learning content. All of these learning behaviors will be recorded. Meanwhile, such records will create a large volume of data.

Using these records, educational effectiveness can be verified, and the features of students' learning behaviors analyzed. The present study continues the research on analyzing learning behaviors.

1) Shimada et al. (2014) analyzed students' learning behaviors in using the e-textbook system, including the time each student spends before the lecture and time spent browsing each page of slides. This work also investigated the effectiveness a learning environment in helping students understand the contents of lecture materials.

2) Yamada et al. (2014) investigated the relationship between self-efficacy and learning behaviors using the e-textbook system. The methods used for data collection were based on MSLQ and a log that recorded the number of pages students read over a short period of time. The students' behaviors of using markers and annotations were found to be related with their self-efficacy and with the intrinsic value of the learning materials.

As such, the present work will analyze learning behaviors and identify students' learning styles by analyzing their learning logs, continuing the work of Yin et al. (2014). Processing methods for these learning logs, such as data collection, data integration, and data cleansing, will also be discussed. By performing partial correlation analysis, the study found that a number of learning behaviors have a significant relation with students' final exam scores. Students' learning logs were also used to identify learning styles. Students were clustered into four groups using k-means clustering to analyze their learning features in detail.

2. Related Works

Educational Data Mining is an emerging discipline, concerned with developing methods for exploring the unique types of data that come from educational settings, and using those methods to better understand students (Yin et al., 2013). Many researchers have focused on educational data mining. Kay et al. (2006) mined the patterns of events in students' teamwork data based on electronic traces of students' collaboration. Pechenizkiy et al. (2008) discovered student preferences on educational materials, and the system could decide if a learning material is appropriate for a student or not.

Especially, analyzing learning behaviors is a critical topic in learning analysis. Chiang (2014) indicated that knowledge-sharing behaviors are important during the inquiry learning process. Tsai et al. (2011) explored the correlates among instructors' epistemological beliefs concerning Internet environments, their web search strategies, and search outcomes.

Collecting data is the first step in learning analysis. Based on the data source, studies on learning behaviors can be classified into three categories:

A) **Analysis using a questionnaire**: In this category, data are collected using a pre-designed questionnaire. Li-Hsing Ho et al. (2013) used a questionnaire to investigate the teacher behavior of adopting mobile phone messages as a parent–teacher communication medium. Tan and Seah (2011) explored questioning behaviors among elementary students engaged in science inquiry via a computer-supported collaborative learning tool. Using a Web-based portfolio assessment questionnaire, Chang (2012) attempted to categorize Global behaviors in a Web-based portfolio assessment using the Chinese Word Segmenting System.

B) **Crowdsourcing data:** In this category, a crowdsourced data collection system is opened to users. Users use the system and consciously leave data on their learning behavior. For example, Chiang (2014) provided an augmented reality (AR) system to guide students in knowledge sharing in inquiry learning activities, where students capture images from an authentic environment and share these with others. Ogata et al. (2011) also provided a system called SCROLL, in which students can share their every data learning log using learning memos, RFID tags, and cameras. Hwang et al. (2008) proposed the use of a meta-analyzer to assist instructors in analyzing students' Web-searching behaviors while using search engines for problem solving. In this system, students share their search logs with others.

C) **Automatically recorded behaviors:** In this category, learning behaviors are recorded automatically; users leave records subjectively. Zeng et al. (2009) collected users' reading behavior logs while reading e-documents to verify their course ontology. Huei-Tse Hou (2012) explored the behavioral patterns of learners in an online educational role-playing game. The actions (gaming behaviors) conducted by these participants were recorded automatically in the game database.

For categories A) and B), the data are collected consciously. Therefore, data are affected by users' own subjective factors. For category C), the data is collected objectively, removing the subjective factors that affect data authenticity. The present work falls under category C).

Thus far, research on learning logs of learning contents in the classroom has received limited academic attention. The current research is on using e-books to collect students' learning logs throughout the study period and then analyze their learning behaviors. This work has three features.

1) Data are collected automatically from e-books used in the classroom.
2) Data are collected objectively to avoid subjective factors that affect the authenticity of data.
3) Two learning styles are identified from the learning log, the features of which are analyzed.

3. Data Collection and Processing

3.1 Data Collection

The first stage of data processing is data collection (Yin et al., 2013). The server structure consists of four parts: data collection, data analysis, data backup, and data providing. Two systems are used to collect educational data in Kyushu University: Moodle and BookLooper. Students' learning logs are collected using BookLooper. Instructors and students can access these two systems using their smart phone or laptop anywhere on or off campus.

3.1.1 Kyocera Server

Through BookLooper, students can read learning contents used in the classroom, and all actions of using BookLooper will be recorded to a database. The students' learning data are collected and stored on the data server of Kyocera.

In the second semester of 2014, BookLooper was used in five courses, with 297 students, in Kyushu University. A total of 262,193 records were gathered from October 1 to November 25, 2014. These data occupied 138 MB in storage. The average size of records was 1.67 KB/student/day/course. In 2015, 2,700 students will use BookLooper, which will yield a large volume of learning logs to build educational big data.

Two types of data are stored in the database.

a) Teaching materials and teaching slides used in the classroom
b) Students' learning actions, such as "next page," "previous page," "add marker," "search," "zoom," "memo," and "reading time"

3.1.2 Kyudai Server

A Moodle server called Kyudai Server was created to provide an e-learning system for instructors and students in Kyushu University. Students can use this system to take tests and submit reports, whereas instructors can use it to take attendance, distribute questionnaires, carry out tests, manage students' achievements, and carry out questionnaire surveys. All of these data are stored on two data servers: a backup of the Moodle server and another for data integration, data cleansing, and data migration.

3.1.3 *Data Integration, Cleansing, Migration*

Four systems were developed to process data daily.

a) A data migration system for transferring data between BookLooper and Moodle systems
b) A system to calculate the time difference between actions every day. The BookLooper system only records action time. When an action occurs, the current time will be recorded, but not the duration. A system was thus developed to calculate the time difference between two actions.
c) A system for integrating the data from BookLooper and Moodle, such as statistical reading time and number of markers. These data were used for a Moodle plugin, which can provide learning feedback to instructors and students.
d) A system for integrating the user information data of BookLooper and Moodle

3.2 *Data Explanation and Processing*

This research focused on analyzing the learning logs of 100 freshmen at a university in 2014. They attended the class Information Science opened in October 2014. All the learning contents of the lectures were prepared as e-books in the BookLooper system.

3.2.1 BookLooper Log

In BookLooper, e-books are organized in three layers: bookshelves, books (learning contents), and pages. Users can read, go to next, and return to previous. They can also make bookmarks and leave memos. These actions are logged in the system (Fig. 1).

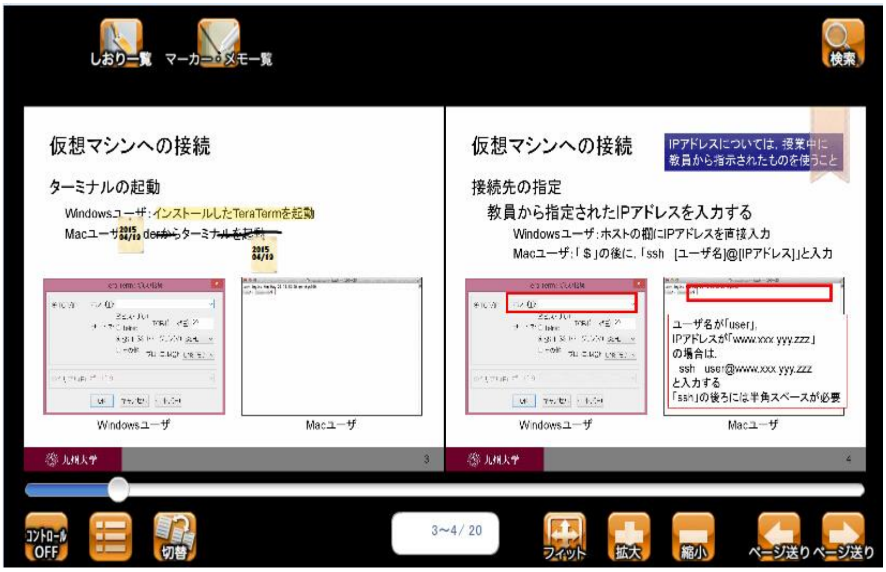

Figure 1. Marker and Memo

Table 1: Sample Action Log.

Userid	Action name	Document ID	Page Number	Action time
S1	Next	00000000NBU1	16	2014/11/22 10:40:55
S1	Prev	00000000NBU1	15	2014/11/22 10:42:15
S1	Memo	00000000NBU1	15	2014/11/22 10:42:16
S2	Marker	00000000NBU1	15	2014/11/22 10:42:18

One data log contains the date, time, user ID, learning content ID, page number, user action, and other data. Students' reading history will be recorded whenever they use BookLooper. Table 1 shows a sample learning log. While a user performs an action, the action and target page number will be saved as one record. Table 2 lists the actions and their explanation.

Table 2: Action Explanation.

Action name	Explain
NEXT	While a user goes to next page, he will click "NEXT" button, and the action name will be saved as "Next".
PREV	While a user goes to previous page, he will click "PREV" button, and the action name will be saved as "Prev".
MARKER	While a user want to highlight some row in the learning content, he will click "Marker" button, and the action name will be saved as "Marker".
MEMO	While a user want to write some memo in the learning content, he will click "Memo" button, and a textbox will be shown. After he finished writing memo, the action name will be saved as "Memo".

3.2.2 Data Processes

To use valid learning logs, the following data processes were performed:

a) Invalid record: If the time difference between two actions is longer than 30 minutes, then the record is invalid. It means that the student did not read the contents, as he/she did not conduct any action in 30 minutes.
b) Invalidity preview: If a student did not preview for the lesson (read the learning content before class) up to three minutes before the class, then he/she is considered to have not done a preview for the lesson.
c) Invalidity score: Students' final exam scores are not analyzed if they used BookLooper during a test.
d) Repetitive answers: Tests are carried out using Moodle, and students could answer the question more than one time. Record of the first time is used to calculate students' final exam scores.

4. Data Analysis

4.1 Learning Style

Learning style can be identified using the learning log. For example, the "Next" and "Prev" logs show when a user goes to a next or previous page. Figure 2 is a graph of the learning behaviors. The graph visualizes the students' actions using the "Action time," "Page No," "Prev," and "Next" logs.

The study found that a number of students recorded many "Prev" actions, indicating their review of previous pages many times. Meanwhile, other students had more "Next" actions, indicating that they just read the pages of the learning contents in sequence. According to these results, this research defines two types of e-book learning styles: Digital Sequential Learning (DSL) style and Digital Backtrack Learning (DBL) style.

a) DSL style: This style refers to students who, upon finishing reading one page, proceeds to the next page, and who rarely go back to previous pages. They read the pages of the learning contents in sequence. For students of this style, the "Next" action appears the most in their learning log. The following formula is used to determine whether a student belongs to the DSL style. Formula (1) is used to compare the number of "Next" and "Prev" actions.

   As shown in Figure 2, the "Next" action could appear independently or paired with the "Prev" action. Formula (1) also calculates the number of "Next" actions that appear independently. The result "N" of formula (1) is used in Formula (2). Formula (2) is used to compare the "N" and the number of "Prev" actions. A bigger DSL value thus indicates a higher frequency of independent "Next" actions. A large DSL value indicates that the learning style of the student is DSL style.

$$N = num(Next) - num(Prev) \quad (1)$$

$$DSL = N/num(Prev) \quad (2)$$

$num(Next)$ *represents number of* "*Next*"; $num(Prev)$ *represents number of* "*Next*"

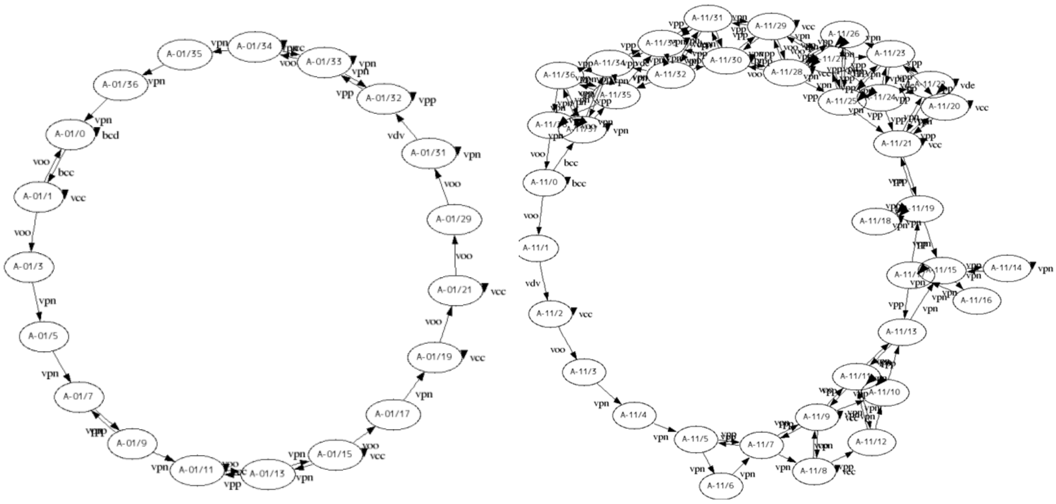

Figure 2. Visualized learning behavior

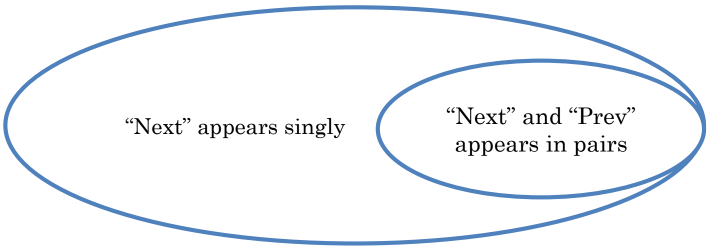

Figure 3. Relations of "Next" and "Prev"

b) DBL style: This style refers to students who often backtrack in their reading many times. For example, if current knowledge refers to a previously discussed knowledge, then they go back to previous pages to review or reflect. This action can be linked to a review learning strategy, which allots time to commit information to long-term memory (Lindsey, 2014), and this action can be linked to a reflection learning strategy, which involves linking current knowledge to previous knowledge (Costa &, Kallick, 2008).

The learning logs of this style show the "Prev" and "Next" actions in pairs many times, and the frequency of pairings is very high. The following formula is used to determine whether a student belongs to DBL style. Formula (3) is used to compare the number of "Prev" and "Next" actions.

$$DBL = num(Prev)/num(Next) \quad (3)$$

As shown in Figure 4, "Next" often appears with "Prev" in pairs. Formula (3) is used to compare the "N" and the number of "Prev" actions. A large DSL value indicates a high frequency of "Next" actions, identifying the learning style of the student as DSL style.

4.2 Partial Correlation (SPSS)

SPSS was used to find the partial correlation of Score(final exam scores) with other variables, such as the number of “Next” and “Prev” actions, Preview Times, Read Pages, and Read Time. The variable Score has a significant correlation with Score RP, as well as with PT, RT, NN, and NP. Further, variable RP has a significant correlation with Score, PT, RT, NN, and NP (Yin et al., 2015).

Table 3: Partial Correlation Result.

		RP	PT	RT	NN	NP
Score	PCC	0.728	0.417	0.681	0.665	0.532
RP	PCC	1.000	0.557	0.903	0.955	0.771

PCC (Pearson correlation coefficient) *$p < .0001$*

According to these results, a k-means clustering analysis was conducted to cluster students in groups according to their similarity in learning behavior, and then analyze the features of learning behaviors in groups.

4.3 K-means Clustering

The main problem of k-means is in determining the *k value* and selecting cluster centers. Firas-Matinez et al. (2007) analyzed users’ similar behavior by k-means clustering. The same method was used in this study. Formulas 4 and 5 were used to determine the k value.

$$y_i = \frac{\min(b_{i,m}, m=1,\ldots,k) - d_i}{\max(d_i, \min(b_{i,m}, m=1,\ldots,k))}, \quad (4)$$

$$q_k = \frac{\sum_{i=1}^{N} y_i}{N} \quad (5)$$

The initial cluster centers were selected randomly. Given the randomness of the original centers, k-means was run for each value of k 100 times. A minimized distance was selected: from all the data to their own cluster center. *k = 2, …, 9* were assigned, and an algorithm was run using Euclidean distance.

Figure 4 presents the evolution of the quality of the partitions obtained for the values of k tested. The optimum partition was obtained with a value of k = 4, because the q-value (*q-value is q_k*) was bigger than the others. Therefore, the students were grouped into four clusters.

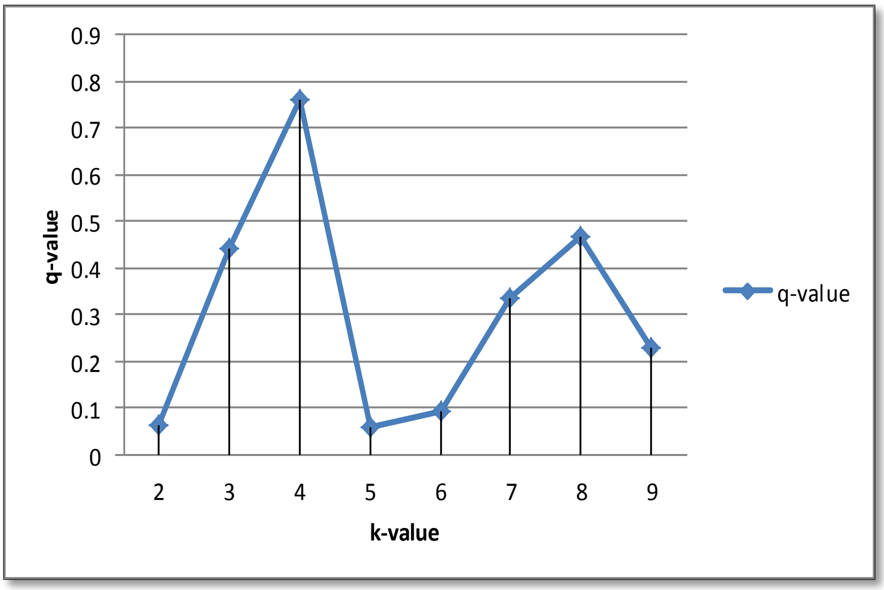

Figure 4. Determine k-value by q-value Marker and Memo

Table 4: K-means Clustering Result.

	Users	Score	DSL	DBL	RP	PT	RT (H)
Cluster1	21	55.24	5.24	0.28	58.14	0.1	2.38
Cluster2	22	80.55	2.35	0.34	205.76	0.48	6.8
Cluster3	36	88.83	1.93	0.4	317.23	1.83	11.29
Cluster4	21	93.4	2.3	0.36	433.35	3.26	15.32

Six variables were used to cluster the students: Score, RP, DSL, DBL, PT, and RT. Table 4 and Figure 6 present the center of each cluster. Clusters 1 to 4 had 21, 22, 36, and 21 students, respectively. Cluster centers translated into the behavior of the users, as described below.

a) Cluster 1: Based on the large DSL value (5.24) is large and small DBL value (0.28), the students were classified to have DSL learning style. They almost do not preview lessons before their class (PT: 0.1). The other variables, such as RT and RP, were also small, which led them to obtain about 55.24 test points.
b) Cluster 2: Based on their small DSL value (2.35), these students fell under the DBL learning style. However, they also almost do not preview lessons before their class (PT: 0.48). In other variables, such as RT and RP, they obtained greater final exam scores than cluster 1. They obtained 80.55 test points.
c) Cluster 3: Their small DSL value (1.93) indicated that these students had a DBL learning style. However, their PT was low (1.83). They recorded greater final exam scores in other variables, such as RT and RP, compared with cluster 2, and they obtained 88.83 test points.
d) Cluster 4: Their low DSL value (2.3) pointed to their DBL learning style. Their PT (3.26) was sufficient, and in other variables, such as RT and RP, they recorded greater final exam scores compared with other clusters. They obtained 93.4 test points.

Based on the above, the DBL learning style is better than the DSL learning style. The students in cluster 2 showed a good learning behavior, as they spent more time to read learning content and preview lessons before class. They also obtained higher final exam scores. However, the DBL learning style is not sufficient; students need to preview their lessons and spend more time to read learning contents.

5. Conclusion and Future work

Analyses on students' learning behaviors comprise an important thrust in education research. This study focused on e-books used in the classroom. Using the e-book system BookLooper, this work recorded students' learning behaviors in their daily academic life.

The paper presented means for collecting and analyzing learning logs using e-books, as well as the analysis of students' learning behaviors based on these learning logs.

The results showed that the number of pages read correlated with students' final exam scores. By clustering students into four groups, this work analyzed their learning behaviors in detail. Digital Global Learning style was found to have merit. Another finding suggested that previewing lessons before class is a positive and beneficial learning behavior.

This research analyzed students' learning behaviors in general. A future effort may delve into cases of learning behaviors among students. Such a study may also differentiate between learning behaviors used by students for different learning contents.

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Learning Style Verification with use of Questionnaire and Page Flip History

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Abstract: The authors verified learners' learning styles with use of learning style questionnaires and page flip history of materials. First, page-flip detection function of material slides on learners' PCs was developed. This function also transfers the result to a dedicated LRS (Learning Record Store) server automatically. From this fine-grained learning activity log, student's learning styles were classified. Second, the authors estimated learners' learning styles with use of widely used learning style questionnaires. The authors verified these two types of learning styles for 100 subjects (research participant) in real 4 units of 2 classes. As a result, a student who "rushes up ladder" during a certain time period was significantly relevant to "Global" learning style tendency rather than "Sequential" one.

Keywords: Learning analytics, page flip, learning style

1. Introduction

1.1 Digitization of Education

Introduction and utilization of digital devices and learning materials have been common in various countries. KERIS (2015) in Korea started investigation and experiment in 2008, and finished implementation throughout the country until the end of 2014. Also China, Singapore, Philippines, India and other Asian countries are carrying investigation and experimental introduction forward. In Europe, England, France, Germany, Spain and other countries are under investigation and experiment. In US, some states including California, Washington and Utah are planning to deliver digital textbooks or complementary devices. In Japan, MEXT (Ministry of Education, Culture, Sports, Science and Technology) (2011) published a roadmap called "The Vision for ICT in Education", which were planning to introduce digital textbooks countrywide until 2020. Also, an experimental project was deployed from 2011 to 2013. It was a joint project between MEXT and MIC (Ministry of Internal Affairs and Communication) to introduce ICT and digital learning materials to selected 20 schools. Final report of this project (in Japanese) is available through MEXT (2015). At the same time, MEXT and MIC started experimental development projects of Digital Textbooks in 2013. In these projects, MEXT is focusing ePub3, while MIC is HTML5. These projects will continue in 2015.

On the other hand, various standardization organizations and communities are trying to specify standard file formats and specifications for Digital Textbooks. IEEE (2015) initiated Actionable Data Book Project in 2011, and published some research papers. Also, CEN (European Committee for Standardization) (2015) and IMS Global Learning Consortium (2015a) began eTernity Project and ICE Project in 2012 and 2013, respectively.

Among them, ISO/IEC JTC1/SC36 (2015), a subcommittee of ISO dedicated to e-learning technical specifications, started e-Textbook Project in September 2012 meeting at Busan, Korea. It is investigating related standardization activities, issued a set of questionnaires of Digital Textbooks to standardization communities, and arranged future issues in a document in 2014 meeting.

The latest and the most active one is called EDUPUB project. It is an alliance of IDPF (International Digital Publishing Forum) (2015), IMS (2015b), and W3C (2015), which specified ePub3 format for Digital Books. The first workshop of EDUPUB was held in October 2013 at Boston, USA, while succeeding ones in February 2014 at Salt Lake City, USA, in June 2014 at Oslo, Norway, in September 2014 at Tokyo, Japan, and in February 2015 at Phoenix, USA.

1.2 Learning Analytics

Learning analytics (LA) has become a major area in learning science and learning technology research in the trend on digitization of education. Ferguson (2012) described a definition of Learning Analytics as follows: "Learning analytics is the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs." A trend of digitization of learning, education and training can be divided into three categories. First one is an adoption of digital learning resources, e.g. LMS-based digital material delivery and client PC-based digital textbooks/ references/ dictionaries. Second is an application of digital environment for learning activities, e.g. interactive learning environment, group or peer-to-peer communication environment for discussion or information sharing, and various active learning supporting tools. The first is considered to be an upper stream of learning, whereas the second one is to be a midstream of learning. Compared to them, LA is considered to be a downstream process of learning. It means collection, analysis, and utilization of learning activity log data.

The learning activity log data has been collected and analyzed since hundreds years ago, even in age of paper-based learning environment. In 2000s, LMS (Learning Management System) based learning environments have been spread. At this period, many types of learning activity logs have been collected in these LMSs and analyzed. These data came from instruction-based activities, e.g. class participations, material views, and answers to quizzes. Also they included active learning-based ones, e.g. enrollments, utterances, interim and final products of group activities. In 2010s, usage of laptop or tablet PCs has been common in K-12 education in various countries. In this environment, various fine-grained learner related information have been available for Learning Analytics, e.g. page flip, learners' actions, eye-track, voice and environmental sound, GPS information, and even heartbeat with use of PC-equipped camera. In future, many types of physiological data like blood pressure and sweating will be available with use of wearable devices. This trend is summarized in Figure 1.

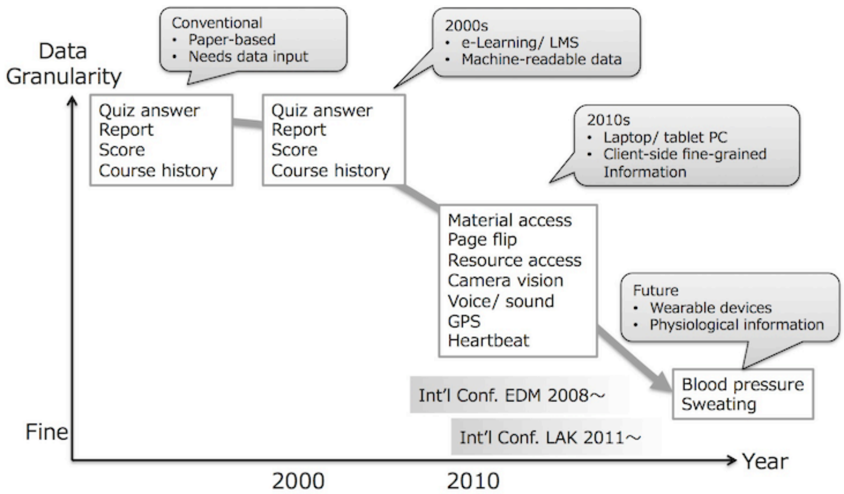


Figure 1. Trend of Learning Activity Data

There are many types of research-based information resources for Learning Analytics. An academic journal called Journal of Learning Analytics is published from SOLAR (Society for Learning Analytics Research) (SOLAR, 2015). Also, two types of International Conferences: Learning Analytics and Knowledge (LAK) and Educational Data Mining (EDM). LAK publishes proceedings from Long et al. (2011) through Baron et al. (2015). Also EDM publishes proceedings since Baker (2008) through Santos (2015). As a general survey, Shum (2012) classifies 5 types of LA activities: (1) analysis dashboard of LMS or VLE, (2) predictive analysis, (3) adaptive learning analytics, (4) social network analysis, and (5) discourse analysis. Especially for active learning and collaborative learning, Shum and Ferguson (2012) shows some LA goal and future issues of these activities. Up to date discussion and information are available on Google Groups on Learning Analytics (2015).

Standardization organization of ISO/IEC JTC1/SC36 has started WG8, devoted to Learning Analytics in June 2015. In the WG8 meeting in Rouen France, an overall framework of Learning Analytics was discussed. Figure 2 is based on this discussion, and includes some expansion.

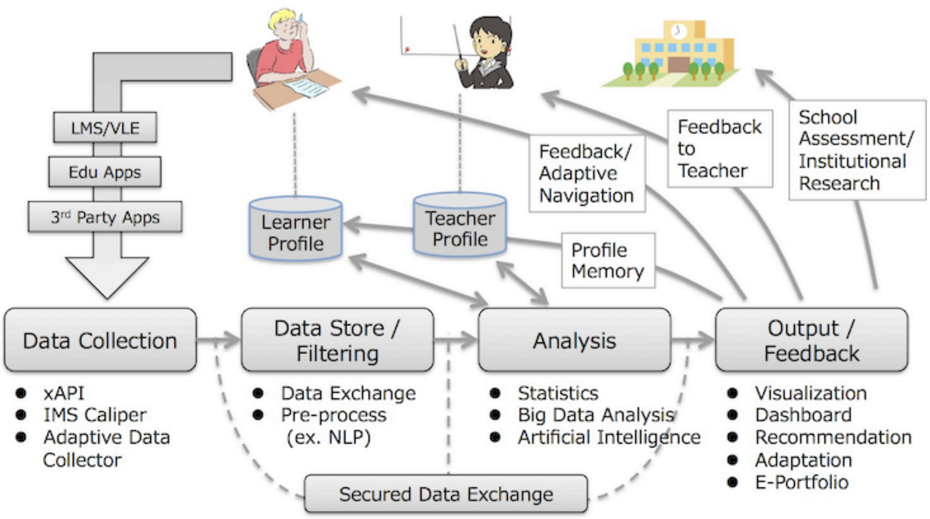


Figure 2. Overall Framework of Learning Analytics

There are major 4 steps: (1) data collection, (2) data store/ filtering, (3) analysis, and (4) output/ feedback. In the first step of data collection, learning activity data is collected with use of LMS, VLE (Virtual Learning Environment), education application or 3rd party application programs that are used by learners.

1.3 Learning Styles

There are theories that each person can be classified according to their style of learning. Often, it is used term cognitive style instead of learning style. Cognitive style is included under the term learning style, and it is defined as an individual's consistent approach to organizing and processing information during learning (Messick, 1984). Researches on the learning style started in 1970s, and various theories or models have been proposed on the field of educational psychology or cognitive science. Riding (1997) reviewed and organized these theories of learning styles, and pointed out two fundamental and independent dimensions of cognitive styles; the Wholist-Analytic dimension and the Verbal-Imargery dimension.

Table 1. The two dimensions of cognitive style (Riding, 1997)

Wholist-Analytic dimension: This dimension describes the habitual way in which an individual organizes and structures information.	Wholists	People who will retain a global or overall view of information
	Analytics	People who will deconstruct information to its component parts
Verbal-Imargery dimension: This dimension reflects an individual's habitual mode of representation of information in memory during thinking.	Verbalisers	People who consider the information they read, see or listen to, in words or verbal associations
	Imagers	People who read, listen to or consider information, experience fluent spontaneous and pictorial mental pictures

Taki (2005) argued that though e-Learning has the advantage allowing for learners' individual differences, today's design methods of e-Learning materials are based on Instructional Design paradigms which maintain the traditional "One-size- fits-all" approach; that is, one type of material designed for all. The advantage of e-learning that Taki pointed out is as follows; e-learning can generate and provide an appropriate learning environment according to learners' interests and abilities, or allow them to control the order and pace of learning. Taki prepared four types of e-learning materials based on Riding' s four types of cognitive styles (Wholist-Verbalisers, Wholist-Imagers, Analytic-Verbalisers, and Analytic -Imagers). The reported results indicate that e–Learning materials with a suitable design regarding the cognitive styles bring higher learning performance.
There are various types of questionnaires or inventories that include Riding's two dimensions of cognitive style. Felder (1995) reviewed theories of learning styles and organized them into these four dimensions:

(1) Active-Reflective (Kolb, 1981, 1985),
(2) Sensing-Intuitive (Jung, 1971) (Myers, 1985),
(3) Visual-Verbal (Dale, 1969) (Oxford, 1993), and
(4) Sequential-Global (Kirby, 1988) (Pask, 1988) (Marton, 1988).

Among Felder's four dimensions, dimension(3) is equivalent for Riding's Verbal-Imargery dimension and dimension(4) is equivalent for Wholist-Analytic dimension.
Soloman (2005) proposed a questionnaire based on Felder (1995), named Index of Learning Styles Questionnaire (ILSQ). ILSQ has advantages below.

- This set of questionnaires is publicly available, while some inventories are commercial.
- The method is publicly available to calculate or estimate one's learning style.
- Number of questions is relatively few (44), while some inventories supplies near 100 questions.

1.4 Research Questions

Among various data in Learning Analytics, one of the authors Tamura (2015) focused on "page flip" information of e-textbook, and visualized page transition history of each learners. Page flip information or page transition history is the information when and in what order the learners flip the page. This page flip information could not available from paper-based textbooks or other materials, and therefore teachers using paper-based textbooks conduct lessons on the assumption that their learners follow the teacher. However, if teachers use digital textbooks on client PCs, page flip history of each learner can be visualized by equipping function to collect page flip information. Even in the age of LMS, theoretically it was available. However, its granularity was mainly "HTML file-wise", not page-wise.
Page flip history may show characteristic shapes or features that reflect various factors: such as learner's academic ability, motivation, difficulty level of the class, environment of classroom. The examples of features of page flip history and learning styles that may be relate to are as follows:
A) Glance all materials during a certain time period – Global style
B) History along with progress of the class – Sequential style

Among various factors, the authors focused on learning style in this research, and attempt to model features of page flip history and learning styles that may be relate to. As stated 1.3, one's learning style is usually estimated by using paper-based questionnaires or inventories. However, considering estimation of learners' learning style in real classroom, it imposes workload to use paper-based questionnaires on both teachers and learners. If their learning styles can be estimated automatically from their page flip actions, this workload of questionnaires or inventories can be decreased.

2. Experiment

2.1 Learning Analytics Data Acquisition Scheme

The authors developed a function to collect page flip information in real classrooms. One of the authors already developed a similar function on EPUB reading system (Tamura, 2015). This time, instead of EPUB based textbook, the target was moved to PowerPoint slide transition, because the author's classes mainly utilizes these slides in the lectures. The proposed scheme includes functions below.

A) Make input student's ID and memorize it
B) Fetch an action to move to another slide automatically
C) Transmit information (Unit ID, date & time, A), and B)) to a server automatically
D) A server to save transmitted information C). It is so called LRS (Learning Record Store)

One of the authors (Yamazaki) developed functions A), B) and C) in JavaScript. Also, PowerPoint slides were converted into JPEG and HTML files manually. For these HTML files, the other author (Horikoshi) added functions A), B) and C) manually.

Subjects access the materials from the link on LMS, and page flip information is sent to LRS when each subject change pages. The items stored in LRS are as below:

- Actor: student's ID
- Verb: lunched/ experienced
- Page: page number
- Date: date and times

In general, there are majorly two community standards to specify data format and protocol to transmit Learning Analytics data; ADL xAPI (ADL, 2015) and IMS Caliper (IMS, 2015c). xAPI data format is very flexible to represent any types of learning activities. However, because the format is based on JSON, there needs translation from simple set of 4 types of data into xAPI format. xAPI is good for anonymous client-server data transfer. At first the authors tried to implement a function C) based on xAPI, however we changed it into simple comma-separated string afterward, because the this experiment deal with only the above five items (actor, verb, title, page, date), and only dedicated clients and a server.

2.2 Learning Style Estimation

The authors utilized ILSQ (Soloman, 2005). As showed in 1.3, ILSQ originally has four dimensions. Among these dimensions, the authors focused on (3) visual-verbal and (4) sequential-global. There are two reasons for this selection. First, only these two dimensions correspond to Riding's two dimensions of cognitive style. Second, the authors hypothesized that features of page flip history related to these two dimensions observe easily from learner's page flip history. The authors translated ILSQ into Japanese and imported into Google Form.

2.3 Target Classes, Units, and Subjects

The authors set the two target classes. Both classes were held in Sophia University, Japan, and one of the authors was in charge. Target classes, initial number of students, and target units were as follows.

Class "Information literacy" (100 level): 90 students
Unit "Journal search", on May 18, 2015 (abbr: <u>IL518</u>)
Unit "Numerical data", on June 1, 2015 (abbr: <u>IL601</u>)
Class "Learning technology" (300 level): 80 students
Unit "Instructional design", on May 19, 2015 (abbr: <u>LT519</u>)
Unit "Test and Feedback", on May 26, 2015 (abbr: <u>LT526</u>)

The first Information Literacy class was entry level for 1st year students, so contents were rather easy. In contrast, Learning Technology was for 3rd year students, so contents were relatively difficult.

2.4 Procedure

Lecture slides, usually on PowerPoint, were converted into the target data described in section 2.1 beforehand. In the classes, one of the authors (Tamura) held lectures as usual, while page flip information are collected and transmitted into a dedicated server automatically. After the classes, all subjects were requested to answer ILSQ questionnaire in Google Form described in Section 2.2. This result was downloaded and used to estimate their learning styles.

3. Result

3.1 Numbers of Acquired Data

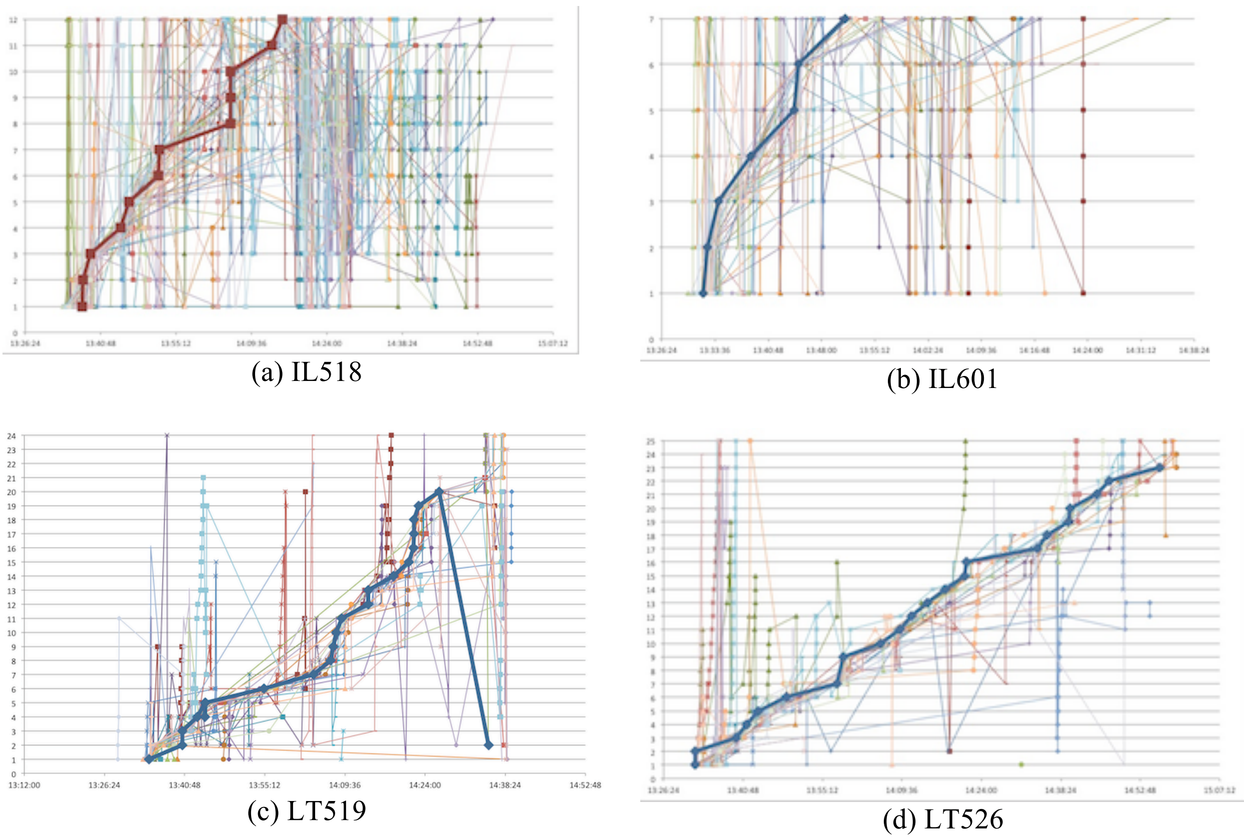
Numbers of subjects that succeeded to collect data is shown in Table 1. Not all subjects answered ILSQ, and not all ILSQ-answered subjects used the target materials described in section 2.1. The following analysis focuses on the subjects both to use the target materials and also to answer ILSQ.

Table 2. Numbers of collected data

Unit ID	LA data	ILSQ	Both
IL518	71	74	62
IL601	64	74	59
LT519	37	40	23
LT526	34	40	24

3.2 Page Flip History

Visualized page flip histories of teachers and all subjects are shown in Figure 3. In these figures, vertical axis shows slide page number and horizontal axis shows time (maximum of 90 minutes). A thick line shows a history of a teacher, other thin lines show subjects'.



(a) IL518 (b) IL601

(c) LT519 (d) LT526

Figure 3: Page flip history of 4 units

As observed from Figure 3, lines of (a) and (b) are scattering, but (c) and (d) are relatively closer to teacher's line. This difference suggests that (a) and (b) (Information Literacy classes) is relatively easy to understand so subjects view slides that are not lectured at that time, while (c) and (d) are relatively difficult to understand so subjects concentrate on viewing slides currently lectured.

Quantitatively, this difference is shown in the sum totals of standard deviation of each unit. The result is shown in Table 2. Since total numbers of slides depend on the units, divided results are shown in row 4. From the result, IL518 and IL601 units shows bigger number of standard deviation than LT519 and LT526.

Table 3. Standard Deviation of 4 Units

Unit ID	SD	slides	SD/slides
IL518	2.933	12	0.244
IL601	2.004	7	0.286
LT519	4.401	24	0.183
LT526	4.604	25	0.184

3.3 Cluster Analysis

The original research question was to verify that Questionnaire-based learning style estimation matches the classification of page flip history or not. In order to do it, the authors adopted cluster analysis for page flip histories. First, the authors classified them with use of hierarchical cluster analysis to determine adequate cluster numbers. A cluster dendrogram of unit IL518 is shown in Figure 4. Second, they were divided into six or seven clusters by nonhierarchical cluster analysis.

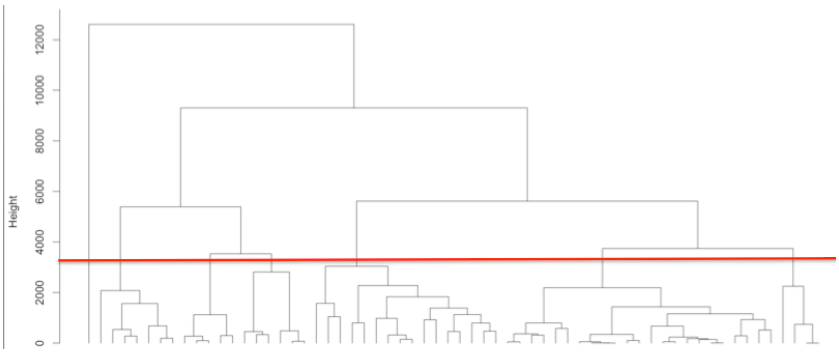
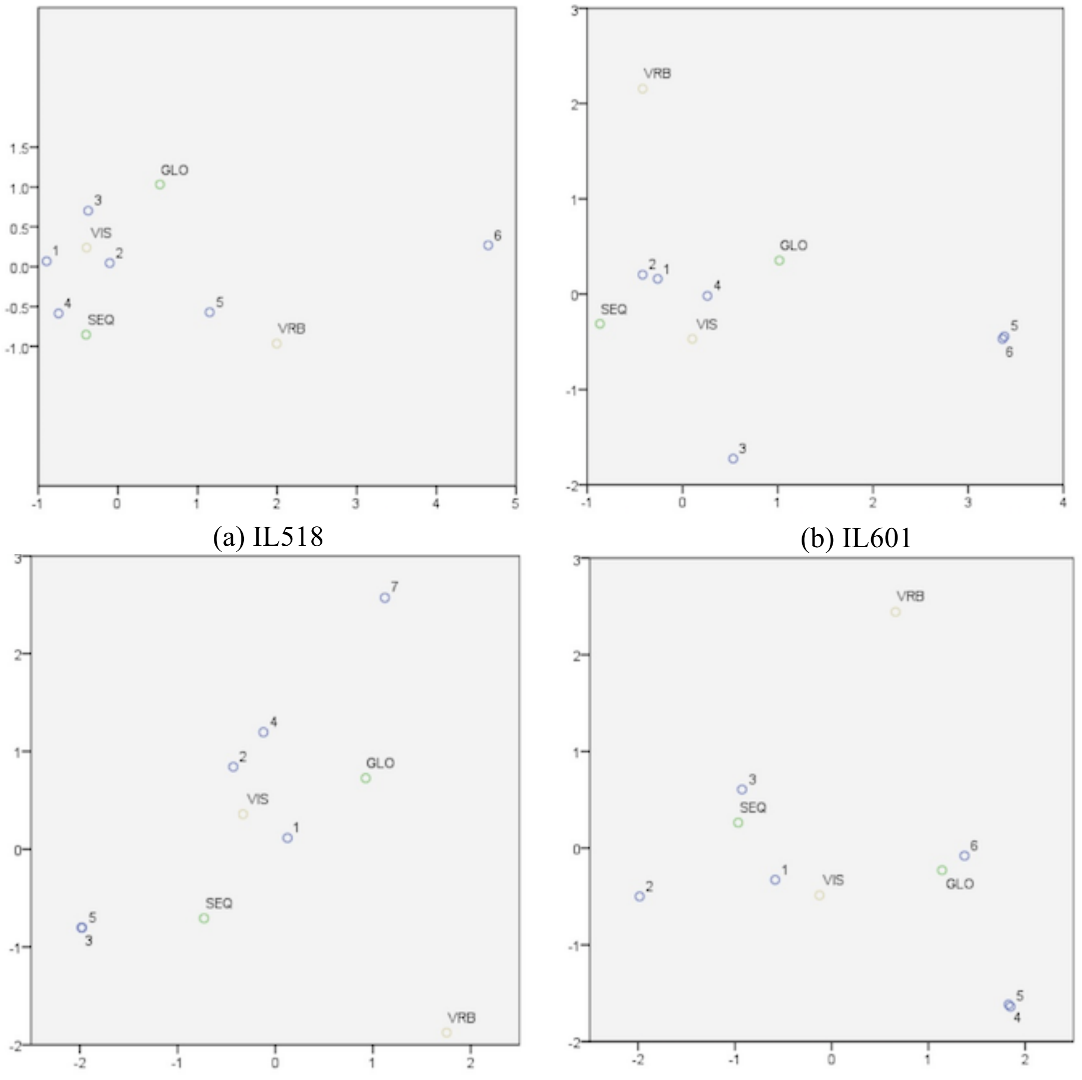


Figure 4. Cluster Dendrogram of Unit IL518

3.4 Multiple Correspondence Analysis

Based on cluster analysis in section 3.3 and learning style estimation on ILSQ in section 2.2, the authors checks correspondence between clusters and visual-verbal / global-sequential styles. The result is shown in Figure 5. In the figure, number 1 to 7 shows cluster numbers, while global as GLO, sequential as SEQ, visual as VIS, and verbal as VRB. From (a) to (d) in Figure 6, there was no significant correspondence between cluster number and learning styles. Quantitatively, as a result of chi-square tests of independence based on cross-tabulations, only one unit IL518 showed significant correspondence (χ^2 (5)=13.311, p=0.021) only in visual-verbal learning styles.



(a) IL518 (b) IL601

(c) LT519 (d) LT526

Figure 5. Result of Multiple Correspondence Analysis

3.5 Style estimation based on manual "Ladder" detection

In the multiple correspondence analysis in the section 3.4, there found no significant correspondence. The authors supposed this reason that the cluster analysis described in the section 3.3 had its own limit: it just classified the target data but did not identify "semantic" feature of the data.

In order to identify this semantic feature in page flip history, the authors used the hypothesis as stated 1.4: "Global learning style learners will glance all materials during a certain time period". Based on this hypothesis, the authors divided all subjects' page flip history into 2 groups manually. The target group's history included shapes to "rush up ladders" during a certain time period, while the control group's history did not. After that, the authors examined a cross-tabulation of these TG/CG and Global/Sequential learning styles. The result of chi-square test of independence based on the cross-tabulation showed significant correspondence ($\chi^2(1)=6.827$, $p=0.009$). It shows that the TG ("rush up ladder") significantly includes Global learning style, while the CG does not. In other words, there is significant association between Global style and the feature of page flip history that glance all materials during a certain time period.

4. Discussion

The authors first classified subjects with use of automatic cluster analysis. However, as shown in Figure 5, there were no significant correspondence between these clusters and ILSQ-based learning style estimation. On the other hand, the process described in section 3.5 found a significant correspondence when the authors detected “rush up ladders” manually. Currently, this “partial characteristics” detection is not available with use of general cluster analysis method , because the cluster analysis method treats one data set as a whole. In this sense, we need another method to identify a partial characteristic like “rushing up ladders”. It might be some methods like feature extraction algorithm, or be refinement of cluster analysis method.

5. Conclusion, Future Works

The authors verified learners’ learning styles with use of learning style questionnaires and page flip history of materials. The first approach was to classify learners with use of automatic cluster analysis, but the authors could not find any significant correspondence between clusters and learning styles. With use of the second approach, to distinguish learners with “rushing up ladder” characteristics, the authors found significant correspondence with “Global” learning style tendency.

There are some future works related in this paper.

- As described in section 4, there needs a method to identify a partial characteristic like “rushing up ladders”. It might be some methods like feature extraction algorithm, or be refinement of cluster analysis method.
- ILSQ, described in section 2.2 in order to estimate learning style, has features to estimate other styles of active-reflective and sensing-intuitive, rather than global-sequential, and visual-verbal in this paper. Then there are still other hypotheses for these other learning styles.
- There might be some other factors to characterize page flip history, like difficulty of learning contents, teaching styles and strategies of instructors and units, etc.
- Page flip history might be used for “formative evaluation” of learning materials. For example, if page flip history of a learner includes a zig-zag manner, these parts of learning materials might have some problems: to be too difficult or assigned in wrong sequence. There can be variety of hypotheses like them.

Acknowledgements

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Development of Cloud e-Bookcase System---Perspective of User Satisfaction

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Abstract: To develop the cloud e-bookcase system, this study evaluate users' satisfaction on cloud e-bookcase system and results is referred to the system development. Thus, this study consider users concern on the system's guide service and respond to questions. Based on an analysis of the results, the system developer should focus on system quality and service quality.

Keywords: E-Bookcase, Cloud Service, e-Books, User Satisfaction

1. Introduction

The technology of e-books has consolidated a large number of multimedia applications and mobile technology. The e-Book has changed users' reading habits (Grimshaw, Dungworth, McKnight, and Morris, 2007; Kroski, 2009; Chang, 2013; Huang and Liang, 2014; Liang and Huang, 2014). This has boosted Readers for reading e-books. Thus, libraries have started e-book services for readers (Huang and Liang, 2014; Huang and Chiu, 2015; Huang and Chiu, 2015; Pažur, 2014; Pu, Chiu, Chen, and Huang, 2015). However, some mobile devices' specifications do not support the e-book need a large of computation speed and storage capacity. Thus, the use of Cloud-based e-Bookcase System can support mobile devices to conduct on searching, storage, and play e-Books (Lin, Wen, Jou, and Wu, 2014). To develop a success cloud e-bookcase system, this study should explore users' evaluation of the system. In this study, using system quality, service quality and user satisfaction to measure users' evaluation, and develop system with reference. Purposes of this study is following users' satisfaction, and providing suggestions for development of cloud e-bookcase systems.

2. Literature Review

2.1 Mobile Library Service and Cloud Bookcase

With the development of library e-book services and using the mobile devices, users will focus on the assistive functions, reading experiences and personalized portfolio (Richardson Jr, and Mahmood, 2012; Chang, 2013; Pažur, 2014). The e-bookcase system integrate searching function, e-Books player and personalized portfolio tracking (Liao, Li, Su, and Yu, 2012; Li, Liao, and Yu 2013). When e-bookcase system combines with cloud technology, it makes libraries share their storage space and computing resource to support a large of type of mobile devices (Mell and Grance, 2009).

2.2 User satisfaction

Schuchhardt, Scholbrock, Pamuksuz, Memik, Dinda, & Dick (2012) indicated the purpose of systems are to satisfy the end-user. User satisfaction refers to the degree of satisfying users' demand; in other words, it refers to the difference between actual effect and expected effect. When the difference is closely or actually effect exceeds expected effect, users' satisfaction is highly (Thong, and Yap, 1996; DeLone and McLean, 2003; Petter, DeLone, and McLean, 2008).

User satisfaction is had an influence by system quality and service quality. System quality and Service Quality are positively effects to users' satisfaction (DeLone & McLean, 2003; Bharati, & Chaudhury, 2006). System quality refers to the expectation of ease of use, speed, reliability, and so on; Service quality refers to the expectation of speed and accuracy of the system's responses, and system supplier's level of professionalism, attitudes and response speed. These two dimensions have influence on user satisfaction (Pitt, Watson, and Kavan, 1995; DeLone and McLean, 2003; Petter, DeLone, and McLean, 2008). Through the perspective of end-user computing satisfaction, which based on users awareness to a system, the results support discussion above (Aggelidis, & Chatzoglou, 2012).

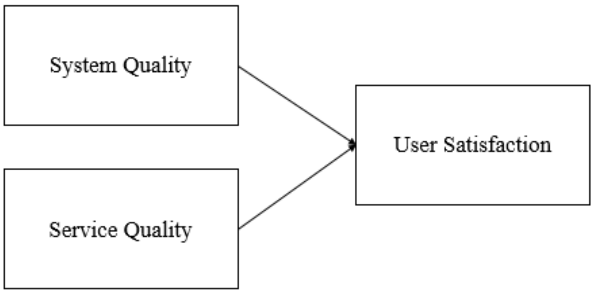

Figure 1. Research Dimensions

3. Description of Systems Used in This Study

The cloud e-bookcase system in this study include bibliographic searches, personalized management and e-book playing. The system is installed in the central computer facilities, servers provide computing resource and run the system. The system can be accessed through mobile networks. Users are verified personal ID and start using the system, and through interface run the application or operate personalized bookcases, and built-in players allow users to read e-books.

The central computer facilities provide resource to support applications and storage space, reducing the burden on the terminal device, so that the terminal device may use e-books' applications which require a higher level of implementation on hardware.

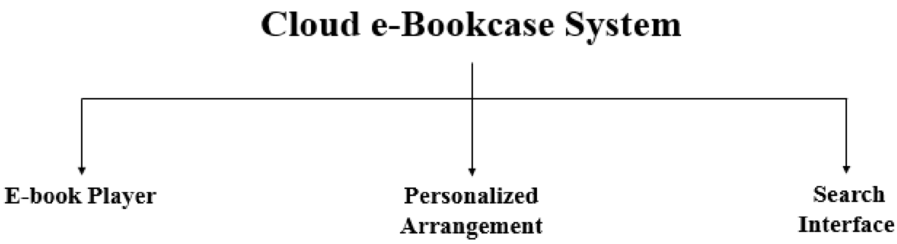

Figure 2. The structure of the Cloud e-Bookcase system

Figure 3. Interface of Cloud e-Bookcase System

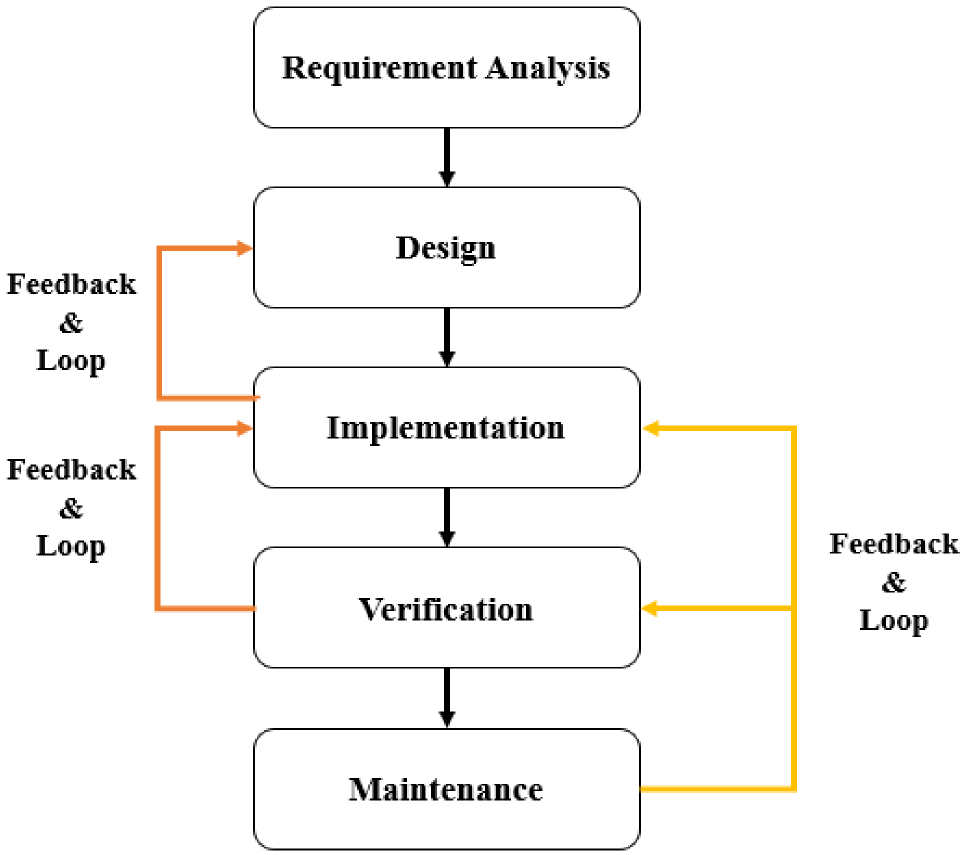

Figure 4. Development of Cloud e-Bookcase System

4. Method

This study uses questionnaire survey method to investigate. The questionnaires are retrieved and analyzed after using the system. A 5-point Likert scale is adopted in the questionnaire, 36 questions remain on the questionnaire. Participants from three universities in southern Taiwan were chosen. Three hundred copies of the questionnaire were administered, and 123 valid copies remained, yielding a valid response rate of 41%.

5. Results

This study uses the SmartPLS 2.0 M3 to perform statistical analyses.

5.1 Validity Analysis and Reliability Analysis

Validity and reliability analyses were conducted the effectiveness of the questionnaire. Validity analysis is examining the level of compliance between the participants' comprehension and dimensions definitions. Factor loading larger or equal to 0.5 is applied as the assessment standard (Hair, Black, Babin, and Anderson, 2010); Reliability analyses is examining whether the repeated measurements items are consistent (Hair, Black, Babin, and Anderson, 2010). Composite reliability (CR) larger or equal to 0.7 is applied as the standard (Bagozzi and Yi, 1988). Table 1 shows the result. The CR in this study ranges between 0.903 and 0.928, while the Factor loading ranges between 0.692 and 0.868. The test results are all larger than the standard value, therefore, the questionnaire has decent validity and reliability.

Table 1: Results of Reliability and Validity Analysis

Construct	Item	Factor Loading	Composite Reliability
Service Quality (SVQ)	SVQ1	.843	.928
	SVQ2	.780	
	SVQ3	.802	
	SVQ4	.868	
	SVQ5	.801	
	SVQ6	.842	
System Quality (SQ)	SQ1	.692	.903
	SQ2	.775	
	SQ3	.790	
	SQ4	.792	
	SQ5	.815	
	SQ6	.814	
User Satisfaction (US)	US1	.833	.924
	US2	.806	
	US3	.794	
	US4	.807	
	US5	.806	
	US6	.863	

5.2 Analysis of Influencing User Satisfaction of System Quality and Service Quality

Using path coefficients and T-values to analyze the influence and significance of dimensions. Table 2 and Fig. 4shows that system quality and service quality influence user satisfaction are significance that positive influence on user satisfaction with the cloud e-bookcase system.

Table 2: Results of structural model examination.

Relationship	T-Value	Path coefficient (β-value)	Result
SQ -> US	2.310	0.218	**Significance**
SVQ -> US	3.194	0.240	**Significance**

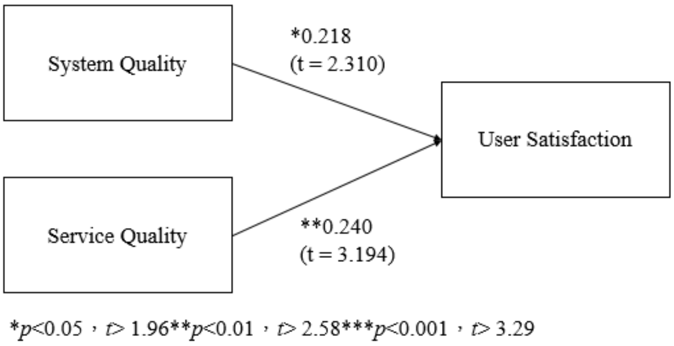

Figure 5. Results of the Research Dimensions

6. Conclusion

System quality has a significant positive influence on user satisfaction (β-value=0.218, t-value=2.310). Thus, developer should pay attention on the search function, system performance and smoothness of the operation. Service quality has a significant, positive influence on user satisfaction (β-value=0.240, t-value=3.194). Thus, developer should focus on the system's guide service and respond to questions. Based on the results, developers should focus on system quality and service quality that development or improvement of cloud e-bookcase system.

Acknowledgement

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Visualization Supports for E-book Users from Meaningful Learning Perspective

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Abstract: In this paper, we present a meaningful learning environment to visually support e-book learners to effectively construct their knowledge framework. This personalized visualization support is intended to encourage learners to actively locate new knowledge in their own knowledge framework and check the logical consistency of their ideas for clearing up misunderstandings. On the other hand, we also propose to visually support e-book instructors to decide the group distribution for collaborative learning activities based on knowledge structure of learners. To facilitate those visualization supports, we present a method to semi-automatically construct a course-centered ontology to describe the required information in a map structure.

Keywords: Visualization support, personalized learning, course-centered ontology, knowledge framework, collaborative learning

1. Introduction

Nowadays, e-book systems are widely used in education field. For example, in Arts and Science Department of Kyushu University Faculty, BookLooper e-book system, developed by Kyocera Communication Systems, is used for supporting daily classroom teaching. Those systems provides a platform for instructors to easily upload teaching materials in PDF files; on the other hand, learners can conveniently browse those files, even make markers or put comments on them. Some E-book systems, such as BookLooper, can record learners' learning activities (including which pages they read and how they switch between pages) and report to instructors (Yin et al., 2015). However, those existing systems do not provide a function to support learners to construct their knowledge framework effectively. Furthermore, it is also difficult to identify the relevant knowledge a learner possesses before and after a learning activity.

Evidence from diverse sources of researches suggests that knowledge gets incorporated into human brain more effectively when it is organized in hierarchical frameworks. "Hierarchical knowledge framework" is an organizational structure where every knowledge in this organization, except one, is subordinate to a single other knowledge; in other words, the arrangement of knowledge should be in order of rank. Learning approaches that facilitate this kind of organization significantly increase the learning capability of learners (Bransford et al., 1999; Tsien, 2007). Ausubel's learning psychology theories (Ausubel, 1963; 1968; Ausubel et al., 1978) define this effective assimilation of new knowledge into existing knowledge framework as the achievement of "meaningful learning". Therefore, how to help learners to efficiently develop their conceptual framework becomes the main issue for fostering meaning learning in e-learning field.

In response, a visualization support system for Booklooper users is designed and under development. This system is intended to not only effectively support the construction of leaners' knowledge framework, but also help instructors to decide group distribution for collaborative learning activities based on learners' knowledge structures.

2. Visualization supports for both learners and instructors

2.1 A Visualization support for learners of e-book users

For the learners in an e-book system, normally in one activity, they read several pages of a file. As shown in Fig.1, after one preview activity (for example, studying Page 10-13, which cover 7 new knowledge points) in Booklooper, the learner can login in our support system to check the new knowledge points just studied. In this research, a knowledge point (KP) is defined as "a minimum unit which can independently describe the information of one knowledge "; a KP can be acquired by practice or can be understood by its own expression. Our system will try to encourage the learner to understand the relations between the new KPs visually. Furthermore, the system also will make use of the quiz results of learners to identify the learner's acquired KPs and then encourage the learner to compare the new KPs with related acquired ones visually. Finally, the system is also expected to recommend one KP or some KPs based on individual knowledge structure and guide learners to receive personalized learning processing. With this kind of visualization support, learners using Booklooper are expected to build up their knowledge framework more effectively.

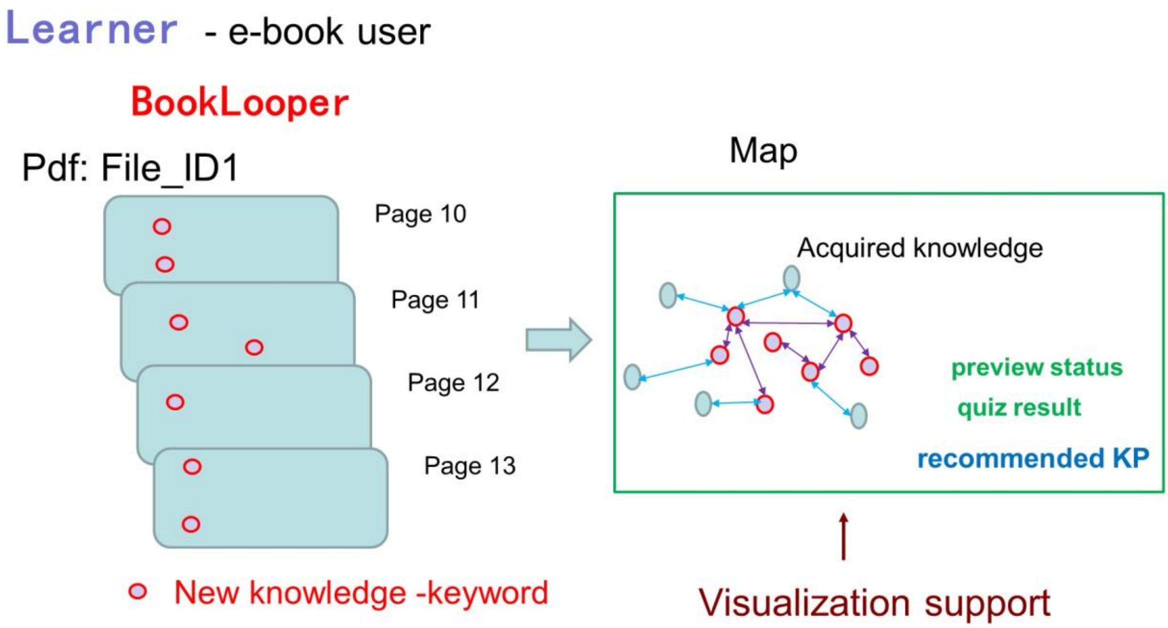

Figure 1. Visualization support for learners of e-book users.

2.2 A Visualization support for instructors of e-book users

For instructor of e-book users, we also intend to provide serval visualization supports. Firstly, the instructor can visually check all the learner's knowledge structures (including preview statuses and quiz results) thought our systems. Secondly, the system will identify the most difficult KPs or relations based on the most frequently marked keywords and will highlight them to attract instructors' attention.

Most importantly, the system will make use of the quiz results of learners to identify the learner's acquired KPs or relations and then support the instructor to decide group distribution for collaborative learning activities based on learners' knowledge structures. For example, as shown in Fig.2, assumed an instructor of a given course plans to organize collaborative learning groups to study a new KP which have 8 related KPs already taught in the course. To encourage the cooperation between learners in the same group, the system will identify Learner A, B and C, who acquired several KPs (overlap is allowed) related to the target KP respectively, and recommend the instructor to put those three learners in one group. Otherwise, if learners in one group simple know the same related KPs, it is difficult for them to realize the rest of related knowledge and reach the full understanding of the target

KP effectively during the learning processing. Based on this principle, the system will be designed to visually support instructors to decide group distribution for collaborative learning activities.

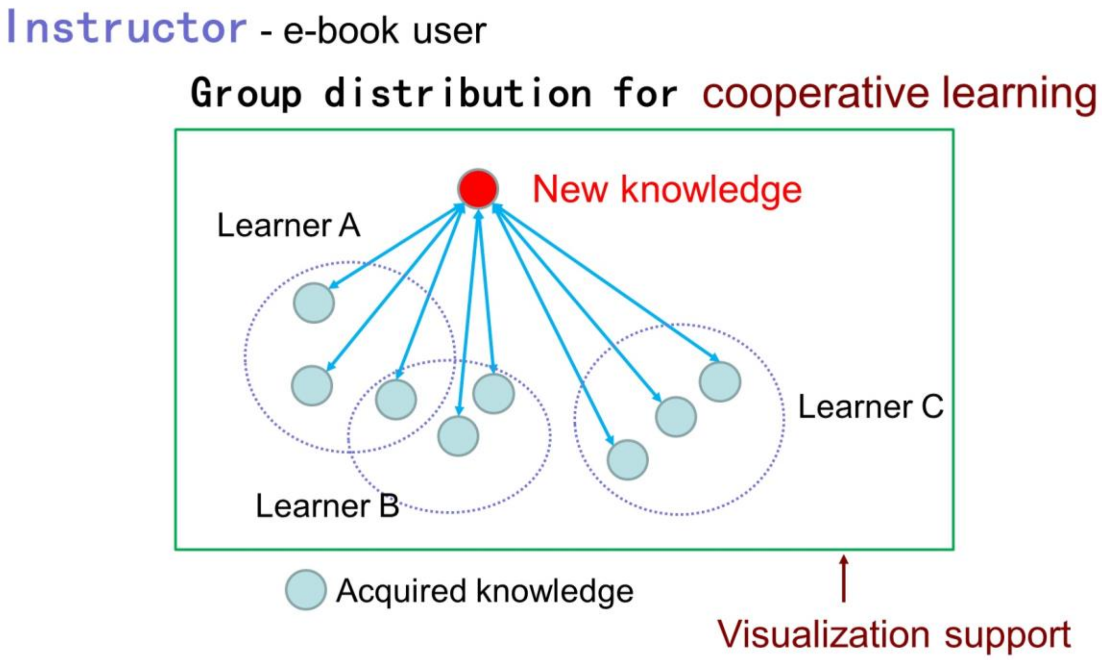

Figure 2. Visualization support for instructors of e-book users.

3. A course-centered ontology for the visualization learning support system

To facilitate visualization supports mentioned in the previous section, the description of the information about all the KPs and relations between KPs is required for the system. In this paper, we present a method to semi-automatically develop a course-centered ontology to describe all those required information from the knowledge in courses.

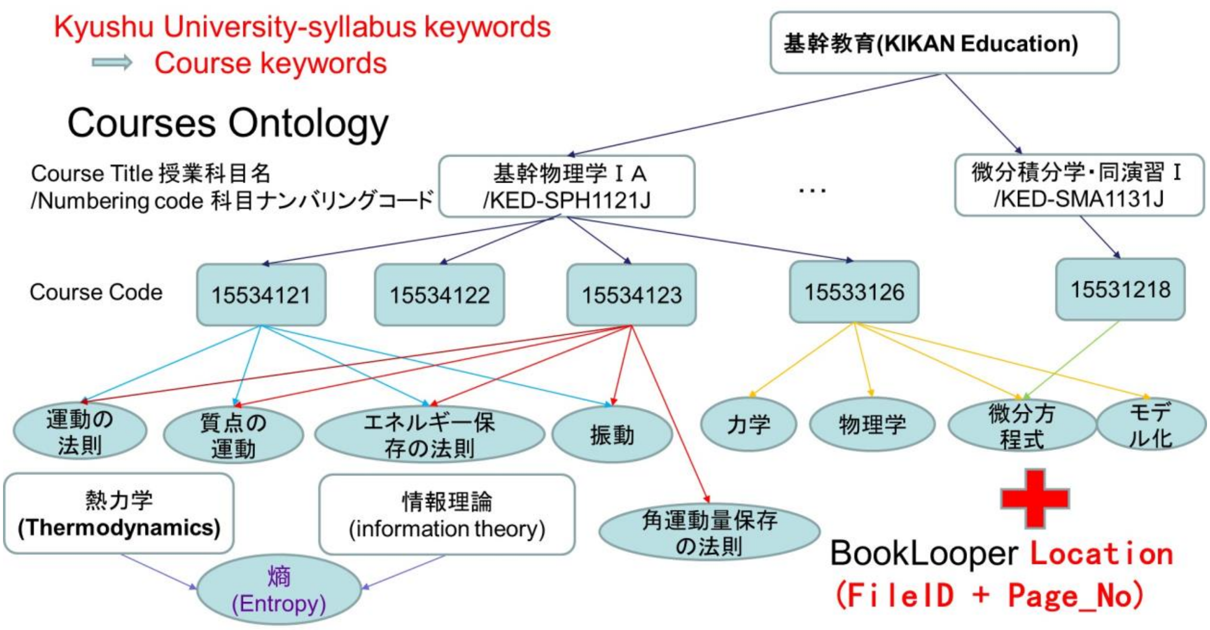

Figure 3. The basic framework of the course-centered ontology based on Syllabus information.

Firstly, we automatically exact the information from “Syllabus system” of Kyushu University and create the basic framework of the course-centered ontology. As shown in Fig. 3, for example, for the Kikan Education of in Arts and Science Department, there is 3730 courses registered in syllabus system. For one Course Title, there are several courses taught by different professors or instructors; those courses may share some same keywords or have completely different keywords. One keyword also can be shared by courses which have different Course Titles. One typical example is “Entropy”, which is not only taught in *Thermodynamics* courses but also in *Information theory* courses. In this step, the information of “course title/numbering code”, “course code” and “keywords” from Syllabus are automatically exacted and used for the construction of the basic framework for ontology.

However, for most of the courses in syllabus system, less than 10 keywords are described; the basic ontology framework built on those syllabus keywords is far sufficient to provide the visualization support described in the previous section. Therefore, in the second step, we encourage professors/instructors to manually modify the ontology using `protege` ontology editor (Horridge M., 2011) and then upload the modified ontology with the description of its related PDF file IDs in BookLooper.

For build up a demo, we applied and adjusted the ontology design method described by Wang et al. (Wang et al., 2014) to develop a course-centered ontology of an existing computer science course (called COCS). We analyzed the learning materials of this computer science course, extracted about 100 KPs and about 20 kinds of relations, and defined them in COCS. Fig 4 illustrates some KPs and their relations in COCS. We will describe the way, in which COCS is designed and developed, to show professors/instructors of other courses how to build up their course-centered ontology. Without doubt, how to combine all the course-centered ontology made by different professors/instructors into one ontology will be another issue we need to discuss in the future.

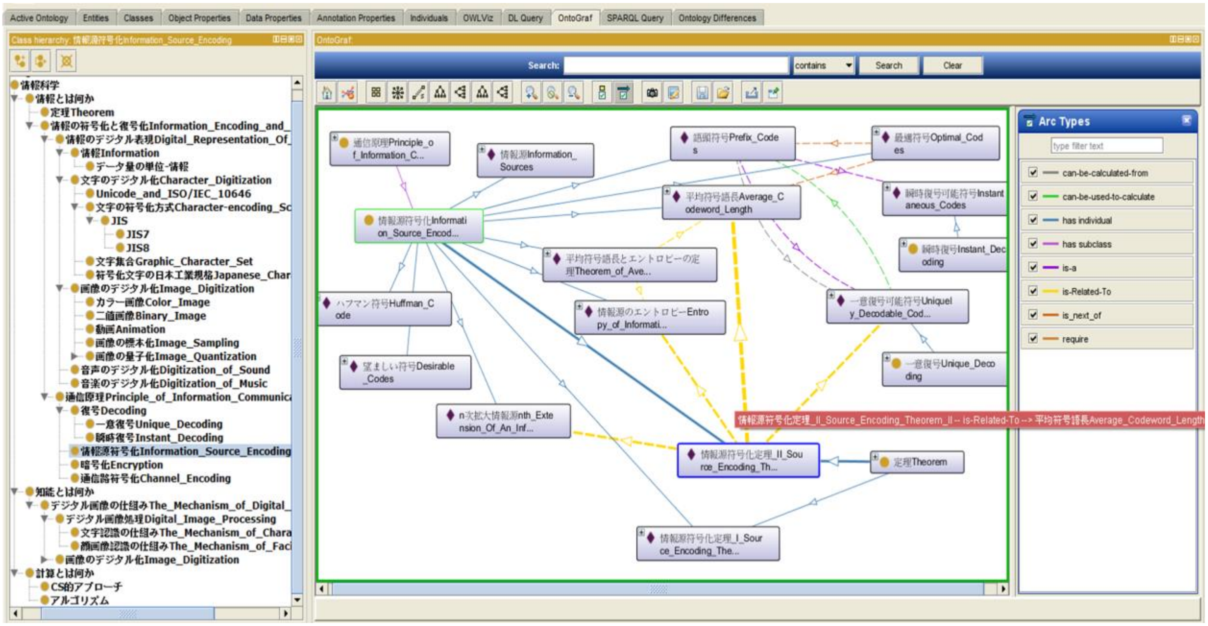

Figure 4. The Course-centered Ontology of Computer Science (COCS)

In the Last step, we will try to automatically identify the location (including the file ID and the Page Number) of the KPs in the BookLooper system and put those location information into the ontology.

Based on these three steps, the course-centered ontology will be developed semi-automatically. Then, to automatically manipulate this ontology, a system which is intended to provide visualization learning supports will be developed. We expect the system not only can provide the visualization support for the construction of learner knowledge framework but also can help instructors to understand the learners' knowledge structures and easily decide group distribution for collaborative learning activities.

4. Combination with the information from "Academic Staff Educational and Research Activities Database"

Beside the information of KPs and their relations in courses, we also plan to input the research information into the course-centered ontology by making use of the information from "Academic Staff Educational and Research Activities Database" of Kyushu University.

"Academic Staff Educational and Research Activities Database"(ASERAD) is a system disclosing educational and research activities of professors/researchers in Kyushu University. All the information in this database derives from the data submitted by professors/researchers. Each professor/researcher's field of specialization can be browsed from ASERAD. However, it is difficult to understand the exactly meaning of those words written in "Field of Specialization". Therefore, we propose to provide a visualization support (as shown in Fig. 5) to enable the users of ASERAD to check the words in "Field of Specialization" from the university courses point of view.

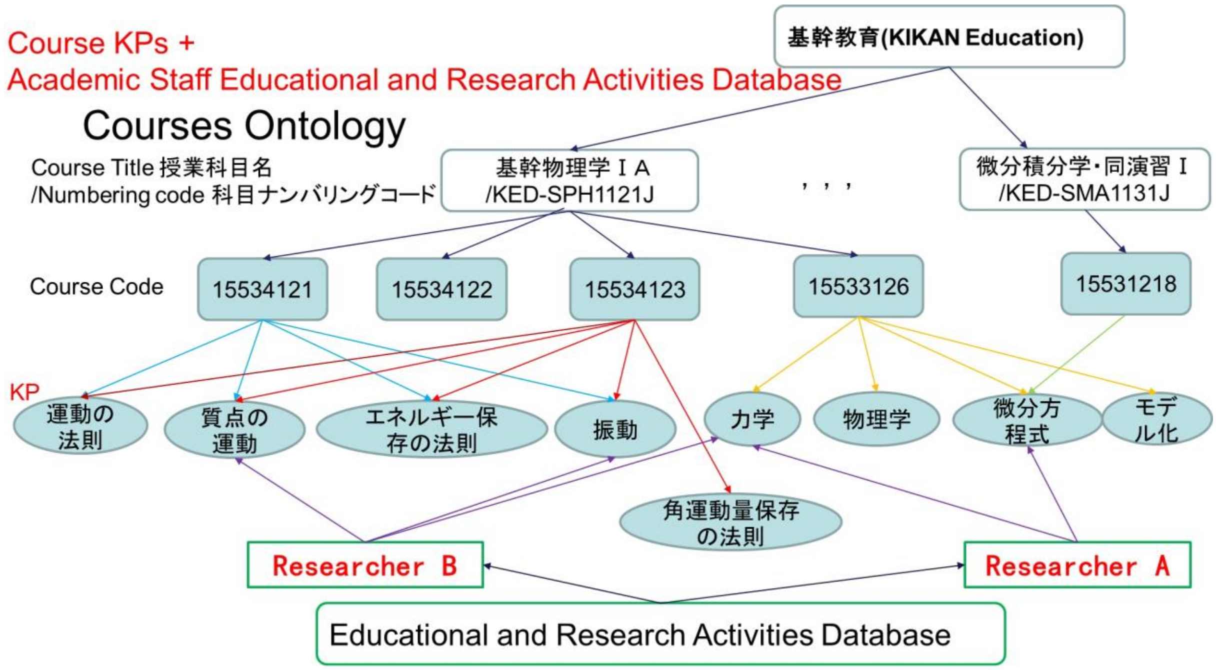

Figure 5. Visualization support for instructors of e-book users.

The information of "Organization", "Position", "Name", and "Field of Specialization" from syllabus will be automatically exacted. And then the system will calculate the similarity's and make matches between "Field of Specialization" and the name of KPs in the course-centered ontology described in the previous section. We expect "Field of Specialization" of professors/researchers will be understood more easily based on this support.

5. Conclusion

In summary, we present a semi-automatically method to construct a Course-centered Ontology. Based on this Course-centered Ontology, we intend to design a system to provide visualization support for BookLooper e-book users. For learners of BookLooper users, the system is designed from the perspective of meaningful learning to visually support them to effectively construct their knowledge framework. For instructors of BookLooper users, when they are planning collaborative learning activities, the system can provide visualization support to help them to decide the group distribution based on knowledge structure of learners.

Acknowledgements

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Cubic Gantt Chart as Visualization Tool for Learning Activity Data

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Abstract: This paper proposes a new tool called Cubic Gantt Chart, 3D version of Gantt Chart for visualizing e-learning activity data such as how long and how often students look at each page of an e-learning material like PowerPoint slides. Using a dedicated tool called BookLooper can collect these activity data. The analysis of e-learning activity data is significant for instructors to understand students' learning states and the difficulty levels of e-learning materials because those can suggest more efficient instructional ways. So, in this paper, the authors propose Cubic Gantt Chart as a visualization tool for the analysis of students' e-learning activity data and justify its usefulness by showing visualization examples of actual data collected by BookLooper.

Keywords: Visualization, Activity Data, e-Learning, Instructional Design

1. Introduction

Recently, researches on cyber-physical systems have become more popular because various electric appliances have sensor equipment to gather some data through the Internet called the cyber world and by analyzing those data, it becomes possible to provide more efficient services to the physical world. As for e-learning based education environments, if we could understand students' e-learning activities by analyzing their activity data, we can employ more efficient instructional ways more suitable to those students. To do so, instructors need any tools that help them for collecting and analyzing students' e-learning activity data.

We employ BookLooper for collecting those data. It watches students to store their e-learning activity data such as how long and how often the students look at each page of an e-learning material like PowerPoint slides. We explain for details about BookLooper in section 4.1.

On the other hand, one of the most effective tools for analyzing those data is the visualization tool. It is important to apply the statistical methods to testify the fact of data user finds, but user needs to know what the data mean directly at first. That is more effective to notice the new facts, build up the hypothesis and discuss about data. Therefore, we propose a new visualization tool called Cubic Gantt Chart, 3D version of Gantt Chart in this paper. We also justify the usefulness of the proposed Cubic Gantt Chart by showing visualization examples of actual data collected by BookLooper.

Gantt Chart (2D version) is well known as a project management tool. It is one of the bar chart and proposed by Henry L. Gantt. Vertical line represents a kind of work and horizontal line represents time flow. Cubic Gantt Chart is the better tool to visualize the data which has multidimensional attributes. User select three from the attributes and each attribute is assigned to the each axis and he/she can look down the whole graph or look in any orthogonal direction, for example, X-Y plane, Y-Z plane and Z-X plane.

The remainder of this paper is organized as follows. First of all, Section 2 describes related works of educational data and visualization tools for them. Section 3 introduces basic functionalities of Cubic Gantt Chart we proposed. Then, Section 4 describes the usefulness of Cubic Gantt Chart by adopting actual data collected by BookLooper. In Section 5, we discuss what those data mean when we visualize them by Cubic Gantt Chart. Finally, we conclude the paper and describe our future work.

2. Related works

2.1 Learning data

The analysis of students' learning activities is more important for the effective education rather than the check of semester's end tests. According to Darrell et al [1], using online tools allow instructors to recognize students' activities, for instance, how long they read online electronic textbooks and how they understand the important parts of them. There is also the research about relationship between Self-Regulated Learning (SRL) and students' learning behavior by using learning data [2]. When students do e-learning with a smart phone, SCROLL is one of the effective e-learning systems using learning activity data [16].

2.2 Analyzing data

The way which decide the solution by analyzing data has been used and popular since a decade ago. However, this does not always lead a correct strategy. Picciano et al [3] stated "As data-driven decision making has entered learning analytics era of the big data, these new approaches are not silver bullets while they may be the part of solution. Higher education administrators should employ them by evaluating whether they can be used in their institutions and by recognizing what roles they can play."

Visualization of data is one of the ways to analyze them. User can notice the new fact by looking at visualization results of the data however it can be found by statistical methods. It can be said that analysis by looking at the data enables the user to understand what the data mean more directly, i.e., interactively and intuitively. Paul et al [4] can insist a certain hypothesis by visualizing the multivariate data using multiple connected view.

2.3 Visualizing methods

There are a lot of visualization tools so far [5]. For instance, Tree Map, Bullet Chart, Parallel Coordinate and so on. It is too many to explain them, respectively. Although the visualization of time oriented data is not easy task, various visualization methods have been proposed so far [6].

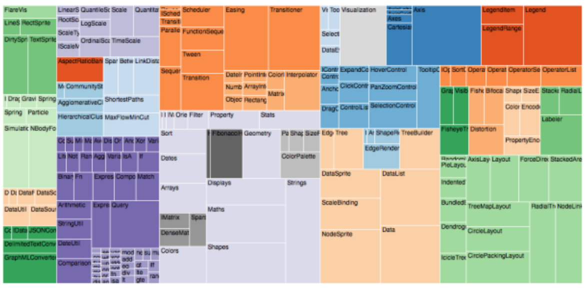

Figure 1. Treemap (from D3.js example)

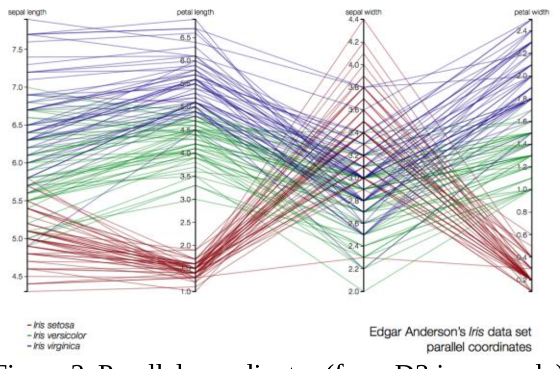

Figure 2. Parallel coordinates (from D3.js example)

Treemap is one of the popular visualization tools. It is proposed by Ben Shneiderman[13]. It displays hierarchical data as a set of nested rectangle. Each rectangle's area is decided by the weight value assigned to the corresponding node. The color can be used as another information of the node. Parallel coordinates is one of the methods to visualize multidimensional data. It is proposed by Alfred Inselberg et al [12]. Parallel coordinates has parallel multi-lines in 2-D plane, each of which represents an axis for each attributes of data. Making the line chart by connecting vertices on each axis, user can see relationships among all attributes of each data. Aigner et al [10] pointed out time, data and representation as the three main criteria for the visualization of time oriented data. Time means how time axis is represented, data and representation mean what kind of data and how those are visualized, i.e., dynamic graph or static graph. Time-tunnel is a visualization tool for time-series numerical data proposed by Akaishi, et al [7, 8, 9]. Time-tunnel is mainly composed from three components those are called Data-wing, Time-plane and Time-bar respectively. Time-bar is a long thin cylinder works as a time-axis. Data-wing is like a sheet. One time-series numerical data is displayed as one chart on each Data-wing. Each Data-wing is connected to Time-bar and by rotating several Data-wings and putting them together, it is possible to compare the multiple time-series numerical data displayed on them. Time-plane is also like a sheet connected to Time-bar perpendicular to Data-wing. It is used for displaying a radar chart. Users can understand the relationship among multiple data which are extracted at any time.

3. Basic functionalities of Cubic Gantt Chart

This section introduces our proposed visualization tool called Cubic Gantt Chart. Cubic Gantt Chart is 3D version of Gantt Chart. Before explaining its details, we introduce the standard Gantt Chart (2D version).

3.1 Gantt Chart (2D version)

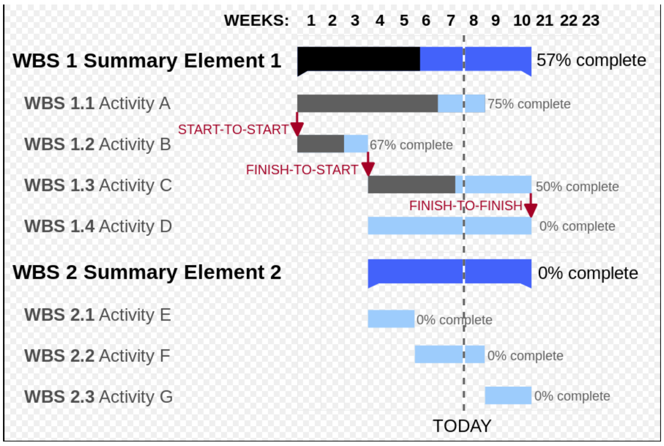

Figure 3. Gantt chart (from Wikipedia)

Gantt Chart proposed by Henry L. Gantt in 1910s is a kind of bar chart. It is well known as a project management tool. Vertical line represents a kind of works and horizontal line represents time flow. Each job is illustrated by rectangles. Left and right side of each rectangle are the start and end time of the corresponding job. This graph allows users to understand the below at once.

- What kind of activities there are
- When each activities starts and ends
- How long each activities are
- What activities overlap to other activities
- How far project goes
- When project starts and ends

3.2 Cubic Gantt Chart (3D version of Gantt Chart)

This visualization tool uses a 3D space so that it can treat three attributes, one additional attribute besides two attributes of the standard Gantt Chart, each of those is assigned to each X, Y and Z axes of the 3D space, separately. By looking at the tool in the direction toward any face, i.e., X-Y plane, Y- Z plane or Z-X plane, the user can understand relationships between the corresponding two attributes of the data.

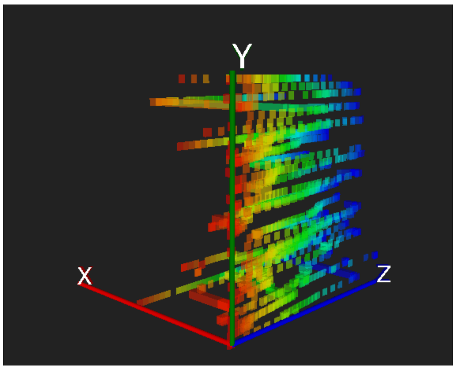

Figure 4. Perspective view of Cubic Gantt Chart

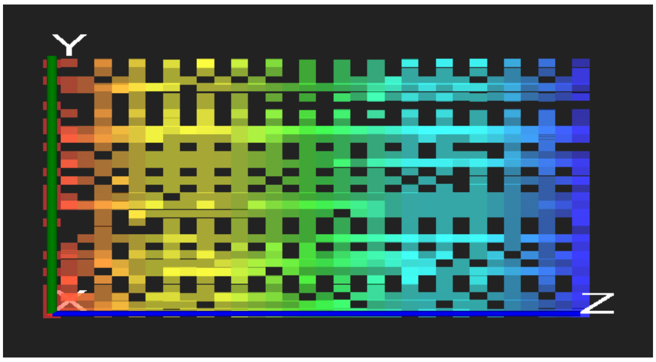

Figure 5. Orthogonal view of Cubic Gantt Chart

When a user looks at this graph, he/she can select the perspective or orthography camera (See Fig. 4 and Fig. 5). A user selects the perspective camera if he/she wants to look down at the whole graph and user selects orthography camera if he/she wants to look only two attributes relationship such as X-Y plane, Y-Z plane or Z-X plain.

Each voxel located in this visualization tool has semi-transparent. Therefore, users can understand how voxels are overlapped by checking those color depth and it represents the information same as that of heat map. A user can easily find out where he/she should pay attention to at first.

The length between the two sides of each voxel represents the value of that attribute if the attribute is continuous variable. If the attribute has discrete values, the length is always one and the position of each voxel treats as the same meaning as that of a standard Gantt Chart. The standard Gantt Chart represents time flow in horizontal axis and a kind of works in vertical axis. If the horizontal length of a rectangle is one that means the task takes one minute. The first location at vertical axis represents a first task, the second location represents a second task and so on.

The color of each voxel is reddish if it is located in at begin point and bluish if it is located end point in Z axis. We explain the details what colors represent in Section 4.

Cubic Gantt Chart offers not only the functionalities mentioned above but also the functionality similar to the standard Gantt Chart. By selecting any plane, i.e., any two attributes of three attributes at a certain value of the remaining attribute, the proposed tool visualizes the selected data similarly to the standard Gantt Chart. Users can understand the features of the selected data quickly like the standard Gantt Chart.

3.3 Web based visualization tool

For implementing the proposed visualization tool, we selected JavaScript as a programming language although there are many programming environments. Its reason is that JavaScript contents can be used in any web browser on any hardware platform without installing the dedicated software. Another reason is that there are a lot of libraries such as Three.js can be used when making applications like visualization tools.

4. Visualization Examples about eBooks Access Logs

This section presents visualization examples of Cubic Gantt Chart about students' e-learning activity data actually collected using BookLooper. Cubic Gant Chart is most suitable for the visualization of students' e-learning activity data because it can visualize the transition pattern among pages of PowerPoint slides and the stay time of each page about each student, and it also makes possible to atomically understand the same information among all students. In the following subsections, first of all, we introduce the detail of BookLooper data. After that, we shows the visualization examples of Cubic Gantt Chart.

4.1 Detail of BookLooper data

BookLooper developed by KYOCERA Communication Systems Co., Ltd is one of the cloud services in which users can read electronic textbooks stored into the service through the Internet. Users can access this service on any platform, i.e., any device and any OS. This service gathers users' learning activity data of reading electronic textbooks, e.g., how long each user reads an electronic textbook, from and to which pages of the textbook the user traverse. The attributes of such data are date, time, user name, material name, activity information represented as a sequence of reading page indices. As other functionalities of Booklooper, users can add a marker to important places and can also write memo.

Our university has promoted BYOD (Bring Your Own Device) and asked students bring their own device for taking a class since 2013 and also asked to use an electronic textbook instead of the paper textbook through BookLooper. As a result, a huge number of learning activity data have been stored in a database.

In this paper, we employ learning activity data of information technology class collected by BookLooper from October 2014 to January 2015.

4.2 Visualization Examples

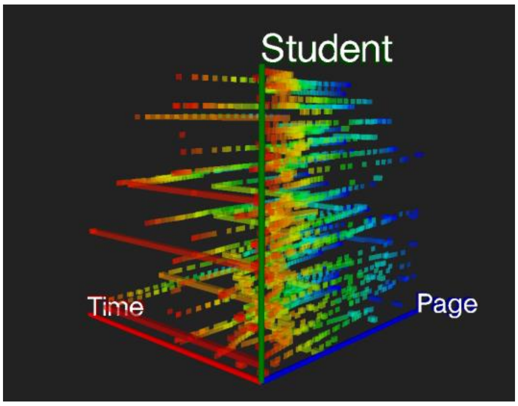

Figure 6. Perspective view of Cubic Gantt Chart.

In the followings, we introduce several visualization examples of the proposed Cubic Gantt Chart for students' learning activity data actually BookLooper gathered. First of all, Fig. 6 is the graph when the user select the perspective camera to look down in this graph. There are three long red voxels, which mean three students open the textbook at first page and those students did not look at other pages.

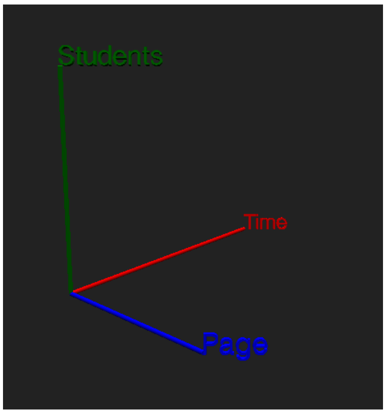

Figure 7. The axes in Cubic Gantt Chart.

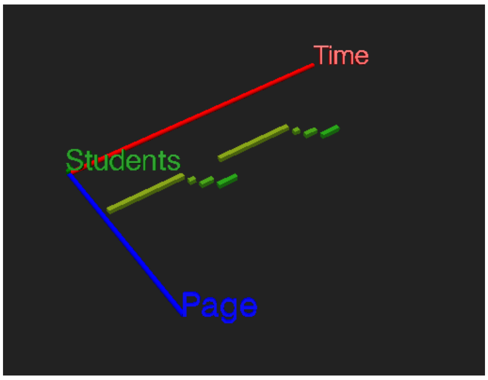

Figure 8. The length of a voxel toward x-axis represents reading time of a certain student for a certain page.

We used reading time of each page, student ID and page index of PowerPoint Slides those are assigned to X (red), Y (green) and Z-axes (blue), respectively as shown in Fig. 7. As shown in Fig. 8, each rectangular solid called a voxel means one recorded data consisting of page index, student ID and reading time of the student for the page. The length of each voxel toward x-axis represents reading time of the student for the page. For example, the length of voxel toward x-axis has one if the student look at the page for one minute. Therefore, users can understand how long and which page in this material students read. The each voxel of the material represents start time and end time like the standard Gantt Chart. So, users can find out when and which page in this material students read.

Each voxel has a color value corresponding to its attribute value. For instance, early pages of the material have a reddish color and ending pages have a bluish color. Since it also has a semi-transparency value, a deep color means a higher density area of voxels. Therefore, as shown Fig. 9, by checking the color depth, it is possible to easily understand which pages are frequently read, who spend much time to read the page.

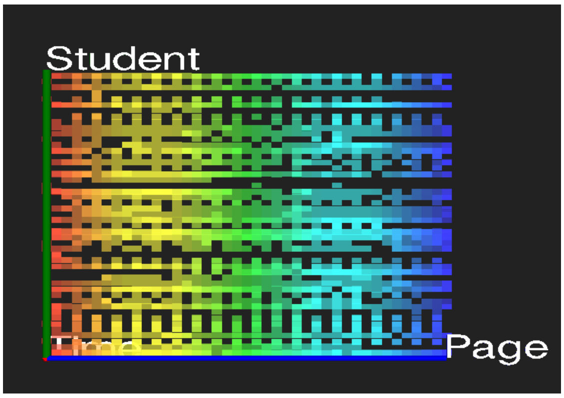

Figure 9. Orthogonal view toward the plane of student ID and Page indices.

Fig. 9 indicates relationships between students and page indices of the material. Voxels in some lines has a deep color which mean those students read the page many times or by spending much time. You can also understand some students read pages skipping hear and there, and some students did not read any pages at all because no voxels are in those students' line. There are not only students who learn hardly but also students who do not learn at all. And also, you can understand which pages students read frequently by checking the color depth. You can also understand that some pages are difficult for almost students to understand in this material if those pages need to be looked at for long time. For example, the areas of yellowish and sky bluish have a deep color so that it can be said that those pages are difficult for students because they looked at many times or by spending much time.

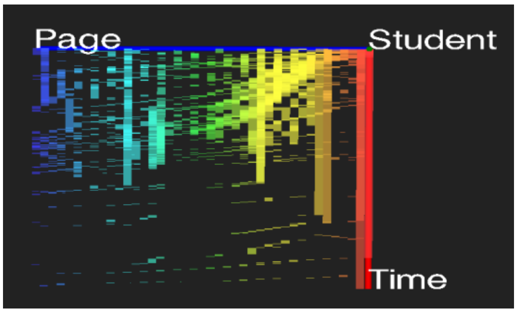

Figure 10. Orthogonal view toward the plane of reading time and Page indices.

Fig. 10 indicates relationships between page indices of the material and reading times for them. Firstly, it can be seen that some students looked at the ending pages for long time. By checking reading times, all students take the same actions at early time because of those color depth, and there are some students who gradually came to spend time back to early page and some students who came to spend time toward ending pages. There are also some students who have been looking at a first page. They may listen to teacher hardly or they may be asleep after opening their textbook in this lecture. Students reading the ending page at early time may do homework assigned in this lecture. The areas of sky bluish voxels and yellowish voxels have a deep color at middle time of this lecture. So, it can be said that at that time, almost students read the pages of sky bluish or yellowish colors many times with spending much time.

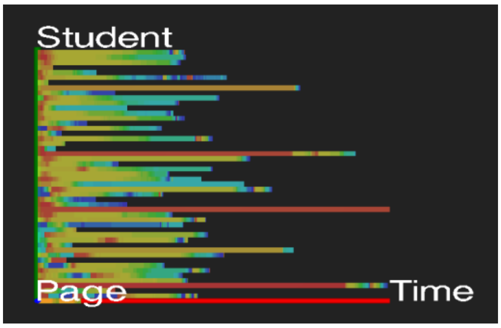

Figure 11. Orthogonal view toward the plane of student ID and reading time.

Fig. 11 indicates relationships between students and their reading times. From this viewpoint, you can compare students learning activities with each other by checking those color changes. For instance, you can understand learning activities are the same if those voxels' color changes and total lengths are the same.

In Figure 11, you can see three red long voxels those are corresponding to the first pages. This means that three students spent long time to read the first pages. Additionally, you can also see that yellow voxels occupy the most areas. So, some students spent moderate time. On the other hand, some students spend long time to understand this page. This means the page of the material must be important part in this lecture. If students can easily understand the material, the changing color becomes red to blue. If students read back frequently, the changing color becomes reddish on the way. You can also see long sky bluish voxel. This means students spent long time to read the ending pages.

The total length of voxels in each student is different. This means that students stopped the BookLooper application at different time or some students stopped on their learning. Anyway, this lecture ended earlier than the regular time because almost students stopped BookLooper at the half of the maximum total length.

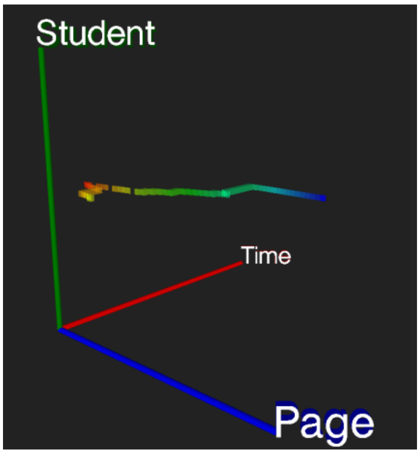

Figure 12. One student activity data

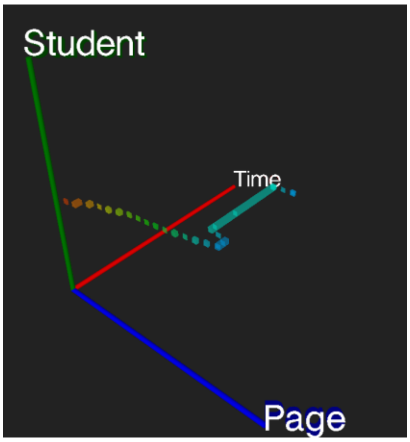

Figure 13. Another student activity data

It is possible to look at not all students' activity data as shown in Fig. 11, but also one of the students' activity data as shown in Fig. 12 and Fig. 13. In Fig. 11, there are several students who did not spend long time at the page represented as yellow voxels, but did spend long time at the page represented as sky blue voxels. Maybe, users want to check more detail of such students' activity independently. In this case, you can choose one of the students and can check details of the student' activity data by visualizing the data separately as shown in Fig. 12 and Fig. 13.

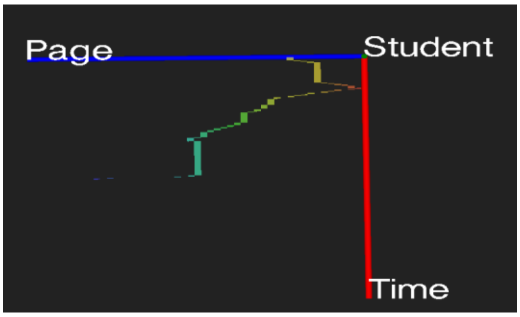

Figure 14. Orthogonal view of Fig. 12.

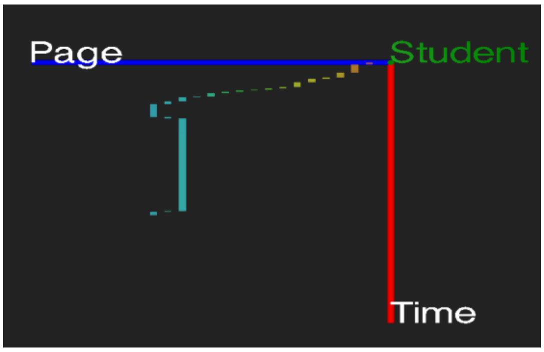

Figure 15. Orthogonal view of Fig. 13.

Fig. 12 and 13 are perspective views. You can select orthogonal views for them as shown in Figure 14 and 15. From these views, you can clearly understand the students' learning activity transitions. As for the student of Fig. 14, maybe you wonder he/she started the middle page and went back to the beginning page. As for the student of Fig. 15, you can understand he/she looked at the pages in the normal order one by one, but he/she went back to the a few previous page around the page of sky bluish voxels. Anyway, it can be said that there is one common characteristic of the two students which they looked at the page of sky bluish voxels for much time just after looking at the next page. From this visualization result, we can understand that the pages of sky bluish voxels are more important than others in this material.

5. Discussion

Using our proposed visualization tool called Cubic Gantt Chart for students' e-learning activity data, mainly it becomes possible to understand the following three points.

- How long and which pages students look at
- How students transit among pages
- Similar transit patterns of pages among students

From these points, with the use of Cubic Gantt Chart, users can grasp all students' learning behaviors. For example, from Fig. 11, users can understand that some students spent much time at the pages represented as yellow voxels although most students could understand easily. A teacher should spend more time for such students when teaching the corresponding contents in a lecture. Then, the students will come to understand the contents more deeply and rapidly. As another example, although there is not the case in this paper, if it could be found that many students go back to the previous pages to conform the contents related to the current page, a teacher should spend more time for teaching the contents enough at the first time. Furthermore, if it could be found that there are several patterns of students' transitions among pages, a teacher can divide students into several groups according to the patterns and then will be able to teach adaptively to each group.

From Fig. 10, we can understand there are sigmoid patterns at the beginning part of the pages by focusing on the deep color voxels. Some classes have sigmoid patterns although most classes do not have. We wonder there are some factors that cause sigmoid patterns. In this study, although we have not used any statistic methods for analyzing those data, as our feature work, we may find such factors by adapting statistic methods.

Unfortunately, we have not yet received end semester test results of the students. If we have such test results, by investigating relationships between learning patterns of students and their obtained grade, it becomes possible to find out the learning patterns of high achievers and the learning patterns of low achievers, e.g., what pages high achievers spent much time and how different between the high achievers' and low achievers' patterns. As we stated in Sec. 4.2, as shown in Fig. 11, some students spend moderate time to look at the pages represented as yellow voxels and some students spend much time to understand those pages. This result is very important as a remarkable difference among students in this lecture if we can compare the students' learning pattern about the rest of lectures and find out how this result affects their grades. Furthermore, if there are any characteristics of the students of higher grade, by analyzing difference between learning patterns of those students, a teacher can find more efficient instruction methods. In general, it is better to get higher grade by the study spending little time rather than spending much time. If low achievers can check and understand learning patterns of high achievers, they can improve their learning manner so as to get higher grade efficiently. In this way, the visualization of learning patterns of students is very significant for the both of teachers and students.

In this visualization tool, users can select any three attributes, e.g., in the case of this paper, X, Y and Z axes are time, students and indices of page. However, the data collected by BookLooper has more attributes such as device types, user access date and so on. We think that by applying any statistic methods to the data and by visualizing those results using Cubic Gantt Chart, it will become possible to analyze the data more and more efficiently.

6. Conclusion and future work

In this paper, we proposed new visualization tool called Cubic Gantt Chart, 3D version of Gantt Chart. Using a 3D space in Cubic Gantt Chart, we can employ one more additional attribute besides two attributes of the standard Gantt Chart. Also by adopting color and color depth information, the proposed visualization tool becomes useful for analyzing not only relationships between any pair of two attribute values but also relationships among the all three attribute values. In this paper, we clarified the usefulness of Cubic Gantt Chart for students' learning activity data actually collected by BookLooper. By using this visualization tool, users can understand how long and which pages of a learning material students look at, how students transit among pages and whether there are any similarities among students learning activity patterns. Although in this paper, we showed the usefulness of the proposed visualization tool especially for students’ e-learning activity data collected by BookLooper, this tool is also available for visualizing other types of data those include more than three attributes, e.g., for visualizing network traffic data.

Finally, as future works, we will try to analyze more and more learning pattern of students by visualizing such data for making possible to suggest more efficient teaching strategies by improving the functionalities of the tool.

Acknowledgements

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Visualization of e-Book Learning Logs

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Abstract:. Learning environment with e-book enables learners to learn anytime and anywhere they like according to their own pace. There is a large expectation on e-book as personal learning tool. Understanding and grasping the learning status of students is crucial matter for teachers and for the learning system. Access log of e-books should be basis for analyzing the learning behavior. The authors are constructing an analysis system of learning logs kept in BookLooper system operated in Kyushu University. The present paper overviews the system and shows some "learning log graphs" which represent the learning process of students. The graphs tell which pages a student had difficulties and if the student grasps the thread of course as the teacher expected.

Keywords: Learning analytics, Visualization tool, Learning log, E-books, Educational Data Mining

1. Introduction

By 2020, Japanese government is scheduled to use digital textbooks for elementary, middle, and high schools with e-books[1]. "e-book" is defined as "Texts that are digital and accessed via electronic screens", and e-book is as effective for learning as the traditional textbook. (Rockinson-Szapkiw et al., 2013). The good usability of e-book was also reported (Shepperd et al., 2008).

As a forerunner to this institutional effort, Kyushu University carried out the BYOPC (Bring Your Own PC) program in 2012, which encourage all students to use their own PCs in the University campus, and then provide 3 learning support systems Moodle, Mahara, Booklooper, which is called M2B. Currently the M2B has around 19,000 users.

Instead of traditional textbooks, traditional classrooms in Kyushu University use BookLooper. BookLooper is a document viewer system provided by a partner to this research, Kyocera Communication Systems. Instructors' lecture materials, such as slides or other notes, can be posted to BookLooper, which can record students' learning behaviors when they use e-books to read their learning contents (Yin et al., 2015).

Yin et al. (2015) proposed that the students' learning status can be shown through visualization tool. A tool, which can visually show learning behaviors of students to both students and teachers, was present by Yin et al. (2015). This tool have 2 features: (1) it can infer the relation between knowledge through learning log data; (2) it can analyze the learning styles of learners and then discover if there are correlations with learning achievements. The paper also suggests that learners with the habit of digital backtrack reading study more efficiently.

Uosaki et al. (2105) analyzed the access logs and evaluated the effect of e-book system to increase up outside-class learning time. Worm et al. (2013) evaluated e-learning effects on simple recall and complex problem-solving. For simple recall both methods were equally effective. For problem-solving, they confirmed that the e-book group achieved a comparable knowledge level compared with the text book group. They evaluated the number of logged-ins and revealed that e-book group spent significantly more time. Their analysis is limited on the number and the time. On the other hand, the present paper analyzes the sequence of access patterns in detail. Littlewood et al.(2014) analyzed the change of e-book usage for 10 years from 2003 to 2013 at the Library of the University of Waikato. They showed the number of user sessions and pages viewed over time. They succeed to confirm the increase of eBook usage. However, the target of the analysis is not on individual users but on the whole statistics.

[1] http://www.mext.go.jp/

They did not consider the linkage of pages of e-book and how the user followed the pages. Ahmad et al.(2014) applied binary logistic regression to distinguish the e-book power user from the non-power user from their log data. They adapted as the predictor variables, minutes max, sessions, titles browsed, titles read, and unique titles and obtained a model with high success rate.

Clickstream has been an important issue in Web mining for more than a decade (Facca et al.2005). Mobasher et al.(2002) analyzed the users by their behavior on access logs of Web sites and their profiles to predict their next access or give them useful recommendation. The approach of the present paper is a visualization of clickstream of learning log. Behavior analysis of students' e-book usage is gaining hot attention. Pan et al.(2014) applied the eye-tracking to evaluate graphic design effects on e-book reading. They analysed the eye-tracking as well as clickstream which were kept as log.

The present paper reports on the visualization system of e-book learning log. The system is constructed on a special search engine for log data. The thread of pages that students followed are displayed as directed graphs. Case analysis are conducted on samples of log graphs based on 298,054 logs of 108 freshmen at Kyushu University on the course of "information science".

2. Access Log Graph System

2.1 Access Log Data

The authors constructed a visualization system of e-book learning logs for the class of "information science" in Kyushu University. The class consists of 108 freshmen. The log was collected from November 2, 2014 to January 21, 2015. The total number of logs is 298,054. Each access log contains the student's ID, the section of the course, the page number of the slides, the action which the student took, access date, access time and the duration of the reading time of the page. There are 20 kinds of action, such as open, close, next, previous, zoom and jump. The system visualizes how students read the pages and how moved to one page to another page. The present paper concerns the page transition by students.

2.2 Search Engine of Access Log

Fig. 1 shows a part of access log. To improve the efficiency of the analysis, we constructed a search engine for the access log. We utilized GETA[2] system in our implementation. We considered each log data as a document that consists of items of student's ID, the section, the page, the action, the date and the time. Those items are indexed as the following index file (Fig.2). For example, the first line of the log (Fig.1) is indexed as the data #92733 that contains the keywords with "tag" (Fig.2). The at-mark symbol (@) represents an item. Each line below the item number represents an item that contained in the log. The words are augmented with a tag to distinguish the interpretation.

```
user id,section,operation,page,date,time,duration
399889bc2c3efb4cf1e2962fc4eadb4e,C-03,NEXT,29,2015-01-14,09:30:37,1
399889bc2c3efb4cf1e2962fc4eadb4e,C-03,NEXT,30,2015-01-14,09:30:38,1
399889bc2c3efb4cf1e2962fc4eadb4e,C-04,OPEN,0,2015-01-14,09:30:49,7
399889bc2c3efb4cf1e2962fc4eadb4e,C-04,NEXT,3,2015-01-14,09:30:56,10
399889bc2c3efb4cf1e2962fc4eadb4e,C-04,NEXT,5,2015-01-14,09:31:06,10
399889bc2c3efb4cf1e2962fc4eadb4e,C-04,NEXT,7,2015-01-14,09:31:16,18
399889bc2c3efb4cf1e2962fc4eadb4e,C-04,NEXT,9,2015-01-14,09:31:34,6
```

Figure 1 Sample of Access Log

```
@92733
1 x:92733
1 d:150114
1 h:09
1 a:1421195042
1 i:21
1 u:399889bc2c3efb4cf1e2962fc4eadb4e
1 t:C-03
1 o:prev
1 p:29
```

Figure 2. Index of an Access Log

```
Log_Graph_Generation (Input : query) {
  @LOG = search_log(query);
  foreach user in @log {
    @log = grep {$_.id == user} @LOG;
    for(i=0;$i<@log_i;$i++){
      from = log[i].sec/log[i].page;
      to   = log[i+1].sec/log[i+1].page;
      add edge from->to
    }
  }
}
```

Figure 3. Graph Generation Algorithm

2.3 Algorithm of Graph Generation

The first line and the second line of Fig.1 indicates that the student read the page 29 of the section C-03 and then moved to the next page 30. Note that the BookLooper system displays the consecutive two pages at the screen. It may happen that only the left of the right page was kept in the access log. It is not always the case that access by the same student is kept in consecutive position in the log. In fact, when many students are using the system, the next log of a students may be other student's log. So, we have to extract all the logs of the same student to track his/her learning behavior. Then we have to follow the pages he/her read according to the time.

The system generates a directed graph whose nodes represents the pages of a section and whose edges represent the student's move to one page to another page. Even if two students moved from a page X to another page Y, the nodes X and Y and the edge X->Y are not duplicated. The frequency of the visit to the page is shown in the node.

To analyze repeated paths that students visits, such nodes are emphasized by the red color with 5 level graduation according to the frequency. The repeated paths are identified as directed closed path in the graph. The nodes in non-closed paths are drawn with no color. The red line represents the frequency of students' visiting. There is 5 levels in total. The higher frequency is, the thicker the color is.

3. Analysis Example -- access relationship map

The total of 108 freshmen attended the course of Information Science opened in October 2014. We analyze the students' learning log of the Information Science course and describe them by maps. Each map shows the reading orders in a period of time. Fig.4 shows a log/access relationship map which describes sequences of pages. The description of this map is based on the time when the learner read the pages. The words inside the circle represent the name of a document, the visited pages, and the times of the visiting. For example, "B-10/63 (6)" means that the learner read page 63 of a document called "B-10" 6 times. When a student study some document, she/he may come back to confirm some related knowledge in prior documents.

3.1 Analysis knowledge relationship Sample 1:

Fig.5 shows an example of a student's log/access relationship map. As shown in the figure, there is 5 nodes around Node"B-10/63 (6)".When the learner is reading page 5 (Linear Search) and page 27 (Suffix Array) of doucument B11, , she/he went back to page 63 (Complexity of Sort) of doucument B10 to check the related knowledge. Similarly, when the learner is reading page 63 of doucument B10, she/he jumps to page pape 1（What is Computation?） once and pape 25 (Bomplexity of Binary Search) of B11 twices.

[2] http://geta.ex.nii.ac.jp/

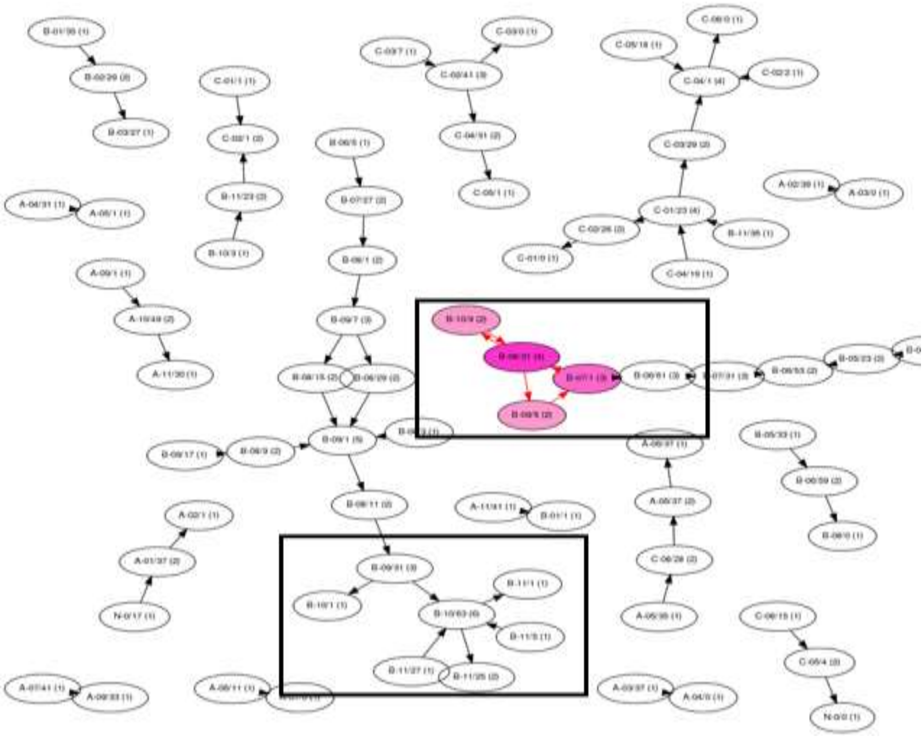

Figure 4. Visualized learning behavior

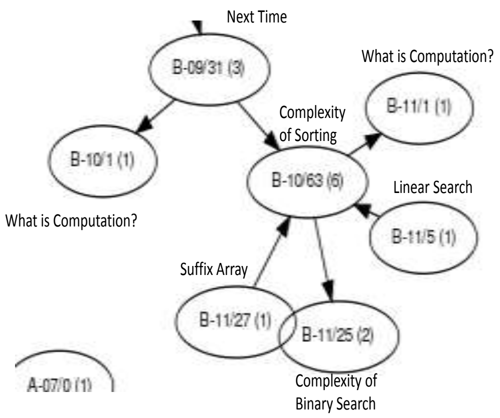

Figure 5. Relation of Contents of Slides in Figure 4 (lower sub graph)

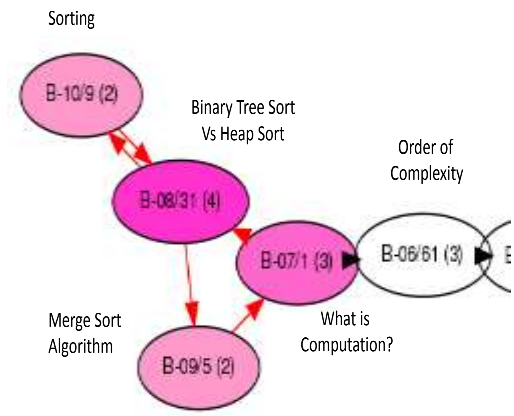

Figure 6. Repeated View in Figure 4 (upper subgraph)

3.2 Analysis knowledge relationship Sample 2:

Fig.6 descibes a situation that a student access a high frequency node repeatly. This figutre shows a log/access relationship map centered on page 31 (Binary Tree Sort vs Heap Sort) of document B-08. When a student is reading page 31 of B-08, she/he jumped to page 9 of document B-10.

Page 31 of B-08 was accessed, when the learner was reading page 1 of B-07, page 5 of B-09 and page 9 of B-10.

We confirm that those page have some knowledge is highly related. This suggest our access relationship map can successfully infer the relationship between knowledge.

4. Analysis Example -- Digital Backtrack Reading

The students received the paper tests twice at the middle and at the end of the semester. We compared the graphs of high achievement students who gained high score at the final test with that of low achievement students.

4.1 Samples of high achiement student

The students with high achievement normally repeatedly studied some key points related to the final test contents. Moreover, those key pages appear in the connected components in the graph and shown by colored nodes and edges. This kind observation would not be able to obtain by simple counting of views. Relation of pages is not clear without using visualization of the page linkage. In fact, the paths and the cycles in the graph displays the linkage so clearly that we can grasp immediately.

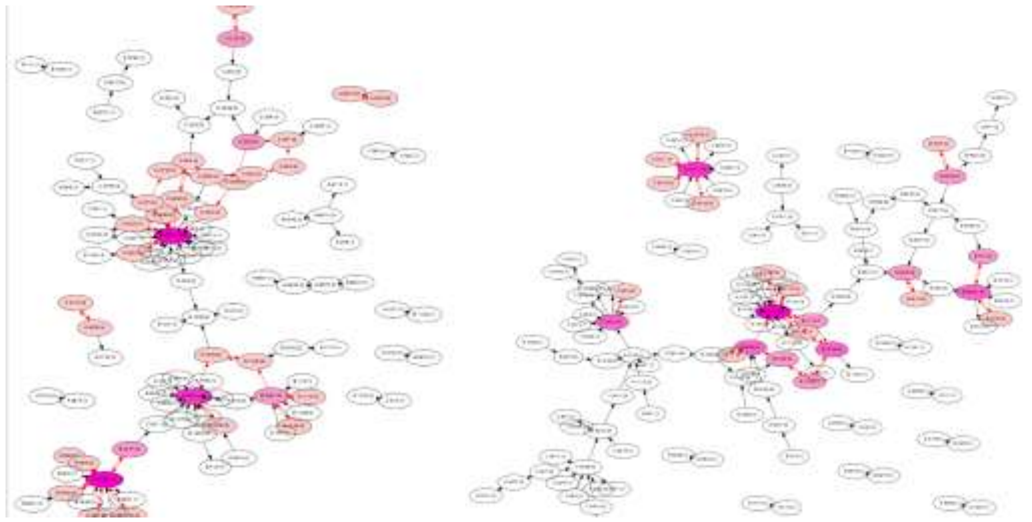

Figure 7. Two samples of high achievement students

4.2 Samples of low achiement students

There were two types of students with low achievements. One type is the students who study with some key points of the course that do not related to the test contents (Fig. 8 left). The other type is students who put very few time on study and hardly study key points (Fig.8 right).

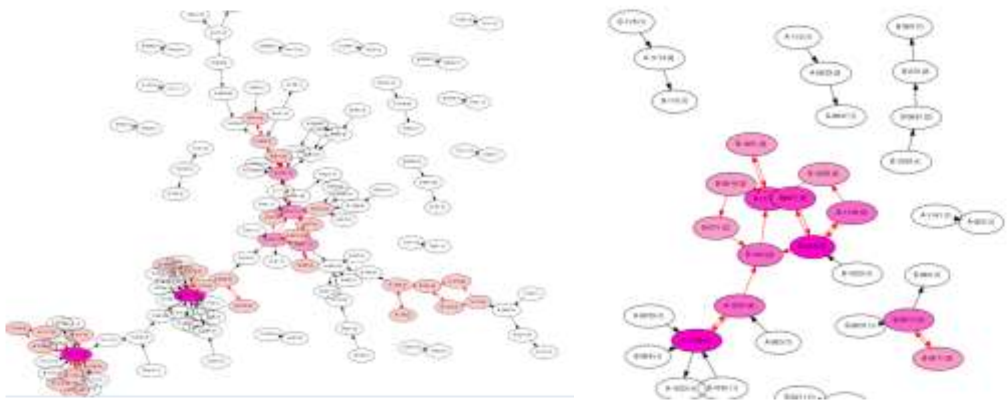

Figure 8. Two samples of low achievement students

5. Conclusion and Future work

The present paper showed a visualization system of e-book learning logs. Student learning behavior is displayed as a directed graph consisting of course pages and transitions between pages. The system overview is shown as well as samples of learning log graphs constructed from 298,054 logs of 108 freshmen at Kyushu University on the course of "information science". The graph generation system is constructed with a special search engine for log data.

By very simple analysis of those graphs, it is confirmed that students trace not only next/previous relationship of pages, but also follow the contents of course pages. Those pages are not always in the same section and do not have explicit links. We implemented the extraction of directed cycles among the graph by which we can find repeatedly studied pages. Those pages are highlighted with color and easy to recognize.

Some typical patterns were found to distinguish high achievement students from low achievement students. However, the quantitative analysis is further work as well as the improvement of the system for interactive use.

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Analysis of Links among E-books in Undergraduates' E-Book Logs

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Abstract: The purpose of this study is to investigate the relationship between academic achievement and learning patterns of students using e-book logs. Specifically, we examined how students who maintain good academic achievement *link* among knowledge of different e-books. We hypothesized that good achievers might access e-books sequentially those were used in the same class session and/or consecutive class sessions, for systematically linking among the different knowledge of related e-books. Logs were collected from first-year students in an information science course at Kyushu University. The present study revealed that the good achievers more frequently linked e-books which were used in the same class sessions than the poor achievers. This result suggests that the good achievers more frequently linked knowledge of e-books which deeply related each other.

Keywords: E-book, log, link, learning pattern

1. Introduction

"The race to replace traditional textbooks with electronic versions is on" (Daniel & Willingham, 2012, p. 1570). As of the year of 2010, Amazon.com sold more e-books than print books (Bounie, Eang, Sirbu, & Waelbroeck, 2012). E-book sales show strong and steady growth (Reynolds, 2011). In recent years, many countries (e.g., Japan, South Korea, and Singapore) have implemented and begun the assessment of information and communication technology (ICT)-based education and learning materials in schools, especially of electronic textbooks, called *e-books* (Nakajima, Shinohara, & Tamura, 2013). For example, in Japan, the Ministry of Education, Culture, Sports, Science and Technology (MEXT) compiled a "Vision for ICT in Education," a comprehensive policy to promote the utilization of ICT in education in 2011 (MEXT, 2011). In Korea, the research on e-books in learning started in 1997 and, in 2007, an e-book usage plan was announced by the Korean Education and Research Information Service (KERIS) (Shin, 2012).

Previous e-book research has mainly focused directly on the effectiveness of e-books for students (e.g., Chen & Chen, 2014; Daniel & Woody, 2013; Eden & Eshet-Alkalai, 2013; Huang, Liang, Su, & Chen, 2012; Ihmeideh, 2014; Korat & Shamir, 2008; Morineau, Blanche, Tobin, & Guéguen, 2005). For example, Ihmeideh (2014) investigated learning effectiveness of e-books and paper books on preschool children. The pre- and post-test data was collected on several literacy skills (i.e., print awareness, vocabulary, alphabetic knowledge and phonological awareness). After the pre-test, the children in the experimental groups were exposed to e-books, whilst the children in the control groups were exposed to printed books. In the results, children in the experimental group achieved better improvement in the areas of print awareness and vocabulary. On the other hand, Ogata and his colleagues carried out a series of studies in which they focused on e-book logs[1] as a research tool to investigate students' learning patterns and their relationship with academic achievements (e.g., Ogata, Oi, Okubo, Shimada, Yin, Kojima, & Yamada, in press; Okubo, Shimada, Yin, & Ogata, in press; Oi, Okubo, Shimada, Yin, & Ogata, in press; Shimada, Okubo, Yin, Kojima, Yamada, & Ogata, 2015; Yamada, Yin, Shimada, Kojima, Okubo, & Ogata, 2015; Yin, Okubo, Shimada, Hirokawa, Ogata, & Oi, in press). Their e-book log was a Cloud-based system for e-book usage

[1] More information (in Japanese) can be found at http://www.kccs.co.jp/ict/cloud-booklooper/.

monitoring. It provides a detailed of which student used which e-book when and for how long, and which pages they looked at.

Oi et al. (in press) examined patterns of students' e-book logs before and after the main content learning in class (that is, 'Preview' and 'Review'), using e-book logs as an objective measure. Logs were collected from first-year students in an information science course at Kyushu University. To measure preview and review learning, we analyzed data using three types of measurement: Change indicates how many times a student changed e-books over the course of one hour. Duration indicates how many seconds a student access a given e-book for during one Change (i.e., one turn). Page flip indicates how many pages of a given e-book a student flipped through during one Change. To analyze the relationship between academic achievement and preview/review, the students were categorized into six groups according to their scores on midterm and final (term-end) examinations. For preview, students who had consistent good achievement showed higher values for Change and Page flip than students who showed poor achievement. In contrast, for review, none of the three measurements showed differences among the six groups. These results suggest that preview is more deeply relevant to academic achievement and assessment than review. Furthermore, they reported the frequent Changes and Page flips in good achievers. These frequent Changes and Page flips suggest that students who maintain good academic achievement using e-books actively link (Hartman, 1995; Strømsø & Bråten, 2002) different texts not only within an e-book but also among different e-books, and understand content more deeply as a result. In Oi et al. (in press), the details of link among different e-books were not reported. To clarify how students, especially good achievers, linked knowledge of different e-books, the present study examined the details of the links among different e-books. We hypothesized that good achievers might access e-books sequentially those were used in the same class and/or consecutive classes, for systematically linking among the different knowledge of related e-books.

2. Methods

2.1 Participants and data collection

Logs for this analysis were collected from 98 first-year students in an information science course taken in the second semester of the 2014/2015 school year at Kyushu University in Fukuoka, Japan, via BookLooper (Kyocera Maruzen Systems Integration Co., Ltd.). Figure 1 shows samples of logs. The data from 15 students who did not take the midterm or the final (term-end) examination for the course were discarded from further analysis.

Devices	User ID	e-book ID	Title (e-book)	Operation	Page	Status	Marker Start	Marker End	Date	Time	Duration
AIR	xxxxxxxxxx	00000000NKFS	A-10-通信路符	OPEN	50	0	0	0	2014-11-12	08:54:35	3
AIR	xxxxxxxxxx	00000000NKG4	A-11-暗号	OPEN	0	0	0	0	2014-11-12	08:54:42	0
AIR	xxxxxxxxxx	00000000NKG4	A-11-暗号	PORTRAIT	1	1	0	0	2014-11-12	08:54:46	2
AIR	xxxxxxxxxx	00000000NKG4	A-11-暗号	NEXT	2	1	0	0	2014-11-12	08:54:48	1
AIR	xxxxxxxxxx	00000000NKG4	A-11-暗号	NEXT	3	1	0	0	2014-11-12	08:54:49	6
AIR	xxxxxxxxxx	00000000NKG4	A-11-暗号	CLOSE	3	0	0	0	2014-11-12	08:54:55	68
AIR	xxxxxxxxxx	00000000NKG4	A-11-暗号	OPEN	3	0	0	0	2014-11-12	08:56:03	5
AIR	xxxxxxxxxx	00000000NKG4	A-11-暗号	NEXT	4	1	0	0	2014-11-12	08:56:08	1
AIR	xxxxxxxxxx	00000000NKG4	A-11-暗号	NEXT	5	1	0	0	2014-11-12	08:56:09	8

Figure 1. Samples of e-book logs.

2.2 E-Books

Nineteen e-books were used in the course which had 15 class sessions. Table 1 shows the date when each e-book was used in a class session.

Table 1: Number of pages of each e-book.

	Shortened titles of e-books									
	A-01	A-0678	A-09	A-10	A-11	B-01	B-04	B-05	B-06	B-07
Date	10/08	10/15	10/22	10/29	11/12	11/12	11/19	11/19	11/26	11/26

	Shortened titles of e-books								
	B-08	B-09	B-10	B-11	C-01	C-02	C-03	C-04	C-05
Date	12/10	12/10	12/17	12/17	01/07	01/07	01/14	01/14	01/14

2.3 Data analyses

2.3.1 Link between e-books

To identify the links among the e-books, we investigated which e-book was accessed before and after a given e-book from e-book logs for each participant. After identification of before and after e-books, we categorized those links according to an interval between e-books, to clarify relationship between e-books. For example, e-book "B-04" and "B-05" were used as textbooks in the same class session, then if "B-04" was accessed after "B-05", the link between "B-04" and "B-05" was categorized as 0. And if "B-06" was accessed after "B-05" which was used in a class session after one week of "B-05" was used, the link between "B-04" and "B-05" was categorized as + 1 week. The maximum value of the interval is +14 and minimum value is -14.

2.3.2 Categorization of academic achievement

First, we coded quartiles of students' midterm and term-end examination scores (first quartile: A, second quartile: B, etc.). Then, the students were categorized into six groups according to a combination of midterm and term-end coded scores. Figure 2 shows the six groups and the number of students in each. Students who received the same scores on their midterm and term-end examinations were subcategorized into A (A-A), B (B-B). Since C-C and D-D students were too few as groups, they were combined into a group CD. Students who improved their scores were categorized into two groups: Students in group U1 got a B, C, or D on the midterm examination and an A on the term-end examination, while students in group U2 got a better score on the term-end examination than on the midterm examination, but not an A (thus, a B or C). The last group, L, got worse scores on the term-end than on the midterm examination.

	Term-end			
Midterm	A	B	C	D
A	10	6	4	6
B	9	11	6	4
C	3	10	1	7
D	-	-	2	4

Figure 2. The six groups and the numbers of students of each group. Yellow: A, Green: B, Blue: CD, Red: U1, Pink: U2, Gray: L

3. Results and Discussion

To examine whether link patterns differed among the six groups of students, the average frequency of interval of the links were calculated for each student. Then, averages of interval of the links for each group were calculated across the 19 e-books. Figure 3 shows these averages. Two-way analysis of variances (ANOVA) with group (6) as a between-participant factor and interval (29) as a within-participant factor was conducted on the average of the frequency of the links of before and after. Results revealed for both of before and after links, significant main effects of group, before: $F(5, 76) = 2.656$, $p = .029$, $\eta_p^2 = 0.149$; after: $F(5, 76) = 2.624$, $p = .030$, $\eta_p^2 = 0.147$, and interval, before: $F(28, 2128) = 131.121$, $p < .001$, $\eta_p^2 = 0.633$; after: $F(28, 2128) = 130.985$, $p < .001$, $\eta_p^2 = 0.633$, and interaction, before: $F(140, 2128) = 3.023$, $p < .001$, $\eta_p^2 = 0.166$; after: $F(140, 2128) = 3.014$, $p < .001$, $\eta_p^2 = 0.165$. In multiple comparisons with Bonferroni adjustment ($p < .05$), the group A who maintained good academic achievement revealed that compared to the groups CD, L, and U2 who showed poor academic achievement, significantly higher values for 0 week. In other words, the group A more frequently linked e-books which were used in the same class sessions. These results suggest that compared to other groups, the good achievers more frequently linked knowledge of e-books which deeply related each other.

A: Before

	Interval																												
Group	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
A	0	0	0	0	0	0	0.6	0.2	0.4	0.6	0.8	2.3	5	14	62	8.7	3	0.9	0.6	0.5	0.5	0.2	0.6	0.2	0	0	0.3	0.2	0
B	0	0	0.2	0	0	0	0.2	0.1	0.2	1	1.7	2.4	6.1	9.4	39	4.7	3.7	0.9	1.8	0.3	0.1	0.3	0.4	0.2	0	0.1	0	0.1	0
CD	0	0	0	0	0	0	0	0.2	0.4	0.4	0.8	1.2	2.8	5.2	22	3.2	1.6	0.8	1	0.6	0.2	0	0.2	0	0	0	0	0	0
U1	0	0	0.1	0	0	0	0.2	0.2	0.4	0.7	1.2	1.7	4.4	9.6	37	5.2	2.6	0.6	1.1	0.6	0.1	0.1	0.1	0	0	0.1	0.1	0.1	0.1
U2	0	0.1	0.1	0	0.1	0	0.1	0.3	0.1	0.3	0.8	1.8	3.6	7.9	29	3.6	1.4	0.7	0.9	0.5	0.1	0.3	0.2	0.3	0.1	0.2	0	0.1	0.1
L	0	0	0	0	0	0.1	0.1	0.1	0.3	0.7	0.9	1.8	4.8	9.1	31	3.9	2.8	0.5	1.2	1	0.6	0.1	0.2	0.1	0	0	0	0.1	0.1

B: Next

	Interval																												
Group	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
A	0	0.2	0.3	0	0	0.2	0.6	0.2	0.3	0.5	0.6	0.9	3	8.7	62	15	5	2.3	0.8	0.6	0.5	0.2	0.6	0	0	0	0	0	0
B	0	0.1	0	0.1	0	0.2	0.4	0.3	0.1	0.3	1.8	0.9	3.7	4.7	39	9.7	6.2	2.4	1.8	1	0.2	0.1	0.2	0	0	0	0.2	0	0
CD	0	0	0	0	0	0	0.2	0	0.2	0.4	1	0.8	1.6	3.2	22	5.2	2.8	1.2	0.8	0.4	0.4	0.2	0	0	0	0	0	0	0
U1	0	0.1	0.1	0.1	0	0	0.1	0.1	0.1	0.5	1.1	0.6	2.5	5.2	37	10	4.5	1.7	1.2	0.8	0.4	0.2	0.2	0	0	0	0.1	0	0
U2	0	0.1	0	0.2	0.1	0.3	0.2	0.3	0	0.4	0.9	0.7	1.4	3.6	29	8.6	3.6	1.8	1.2	0.3	0.1	0.3	0.1	0	0.1	0	0.1	0.1	0
L	0	0.1	0	0	0	0.1	0.2	0.1	0.3	0.9	1.2	0.5	2.8	3.8	31	9.4	4.9	1.8	0.9	0.9	0.3	0.2	0.1	0.1	0	0	0	0	0

Figure 3. Average of frequency of interval between e-books. Figure 3A shows which e-book was accessed before the given e-book, and figure 3B shows which e-book was accessed after the given e-book. More red means higher value.

4. Conclusion

The present study investigated how students, especially good achievers, linked knowledge of different e-books. Our hypothesis is that good achievers might access e-books sequentially those were used in the same class and/or consecutive classes which relate each other, for systematically linking among the different knowledge of e-books. The results partially support our hypothesis. The present study revealed that the good achievers more frequently linked e-books which were used in the same class sessions than the poor achievers. This result suggests that the good achievers more frequently linked knowledge of e-books which deeply related each other.

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Developing a neurofeedback-based e-book system to maintain an effective learning status

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Abstract: The development of e-book creates a revolutionary of knowledge dissemination and changes the way of teaching and learning. More and more studies have established that learning by e-book is an effective approach to enhance reading comprehension. On the other hand, learning is an actively processes of cognition, including attention, comprehension, perception, and organization. Past researches had been established that learner's reading attention and anxiety influenced learner's performance obviously. In tradition, it was very difficult for a teacher to maintain every student's learning status effectively. However, in recent years, the relationship between brain and education had been heeded because there was a strong correlation between them. But holding a brainwave experiment in the past was required a lot of preparations and equipment settings. Hence, this study aimed to develop a neurofeedback-based e-book system to maintain an effective learning status through improving reading attention and reducing reading anxiety. It also provided a web-based interface to help teacher to observe student's reading concentration and detect his/her learning status. Finally, an expert interview was adopted to ensure the effectiveness of neurofeedback proposed in this study. Five experts were enrolled in this interview. They stated several important suggestions of neurofeedback, e-book, teaching, and learning phase to improve this e-book system in the future.

Keywords: E-book, neurofeedback, brainwave, attention, anxiety

1. Introduction

In recent years, with the rapid development of technology, learning was no longer confined to paper-based presentation (Huang, Chen, & Mo, 2015; Huang & Chiu, 2015a, 2015b). The development of e-book not only changed the way of traditional publications, but also created a new revolutionary of knowledge dissemination. Undoubtedly, the e-books created a novel way of teaching and learning. Researchers have paid more much focus on e-books, which have become an effective pedagogical tool for educators (Huang & Liang, 2014; Liang & Huang, 2014). Meanwhile, the past studies tried to integrate e-books as knowledge vehicles and implement them into different grade schools. Korat (2010) found that reading e-book could significantly enhance the understanding of vocabulary, use of vocabulary, reading comprehension, and reading ability of preschool children. Grimshaw, Dungworth, McKnight, and Morris (2007) applied e-book with multimedia content to enhance learning motivation of elementary school students. The results indicated that the reading comprehension of students who reading e-books was significantly higher than students who reading paper books.

On the other hand, psychologists have demonstrated that learning is an actively processes of cognition, including attention, comprehension, perception, and organization (RCelsi & Olson, 1988). Attention is considered as a critical factor in cognitive processes (Kalyuga, Chandler, & Sweller, 1999; McDowd & Birren, 1990). Cimprich (1992) stated that learner's sustained attention on learning content affected learning obviously. Learner's reading ability is highly correlated with his/her reading attention (Rabiner, Malone, & Group, 2004; Savage, Cornish, Manly, & Hollis, 2006). Especially in the activities of reading digital content, providing tools or strategies to sustain learner's attention is a very important issue (Schneps, Thomson, Chen, Sonnert, & Pomplun, 2013). Learner's performance will decrease if he/she cannot sustain his/her attention. Therefore, it is necessary to observe learner's sustained attention and focus on reading content in order to improve reading comprehension and performance.

Reading anxiety influences learner's performance obviously (Saito, Garza, & Horwitz, 1999). Huang, Huang, and Wu (2014) developed a mathematics game-based learning system based on Input-Process-Outcome model to mitigate learner's anxiety. Sun (2014) adopted smartphones, which are considered with much familiar devices to college students, as pooling tools to engage learners and reduce their anxiety. Lower anxiety leads better performance (Sellers, 2000; Tsai & Li, 2012). In other words, it is effectiveness to observe and mitigate learner's anxiety in order to enhance their performance (Liu et al., 2015).

The most often approaches to detect learner's attention are based on visual sensors (Frintrop, Rome, & Christensen, 2010). Hsu, Chen, Su, Huang, and Huang (2012) developed a reading concentration monitoring system based on webcam in e-books to help teacher to detect student's reading concentration and understand his/her reading status. Furthermore, detection learner's anxiety general use questionnaire to understand student's reading anxiety.

The relationship between brain and education has been heeded in recent years (Fischer, 2009). It has a strong correlation between EEG and attention (Klimesch, Doppelmayr, Russegger, Pachinger, & Schwaiger, 1998; Loo & Makeig, 2012). On the other hand, learner's anxiety can also be estimated by brainwave (Blackhart, Minnix, & Kline, 2006). Hammond (2005) found that there had a high correlation between EEG and anxiety. Learner's attention can also be detected by brainwave (Rebolledo-Mendez & de Freitas, 2008). However, holding a brainwave experiment in the past was required a lot of preparations and equipment settings.

In order to simplify the measurement of brainwave, NeuroSky Company produced a simple, comfortable, and mobile headset device that can measure learner's attention and meditation easily (Fiolet, 2011). Chen and Huang (2014) implemented NeuroSky Headset into their attention-based self-regulated learning mechanism to enhance learner's sustained attention and promote his/her reading performance. NeuroSky Headset allows teacher to monitor a learner's attention during the learning activities.

Hence, the purpose of this study is developing a neurofeedback-based e-book system, which can provide a way of feedback to affect learner's brain state when he/her learns in e-book. Moreover, this system also provides a web-based interface to teacher. The teacher can use this interface to observe each learner's status and give appropriate tutoring. Finally, this study aims to interview two elementary school teachers and three e-book experts and improve the design of neurofeedback-based e-book system proposed in this study through their comments.

2. Research methodology

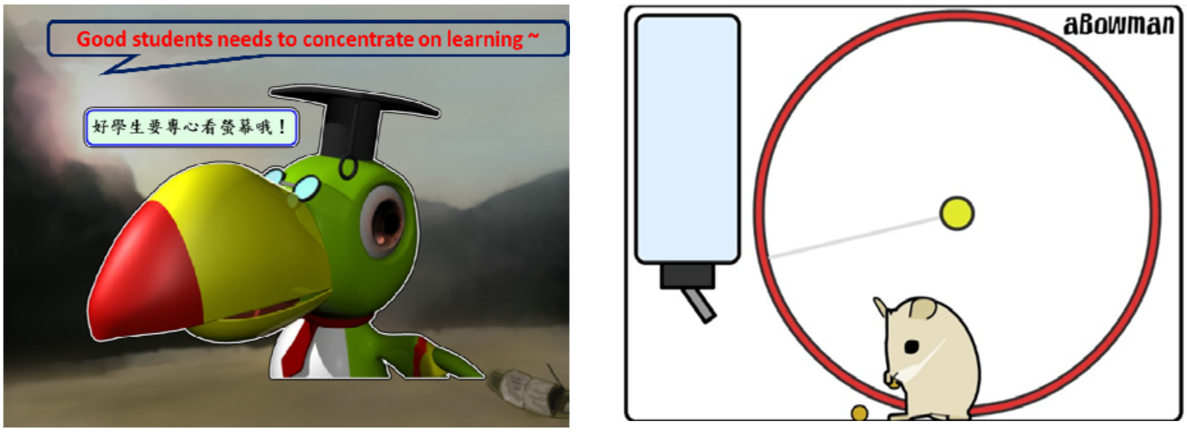
2.1 System design

This study adopted the processes of Systems Development Life Cycle (Blanchard, Fabrycky, & Fabrycky, 1990) to develop a neurofeedback-based e-book system, which provided immediate detection and feedback to maintain an effective learning status through measuring learner's brainwave. Moreover, this system was constructed on basic functions of an e-book including text, audio, graphic, and annotation, which are shown as Figure 1.

The main aim of this system was to develop a mechanism to improve learner's reading attention and reduce his/her reading anxiety to maintain an effective learning status. Learner was asked to wear an EEG sensor when reading in e-books. Hence, a feedback technique, which was named neurofeedback, was designed based on EEG. When learner read in the neurofeedback-based e-book system, the brainwave functions were automatically activated to detect learner's attention and anxiety. The estimation period of attention was ten seconds. The measured brainwave data were transferred, stored, and analyzed in the cloud server. When learner's reading attention was detected too low, the e-book system will activate a feedback to improve his/her attention immediately (see Figure 2a). On the other hand, when learner reads difficult content and his/her reading anxiety was detected to high, this e-book system will also activate a feedback immediately. The estimation period of anxiety was thirty seconds. This feedback is a simple game, which can make learner get a short break and reduce his/her anxiety (see Figure 2b).

Moreover, in order to let teacher can observe each learner's reading status effectively, this system provided a web-based interface to illustrate learner's attention and anxiety. The brainwave data were analyzed and drawn as a dynamic graph in the teacher's interface. Teacher can understand learner's reading status and give appropriate tutoring to enhance teaching and learning. In this interface, when learner's reading status is abnormal, the system will give a warning to teacher immediately. As shown as Figure 3, it denoted that learner's anxiety was too high.

Figure 1. The proposed e-book system.



(a) (b)

Figure 2. The proposed neurofeedback technique.

Figure 3. Students' attention and anxiety of dynamic graph.

2.2 Expert interview

In this study, the researchers developed a neurofeedback-based e-book system based on literature reviews. Finally, they focused on learner's reading attention and anxiety. Moreover, in order to ensure the effectiveness of neurofeedback-based e-book system, an expert interview was adopted. The usability of neurofeedback-based e-book system was evaluated with the K-12 grade learning stage, which was proposed by Gibson and Gibb (2011).

The expert interview was involved to confirm the usability of neurofeedback, e-book system, teaching, and learning. Totally, five experts were enrolled in this interview, including two elementary school teachers and three e-book experts in Taiwan. These two elementary school teachers have taught students using e-books more than three years, and the three e-book experts are researchers who designed, developed, and researched in e-books area more five years. The evaluating processes included the e-book system operation (20 minutes) and interview (20 minutes). They focused on observing the characteristics of this e-book system and gave suggestions to improve it. Each expert's background and teaching experience are listed in Table 1.

Table 1: Expert information.

Expert Code	Classification	Experience (years)	Teaching grade
A	Teacher	17	10
B	Teacher	14	11
C	Technologist	8	Null
D	Technologist	12	Null
E	Technologist	9	Null

3. Results & Discussions

The results of expert interview can be broadly classified into two categories. One is the summary insights of the characteristics of this e-book system from each expert, and the other one is the suggestions to this e-book system. After the evaluation of this e-book system, the five experts expressed their summary insights about the neurofeedback-based e-book system. Each expert's comments are listed as follows.

1. For the expert #A: This system can help students to monitor their reading status and support teachers to understand students' learning state. But the detection of anxiety and feedback seem that need more investigation to different high or low achieving students.
2. For the expert #B: For the feedback of reading anxiety, the simple game can make student relax in learning, but it also may lead student to addict in the game and loss learning.
3. For the expert #C: Integrating EEG technology into e-book learning system is a novel and interesting idea, it solves the problem that it is difficult to identify reading attention and anxiety.
4. For the expert #D: The detection of brainwave was accurate, but students wear the EEG sensor when reading in e-book may be a burden in learning.
5. For the expert #E: The proposed system is suggested to add some refocus functions that can help students to concentrate their attention.

In order to investigate the effectiveness of neurofeedback-based e-book system, an interview was involved to verify and improve this study. Five experts gave several important suggestions and insights to maintain the system proposed in this study. The suggestions can be arranged in four phases: neurofeedback phase, e-book phase, teaching phase, and learning phase. They are listed as follows.

1. In the neurofeedback phase, to maintain learner's attention and mitigate their anxiety through neurofeedback-based approach were meaningfulness and usefulness. However, the baseline of attention and anxiety levels to each learner was different. The experts suggested adopting some personalized approaches to detect personal attention and anxiety levels.
2. In the e-book phase, the teachers and experts considered that the neurofeedback-based e-book system could help learner to adjust his/her attention and anxiety but they hoped the system didn't disturb learner too much frequently.

3. In the teaching phase, the teachers thought that the neurofeedback-based e-book system could help them to monitor learner’s state. But the teacher observed interface still was too poor. They suggested to improve the usability of the teacher observed interface.
4. In the learning phase, the teachers and experts agree this system was useful to implement into the real classroom since this system can capable to adjust learners' attention and anxiety. The past researches also indicated that enhancing learner's reading attention and reading anxiety influences learner’s performance.

4. Conclusion and Future work

A neurofeedback-based e-book system was proposed in this study. Learner’s attention and anxiety levels were detected by measuring his/her brainwave. And then, the results of attention and anxiety were feedbacked to learner and teacher. Learner’s attention and anxiety could be adjusted by the feedback of e-book; and teacher could observe the learner’s brainwave state to arrange the learning content or activities. Through the interview to the teachers and experts, they all considered that the neurofeedback-based e-book system was useful to implement into the real classroom. They also gave several important suggestions to improve this system.

However, there are still some limitations of this study. First, the device used in this study to measure learner’s brainwave was too simple. It only has one channel. Its accuracy and validity may be challenged. The much powerful brainwave devices may be considered in future. Second, the principles of detecting low attention and high anxiety need to be verified. Finally, the cues of presenting the neurofeedback also need to be verified. The format and frequency of feedback is help or disturb has to be further study. Therefore, in future, we suggest designing further experiments to verify or enhance the principles and cues adopted in this study.

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AR-Lab for Learning Science Concepts: Two Case Studies

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Abstract: The purpose of this study was to investigate the effects of augmented reality laboratory on students' learning of science concepts. Two cases were implemented and examined, including learning of convex lens image forming for junior high school students and learning of electrochemistry concepts for senior high school students. The results revealed that (a) the use of augmented reality helped learners achieve better knowledge application performance and (b) students showed positive motivation toward science learning.

Keywords: augmented reality, learning strategy, scaffolding strategy, motivation

1. Introduction

The course of convex lens image forming at junior high school level and the electrochemistry concepts for senior high school students are two abstruse lessons in physics and chemistry; it is due to the reason that students can hardly imagine the form of light and electrochemistry, they have the difficulty constructing their concepts. Learners have plenty of experiences related to light and electrochemistry in daily lives, but light and electrochemistry have features such as untouchability and unobservability, hence students would possibly come up with various personal thoughts and ideas (Enyedy, Danish, Delacruz, & Kumar, 2012). If such abstruse concepts can be presented with virtual animation or gamification by digital technologies, it would be tremendously helpful for students to learn the abstract concepts in science (Tatli & Ayas, 2010).

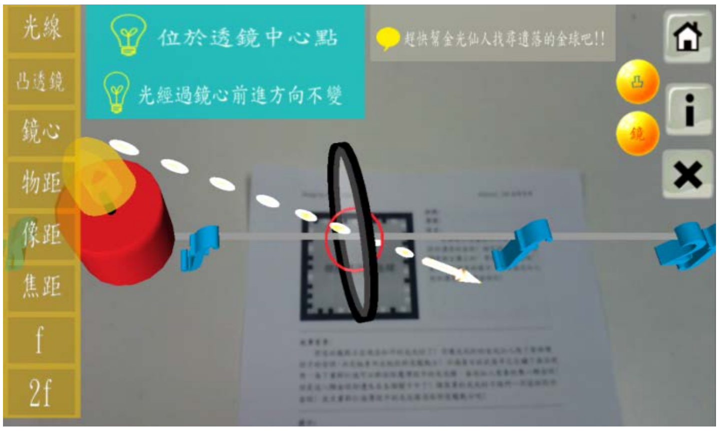
The technology of augmented reality had been renowned, and its most remarkable feature was the combination of virtuality and reality in which the users could interact with the augmented virtual objects in the real world and attain more real experiences of interactions. Augmented reality combines both features of virtual environment and real world thus it is possible to operate virtual objects in real world (Cuendet, Bonnard, Do-Lenh, & Dillenbourg, 2013). With this feature, virtual information can be added to experimental teaching instruments as to provide more assisted information for the learners during experiment operation (Fiorentino, E-Uva, Gattullo, Debernardis & Monno, 2014). Augmented reality is an innovative method of learning for simulation experimental teaching; in comparison to virtual experiment, learners can self-explore in augmented reality and combine with real world, which is extremely helpful for experiments with abstract concepts. Hence, if learning with the help of augmented reality during hands-on experiment sessions, the learners could gain such experiences from experiments and experience the micro worlds of chemical reactions or physics concepts via augmented reality.

Furthermore, game-based learning can be an inspiring and effective way of learning. Gaming allows learners to solve tasks in virtual scenarios and construct knowledge during the process (Prensky, 2001). The gaming situations allow learners to attain the sense of challenge and feel the excitement during learning. However, in the digital learning environment learners may have difficulty in attaining feelings and experiences of the real world while they are operating the objects virtually, which will lead to the possible inability to connect concepts with reality. Thus, if learning in the real world environment, learners can be helped efficiently construct knowledge (Arslan, Moseley, & Cigdemoglu, 2011). In comparison, augmented reality is situated between real and virtual environments. Augmented reality scans environment or objects in reality via sensor devices and superposes virtual information on scenes of reality by user interface; users interact with real or virtual objects to gain experiences of augmented reality. Billinghurst (2002) suggested that the application of augmented reality in education may have three advantages, including (1) allowing learners to interact instantly with virtual objects under real environment; (2) containing real teaching materials so leaners could operate with instinct; and (3) promoting learning transfer smoothly between virtuality and reality. Therefore, with the expectation to let learners experience interesting experiments and improve comprehension and application by the assistance of digital technologies, the present research employed the augmented reality technology with gamification to (1) investigate the effect of augmented reality on junior high school students' performance and motivation toward the learning of convex lens image forming and (2) examine the effect of augmented reality on senior high school students' performance and motivation in learning electrochemistry concepts.

2. Implementations

2.1 Case 1: Learning of Convex Lens Image Forming—Dragon Fighter

The purpose of *The Dragon Fighter* was developed for learners to learn the Convex Lens Image Forming knowledge by conducting the augmented-reality experiment. As shown in Figure 1, at the first stage, learners had to collect 8 golden balls by going through the prior concepts. As shown in Figure 2, at the second stage, learners need to assemble a firearm by performing the image forming in different object distance. In more details, learners need to fabricate the legendary lighting gun with the procedure of fabrication, including (1) gun barrel making: learners had to move candles and boards to the double focal distance and click on the learning content, (2) gun body making: learners had to move the candles and boards within double focal distance and then click on the learning content, (3) gun pistol making: learners had to move the candles and boards less than the focal distance and then click on the learning content, (4) magazine reloading: learners had to move the candles and boards greater than double focal distance and then click on the learning content, and (5) gun coloring: learners had to move the candles and boards at the focal distance and then click on the learning content. Finally, at the last stage, learners had to apply the learnt knowledge from the previous stages and defeat the evil dragon by applying the image forming steps of convex lens image forming, including (1) draw the light of parallel principal axis, (2) draw the light which travels through doubled focal distance, and (3) draw the light that travels through the mirror center. When learners completed such steps correctly, the legendary lighting gun would appear and the evil dragon fighter will be defeated.



<u>Figure 1</u>. Review prior knowledge and collect golden balls.

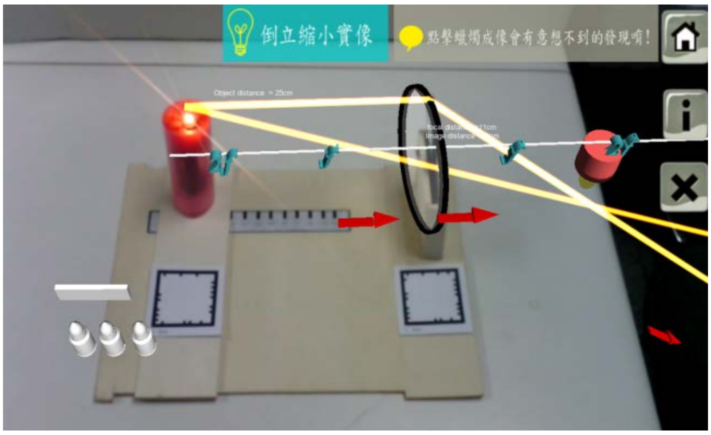


Figure 2. Operate AR experiment to get firepower.

2.2 Case 2: Learning of Electrochemistry Concepts—Manufacturing Iron Man

The AR-laboratory of the *Manufacturing Iron Man* game aimed to help the learners comprehend electrochemical reaction concepts by collecting electrical power for Iron Man as shown in Figure 3 and Figure 4. Two experiments were implemented including (1) the zinc-copper battery and (2) electrolysis and electroplating. Powering up Iron Man was employed as the cumulated feedback structure for learning. Iron man will be powered up gradually when learners conduct correct actions during the experiment. Finally, Iron Man will get enough power to fly and fight against the enemy.

Figure 3. The gaming task challenges the learner to power up Iron Man.

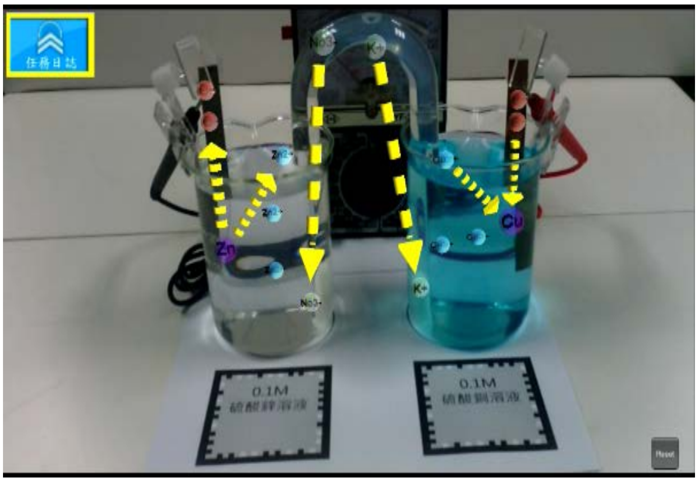


Figure 4. The dynamic motions of electrons were presented using AR.

Hybrid Game-based Learning Research at English Class of Primary School

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Abstract: As ancient tricks enjoyed by most people, game and game-based learning has been long valued by educators. However, there exist some obstacles for the application of educational games in formal school education. For example, some content in games has nothing to do with learning, or the content doesn't match the learning goals. While, in this aspects, "Light games" can do a good job.
We find that game-based learning is indeed used by teachers in the classroom nowadays, but most of form is offline, not online. This paper first sorts out the common offline game-based learning methods. Then based on these traditional ways, the paper designs the corresponding online methods: the construction of Digital Library, designing and developing related application, etc.. In the end, the paper advocates the concept of "Hybrid Light Game-based Learning".

Keywords: game-based learning, online game-based learning, offline game-based learning, light game

1. Introduction

As ancient tricks enjoyed by most people, game and game-based learning has been long valued by educators. Vygotsky thinks that learners can use their imagination to satisfy themselves through the games (L. Vygotsky, 1967). Chamillard points out that if learners can learn things with simple games, then they can be more active in the learning (A. T. Chamillard, 2006). Virous et al. also find that learners can enhance the learning motivation and learning effects when using game-based learning approach (M. Virvou, G. Katsionis, and K. Manos, 2005). Then what is game-based learning?

On the basis of the previous theories, this paper defines game-based teaching as a teaching method combining effectively games and teaching, entertainment and education while focusing on children's comprehensive development. It plays an indispensable role in arousing children's enthusiasm for learning, developing a right cognitive need and promoting their individual socialization as well as their healthy physical and mental development.

Therefore, recently, Game-based teaching has been commonly applied in lower-grade education in the primary school in recent years (Nannan Hou, 2014).

"Light Games" can be expressed in the following formula:

"Light Game" = educational software + intrinsic motivation of mainstream games. Light Game and Serious Game are similar in some aspects, but the concepts are not entirely coincident. Both of them emphasize that entertainment is not the main purpose. But besides this aspect, Light Game particularly emphasizes the close integration of games and courses, and requires that application in teaching should be considered when the Light Game is designed in the beginning(Junjie Shang, Shaoyong Zhuang, Yu Jiang, 2011).

Recently, we have collected 54 instructional design programmes from 12 schools in China. We find that almost all of them are offline game-based learning. To be sure, many small games are suitable for offline form, such as Drama Performance. However, for others, online form has more advantages: Firstly, as the digital natives, primary school students are very familiar with online activities; Secondly, online games can help teachers save time of preparing real teaching properties and be conducive to sharing resources among teachers; Thirdly, the ultimate advantage of online game-based learning is to save a large amount of data which can provide feedback in time to the players as well as teachers and parents. The feedback can be as teaching reference for teachers, and parents can also get to know children's real-time learning situation.

This paper tries to introduce several commonly used offline game-based learning methods and put forward my design about corresponding online game-based learning methods.

2. Offline Game-based Learning Method

The following challenge forms are often used by elementary school teachers in the classroom: speed challenge, reaction challenge, memory challenge, observation challenge, imagination challenge, idea challenge, and so on (Jie Zhang, 2014). This paper mainly introduces several game-based learning methods from three aspects of English learning (pronunciation, vocabulary, sentence / writing).

2.1 Pronunciation

Here comes the introduction of the riddles and Hacky Sack.

(1) Riddles.

The game of riddles has easy rules and easily operated, and students usually take actively part in it. The game can help train students' listening and speaking ability, develop intelligence and promote strategic thinking. For example, the following two riddles are designed according to the specific meaning and pronunciation of the letters:

What letter is a kind of animal?

What letter is a kind of drink?

In this game, students need quickly match the pronunciation of 26 letters with that of a certain animal or drink, which can help review alphabet.

(2) Hacky Sack.

This game helps exercise the pronunciation or translation of words between Chinese and English. In this game, teachers need to prepare cards with English words being just learned in advance and post them on the blackboard at class. The students stand in a line and take turns to throw the sandbags to the cards. If students throw at words successfully, they need to read the chosen word or translate it according to the teachers' requirement. If the students couldn't hit any card or give the right answer, they need to stand back to the end of the line until they succeed (Hengbati·Yiliyasi, 2014).

2.2 Vocabulary

About vocabulary, three games are to be introduced:

(1) Word Riddle.

The riddles are mainly designed according to the pronunciation, spelling and meaning of the English word. Teachers need to choose appropriate riddles, considering the students' vocabulary.

For example: Which word has three "a"s and two "n"s in it?

(2) Word competition.

In this game, the teacher puts forward an English letter, and then the students need to speak as more as English words beginning with the given letter. If necessary, teachers can limit the categories of words. Of course, student giving the most number of correct words win.

(3) Making new words.

This is a very classic game. This game has many forms of operation. For example, the teacher prepares 78 cards, writing one letter in each card, that is to say 26 letters occur three times repeatedly, and then put them into a box. Students take 15 cards from the box every time, and make different words using these 15 letters. In a limited period of time, the students giving the most number of words win.

For example, A B C D E F H I M O P S T V W. If students take these 15 letters, they can make the following words: we. Stop. Me. Face. Mop. Have. Fact. Fat. Map. Tea. Pea. Fast. Most. Hi. Steam. Eat. Team. Pop. Pat. Meat. Past…

2.3 Sentence/Writing

(1) Survey Task Game.

This kind of game has inquiry value. Letting the students carry out the investigation task using English can not only improve the students' ability of English application, but also develop the students' ability of analyzing and solving problems. But for the elementary school students, they have limited knowledge and inquiry ability, so the teacher should design some easy topics.

For example, after learning words about fruits, the teacher can require students to investigate the proportion of the most favorite fruits. The whole class is divided into several groups. Each group makes a table with students' names and words about fruits in English, such as peach, grape, apple and so on. Students in the group investigate the situation of their favorite fruits using the sentence like "What is your favorite fruit", and then get the promotion. Students need to use English when reporting as well.

About this kind of investigating game, the following will not introduce online form. Because we think that offline form is more suitable for this kind of game.

(2) Role Play.

Role Play is a game that is very suitable for English learning. English is a communication tool in essence. Making a student play a role to stimulate the real situation communicating using English is a quick way to improve English. It is a kind of situational teaching method to help students get into the situation quickly. In the English textbook, there are many dialogues that are suitable to use Role Play.

3. Online Game-based Learning

In China, the class in primary school is generally 40-45 minutes long. But some researches show that the children's continuous attention time is not more than 30 minutes, and the younger children are, the shorter the time of their continuous attention is. Adding some online games they are interested in can help attract their attention (Zhengye Pan, 2008).

According to the above offline game-based learning method, this article will provide the design of the online form of game-based learning. In order to more clearly show the corresponding relationship between offline game-based learning and online game-based learning, the article makes the Table 1. Following the table, the article will introduce the online game-based learning in detail.

Table 1: Corresponding Relationship Between Offline Game-based Learning and Online Game-based Learning

Aspects	Offline Game-based Learning	Online Game-based Learning
Pronunciation	Riddles	Resource Libraries
	Hacky Sack	Online "Hacky Sack"
Vocabulary	Word Riddle	Resource Libraries
	Word competition	
	Making new words	
Sentence/Writing	Survey Task Game	
	Role Play	StoryMaking

(1) Building Resource Database

We can build a riddle database that is made of many categories, such as pronunciation class, vocabulary class.

In the pronunciation class which is made of many categories as well. Such as, alphabet, then the following two examples can be put into this part:

What letter is a kind of animal?

What letter is a kind of animal drink?

(2) Online "Hacky Sack"

We want to design a teaching software, and the main interface of the game is grid with 9 English words which could not be seen. Only when the button of "start" is pressed, one of these words can be displayed randomly. According to the teaching objectives, teachers can require students to pronounce the word, or do the translation exercises between Chinese and English.

This game can be used for pronunciation, and translation. The software needs to support the function that teachers can update the words in the background. That is to say, this game is mainly to provide a platform for teachers, and can be used in different stages of teaching. Teachers only need to input different words in different stages.

(3) StoryMaking

According to the game "Role Play" mentioned in the previous paper, if it is online, I wish to develop such an application. Like RPGMaker, the software can provide some different scenes and some animated characters. After the teacher provides a theme or topic, students can design different scenes and different animated characters to make a story. In the story, the asides and dialogues need to be finished using English. The software can generate the story to a video directly.

This game can help teachers practice the concept of making homework become "homeplay". Teachers can ask students to make a story based on the new words and new topic learnt at class to be their homework. If the homework is required before the class, then it becomes the flipped classroom. The students need to learn the new words and make a story. Then at class, the teachers can assess the video. What is more, teachers can view students' video stories after students finish their stories.

It is important that these data are not only retained, but also timely feedback to the players, teachers and parents.

Conclusion

In this paper, the design of game-based learning is suitable to Chinese class in some way. Because to some extent, "Chinese" is also learning and application of a kind of language.

To be sure, offline game-based learning method has many advantages, such as Drama Performance is fit for the offline form. Therefore, we believe that online and offline should be combined to be used. Like the concept of "Hybrid Learning", we advocate the concept of "Hybrid Light Game-based Learning".

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3. Summary of Results and Conclusions

The findings of Cases study 1, Learning of convex lens image forming, suggested that (a) the augmented reality learners outperformed the virtual reality learners on both the knowledge comprehension performance and the knowledge application performance; and (b) all learners showed positive learning motivation and the augmented reality learners revealed higher degree motivation toward learning. Furthermore, Case study 2 suggested that (a) while receiving the static augmented reality learning, the procedural guidance group achieved better learning application performance than the question guidance group; (b) as for the knowledge comprehension performance, the static augmented reality group outperformed the dynamic augmented reality group; and (c) students showed positive motivation toward learning Chemistry no matter which augmented reality type they used, especially students who used the static augmented reality revealed higher motivation than those who used the dynamic augmented reality. Finally, the implementation of these two AR-laboratories suggested that the augmented reality technology can be integrated in science experiments to help middle schools learners to operate and learn the abstract science knowledge and, at the same time, enhance their learning motivation. However, the interactive effects of augment reality and other learning factors need to be further examined with more rigid research designs in future studies.

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Using Digital Game-Based Adventure Education Counseling Course to Adjust Primary Students' Interpersonal Deviant Behaviors

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Abstract: This paper designed a digital game-based adventure education counseling course to adjust ten students' interpersonal deviant behaviors at a primary school far from cities in Taiwan. Researchers take quasi-experimental design to investigate the effectiveness after the course with questionnaires, short-term reflections and feedback forms. The results show that there were significant differences between pretest and posttest results which proved that the course can effectively adjust students' interpersonal deviant behavior and those games were felt satisfied.

Keywords: Digital Adventure Education Game, Human Relations, Deviant Behaviors, Group Counseling.

1. Introduction

In the information society, people have to make more decisions in their daily life. Thus, it is important to train people to have correct attitudes for decision making since their childhood. Proper decisions normally lead to appropriate behaviors which can help people to build great interpersonal relationships, increase self-confidence, reach self-fulfillment, as well as be responsible for their own behaviors. Conversely, inappropriate behaviors in class would be regarded as "deviant behaviors" in scholarly terms. It would cause relationship breakups and psychological diseases. Students' interpersonal deviant behaviors are considered outcomes of maladjustments to situations, which brings normally troubles to parents and teachers. It includes all kinds of situations including people's incapability of solving problems, changing fixed behavior patterns to adapt to the environment. When they encounter difficulties, they demonstrate deviant behaviors. In addition, deviant behaviors are normally long-term behaviors. One can usually find signs of deviant behaviors in juvenile delinquents from their childhood. Therefore, if deviant behaviors can be addressed and prevented since one's childhood, it might have reduced the probability of juvenile crimes.

The participants in this research are students who have mild deviant behaviors such as teasing classmates, playing pranks, noncooperation, and breaking rules. The primary stage of school intervention mainly focuses on the prevention, in which counselors teach students who have school adaption problems. The second stage mainly focuses on interventions, in which counselors help students who have signs of deviant behaviors to make adjustments. The third stage mainly focuses on postventions, in which counselors make treatments to students' deviant behaviors.

In this research, a digital game-based adventure education counseling course was developed to integrate digital adventure education games into group counseling process which guides to the intervention of the secondary stage. In the game-based counseling course, counselors might be able to see behaviors which were unable to be observed in the individual counseling process. The course was conducted with small student groups so that counselors can observe children's social behaviors in groups. Besides, the activities of digital adventure education games provide children different experiences such as practicing social skills, generating more positive interpersonal behaviors. Therefore, the purpose of this study is to investigate whether the primary school students' interpersonal deviant behaviors and interpersonal relationship concepts could be adjusted, and to know students' satisfaction levels to the digital adventure education games.

2. Literature Review

2.1 Deviant Behaviors

Deviant behaviors are the behaviors that individuals contravene social norms, group rules, or people's expectations (Gottfredson & Hirschi, 1990; Brezina, 2000). They lead to problems of personality developments and interpersonal relationships. The categories of deviant behaviors are defined differently in different countries, cultures or organizations. When deviant behaviors cross the legal boundaries, they become crimes.

In past few years, many researchers explored the deviant behaviors from different perspectives. Deviant behaviors are divided into six categories from social perspectives. a). Extrovert behaviors, which refer to the rebellious and anti-social behaviors, such as truancy, theft, and fight. b). Introverted behaviors, which refer to the emotional disturbance, such as autosadism and suicide. c). Academic adaptation, which refer to poor academic performances due to bad behaviors, such as cheating or lazy. d). Bad habits, which refer to the borderline personalities, such as nail biting, stammer or drug user. e). Anxiety disorders, which refer to situations caused by overanxiety, such as nervous, vomit, or hysteria. f). Mental illness, which refer to those who are divorced from reality, such as schizophrenia and bipolar disorder (Wu, 1985). Similarly, Hoghughi and Hoghughi (1992) categorized children's deviant behaviors into eight kinds. a). Lack of socialization: scuffle or lie. b). Anti-social behaviors: truancy or theft. c). Attention-deficit: lack of concentration or patient. d). Type of anxiety/ retraction/ moodiness: nervous or shy. e). Lack of interaction: staring into space or apartness. f). Lack of social competence: bad peer relationship. g). Mental patients: speaking incoherently and intelligibly or auditory hallucination. h). Hyperkinetic syndrome: talkativeness or restless.

2.2 Digital Game-based Adventure Education Group Counseling

Peer group is a small society. Members in the group would gradually show their innate behaviors as the time passes (Yalom & Leszcz, 1992). Consequently, group is the best learning tool for practicing interpersonal interactions. Members in the groups would improve self-confidence, adjust deviant behaviors, and enhance peer relationship through group works. Group counseling has six characteristics, including attraction, leadership, norms, expectations, communication, and cohesiveness (Johns, MacNaughton, & Karabinus, 1989). With those advantages, groups can provide students with deviant behaviors a place to vent their negative emotions, an opportunity to observe others' behaviors, and a way to learn effective social abilities (Berg, Landreth, & Fall, 2013).

This research used group counseling due to its functions of multiple ways of interpersonal interactions and communication conditions. In the course, group members would rebuild the past conflicts and re-experience the interactive patterns. By observing the interactions, counselors can assist members to learn new patterns of interpersonal interactions. This knowledge transfer would help students to put thoughts into actions. The course helps students to correct their deviant interpersonal behaviors, both from learners' gaming experiences and reflection feedbacks after each game. Thus, children have opportunities to modify their deviant behaviors in group counseling. In every short-term reflection, the contents were connected to their living experiences. Children reflect on the events, adjust concepts, and put new thoughts into practices (Teyber, 2000).

3. Digital Game-based Adventure Education Counseling Course

3.1 Design of Digital Game-based Adventure Education Counseling Course

Digital adventure education games functioned as the medium in the group counseling course. Students played those games cooperatively and learned interpersonal interaction methods in the gaming process. The participants in this study were ten 5th grade and 6th grade students from a suburban city in Taiwan.

To investigate the thoughts and behaviors of the participants that changed throughout the counseling course, the activity feedbacks were designed in accordance to the goals of each game; and the form of each activity reflection contents were formulated by counselors depending on the group conditions (Table 1).

Table 1: Activity goals of the games.

	Group goals
Mind Collage	1. Getting familiar with group members. 2. Helping members to know their own characteristics and their influences to their interpersonal relationships.
Moon Ball	1. Experiencing the sense of achievement of mission completion. 2. Being aware of their roles in the groups.
Polar Bear	1. Understanding the messages delivered during the discussion. 2. Understanding that the communication is two-way and finding ways to reduce misunderstanding.
Group Balance	1. Experiencing the importance of listening during communication 2. Understanding the meaning of body language.
Calculator	1. Finding the skills to solve interpersonal conflicts and figuring out 2. Finding out their own interaction patterns.

3.2 Reflections of The Digital Game-based Adventure Education Course

The reflections after each game can enhance learners' self-awareness, helping them to rethink and internalize learned issues after every activity which can accelerate their adjustments to interpersonal deviant behaviors. The reflection questions and details of activity feedbacks are as follow:

Counselor's guided reflections of Mind Collage:

a) Did you find the differences between your original thoughts of yourself and the game feedbacks?
b) Which object did you spend the most time on? Why?
c) Was there any object that troubled you? Why?

Reflection feedback: Self-concept refers to individuals' ideas about themselves including responses and preferences of all kinds of situations. It is the first step of understanding and changing oneself. Keeping the opening attitude to suggestions is the beginning of revaluate oneself.

Counselor's guided reflections of Moon Ball:

a) What did you feel when the ball touches the ground?
b) What were the main factors that stop your group from reaching the game goals?
c) What role did you act in this game? How did you perceive other members' roles in the game?
d) What feedbacks would you give to your members?

Reflection feedback: Moon Ball is a game that participants can discuss and generate common goals. In the game, one learns the importance of strategies such as producing high-performance within confined rules, setting up goals positively, and having great team works. Problem-solving and cooperation are the abilities that come from actions rather than insights.

Counselor's guided reflections of Polar Bear:

a) What did you hear or see in this game?
b) Could you express your opinions or ideas easily?
c) Did any thoughts from others influence you? What was that?
d) What feedbacks would you give to your members?

Reflection feedback: Listening is one of the most important abilities in the interpersonal interactions. It leads to the understanding to the logics of stories. Putting oneself in the storyteller's position, trying to figure out the implications of story, learning to hear what is behind the words, are the important skills of communication.

Counselor's guided reflections of Group Balance:

a) Which stage made you most nervous? Which stage let you feel relieved?

b) What should each member do to get the groups complete the game? What things did you learn?
c) How did the members support each other? What were heard the most?
d) What feedbacks would you give to your members?

Reflection feedback: In the game, the breakable item on the balance board refers to "Trust" in the interpersonal relationships. Trust and support exist side by side. One small mistake can cause chain reactions that might destroy long-term relationships.

Counselor's guided reflections of Calculator:

a) Was the plan changed during the process?
b) How did the members discuss and come up with the effective plan?
c) How did group complete missions with cooperation?
d) What feedbacks would you give to your members?

Reflection feedback: Calculator is an exciting game. It is can train team works and strategies to become a high-performance team. Members have to learn to trust each other, use appropriate strategies, and cooperate effectively to reach the goals.

4. Research Design

4.1 The Digital Adventure Education Games

The five digital adventure education games were developed by Unity3D. The five games were were developed based on five traditional adventure education activities chosen from "Experiential education-learning from 150 games" (Hsieh, Wang, & Chuang, 2008). The purposes of the five traditional adventure education activities were to train students' self-conception, team-building, cooperation, and human interactions. The learners' gaming processes and interactive pattern were recorded by gaming system. Those data will be used to analyze the interactions between learners, game missions, and the environment contexts to see the possibility of learning transfer to adjust their interpersonal deviant behaviors. Except Mind Collage game, the other four digital adventure education games are all multiplayer games. The detail descriptions of the five games are as follow:

Mind Collage (Figure 1): According to psychological projection, players put the twelve objects into the frame in sequence: Rivers, Mountains, Farmlands, Roads, Houses, Trees, Humans, Flowers, Animals, Rocks, Bridges, and Suns. The finished picture will lead to the counseling feedbacks based on the analysis results.

Moon Ball (Figure 2): Group members need to keep the ball in the air as long as possible. Members have to use strategies to cooperate with each other game.

Polar Bear (Figure 3): In the beginning of the game, the facilitator tells a story about polar bears, which gives hints for completing the task. Then, the facilitator throws dices three times for giving more hints. After that, members observe, discuss, and induce for correct answers using the logistics of the story.

Group Balance (Figure 4): The game need to be played by three people. One keeps his balance on the board, and the other two keep pushing the board upward on the two sides until the board reaching the finishing line. The purpose of the activity is to increase members' cooperation strategies, reliance, and courage to face the challenges.

Calculator (Figure 5): Thirty ladybugs are marked with number 1 to 30 in the game. The goal of the game is to catch the bugs in sequence as fast as possible. If group members violate the rules, five seconds will be added as punishment. Four chances will be given to each group for completing the task. The best score will be recorded for competition between groups. The purpose of the activity is to train members to solve problems and communicate with each other. It strengthens group members' concepts and helps them to identify their roles.

Figure 1. Mind Collage

Figure 2. Moon Ball

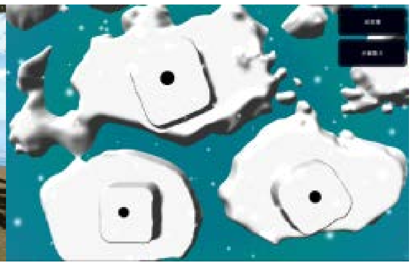

Figure 3. Polar Bear

Figure 4. Group Balance

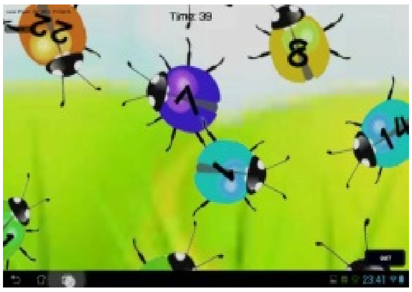

Figure 5. Calculator

4.2 Research Method

This research used quasi-experimental design. The ten students of fifth-graders and sixth-graders who had mild interpersonal deviant behaviors were referred by their mentors. For exploring the effectiveness of adjusting interpersonal behaviors and gaming satisfactions, the students needed to fill up the digital adventure education games questionnaire a week before and after the experiment. The five digital games of the digital game-based adventure education counseling course were conducted and guided by a counselor with forty minutes each week for five weeks. When each game ended, the feedback forms were filled by students and the counselor collected the thoughts and oral feedbacks from the students. After the experiment, the effectiveness of adjusting students' interpersonal deviant behaviors and gaming satisfactions were shown through the results of questionnaires, reflections and feedback forms. The experiment procedure was as figure 6.

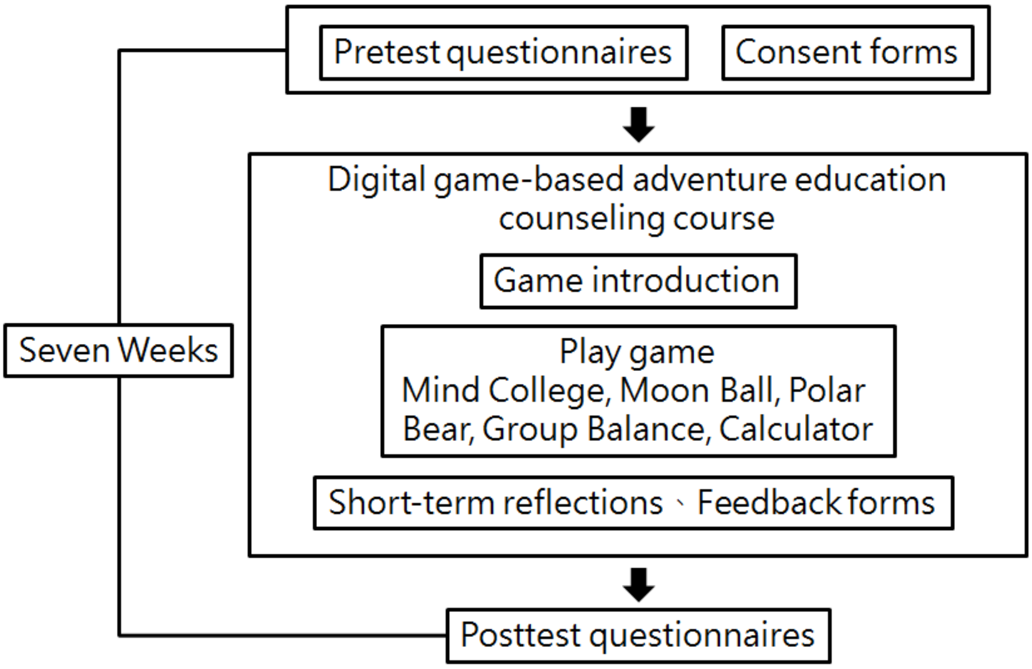

Figure 6. Experimemt procedure

The participants in this research were ten primary school students' with mild interpersonal deviant behaviors (Lack of socialization, Anti-social behaviors, Attention-deficit, Type of anxiety/ retraction/ moodiness, Lack of interaction, Lack of social competence, and Hyperkinetic syndrome) (Hoghughi & Hoghughi, 1992). Mild deviant behaviors identified in this study were emotional disturbance, disobedience, and violations. Emotional disturbance refers to inappropriate behaviors such as making pranks or fighting with peers due to unstable emotional status. Disobedience refers to the behaviors of disregarding teachers' regulations such as making noises in class or uncooperative with others. Violations refer to behaviors such as breaking rules that contribute to great influence to the class.

The digital adventure education games questionnaire was in 6-point Likert scale. Cronbach α is .70, Coefficient of Internal Consistency is .90. The questionnaire includes total of 37 questions. In the pretest, there are 15 questions about group interpersonal behaviors, including participants' perceptions to the group efficiency, group cooperation, and interpersonal interactions after participating the game-based counseling sections. Among which, there are 7 questions regarding to emotional disturbance, 5 regarding to disobedience, 3 regarding to violations behaviors. In the posttest, there are also 8 questions regarding to gaming satisfactions, which include gaming interactivities, guidance content, fun, challenges, and simulations.

5. Results

The course in this research included five digital games. The course content was designed for 5 to 9 graders. Therefore, this research targeted 10 fifth- and sixth-graders to participate the course. The ages of the students are between 12 and 14. There were 4 sixth-graders, and 6 fifth-graders; among which, there were 9 males and 1 female. Total questionnaire received were 10 with recovery rate of 100%.

Since the sample size of this research is below 30, Wilcoxon signed-rank test was used, and the results were shown in Table 2. The results show that group interpersonal behaviors aspects has reached significant differences (z=-2.091*, p=.037), which signified that the 10 students with mild interpersonal deviant behaviors were improved after taking the digital adventure education counseling course.

Table 2: Statistic results of group interpersonal behaviors.

Topic		N	Mean	SD	z	p
Interpersonal Behavior	pretest	10	5.127	.5564	-2.09*	.037
	posttest	10	5.507	.5166		

*$p<0.05$

The mild interpersonal deviant behaviors of the 10 students included teasing classmates, making pranks, uncooperative, breaking rules. The questionnaire of this research investigated three aspects about students' perceptions to their own deviant behaviors both before and after taking the game-based counseling course. In the emotional disturbance aspect, all 10 students showed willingness to respect different opinions from group members (Q8) with pretest (m=4.8) and posttest (m=5.8); think in other members' perspectives (Q2) pretest (m=5.3) and posttest (m=5.6); respect people in different ethnicity, beliefs, and physical conditions (Q3) with pretest (m=4.4) and posttest (m=5.0); worry about whether other members like the things they have done and do not make arbitrary decisions (Q14) with pretest (m=4.9) and posttest (m=5.6).

In disobedience aspect, after the course, all ten students who had the situations of arguing with classmates and refusing to obey teachers' orders showed they would like to discuss with their classmates peacefully even when they have divarication (Q7) with pretest (m=5.2) and posttest (m=5.3); handle appropriately about the unfair rules or fouls results (Q9) with pretest (m=4.6) and posttest (m=5.7); play their roles no matter they are leaders or followers (Q12) with pretest (m=5.3) and posttest (m=5.7).

In the violation aspect, the violation followed once students have emotional labiality or unmoral interaction between classmates and teachers. After the course, 10 students showed they have to focus on listening to member discussion rather than against that.

The main course content of this research is the digital adventure education games. Therefore, the design of the gaming system would directly influence students' learning effectiveness. The gaming satisfaction results showed that the overall satisfaction level of all aspects were above 5.8, which includes gaming interface, situation setup, gaming interactions, fun, adaptively, problem-solving, competitions, and challenges. It was evident that the games designed in this research were both satisfactory in both manipulations and learning content.

The feedback forms were used after each digital adventure education games with the reflection sessions. Students filled up the feedback forms with open-ended questions.

In stage one, from the feedback forms and reflections of Mind Collage game, students thought the game was fun, and could uncover their hidden personality. In the beginning, most students have negative thoughts about themselves, such as having bad behaviors, unable to make friends, timid, and impulsive. After taking the counseling course, they found some hidden characteristics such as active, thoughtful, adventurous. The students said, "I think the games were fun, and I find a new self in myself" (G1-07-HBH), and "I get to know more about myself in the activities" (G1-07-THS).

In stage two, from the feedback forms and reflections of Moon Ball game, students experience the process of completing tasks cooperatively. Students can clearly find their own roles in the group, can positively and actively participate group discussions, and generate strategies for completing tasks. The students said, "We discussed gaming strategies together" (G2-02-HBH)), "I learned how to interact with others" (G2-03-HBH), "Group members would support me by my side" (G2-02-WTY), and "We help each other, face challenge, interact, cooperate, and discuss in the process" (G2-03-CTH).

In stage three, from the feedback forms and reflections of Polar Bear game, students learned about the importance of listening and expressing their thoughts and feelings. The students said, "I tried to listen to other group members and felt interesting" (G3-05-CYJ)", and "I found it important to let others understand before exchange ideas" (G3-05-THS).

In stage four, from the feedback forms and reflections of Group Balance game, students can observe members thoughts, feelings and messages of their boy language insightfully due to the time limit. Also, they can learn and understand meaning of cooperating with each other, sharing enjoyments, and getting together peacefully. The students said, "We needed to help each other, get together peacefully. Do not bully!" (G4-03-CYJ), "Make a suggestion or give an idea" (G4-04-CYJ), and "Share my ideas and suggestions to discuss" (G4-03-HYC). At the point of the seventh week, students found others advantages gradually. For example, "Actually, everyone had their goodness and a good nature" (G4-05-HYC) and "It was a great thing to help people and I also felt relaxed" (G4-06-HYC).

In stage five, from the learning sheets and reflections of Calculator game, five students said they would resolve their bad emotions in the activities such as playing basketball, jogging, and riding bicycle; the others said they prefer quiet ways, such as, chat with friends and teachers, or sleep. Those feedbacks showed that participants could use positive ways to face and solve their negative emotions, willing to accept different suggestions and thoughts, and solve interpersonal conflicts after the course. After the 7-week counseling course, researchers followed up the 10 students' interpersonal deviant behaviors in their own classes investigating whether the deviant behaviors were adjusted, and whether the 10 students could get along with their classes better. The mentors expressed that two of the students' interpersonal deviant behaviors were adjusted after the course. The other eight students, although not fully adjusted, were in better conditions. The eight students would show interpersonal deviant behaviors once their classmates kicked up a fuss. There might be two reasons: 1. This experiment was conducted once a week with forty minutes each, five times in total. In the course, the 10 participants had obvious improvement. However, it was difficult to make far learning transfer from two hundred minute course. 2. In the course, the 10 participants were familiar with the pattern of solving problems and completing missions, but they had to rebuild the new patterns when they went back to their own classes. It was hard to adjust the interpersonal deviant behaviors in their classes if mentors did not follow up with the course to build the pattern of positive interpersonal interactions in their own class scenes. These issues will be regarded and considered in the future studies.

6. Conclusion

The purpose of designing the digital game-based adventure education counseling course in this study is to investigate the effectiveness of adjusting the interpersonal deviant behaviors of the ten primary students, and their gaming satisfaction. Furthermore, their thought and feedbacks in short-term reflections and feedback forms about the course were recorded after the course, for example, increasing interpersonal interactions and positive thinking, controlling negative emotions, adjusting deviant behaviors and having positive evaluations for self-adjustment.

As a result, the 10 primary students' emotion intelligence and interpersonal deviant behaviors regarding to emotional disturbance, disobedience, and violations (Lack of socialization, Anti-social behaviors, Attention-deficit, Type of anxiety/ retraction/ moodiness, Lack of interaction, Lack of social competence, and Hyperkinetic syndrome) in group were improved through the digital game-based adventure education counseling course (Hoghughi & Hoghughi, 1992). What's more, participants feel the digital adventure education games were satisfying. Though those students' interpersonal deviant behaviors were adjusted within the counseling course, some mentors found those students still had the situations of interpersonal deviant behaviors when they went back to their original classes. The cause of the situation is their classmates who they meet in class lacks the experiences of counseling course. If the digital adventure education games can be integrated into the formal courses in their classes, the problems might be solved. Consequently, all students not only learn the knowledge of formal course but practice positive interpersonal interactions.

In the future, researchers will help the counselors at schools use the interdisciplinary media in counseling. It was rare to see digital tools integrated in counseling in the past. This research hopes to find evidence that of the use of digital adventure education games can have similar effectiveness to traditional counseling activities.

Acknowledgements

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Meta-work on Leveraging COGBLe in Formal School Education

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Abstract: This is a work-in-progress paper in which we discuss the meta-work on our prior research on integrating constructivist online game-based learning (COGBLe) into formal school education. Farmtasia is an online game that we have developed to implement our COGBLe initiative. Based on the theoretical foundation of distributed authentic professionalism, we are further designing and implementing a number of non-player characters (NPCs) in Farmtasia, aiming to better support non-gamer students in the course COGBLe.

Keywords: COGBLe, game-based learning, non-gamer students, non-player characters, Farmtasia

1. Introduction

The advancement of information and communication technology (ICT) over the last decade has changed the landscape of human interactivities (Pachler et al., 2013; Prensky, 2012). From the perspective of education, researchers and technological educators have been looking into the potential of ICT for providing learners with new opportunities of constructivist learning (Papert, 1993; Piaget, 1970). One of the foci has been on constructivist online game-based learning (COGBLe).

Drawing on the notion of situated learning (Lave & Wenger, 1991), we have been studying the possibility of harnessing COGBLe in school education to scaffold students to learn in an authentic, constructivist manner, through interactive multi-player gaming. We proposed VISOLE (Virtual Interactive Student-Oriented Learning Environment) — a pedagogical approach to integrating COGBLe into formal curriculum teaching at school, and developed Farmtasia — an online multi-player interactive game for Geography education (Jong et al., 2011).

In our previous study on VISOLE with Farmtasia (Jong, 2015), compared to the traditional teaching approach, in terms of knowledge acquisition, we obtained a significantly positive results on the pedagogical effectiveness of this educational innovation on students in general, but not on non-gamer students (who had very little prior experience in online gaming). The analysis revealed that the gaming tasks in Farmtasia had introduced strong "extraneous cognitive loads" (Sweller, 1988) in the non-gamer students' learning process. They found the game was so difficult to play. Their bad ongoing gaming results also frustrated them a lot.

Instead of drawing a simple conclusion about VISOLE or COGBLE in general is not suitable for non-gamer students, we are interested in further investigating how to design and implement more effective scaffolds (Brush & Saye, 2002) in Farmtasia so as to better support these students in the COGBLe process. This working paper discusses the meta-work based on our previous study (Jong, 2015).

2. Distributed Authentic Professionalism

Shaffer (2007) argued that games can change education because game technology can empower students to learn on a massive scale by doing the things that humans really do in real-life. He deemed that members of a profession have an epistemic frame—a particular way of thinking and working. From the learning perspective, epistemic frames are the conventions of participation to which learners become internalized and acculturated. Thus, developing people to be members of a particular profession is a matter of equipping them with a right epistemic frame. He proposed a game-design framework, *distributed authentic professionalism* — the distribution of authentic professional expertise between NPCs and players. Based on this framework, Shaffer and his colleagues developed a number of epistemic games which allow middle-school students to participate in simulations of various professional communities that they might someday inhabit. The communities include, for example, biomechanical engineers in *Digital Zoo*, and ecological thinkers in *Urban Science* (Gee & Shaffer, 2010)

3. Farmtasia: The Second Version

VISOLE consists of three pedagogical phases grounded on the theoretical foundations of scaffolding (Vygotsky, 1978), reflection (Dewey, 1938), and debriefing (Crookall, 1992). In Phase 1 — Scaffolding, through a number of face-to-face lessons, the teacher equips students with "just enough" preliminary high-level abstract knowledge as their prior knowledge to the next phase. The activities in Phase 2 — GBL and Reflection crossover with Phase 3 — Debriefing. Phase 2 deploys an online multi-player interactive game portraying a virtual world in which each student will play a role to shape its development. All tasks in this virtual world are close to the real life and problematically open-ended. In order to accomplish the tasks, students have to acquire new knowledge themselves from some designated learning materials or the Internet. As every single action can affect the whole virtual world, they have to take account of the overall effects associated with their gaming strategies on others. In addition, after each round of gaming, students are required to write a short journal to reflect on what they have learned in the game. In Phase 3, the teacher observes students' gaming proceedings at the backend, and will extract interesting or problematic scenarios in the game to conduct case-study-based debriefing with students through a number of face-to-face lessons. The full details of VISOLE can be found in our previous publication (Jong et al., 2011).

Farmtasia is an online game that we have developed to implement the VISOLE pedagogy. It is a round-based game with 12 rounds in total. Every round (1 hour) equates to six months in the virtual world. The content of Farmtasia is based on the Agriculture module in the senior secondary Geography curriculum in Hong Kong (Hong Kong Examination and Assessment Authority, 2014). Farmtasia features interacting farming systems (cultivation, horticulture, and pasturage) with sophisticated simulations which are modeled upon near real-life geographical, botanical, biological, and economic models. Figure 1 shows the interface of Farmtasia. In the game, each student performs as a farm manager to run a farm composed of a cropland, orchard, and rangeland. He/she competes for financial gain (the quantified gaming outcome) of his/her farm with other students who are at the same time running their own farm somewhere nearby in the virtual world. The financial gain is determined by whether he/she can derive good strategies to yield quality farm products to be sold in the market.

Figure 1. Interface of Farmtasia

Adopting Shaffer's (2007) distributed authentic professionalism framework, we have tried to design and implement a number of new NPCs functioning as virtual tutors in Farmtasia for scaffolding non-gamer students in the course of COGBLe. Figure 1 shows some of these NPCs. At the beginning of Phase 2 of VISOLE, via interacting with the NPCs, students will obtain useful tips on starting up their gaming. In addition, we aim to make the NPCs to be more intelligent so that they will proactively appear in the game to offer weaker students "tailor-made" hints (which are automatically derived from their gaming proceedings in their early rounds of gaming).

Figure 2. Newly designed and implemented NPCs in Farmtasia

4. Coming Work

In order to develop precise and robust mechanisms for triggering the appearance of NPCs to just-in-time assist non-gamer students in Farmtasia, we are still working on analyzing the "big" gaming data obtained in our previous study (Jong, 2015). After working out the mechanisms, another piece of important work will be to compare the pedagogical effectiveness of this revised version of Farmtasia (viz. Farmtasia II) and the original version (viz. Farmtasia I). We believe the findings of our coming study can provide researchers and developers in the field with new insights into leveraging NPCs to address the problem of individual learning differences among students in the course of COGBLe.

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Implementation of Mario-like Digital Game in Chemistry Education: Results on Students' Perception

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Abstract: This paper presents the effectiveness of a Mario-like digital game, called "The Functional Group Game 1" on students' perceptions on six subscales: perceived learning, perceived ease of use, flow, perceived playfulness, enjoyment, and perceived satisfaction. The game was designed based on levels of the cognitive process dimension of the revised Bloom's taxonomy. This study was conducted on 74 twelfth-grade students to investigate students' perceptions toward the game. The results revealed that the student increased their perceptions after experiencing the game. In additions, gender difference has no effect on students' perceptions toward game-based learning of chemistry. Obviously, both females and males increased their perceptions on perceived learning, perceived ease of use, flow, perceived playfulness enjoyment, and perceived satisfaction after interacting with the Functional Group Game 1. It led us to conclude that the Functional Group Game could be an alternative way for promoting chemistry learning in Thai school science.

Keywords: Digital game, chemistry education, perception, Bloom's taxonomy, individual differences

1. Introduction

In 21st century, educational environment has been changed rapidly. Many advanced technologies make the learner finding knowledge from any source for anytime and anywhere such as laptop computer, computer tablet, or smart phone. In additions, visual representation technologies have become increasing important for facilitating students' learning in science (Suits and Srisawasdi, 2013). Digital media technologies have been applied for 21st century learning to make learner learning easier and to attract learner to learn with interesting things, especially the digital games. Because the digital games are used to make relaxation for most people, so learning with the games can promote of students' chemistry motivation. Sung and Hwang (2013) pointed out that combining games with educational objectives could not only trigger students' learning motivation, but also provide them with interactive learning opportunities. Previously, the study about using educational digital game in instructional chemistry such as Meesuk and Srisawasdi (2014) indicated that using educational game to support student' inquiry learning process named student-associated game-based open inquiry (SAGOI) could be an effective way in improving students' science motivation for fostering chemistry learning in the ionization energy topic. Moreover, using of educational digital game-based learning could support student' motivation even they have a positive or negative attitudes in learning (Nantakaew and Srisawasdi, 2014). However, there have been only a few reports of using such learning materials on organic chemistry learning in the functional group topic. Welsh (2003) reported that both chemistry majors and non-chemistry majors struggle with their first attempts to recognize the basic organic functional groups. Moreover, the instruction based on Bloom's taxonomy could encourage students' learning (Krathwohl, 2002). Such that it would be benefit for students' chemistry learning if they receive the attractive learning material as the digital game with Bloom's taxonomy.

Consequently, this study applied the Mario-like digital game to develop “The Functional Group Game 1” grounded by Bloom’s taxonomy. Specifically, the research questions were answered:

1) Do the students interacted with The Functional Group Game 1 perform significantly better by perceptual constructs of perceived learning, perceived ease of use, flow, perceived playfulness enjoyment, and perceived satisfaction?
2) Do the gender differences effect on students’ perceptions within the Functional Group Game 1?

2. Related work

In chemistry learning, both chemistry majors and non-chemistry majors struggle with their first attempts to recognize the basic organic functional groups (Welsh, 2003).They are required to make connections between the macroscopic properties of organic molecules. The organic functional group card deck was created to help visually oriented students recognize the names and structures of 13 common functional groups. However, it the students might have less motivation to learn the topic. In other words, in an effort to make learning chemistry more enjoyable, chemistry instructors have devised and used a wide variety of excellent games in the classroom.

Digital games consist of dazzling and sophisticated images and sounds, alongside textual communication. Players get engagement, which is both pleasurable and challenging. The educational digital game keep players immersed in digital worlds, knowledge, information, and skill development become increasingly accessible outside confines of formal education (Castell, Jenson and Taylor, 2007). In addition, several studies have shown that educational computer games can enhance the perceptions, learning motivation and learning performance of students in science learning. For example, Meesuk and Srisawasdi (2014) surveyed 29 twelfth-grade students in a public school at the northeastern region of Thailand after playing The IE War game, and found that the students increased their perceptions towards playing the game. They further investigated effects of student-associated game-based open inquiry on 81 tenth-grade students’ science motivation. The findings revealed successful of improving students’ science motivation in context of the digital game-based learning environment. Furturmore, Nantakaew and Srisawasdi (2014), Lokayut and Srisawasdi (2014) and Kanyapasit and Srisawasdi (2014) developed The Pipe, The Blood Donor and The Cell Cycle Game respectively and found that the students’ perceptions and motivations were increase.

3. Method

3.1 Participants

The participants of this study were 74 twelfth-grade students in a local public school at the northeastern region of Thailand (male = 25 and female = 49). The age range of the students was 17-18 years. They were attending a chemistry course for basic education level and all of them have satisfactory skills on basic computer and information and communication technology, but they have no experience yet using educational computer game in chemistry learning.

3.2 Learning Materials

Based on the previous work, the research (Meesuk and Srisawasdi, 2014; Nantakaew and Srisawasdi, 2014; Lokayut and Srisawasdi (2014) and Pinatuwong and Srisawasdi, 2014), they created the game to support science leaning based on the open inquiry pedagogy. However, they did not use the revised Bloom’s taxonomy to design the difficulty of the game. So, in this study we decided to apply the revised Bloom’s taxonomy as the ground framework to create Mario-like digital game. According to the researchers mention that the revised Bloom’s taxonomy can be used to design each level of game. Generally, computer game focus on remembering but on our research carries out higher-order level of the revised Bloom’s taxonomy (Remember, Understand, Apply and Analyze)

The Mario-like digital game on organic chemistry of functional group was designed to include five games including The Functional Group Game 1-4 which have four levels of playing. Each game will have an interesting problem involving real-life context in the theme of a medicine used in the treatment of various diseases. The chemical structure of medicine consists of the functional groups of different types and each level of the game was designed based on levels of the cognitive process dimension of the revised Bloom's taxonomy (i.e., Remember, Understand, Apply, and Analyze) (Krathwohl, 2002) and Evaluate was used to design the last game,The Functional Group Game 5,

In this pilot study, The Functional Group Game 1 was used as an exploratory research to examine impacts of the Mario-like digital game idea on students' perception. The game was related to content of classes of organic compounds (i.e., alkene, alkyne, alcohol, and ketone). The game provides interesting problem situation to students. It can trigger the students to link the three levels of representation in chemistry including macroscopic, sub-microscopic, and symbolic level (Treagust, Chittleborough & Mamiala, 2003). Figure 1-4 illustrates examples of user interface of The Functional Group Game 1.

Figure 1. Illustrate playing The Functional Group Game 1 in the first level.

Figure 1 show an example of the game in Level 1. In this level, the game was designed based on the first level of the cognitive process dimension of the revised Bloom's taxonomy that is Remember. The students are provided the opportunity to retrieve relevant knowledge from long-term memory and recognize the knowledge (Krathwohl, 2002).

Figure 2. Illustrate playing The Functional Group Game 1 in the second level.

Figure 2 show an example of the game in level 2. In this level, the game designed based on the second level of the cognitive process dimension of the revised Bloom's taxonomy that is Understand level. The students are provided the opportunity to determining the meaning of instructional messages, including oral, written, and graphic communication and classifying such knowledge (Krathwohl, 2002).

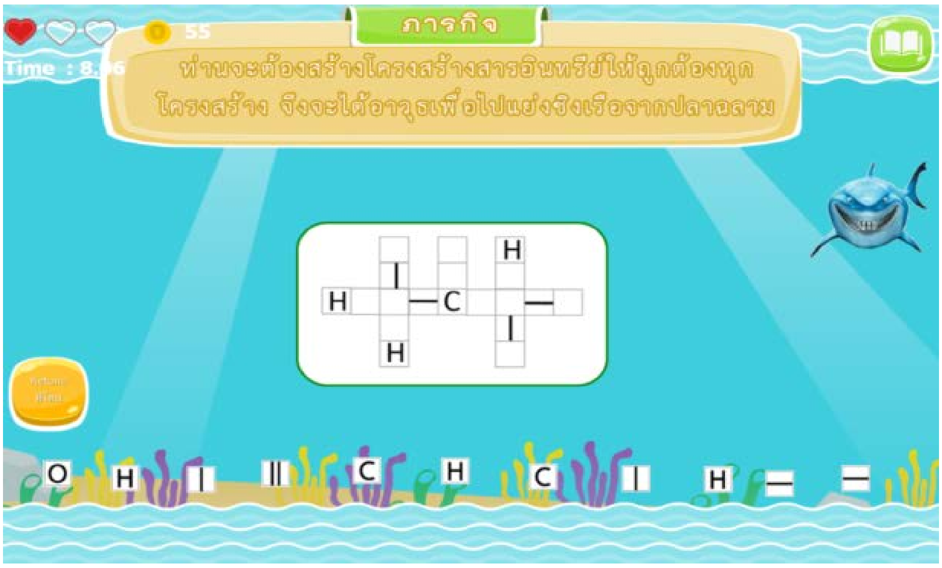

Figure 3. Illustrate playing The Functional Group Game 1 in the third level.

Figure 3 show an example of the game in level 3. In this level, the game was designed based on the third level of the cognitive process dimension of the revised Bloom's taxonomy that is Apply level. The students are provided the opportunity to carry out or use a procedure in a given situation and execute the situation (Krathwohl, 2002).

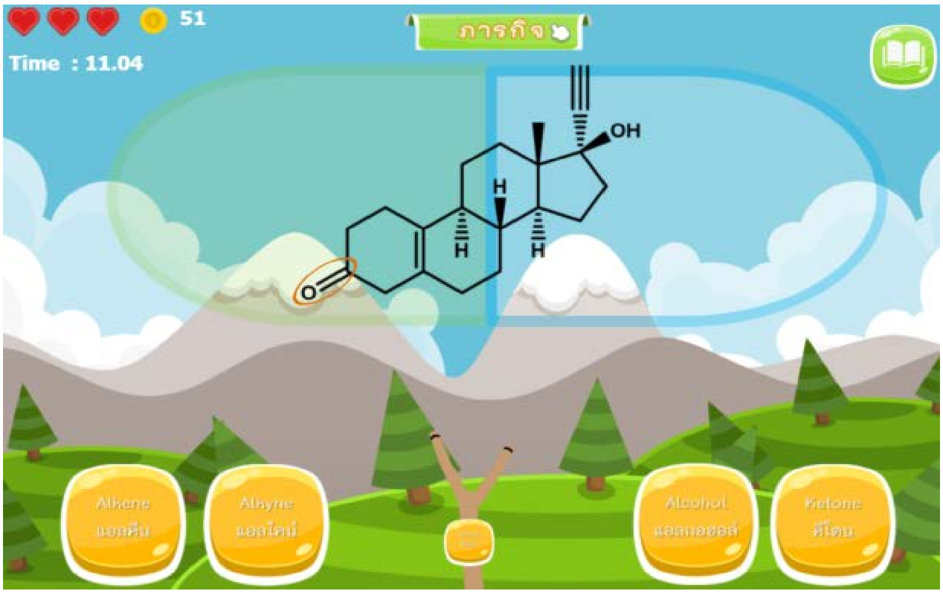

Figure 4. Illustrate playing The Functional Group Game 1 in the fourth level.

Figure 4 show an example of the game in Level 4. In this level, the game was designed based on higher order the fourth level of the cognitive process dimension of the revised Bloom's taxonomy that is Analyze level. The students are provided the opportunity to breaking material into its constituent parts and detecting how the parts relate to one another and to an overall structure or purpose, and also differentiating such parts (Krathwohl, 2002).

3.3 Research Instrument

An 18-item perception questionnaire was used to measure students' perceptions on six subscales: perceived learning, perceived ease of use, flow, perceived playfulness enjoyment, and perceived satisfaction. All of these 5-point Likert scale items obtained from Cheng (2014) and Barzilai and Blau (2014), developed and validated in Thai by Meesuk and Srisawasdi (2014) and Pinatuwong and Srisawasdi (2014). On each item, respondents were assigned to rate how much the respondent agree with in to five scale, from 1-strongly disagree to 5-strongly agree.

Table 1: Example items of perception questionnaire for each construct.

Subscale	Sample items
Perceive learning	The game will help me understand the things I learned. The games increase my learning efficiency. The games allow me to complete my studies faster.
Perceived ease of use	The games are easy to use. Using the games to complete course related tasks are easy.
Flow	I was very involved in the game. I lost track of time when I played. When I played I did not think of anything else.
Perceived playfulness	It is interesting to use games. I feel like exploring more information when I use games. I was totally immersed in the game.
Enjoyment	I had fun playing the game for learning science. I feel relaxed to use games for learning science.
Perceived satisfaction	The use of the system makes this learning activity more interesting I like to learn new skills by using business simulation games. I would like to learn with the system in the future. I would like to know if the innovative approach could be applied to other courses to improve my learning performance. I would recommend this learning system to others.

3.4 Data Collection and Analysis

The regular class consists of 74 students. Students were surveyed to complete the perception questionnaire of the 5-point Likert-scale, to measure their pre-perceptions on perceived learning, perceived ease of use, flow, perceived playfulness enjoyment, and perceived satisfaction for 10 minutes. After completing the instrument, they were exposed to play The Functional Group Game 1 for 20 minutes. After finishing the game, students were administered by the same questionnaire again as post-test for 10 minutes. The statistical data techniques selected for analyzing students' perceptions was repeated-measures MANOVA in SPSS to compare effect of intervention considering gender (female/male) and time (pre-test/post-test).

4. Results

The results for the repeated-measures MANOVA were conducted to determine students' perceptions scores on the six subscales. The assumption of homogeneity of variance-covariance was tested with Box's M Test which was not significant and indicated that homogeneity of variance-covariance was fulfilled (p =.517). The results for the repeated-measures MANOVA indicated significant main effect for gender (Wilks' lambda =.973, $F_{(6,67)}$ =.304, p=.932, η^2=.027) and time (Wilks' lambda =.413, $F_{(6, 67)}$ =15.897, p=.000, η^2=.587). Also, there was no significant interaction effect between time and gender (Wilks' lambda =.895, $F_{(6, 67)}$ =1.305, p=.267, η^2=.105). Univariate analyses of variances (ANOVA) on each subscale were conducted as follow-up tests to the one-way MANOVA. The results of the univariate test for time are shown in Table 2.

Table 2: The students' subscale means of perceptions by time and univariate MANOVA.

Subscale	Digital Technology		F	Sig.	η^2
	Pre-test Mean (SD)	Post-test Mean (SD)			
Perceived learning (PL)	9.28 (1.810)	12.43 (1.952)	75.747	.000*	.513
Perceived ease of use (PEU)	6.91 (1.284)	8.32 (1.415)	35.685	.000*	.331
Flow (PF)	9.34 (1.995)	11.99 (2.084)	59.758	.000*	.454
Perceived playfulness (PP)	10.01 (1.898)	12.28 (1.955)	49.815	.000*	.409
Enjoyment (PE)	6.92 (1.487)	8.31 (1.364)	36.070	.000*	.334
Perceived satisfaction (PS)	18.05 (3.448)	21.26 (3.184)	34.911	.000*	.327

*$p < .001$

In Table 2, the univariate MANOVA from pre- to post-questionnaire of six subscale scores of perceptions were significant differences across time. The univariate results pointed out a significant effect on perceived learning ($F_{(1,72)} = 75.747$, $p < .001$, partial $\eta^2 = .513$), perceived ease of use ($F_{(1,72)}= 35.685$, $p < .001$, partial $\eta^2 = .331$), flow ($F_{(1,72)}= 59.758$, $p < .001$, partial $\eta^2 = .454$),perceived playfulness ($F_{(1,72)}= 49.815$, $p < .001$, partial $\eta^2 = .409$), enjoyment ($F_{(1,72)}= 36.070$, $p < .001$, partial $\eta^2 = .334$), and perceived satisfaction ($F_{(1,72)}= 34.911$, $p < .001$, partial $\eta^2 = .327$). These results indicated that the students have increased their positive perception towards playing the game. Furthermore, the results show that there were no significant difference between females and males for their perceptions. In other words, perceptions toward learning chemistry through The Functional Group Game 1 between females and males were not difference. It indicates that females and males satisfied equally in the in the end of The Functional Group Game 1. In addition, Figure 5 illustrates a graphical representation on students' pre- and post-perception scores. It indicates that the developed game could affect students' perceived learning, perceived ease of use, flow, perceived playfulness enjoyment, and perceived satisfaction to learn science effectively.

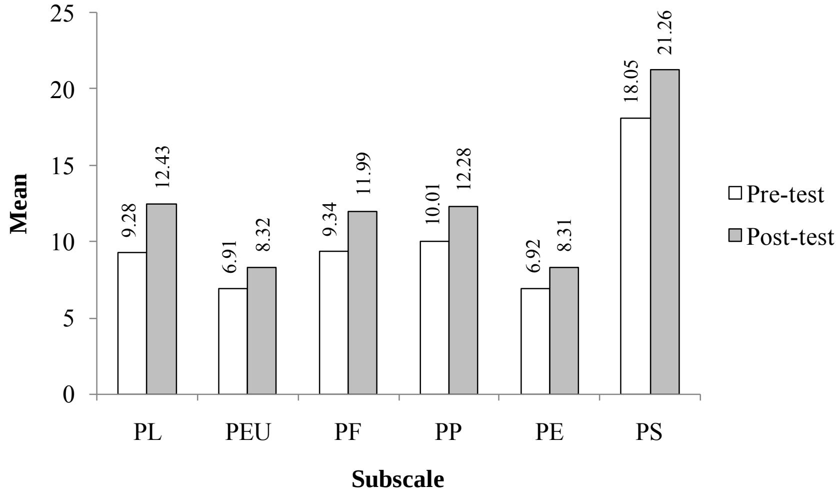

Figure 5. Compare mean scores between pre- and post-questionnaire of six scales.

5. Conclusion and Future work

This study reported impacts of educational computer game on students' perceptions. The findings revealed successful of improving students' perceptions in context of digital game-based learning experience. In additions, the finding showed that gender difference has no effect on students' perceptions towards learning of chemistry through The Functional Group Game 1. As such, it is clear that both females and males increased their perceptions on perceived learning, perceived ease of use, flow, perceived playfulness enjoyment, and perceived satisfaction after interacting with The Functional Group Game 1.This implies that The Functional Group Game 1 can be effective in Organic Chemistry Learning about the Functional Group. The results from this study could lead us to conclude that The Functional Group Game 1 based on the Mario-like game and Bloom's taxonomy could be an alternative way for promoting chemistry learning in Thai school science.

Although there are many researches indicated that teaching and learning via game improve student' motivation, we should collect pre- and post-motivation for comparing motivation before and after learning. In and addition, the challenge is how to immerse the digital game into classroom instruction. A previous study by Meesuk and Srisawasdi (2014) used the educational game to support student' inquiry learning process by integrating with student-associated game-based open inquiry (SAGOI) approach, and they found that the SAGOI can be effective in improving students' science motivation for fostering chemistry learning (ionization energy). Consequently, in further study, based on the findings of this study and successful SAGOI, we will implement The Functional Group Game 1-5 with SAGOI approach for enhance students' conceptual understanding and also chemistry motivation in quasi-experimental design. The mix research methodology will combine quantitative method of non-equivalent control group design with qualitative method of phenomenological research design to carry out chemistry conceptual understanding and motivation.

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Recommendation Method in the Context of Real-world Language Learning

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Abstract: This paper explores a recommendation method in the context of real-world language learning based on ubiquitous learning logs. Ubiquitous learning log stands for a digital record of what they have learned in the daily life using ubiquitous technologies. One of the issues of ubiquitous learning analytics is how we should detect or mine effective and efficient learning patterns from many learning data accumulated in a ubiquitous learning system. To tackle this issues, this paper proposes a visualization and analysis system called VASCORLL (Visualization and Analysis system for COnnecting Relationships of Learning Logs) in order to link learners in the real world and learning logs that are accumulated in a cyber space by a ubiquitous learning system called SCROLL (System for Capturing and Reminding of Learning Log). Using VASCORLL, learners can predict their next learning steps and then find learning patterns related to their current learning situation. The initial evaluation was conducted to measure whether VASCORLL can increase learners' learning opportunities and whether the recommended learning patterns are appropriate for learners or not. In this evaluation, we found important criteria for recommending appropriate learning patterns for learners in the real-world language learning. In addition, VASCORLL succeeded in increasing learners' learning opportunities.

Keywords: ubiquitous learning log, association analysis, spatio-temporal data mining

1. Introduction

Ubiquitous learning has been paid attentions in educational research over the world. For example, CSUL or u-learning has been constructed using ubiquitous technologies such as mobile devices, RFID tags, QR codes and wireless networks (Ogata et al., 2004; Hwang et al., 2008; Yin et al., 2010). These types of learning take place not only in-class learning but also in a variety of out-class learning spaces such as homes, libraries and museums.

Ogata et al. (2011) developed a ubiquitous learning system called SCROLL (System for Capturing and Reminding of Learning Log). The system allows learners to share them by recording on the web or mobile devices what they have learned in their daily lives. Numerous data has been accumulated on the cyber space from 2011 to 2015 (Ogata et al., 2014a). SCROLL has supported various fields of learning such as language learning, science communicator and career support for international students (Mouri et al., 2012, 2013; Ogata et al., 2014b; Uosaki et al., 2015).

These learning log accumulated in the cyber space include spatiotemporal data such as location and time information. In the research studies on spatiotemporal data mining, they explore many challenges in representing, processing, analyzing and mining of dataset in spite of complex structures of spatiotemporal objects and the relationships among them (Rao et al., 2011, 2012).

Similarly, Mouri et al (2014, 2015). proposed an innovative visualization system for analyzing learning logs in order to reveal relationships between learners in the real world and learning logs in the cyber space. However, the objective of their studies was visualization of the collected data and they did not analyze nor mine their data. Therefore it is yet to be realized to recommend proper learning logs in accordance with learners' learning situation in the real world. In addition, it is necessary to examine whether learning logs recommended from the analysis are appropriate for them so that their learning opportunities have been increased.

This paper proposes a visualization and analysis system called VASCORLL (Visualization and Analysis system for Connecting Relationships of Learning Log) for recommending appropriate learning patterns in the real-world language learning. VASCORLL works in a cyber-physical setting to link learners in the real world and learning logs that are accumulated in cyber spaces by using a ubiquitous learning system called SCROLL. Our main objective in this research is to reveal the following issues.

(1) How we can detect or mine effective and efficient learning patterns from complex relationships between learners in the real world and learning logs in the cyber space.
(2) Whether their learning opportunities are increased by recommending appropriate learning logs based on their learning patterns.
(3) Whether learning logs that are recommended from the analysis results are appropriate for learners.

This paper aims to describe how to detect or mine effective and efficient learning experiences accumulated in the cyber spaces, using association analysis. The "effective" means that VASCORLL can increase their learning opportunities by recommending and detecting learning logs similar to their own from past learning histories accumulated in the cyber spaces. The evaluation was conducted to examine whether the recommended learning patterns are appropriate for learners or not.

2. Related Works

2.1 Ubiquitous Learning Log and SCROLL

In this paper, Ubiquitous Learning Log (ULL) is defined as a digital record of what learners have learned in the daily life using ubiquitous technologies (Ogata et al., 2011). As shown in Figure 1, learners can record a ubiquitous learning log with photo, audios, videos, location, QR-code, RFID tag, and sensor data using desktop PC or mobile device and SCROLL. Figure 2 shows a ubiquitous learning log recorded by SCROLL. Learners can reflect what they have learned using this interface anytime and anywhere. To date, there are 27866 learning contents (cumulative total), 1770 users, 19 native languages (Chinese, Japanese etc.) and 30 place elements (Supermarket, post office etc.).

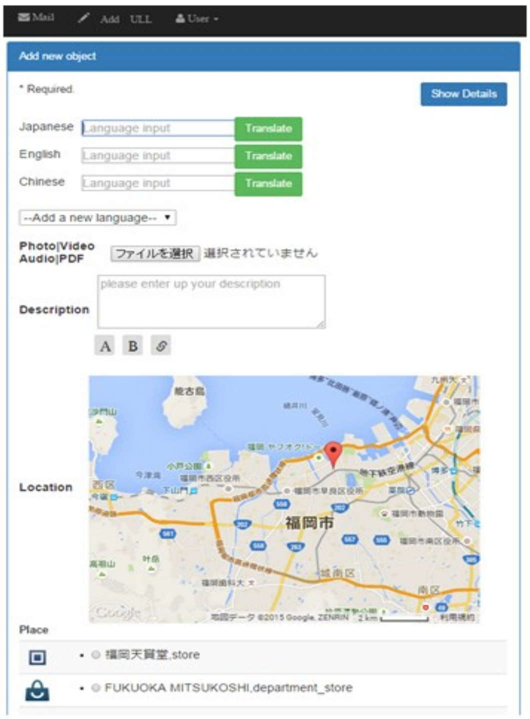

Figure 1. Adding ULL

Figure 2. A ubiquitous learning log

2.2 Spatio-temporal Data Mining

The research studies in the spatio-temporal data mining proposed many analysis approaches to reveal the links and the shifts among the objects on spatial and temporal dimension (Rao et al., 2011, 2012). The researches mainly analyze data to predict disaster, weather and animal actions. For the example in disaster, there is such hurricane. It occurs in different places at various times, and the prediction is made possible by revealing cause-and-effect links behind the disaster.

For the research studies in the spatio-temporal data mining, the relationships between event such as disaster and weather and location or time are importation information. However, for learners in the real-world language learning it is also important to grasp information such as other learners' age, gender, nationalities, learning place and time related to what they have learned. This paper uses spatio-temporal association analysis (Agrawal et al., 1993) in order to detect or mine learning patterns or rules related to what they have learned.

Our proposed VASCROLL implements a recommendation method based on association analysis. By this, VASCORLL can discover learning patterns of what kind of learners learned what kind of knowledge in what kind of place and what kind of occasion.

3. System Design

3.1 Design

Figure 3 shows the workflow to feedback them after visualizing and analyzing ULLs by VASCORLL in a cyber-physical setting.

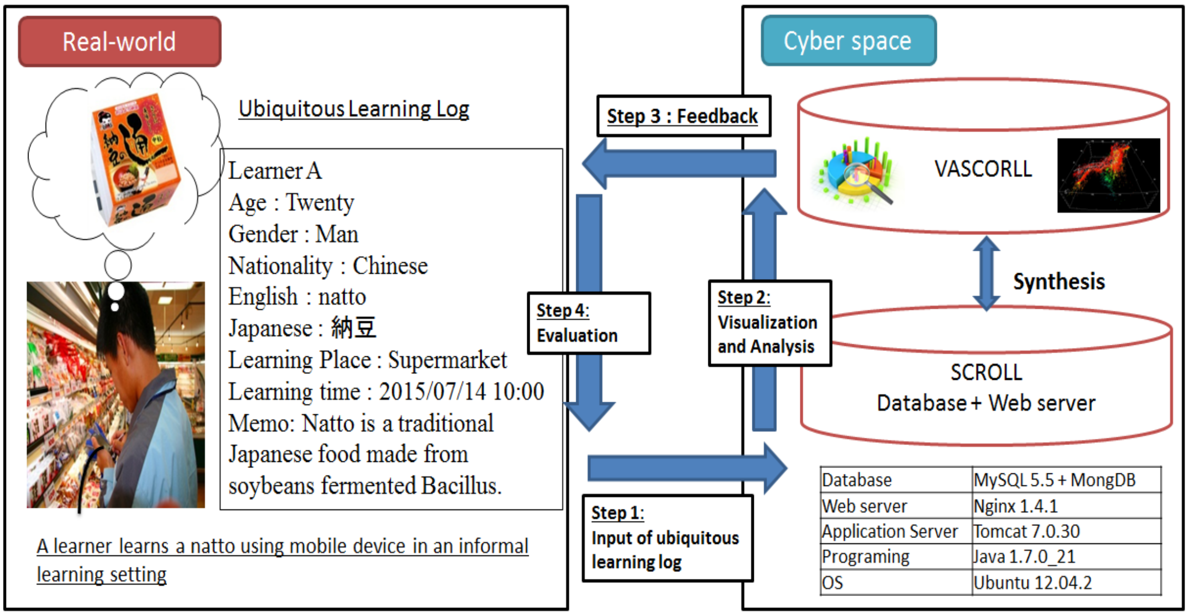

Figure 3. How SCROLL and VASCORLL works

The workflow shows the following four steps:

Step1. Learners can save their experiences as ULLs with photos and videos using mobile device or desktop PC and SCROLL. The ULL includes the author name, language, time of creation, location (latitude and longitude), learning place and tags. For example, if a learner learns a natto at the supermarket, the saved ULL will be accumulated into the cyber space.

Step2. Learners do not have means to know whether their knowledge can be applied to other learning environments or not. VASCORLL allows learners to find knowledge that can be applied into different contexts, by visualizing and analyzing a large amount of ULLs that are accumulated in the cyber space.

Step3. VASCORLL feedbacks important relationships such as the most frequently learned place and time zone from the results of step 2.

Step4. It is important to recognize who is learning what, and when, where and how, so that learners can understand how their own knowledge is used in other contexts. Therefore, VASCORLL supports learners to apply their own experiences to other contexts.

All the above workflow can be supported by SCROLL and VASCORLL.

3.2 LKPTE model

To visualize and analyze several relationships between the learners and ULLs, Mouri et al. (2014 & 2015) uniquely defined them in a three-layer s structure.

This paper proposes an analysis model called LKPTE (Learner-Knowledge-Place-Time-Experiences) based on Three-layer structures and LKPTE parameters in Table 1. Using this model, VASCORLL can find the most important relationships between learners in the real world and ULLs that are accumulated in the cyber space. Table 1 shows parameters of the LKPTE model.

Table 1: LKPTE parameters

Parameter	Details
L_g (Who)	Gender of learners
L_a (Who)	Age of learners
L_n (Who)	Native language of learners (e.g. Japanese, English and Chinese)
L_l (Who)	Level of learners (e.g. Japanese Language Proficiency Test)
K_l (What)	Level of knowledge (e.g. a word level based on Japanese Language Proficiency Test)
K_t (What)	Types of knowledge (e.g. Noun, verb, adverb and adjective)
P_l (Where)	Location of place (e.g. latitude and longitude)
P_n (Where)	Name of place (e.g. University, museum and supermarket)
T_s (When)	Seasons (e.g. Spring, summer, fall, winter)
T_f (When)	Time of the day (e.g. Morning, daytime, night)
E_d (How)	Direct experience
Ei (How)	Indirect experience

Learners' parameter L (Who) shows their gender (L_g), age (L_a), native language (L_n) and Japanese Language Proficiency Test level (JLPT) of learners (L_l). Using these parameters, VASCORLL can find other learners similar to the learner.

Knowledge parameter K (What) shows the level of words (K_l) decided by JLPT and knowledge types (K_t) such as noun, verb, adverb and adjective. Parameter K is to decide whether they fit learners' level when learning other learners' experiences..

Parameter P (Where) shows location (P_l) and place name (P_n). For example, there is a possibility that ULLs in same location contain different place names such as university and restaurant. Also, there is a possibility that same place names contain different location. Parameter P distinguishes ULLs in different contexts, so that VASCORLL can detect learner contexts in the real world and ULLs in cyber space.

Parameter T (When) shows the seasons (T_s) and the time zone (T_f). For example, the most learners have learned morning glory flowers in the morning. But, a learner has learned a morning glory flower in the daytime. Generally, most people regard morning glories as flowers which bloom in the morning, but there are kinds of morning glories which are in bloom until the daytime actually. Therefore, VASCORLL will detect relationships between knowledge and place in different times. By providing their relationships, learners can grasp information regarding time of other experiences.

Parameter E (How) shows direct experiences (E_d) and indirect experiences (Ei). Direct experience (E_d) denotes experience gained through sense perception. Indirect experience (Ei) denotes experience gained through others. Learners can save others' indirect experiences as "Relog" using SCROLL. According to Kolb (1984), he described that it is important to directly experience. By revealing relationships between direct experiences and indirect experiences, VASCORLL can change learners from watcher to doer by using a learning system based on task-based learning (Mouri et al., 2013).

To reveal the distance between learners and ULLs, this paper measures them using cosine similarity. This paper defines the following vectors V_i (1) based on the parameters of LKPTE model.

$$V_i = \{ L_g, L_a, L_n, L_l, K_l, K_t, P_l, P_n, T_s, T_f, E_d, Ei \} \quad (1)$$

3.3 Recommendation based on Association Analysis

To detect learners' learning patterns, trends and other yet-to-be-known learning style, this paper uses association analysis with the appriori algorithm. The analysis was conducted the following those criteria shown below.

1. Suppose ≧ 0.01, Confidence ≧ 0.05, The number of detected rules is 1000, Attributes {gender, age, native language, knowledge, place, time, experience type}

In order to detect association rules, we set the suppose value more than 0.01, and the confidence value more than 0.05. Table 2 shows some samples of items of ULLs. This paper analyzes to detect or mine association rules based on items in Table 2.

Table 2: The part of items of ULLs

Transaction ID	Item set {gender, age, native language, knowledge, place, time, experience type}
1	{man, 21 years old, Chinese, n2, natto, supermarket, spring, daytime, direct experience}
2	{woman, 24 years old, Mongolian, n3, apple, supermarket, summer, daytime, direct experience}
3	{man, 23 years old, Chinese, n2, natto, university, spring, morning, indirect experience}

Table 3 shows the part of the detected association rules. The Rule 1 shows that the learning place of five "fan" words is "university", and that nationality of the learners is all Japanese. This implicates that Japanese learners are likely to learn "fan" at the university. The Rule 2 shows that the learning time of four "fan" words is "Summer", and that native language of learners is all Japanese. This implicates that four Japanese students are likely to learn a "fan" in summer. By mining these rules, it will be revealed their learning trends. For example, if a learner is at the university, system can show him/her the learning trends such as "who (Japanese) is learning what (fan), when (summer) and where (university)" to learner.

The Rule 3 shows that learner A learned 7 learning logs out of 8 logs with the attributes: Chinese (native language) and hospital (place). From this result, it can be predicted that whose learning logs to refer to when in hospital. For example, when a Chinese learner visits a hospital, he can learn the knowledge and events that might possibly happen at the hospital in advance by referring to learner A's logs which he/she learned at the hospital in the past. Similarly, the Rule 4 shows that learner B learned 12 learning logs out of 17 with attributes: Chinese (native language) and city hall (place). The confidence value of Rule 3 is higher than that of Rule 4. That means that its relevance is higher. When the system recommends them to learners in real world, the confidence values can be important criteria of the recommendation.

Table 3: The part of the detected association rules

Association Rules	Confidence
1. Knowledge = Fan && Place Attribute = University (5) →Native language= Japanese (5)	1
2. Knowledge = Fan && Learning Time = Summer (4) →Native language = Japanese (4)	1
3. Native language = Chinese && Place Attribute = Hospital (8) → Username = Learner A (7)	0.88
4. Native language = Chinese && Place Attribute = City Hall (17) → Username = Learner B (12)	0.71

4. Implementation

This section describes ways of the implementation of VASCORLL.

4.1 Analysis interface

To find ULLs by location information (P_l and P_n of LKPTE model), firstly, it is necessary to get learners' current location and place information where they are studying. Green marker on map of the interface shows learner' current positions, and red maker shows the names of learning place near her/him. Using web interface in shown in Figure 4, learners can check in location information.

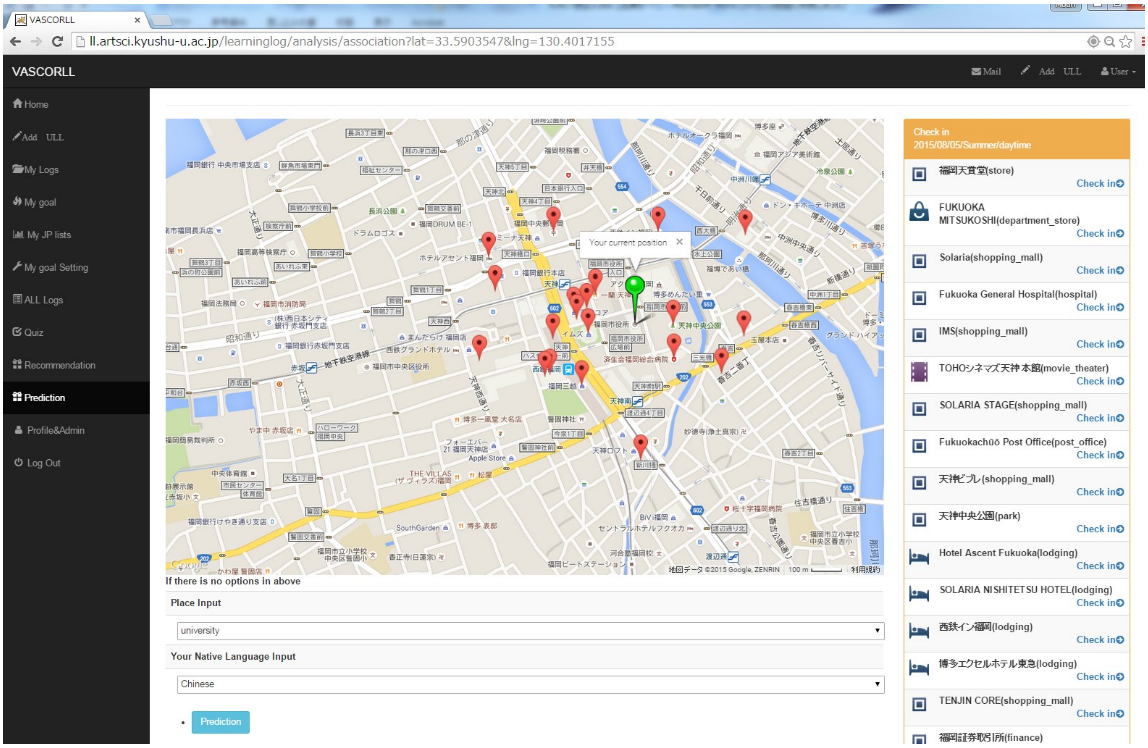

Figure 4. web interface of Checking in learners' current location

Figure 5 shows recommendation interface that are calculated based on LKPTE model. It consists of the following components:

1. Association rules: With understanding association rules, learners can predict their next learning steps. For example, if they are at the restaurant and daytime, the system will recommend knowledge (Case in the Figure 5 is "ramen") related to them based on association analysis. Therefore, the system can recommend appropriate knowledge at appropriate learning place in appropriate learning time.

2. Evaluation of recommendation: To evaluate whether association rules recommended by system are appropriate for learners, learners will be asked some questions such as "Is this recommendation useful for learning?", "Is this recommendation appropriate level for you?" and "Do you feel that this log is interesting to learn?". In the section 6.1, this paper evaluates whether the system was able to recommend appropriate learning patterns in accordance with their learning situations.

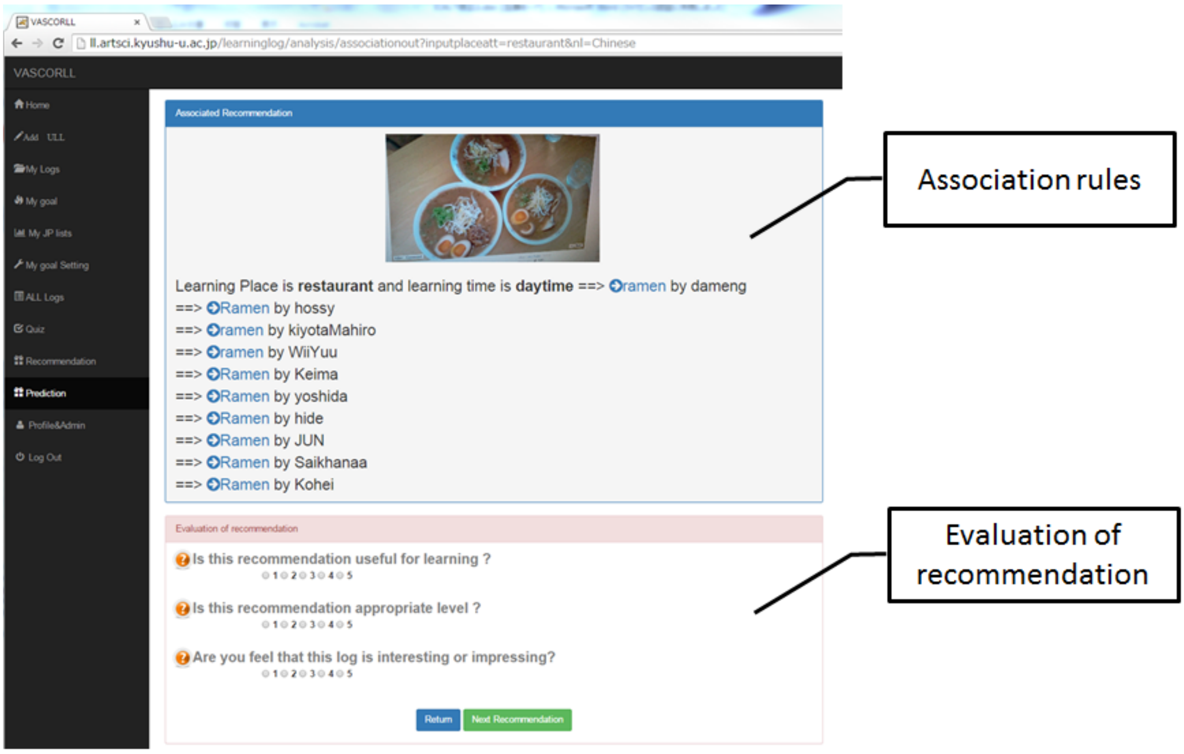

Figure 5. Recommendation interface based on association analysis

5. Evaluation

10 international students (5 Mongolians and 5 Chinese) who are studying at the University of Tokushima and Kyushu University participated in the evaluation experiment. They were from China and Mongolia aged between 21 and 34. Their length of stay is from 1 month to 5 years.

5.1 Method

Before the evaluation started, we explained how to use SCROLL and our proposed VASCORLL. They learned vocabularies in their daily lives for one day. The mobile devices used in the evaluation experiment were three iPhone 4s, five iPhone 5s, and two Samsung Galaxy Note 3s. The objective of this evaluation was to examine whether VASCORLL system can increase students' learning opportunities and whether the recommended learning experiences are appropriate for learners or not.

Table 4. Question on the recommendation

Question on the recommendation interface
1. Is this recommendation useful for learning??
2. Is this recommendation appropriate level for you?
3. Do you feel that this log is interesting to learn?

After the evaluation, the participants were asked to complete a five-point-scale questionnaire, in which they evaluated its performance, and usability, as well as the ease of understanding and discovery of ULL by using VASCORLL system. In addition, the participants evaluated whether the system's association rules are appropriate or not, using recommendation form in Table 4.

5.2 Result and discussion

The questionnaire result is shown in Table 5. The highest mean score was 4.28 when the subjects were asked whether VASCORLL was useful for discovering relationships among ULLs. The response to Q1 indicates that they were able to discover relationships among ULLs. Also, some students commented that VASCORLL was helpful to find relationships among some words in different contexts. The response to Q2 to Q3 indicate that students were able to share them and discovering something to learn by using VASCORLL.

Table 5: Result of the five-point-scale questionnaire

Question	Mean	SD
1. Was VASCORLL system useful for discovering relationships among ULLs?	4.28	0.98
2. Were you able to discover something to learn by using VASCORLL?	3.85	1.12
3. Did you think you were able to share other ULLs by using VASCORLL?	4.14	1.03

Table 6 presents the number of recommendation that the system recommended appropriate ULLs in accordance with each recommendation criteria, and the subjects learned them. In total, they learned 375 ULLs after receiving association rules. This means that their learning opportunities are increased by using VASCROLL.

As shown in Table 6, the system was able to recommend appropriate association rules because the mean is higher if confidence value is more than 0.8.

However, it shows that the system was not able to recommend appropriate association rules for learner if confidence value is less than 0.8. This means that learners disliked association rules if confidence value is less than 0.8. In this evaluation, we found important criteria for recommending appropriate association rules for learners in the real-world language learning. In addition, the recommendation system based on our association rules with high confidence value is expected to keep learners from decreasing their motivation. This is because learners felt that association rules with the high confidence value are interesting and useful for learning. As our future work, we consider this issue.

Table 6. The recommendation based on association analysis

Recommendation criteria	Recommendation number	Mean (Q1~Q3 in Table 4)	SD (Q1~Q3 in Table 4)
1. $0.9 < \text{confidence} \leq 1.0$	24	3.7	0.91
2. $0.8 < \text{confidence} \leq 0.9$	48	3.56	1.28
3. $0.7 < \text{confidence} \leq 0.8$	231	2.32	1.39
4. $0.6 < \text{confidence} \leq 0.7$	72	2.33	1.31

6. Conclusion

In order to link learners in the real world and learning logs accumulated in cyber space by a ubiquitous learning system called SCROLL, this paper proposes a visualization and analysis system called VASCORLL. VASCORLL will find learning patterns and relationships between learners' contexts in real world and past learners' contexts in cyber space, and then recommend knowledge that can be applied into other contexts to learners in the real world. According to the initial experiment, VASCORLL was effective for finding other contexts which can be applied to their own learning experiences. In addition, the system enabled learners to find learning patterns similar to their current learning situation, using association analysis. Consequently, VASCORLL succeeded in increasing learners' learning opportunities.

In the future, the use and evaluation of VASCORLL will continue. Our next consideration is to support international students who aim to take JLPT and to enhance their Japanese language skills by using VASCORLL. Also, we will apply not only life-long learning but also other mobile learning domains, e.g. CSCL (Computer Supported Collaborative Learning) and Seamless learning.

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Design of a Handheld-based Motion Graphing Application for Physics Classes

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Abstract: The design of handheld-based applications for learning support remains open for interdisciplinary research. In particular, technologies such as object-tracking software and augmented reality visualization running on handheld devices need to be explored more. In this work, we discuss how we used such technologies to develop a handheld-based motion graphing application. We made design considerations based on previous work and design guidelines for developing educational software on handheld devices. We compare against the various tools for graphing displacement, velocity, and acceleration as functions of time. Based on this comparison, we discuss how our handheld application could be easier to use and more practical for classroom use. Finally, we discuss our implementation, and then suggest future evaluations and research directions.

Keywords: augmented reality, handheld devices, motion graphing, physics education

1. Introduction

Advances in handheld devices such as smartphones and tablet computers, together with better internet connectivity, have inspired new ideas on how technology can help support the learning process (Wong, 2015). Although there are still barriers and limitations to integrating handhelds to the classroom (Khaddage, et al., 2015), there are already many success stories of adopting handhelds to the classroom (Curtis, et al., 2002; Looi, et al., 2011; Parnell and Bartlett, 2012). In the Philippines, schools such as Miriam College High School have already adopted tablet computers for the use of students and teachers. We expect more schools in the Philippines to do the same and acquire tablet computers. As such, there is growing interest on how handhelds could be leveraged on in daily classroom activities. One of the main concerns is how handhelds could be used properly to transition from the occasional, supplemental use of computers for instruction to more frequent use, thereby making these devices an integral part of the curriculum (Barnes and Herring, 2012).

Aside from the use of handhelds as a tool for documentation in scientific inquiry (Looi, et al., 2011) and documentation of the progress of students (Parnell and Bartlett, 2012), handhelds can be used as tools for experimentation (Kuhn and Vogt, 2013). Although there are several works on the benefits of using handhelds as tools for sketching, mapping concepts, data collection, word processing, brainstorming, etc. (Curtis, et al., 2002), there is limited work on using handhelds for experimentation. Moreover, there is limited work reporting development in this area, especially those using emerging technologies such as object tracking and augmented reality. In augmented reality, virtual information is presented on the real environment as if it coexists with real objects (Santos, Luebke, et al., 2014). To achieve this effect, the handheld device must be able to track the locations of physical objects in the real world. Because we are dealing with emerging technology such as augmented reality, existing design guidelines for educational handheld-based applications may not be enough to arrive at usable systems (Gabbard and Swan, 2008).

In response, we base the design of our handheld-based motion graphing application on previous work and known design guidelines. We explain how the existing design guidelines apply to our application, as well as possible issues that are not covered by the existing guidelines. We also justify the benefits of our system over other methods of motion graphing. We argue that our system could be easier to use, thereby more practical for the classroom setting. We then discuss the implementation of our system which uses readily accessible technology. We conducted a preliminary evaluation of this prototype and found possible improvements. Finally, we discuss how such a system can be used and evaluated in the classroom.

2. Related Work

Science experiments that "…(1) [were] designed with clear learning outcomes in mind, (2) [were] thoughtfully sequenced into the flow of classroom science instruction, (3) [were] designed to integrate learning of science content with learning about the processes of science, and (4) incorporate ongoing student reflection and discussion, …" improve not only student comprehension of the subject matter but also student's curiosity towards science and its reasoning styles (Singer, Hilton, and Schweingruber, 2006, 5). Such student-centered activities use discovery approaches of learning science and integrate metacognition. In this paper, we discuss the design of a handheld application that aims to support these discovery approaches. We explore some existing design guidelines for handheld tools for supporting learning. We then point to existing handheld-based systems for scientific learning, and explain the difference of these systems to our motion-graphing application. We provide an overview of motion graphing in physics education and provide our analysis of existing systems. Based on this analysis, we designed a handheld-based motion graphing application that could be easier to use in the classroom setting.

2.1 Designing for Handhelds

Handhelds have small screens which makes it difficult to show multiple workspaces (windows or panels) at the same time while maintaining overall usability. In response, Luchini, Quintana and Soloway (2004) summarized two general design principles for designing handheld applications based on a review of prior work and their experiences in working in this area. The first design guideline is *task-based workspaces*: developers should "support different component tasks of learning activity within individual workspaces that include the necessary scaffolds, information and tools. This task based decomposition preserves the conceptual integrity of the learning activity while allowing the salient component tasks to be usably supported within handheld screens" (p. 137). Unlike desktop-based applications that can support many components, handheld applications should be designed to support only one task. For example, a desktop application may have many components that support the whole scientific research process, whereas a handheld application should be designed for one specific task within the scientific research process (e.g. on-site data gathering). The second design guideline is *dual-purpose elements*: developers should "design interface elements to serve a dual role by providing both functionality and scaffolding. The use of such dual-purpose elements reduces the number of tools and scaffolds that must be included in an individual workspace and increases the usability of the handheld interface" (p. 137). For example, instead of showing a flowchart of a particular task within the scientific research process, a navigation menu can be used both as a functional menu and a flowchart designed as scaffold for students. By scaffold, we refer to the various supports that help students to mindfully engage in unfamiliar work (e.g. use a handheld device for on-site data gathering).

Aside from usability issues arising from the small screen and limited workspace of handheld devices, unconventional uses of handheld devices such as using it for object-tracking and augmented reality may lead to unique usability issues (Santos, Polvi, et al., 2014). Although augmented reality may be designed to be intuitive and ease cognitive load (Santos, Luebke, et al., 2014), there are limited usability evaluations for this emerging technology (Santos, Chen, et al., 2014). In particular, augmented reality and its enabling technology – object or scene tracking – is susceptible to perceptual and ergonomic issues. As such, we recommend developers to watch out for these issues and make sure that their three-dimensional visualizations are easy to understand, and that the device is easy to handle during the operation of the application.

One important factor that may affect the adoption of handheld-based applications is teacher readiness. In rural Georgia, USA, the lack of adequate faculty preparation contributed to the difficulty of transitioning to the use of handheld devices (Arnold, 2015). We anticipate the same difficulties in the Philippines, not only in rural areas but also in the public schools found within cities. As such, we aim to implement a simple but flexible system that could be easily rolled out in schools, without the need for extensive training of teachers.

2.2 Handhelds for Scientific Inquiry and Experimentation

Looi, et al. (2011) developed a science curriculum for primary students that involve the use of handheld devices for mobile seamless learning. In their work, they asked the students to use handheld devices for note-taking, sketching, word processing, communicating, facilitating games, taking pictures, etc. as part of lessons conducted in collaboration with classmates and parents. Through their research, they have demonstrated the use of handheld devices in supporting mobile inquiry learning. Results of their evaluation show that they were able to encourage positive attitudes from students. Moreover, the students were able to achieve better learning outcomes. Similar to the work of Looi, et al. (2011), we aim to contribute to supporting science learning. However, instead of focusing on more conventional uses of handhelds like communication and documentation, we focus on unfamiliar usage of handheld devices such as motion capture. To achieve this kind of system, we need to use emerging technology like augmented reality, which may have different usability issues.

Aside from documentation, handhelds can be used for experiments in physics (Kuhn and Vogt, 2013). In their work, Kuhn and Vogt (2013) designed three student experiments that use handhelds. Two of the experiments use mobile phones that emit pure tones to measure acoustic beat and acceleration due to gravity. Another experiment is about using the camera of a cellphone to observe the infrared light emitted by remote controls. Kuhn and Vogt (2013) suggest creative uses of handhelds in physics experiments without requiring them to develop a special handheld-based application. They suggested the use of external sensors like microphones attached to a desktop computer, as well as the use of freely available software for desktops. Aside from the three individual experiments proposed by Kuhn and Vogt (2013), we think handhelds are also useful for graphing motion. Handhelds could be used in several experiments and activities in kinematics. To encourage the use of our system, we aim to make the setup and execution time quick and easy.

2.3 Motion Graphs in Physics Education

Motion graphs are graphical representations of the movement of an object through space and time. These representations can be used to emphasize the concepts of slope, and area of a graph (or the derivative and integral, for calculus-based physics classes). Three motion graphs are often used in physics discussions, namely, displacement vs. time, velocity vs. time and acceleration vs. time. The slope of the displacement vs. time graph gives the velocity of the object, whereas the slope of the velocity vs. time graph is the acceleration of the object. Hence, the displacement vs. time graph is essential because the velocity vs. time and acceleration vs. time graphs can be drawn from it.

A review by McDermott and Redish (1999) shows relevant physics education studies that enumerate student difficulties in understanding motion graphs, such as misinterpreting the graph's representation to the object's actual motion, and misreading the values of the quantities from the graphs. The recent study of Wemyss and van Kampen (2013) concludes that "...a correct qualitative understanding of a distance-time graph is not sufficient to correctly determine a value for the speed" (p. 1). In this regard, the use of technology in science instruction could bring increased student performance (Woodrow, Mayer-Smith, and Pedretti, 1996; Shieh, 2012). Technology in physics education can be found not only in graphing motion (Roschelle, Kaput and Stroup, 2000; Kuhn and Vogt, 2013) but also in electricity (Gutwill, Fredericksen, and White, 1999) and thermodynamics (Linn, Bell and Hsi, 1998), among others.

2.4 Systems for Motion Graphing

Plotting the motion of an object on a graph can be done in using several systems. We summarize the advantages and disadvantages that arise from the use these systems.

2.4.1 Ticker Timer

A ticker timer involves a mechanism that prints on a continuous paper (the "ticker tape") at a specific interval or frequency. For example, a ticker timer can be set to print 50 dots a second, or 50 Hz. The ticker tape is attached to an object such that as the object moves, it pulls the ticker tape out of the printer. For every second of the object's motion, 50 dots would have been printed on the ticker-tape. Figure 1 illustrates how a ticker-tape timer works.

The ticker tape is used to graph motion by cutting the ticker tape according to equal intervals of time which are represented by equal number of printed marks. In the previous example, the ticker tape may be cut to strips that contain six dots each. The strips are then placed on a velocity vs. time graph, with the time axis calibrated at 0.1 second intervals (since it takes a second for 50 dots to come out, it then takes 0.1 second for 5 dots to come out). The velocity axis is calibrated based on the lengths of the strip, since the velocity of the cart would be equal to the length of the strip divided by 0.1 s. Figure 2 shows a sample velocity vs. time graph using strips of ticker tape.

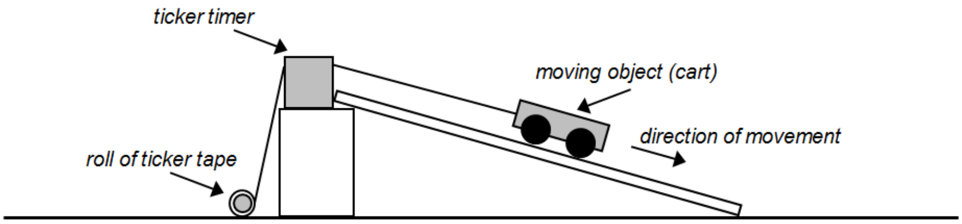

Figure 1: A sample setup which uses a ticker timer. A cart moving down the ramp pulls the ticker tape that is attached to it.

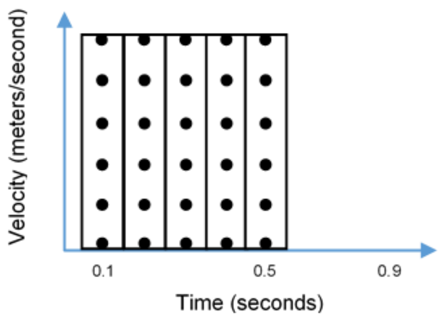

Figure 2: A sample velocity vs. time graph using strips of ticker tape. Note that the strips have the same number of dots on them and they are of the same length, which means that the object attached to the ticker tape is moving with a constant velocity.

One advantage of using this system is the cost. The timer is relatively cheap compared to other methods presented here. Teachers can also improvise on the ticker timers. Another advantage is that this system does not require a lot of technical knowledge to operate. However, paper jam is a common problem with this device because of its mechanical nature. Ensuring the correct frequency of the timer is also an issue, as this will bring inaccurate results. Furthermore, objects that initially move and then stay at rest cannot be properly registered by the ticker-tape. The span of time at which the object is at rest cannot be distinguished on the ticker-tape because the paper will also stop from coming out of the printer and the dots will overlap with each other. Lastly, movements going back to the direction of the printer cannot be registered because the paper can only be pulled in one direction.

2.4.2 Ultrasound Motion Sensor

One motion sensor that can be used to graph the movement of an object is PASCO's Motion Sensor. PASCO (www.pasco.com) manufactures computer-interfaced sensors bundled with software that can be installed on electronic tablets and personal computers. PASCO's motion sensor uses ultrasound to indirectly measure the distance from the sensor to a target object. The system sends out pulses of ultrasonic waves which reflect off the target object and received back by the sensor. The software then analyzes both the roundtrip travel time of the pulse and the speed of sound in air to compute the distance of the object. The software also plots the distance vs. time graph of the object, the velocity vs. time, and acceleration vs. time graphs. The system allows the user input to change the sampling rate. Figure 3 shows how the PASCO Motion Sensor operates.

An advantage of this device is that it can measure the distance of objects as far as eight meters away with the object at least 15 centimeters away from the sensor. This range decreases as sampling rate increases. This feature for adjusting the sampling rate is also an advantage. Higher sampling rate produces more data points which can be processed by PASCO's software, or exported to third-party spreadsheet or data processing application. The primary disadvantage of using this device is its cost. In the Philippines, such dedicated systems may be considered impractical. Schools may only have a few of these PASCO setups, thus making difficult or impossible for a whole class of students to use it simultaneously. In addition to cost, another disadvantage of this system is its complexity. We think the setup and the software used for post-processing the data can be made simpler, thereby easier to use.

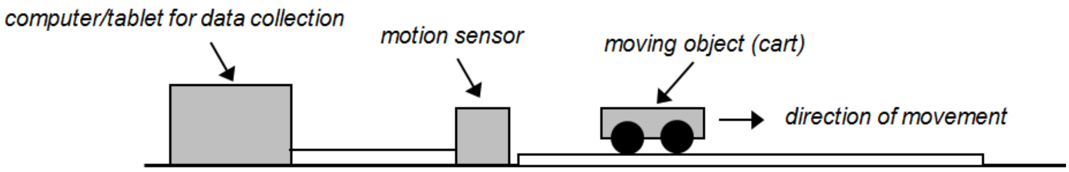

Figure 3: A setup for graphing motion using a motion sensor.

Table 1: Advantages and disadvantages of different motion graphing devices

	Ticker Timer	Motion Sensor	Video Logger
Advantages	• relatively cheap • low-technical knowledge required to operate	• can measure movement ups to eight meters • data can be exported to other programs	• covers many types of movement (projectile motion and circular motion) • can measure movement as long as the object is within the video frame • data can be exported to other programs
Disadvantages	• paper jam, mechanical issues • manual graph plotting • cannot properly register the span of time an object stopped, nor when objects move toward the ticker timer	• expensive • requires technical knowledge (interfacing, post-processing software)	• expensive • tedious marking of individual data points • requires technical knowledge (interfacing, post-processing software)

2.4.3 Video Logger

Vernier's Logger Pro (for desktops) and Video Physics (for tablets), and PASCO's Capstone can analyze recorded videos of moving objects for constructing motion graphs. Similar to PASCO, Vernier (http://www.vernier.com/products/software/lp/) also manufactures computer-interfaced sensors partnered with software.

Generally, video logging systems have four phases of operation. The first phase is to import a video of the object for analysis. The second phase requires the user to place "markers" on the object per frame of the video. The user identifies where the object is and places a mark on it. The desktop application then overlays this mark on the frame. The software advances the video to the next frame and the user marks the object again. This process is repeated until the end of the video clip. The third phase is calibrating the video. The user can set the point of reference (or the zero-meter mark), and the scale that the software will use to measure the distance between the marks on the object. This is done by having a meterstick (or other objects with known lengths) recorded within the video frame. The last phase is when the software plots the motion graphs.

An advantage of this method is that it can analyze motion in two-dimensions, such as the movement of a projectile and circular motion. However, the tediousness of the marking phase is a disadvantage. If a video that lasts 3 seconds is recorded at 50 frames per second, the user has to make 150 marks on the object. Rather than manually tracking the object, we propose in our work to automate this process by applying existing augmented reality software that includes object tracking.

Table 1 summarizes the advantages and disadvantages of existing methods for motion graphing. Based on this analysis, we formulated our design goals listed in Section 3.

3. Design Goals and Research Questions

We have the following design goals for our handheld-based motion graphing software:

- *Task-based Workspaces* – because the screen is small, we need to focus on using the application for one specific task only.
- *Dual-purpose Elements* – to maximize the small workspace and two help the students operate the application, we must provide both function and scaffolding with our interface elements.
- *Comprehensibility* – we should make the augmented reality visualization easy to understand by designing against perceptual issues of handheld augmented reality.
- *Manipulability* – The device should be easy to handle during the operation of the system.
- *Low Training Needs* – the application should not require much training of teachers.
- *Time Saving* – as much as possible, time should be saved in setting up the system, executing the experiment and post-processing the data.
- *Cost Effective* – as much as possible, we should use readily accessible devices and software so that schools can adopt them easily.

Through this ongoing research, we aim to explore the following research questions:

- Can augmented reality technology be used for a handheld-based motion graphing application?
- What considerations must be made to design this application?
- What features of this application make it more useful in physics experiments than the existing methods of graphing motion?
- What are the measurable benefits of using this application to the learning process?

4. The Proposed System

We discuss a sample use case, implementation and preliminary evaluation of our proposed system.

4.1 Sample Classroom Discussion on Motion Graphs

A class discussion involving graphing motion aims to teach students how to draw and analyze the three motion graphs. The analysis includes using the slope and/or area under the graphs. Typical questions ask students to identify instances when the object is speeding up, slowing down, moving with a constant velocity, moving away from the origin, or compute the total distance travelled by the object, or its displacement from the origin. A lesson in graphing motion in a physics class may ask students to plot the graph of the following scenario:

"A fashion model's coach is a hard-core physicist by heart. The coach gave the model the following set of instructions: 'From the back, which is the starting point, walk 3 meters up front in 5 seconds. Then, stay there for 5 seconds. Run fashionably for another 5 meters in just 2 seconds. Stop and pose for your final exposure for 5 seconds until the curtain closes."

Manually graphing the movement of the fashion model will show the following displacement vs. time, velocity vs. time and acceleration vs. time graphs, as shown by Figure 4.

This lesson can be enhanced with technology. Students can be asked to act as fashion models and perform the set of movements in front of a motion sensor. The use of the sensor requires the student to hold a cardboard or any surface that can reflect as much ultrasound back to the sensor as possible. This setup is shown in Figure 5. Similarly, the students may record their movements on a video. The video is then imported to any video logger software in Section 2.4.2. Using the ticker timer in this lesson is not ideal because the fashion model will have to stop twice. As pointed out earlier, a ticker timer cannot properly register the amount of time a target object is at rest.

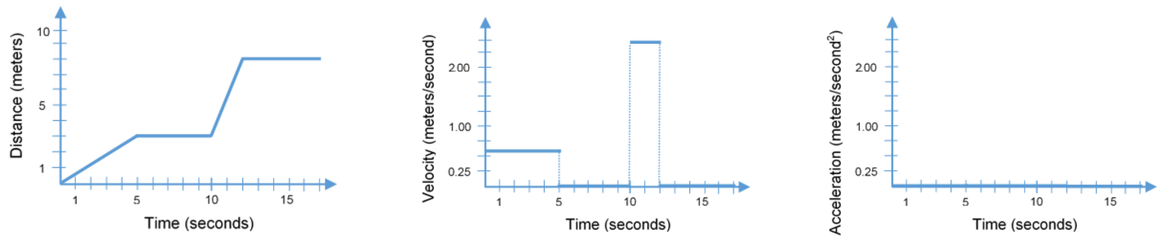

Figure 4: The motion graphs of the fashion model as plotted manually: (from left to right) distance vs. time, velocity vs. time and acceleration vs. time.

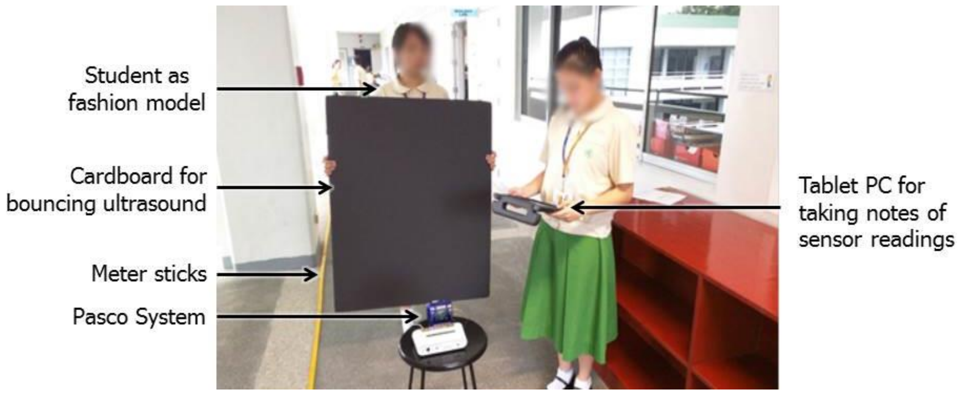

Figure 5: Two students from Miriam College High School perform the set of instructions for the fashion model scenario. A PASCO Motion Sensor is located in front of the student holding a black cardboard. Meter sticks are set on the floor to guide the student's movement. A second student manages the sensor. She also collects the data from the sensor using a tablet computer.

Our proposed system shown in Figure 6 and discussed in Section 4.2 aims to support this use case. The software must be able to measure the distance between an object and a reference point in a given time interval. By having the software take note of the distance travelled by the object at a specific time, a distance vs. time graph can be constructed, from which both velocity vs. time and acceleration vs. time graphs can be drawn.

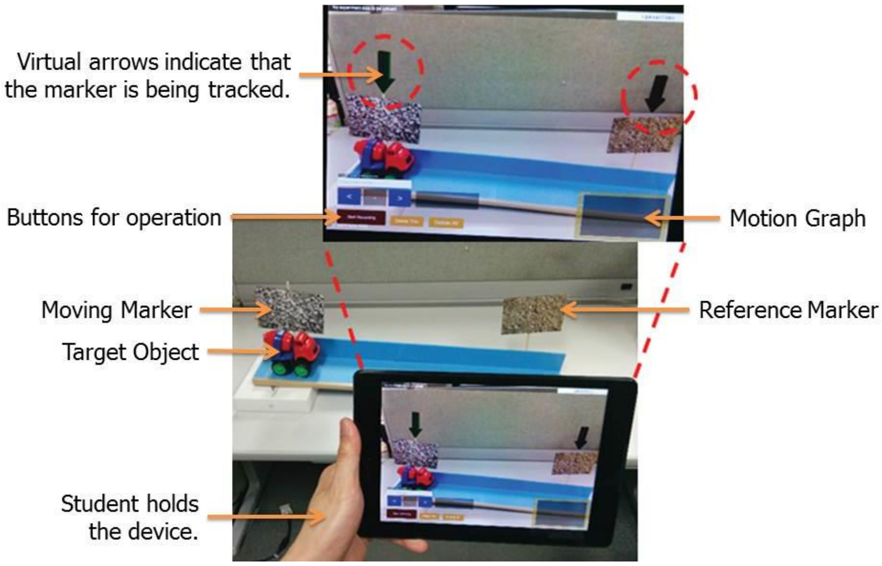

Figure 6: The current implementation of the system.

4.2 Implementation

Figure 6 shows the current implementation of our proposed system. The main operation of the device is as follows: The workspace is a camera view of the scene with a few buttons for operation and a small window at the lower right, to quickly show the graph. The students point the device to markers, then virtual arrows appear to give feedback that the application is tracking. The students simply press the "Start" and "Stop" buttons to capture the movement of the target object. The generated motion graph will be shown at the lower right. If the graph looks incorrect, the student can simply discard the data. If the graph looks correct, they can send it to online database to view the graph in a bigger screen. Students can also download their raw data from the website for further processing. They can also access their data at home for making reports.

Our motion graphing application caters to both Android and iOS handheld devices with a supporting web service and web application. There are three main components: the mobile component, the server component and the web component.

4.2.1 Mobile Component

We use the game development environment called Unity (https://unity3d.com) to develop for both Android and iOS devices. Our mobile component contains several subcomponents including tracking, graphing, database, calculator and networking. The most important subcomponent is the tracking part, which we accomplished using the marker-based tracking technology of Vuforia (https://developer.vuforia.com).

4.2.2 Server Component and Web Component

We prepared a server database to manage the students' experiment data. As such, we implemented a server component to facilitate communication between the database and the handheld application, and between the database and our web application. The web component handles getting the data from the server database, and showing larger motion graphs on a desktop computer.

4.3 Initial Deployment and Testing

We are currently improving the prototype based on initial input and testing from 11 students and two physics teachers of Miriam College High School in Metro Manila, the Philippines. The teachers were able to successfully install the application in Samsung 10.1, 16 GB, Android tablet computers. These tablets are available to the students of the said high school in a 1:1 ratio. Thus, both individual and group explorations are possible.

Given the first prototype, suggestions for improvement were raised from both teachers and students. Suggestions include having an adjustable sampling rate to make the application more flexible to the user's specifications. Currently, motion sensors such as the PASCO Motion Sensor allow for inputs of the sampling rate. Another suggestion is to set the markers such that they are initially close together which corresponds to zero-separation distance. The application will be more intuitive if the markers would follow the same convention of the Cartesian coordinate system, where left and down are negative directions, and right and up are positive. Lastly, students initially thought that the virtual arrows were forces acting on the target object. To avoid this confusion, we plan to replace the arrow with a different symbol.

5. Conclusion and Future Work

In this paper, we discuss our design of a handheld-based motion graphing application for use in physics classes. We draw design requirements from previous work and design guidelines. We also made considerations from the perspective of Philippine education and women's education. We presented different methods of graphing motion in physics classes, including the benefits that they provide, and their limitations. We then described our prototype and the initial feedback from teachers and students.

After we develop an acceptable version of the application, we will evaluate it based on three constructs – usability, interaction and learning outcomes. The evaluation will be conducted following a quasi-experimental method, with a pre- and post-test research design for the learning outcomes. Three groups of students will serve as respondents of the study. The first group will follow a traditional mode of studying motion graphs without the use of any technology. The second group will use PASCO Motion Sensors, while the third group will use our handheld-based motion graphing application. The results of the pre- and post-tests will help quantify learning outcomes.

Usability may be measured by observing the behavior of the three groups. The group which takes a shorter time in setting up their devices and experiments, and also a shorter time in gathering data and analyzing data will reveal the method that is easier to use. Additionally, the length of the laboratory handout which enumerates the steps of an experiment can also be an indicator of a device's ease of use. The handout will be written by teachers who are not aware of this study to remove bias. The frequency of student questions that relate to the use of the device to teachers also indicate ease of use. The fewer questions indicate that the interface is intuitive. Respondents from the second and third groups will also fill up questionnaires. Results of this survey will be used to further gauge how students find the usability of the software.

Classroom dynamics might also be affected with the introduction of the handheld-based application. How the software facilitates collaborative learning can be measured through behavior observation and questionnaires. The groups will be observed to see whether the software encourages more student-to-student interaction and greater participation in pre-lab, actual lab, and post-lab phases of the class discussion.

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Toward Guidelines for Designing Handheld Augmented Reality in Learning Support

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Abstract: Developing systems using emerging technology such as augmented reality is difficult because there are limited guidelines to inform developers during the design process. In particular, there are no established guidelines for learning support systems based on handheld augmented reality. To gather such design guidelines, we first summarize existing guidelines for handheld augmented reality in other fields of application. We then provide our synthesis of these guidelines into five design guidelines. We share our own experience of how we observed these guidelines in developing FlipPin – a handheld augmented reality system for learning new vocabulary. We then propose an additional guideline based on our experience.

Keywords: design guidelines, handheld augmented reality, learning support, mobile devices

1. Introduction

Designing effective user interfaces using emerging technologies is challenging because there are no existing design guidelines or interaction metaphors (Gabbard & Swan, 2008). Experienced developers rely on best guesses and intuition which novice developers have yet to develop. In some cases, developers propose completely new ways for users to perceive and interact with information. Thus, there is limited prior experience to inform the developer during the development process. To address this challenge, it is important to gather and synthesize prior experiences into design guidelines.

Augmented reality (AR) is an emerging technology that may be useful for education (Santos, Chen et al., 2014; Bacca et al., 2014). In AR, virtual information is presented on the real environment as if it coexists with real objects (Santos, Luebke, et al., 2014). It enables many compelling experiences in science education (Kaufmann & Schmalstieg, 2003; Ibáñez et al., 2014), language learning (Santos, Luebke, et al., 2014; Liu & Chu, 2010; Hsieh & Lin, 2006), history and culture (Rodrigo, et al., in press; Di Serio et al., 2013), etc. Among the many forms of AR, handheld AR (HAR) – AR running on handheld devices like smartphones and tablet – may be the easiest to deploy because of the increasing availability of handheld devices in schools. Although some design guidelines for HAR application exists, these guidelines were formed around more mature application areas of AR. There are limited design guidelines for developing HAR for learning support.

To gather design guidelines that may be applicable to learning support, we summarize existing guidelines for HAR applications. We then provide our synthesis of these guidelines and explain how we applied these to the design of FlipPin – a HAR system for learning new vocabulary. Based on our observations, we suggest that these guidelines are also applicable for learning support. Moreover, we recommend one more guideline for further investigation.

2. Related Work

Gabbard and Swan (2008) explain that design guidelines are important to inform the development process. When design guidelines are not available, developers need to conduct user studies to help guide their design. These user studies must be made as general as possible so that the findings could also be applied in other scenarios. Eventually, these individual findings are accumulated into design guidelines and standards. Figure 1 shows how user studies help both the formation of design guidelines and development of a particular interface. Similar to Gabbard and Swan, we try to design our user studies with FlipPin (Santos, Luebke, et al., 2014) to have wider generalization.

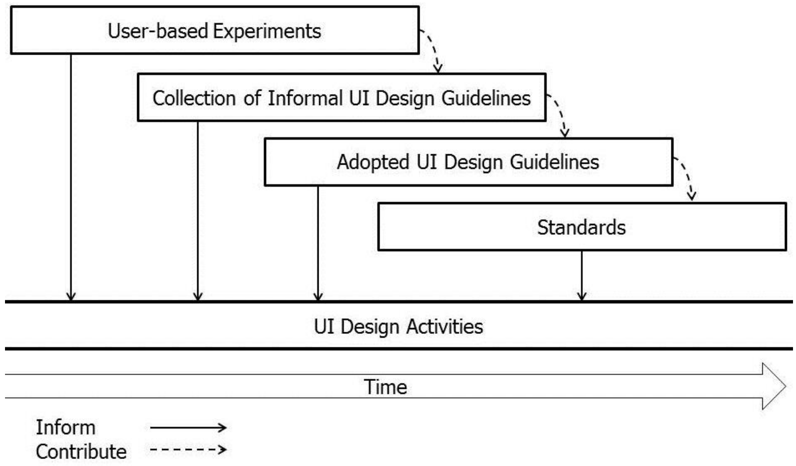

Figure 1. Gabbard and Swan's diagram for the development of design guidelines and standards for user interfaces (UI). The diagram emphasizes on the dual-purpose of user studies (user-based experiments). Experiments can both inform the design of a particular interface and accumulate into design guidelines. These guidelines, in turn, contribute to both UI design and establishment of standards.

Gabbard (2001) lists a comprehensive collection of design guidelines found in the virtual reality and AR literature from 1987 to 1999. Most of the guidelines focus on AR using head-mounted displays as the presentation device. The guidelines include insights on many aspects of AR systems such as visual feedbacks, tracking user location and orientation, data gloves and gesture recognition, users and user tasks, object selection and manipulation, etc.

Improvements in handheld devices (camera, processing power, large screen, etc.) and tracking and rendering algorithms have enabled developers to create AR applications running on smartphones and tablet computers. Some of the design guidelines from HMD-based AR may apply to HAR. However, HAR also has different usability issues that arise from the use of handheld devices (Santos, Polvi et al., 2014). Some design guidelines for HAR application exist. However, these guidelines were formed around more mature application areas of AR such as tourism (Kourouthanassis et al., 2013), navigation (Ko et al., 2013) and games (Wetzel et al., 2008).

3. Summary of Design Guidelines

Table 1 lists the design guidelines proposed by Kourouthanassis et al. (2013), Ko et al. (2013) and Wetzel et al. (2008) based on their experiences in making HAR applications for tourism, navigation and gaming, respectively. We found a total of 23 guidelines including 5 for tourism, 6 for navigation, and 12 for games. Although these guidelines are developed around specific types of commercial application, there are several overlaps that may be true for many HAR applications. For example, finding a specific place with the help of HAR is common for all these application areas. Another example would be the use of intuitive icons and menu navigation, which is also applicable to non-AR handheld applications. We summarize the 23 design guidelines into five design guidelines that we think may be applicable to HAR in learning support.

3.1 Design Guideline 1: Present Context-aware Content

AR is essentially a context-aware technology by its definition of presenting virtual objects or digital information on to a real environment (the context). As such, guidelines G3 and G4 in Table 1 emphasize on the purposeful use of the real environment. Moreover, developers should manage the presentation of virtual elements so that they do not obstruct the view of the real environment, as suggested in G8. Aside from the location as the context, developers can also detect and use other contexts, such as time and user intentions. Based on this context, content can be filtered, as suggested in guidelines T1 and N2.

Table 1: Design Guidelines for HAR in Tourism, Navigation and Games

Application Area	Design Guidelines
Tourism	T1. Provide context-aware content by understanding the users' context using sensing and marker technologies. T2. Provide relevant content by allowing the user to personalize, expand, or limit the presented information. T3. Protect the users' privacy. T4. Provide user feedback on the status of the application. T5. Use familiar icons and interaction metaphors.
Navigation	N1. Allow users to navigate hidden virtual information by operating the camera. N2. Limit the amount of information using the user's context, search result ranking, and/or user input. N3. Use familiar icons consistently and provide quick support to clarify icon meanings. N4. Allow users to modify the breadth of their search. N5. Provide a help menu for HAR features. N6. Support operations using only one hand.
Games	G1. Focus on game design by designing the game experience first before deciding the technologies required for implementation. G2. Stick to the theme of the game by selecting technologies that are relevant to the time period and ambience. G3. Make the user interact with a combination of real and virtual objects. G4. Situate the game in meaningful environments, rather than simply placing virtual objects in arbitrary space. G5. Keep the interaction simple. G6. Allow users to easily share their experience. G7. Encourage interaction with other players, non-players and virtual characters. G8. Show the real environment by managing the virtual objects to not block the entire view of the real environment. G9. Use potential technical problems as game elements, thus part of the gaming experience. G10. Adapt, not directly convert, games from other formats to HAR. G11. Add meaningful virtual content that contributes to the overall game experience. G12. Select the most appropriate tracking method for your target game.

3.2 Design Guideline 2: Provide Content Controls

Aside from automatically managing content based on the users' context, HAR applications should provide ways for the user to adjust the amount and quality of the content. HAR applications are susceptible to presenting too much information, leading to cluttered screens. To address this, T2, N4 and G8 in Table 1 suggest that applications should allow users to hide, expand or personalize the presented content. For content hidden from the current view, N1 recommends to have hidden content be accessible via camera movement, such as appearing/disappearing depending on where the camera is pointing.

3.3 Design Guideline 3: Preempt Technical Difficulties

As an emerging technology, HAR is susceptible to many perceptual and ergonomic errors. Although AR technology is mature for several applications, AR researchers are still improving its related technologies like tracking, sensor fusion and graphics rendering. Developers should compensate for this error by providing feedback to users on the current status of the application. For example, T4 recommends informing the user about the loading time of virtual data and if there is tracking instability. In some areas, it's possible to mask technical difficulties such as including it in the game experience, as recommended in G9. G12 recommends choosing the tracking method that would work best for the application. Lastly, N5 suggests having a help menu to assist users with common errors.

3.4 Design Guideline 4: Preserve Intuitive Icons and Menus

Icons and menus still apply for HAR applications. T5 and N3 suggest the use of familiar icons and menu structure, such as those from WIMP interfaces. In general, G5 suggests keeping the operations simple especially because we are dealing with a smaller screen compared to desktop computers. For novel icons and menus, T4 and N5 recommend features to assist users with operating the system.

3.5 Design Guideline 5: Promote Social Interactions

Aside from using HAR to support intuitive interaction between the users and the real environment, AR should support interactions among users, and between users and other people, as recommended by G7 in Table 1. Moreover, G6 suggests that HAR applications should provide ways for users to easily share their experiences whether face-to-face or through digital means of communication.

4. The FlipPin Application

We developed a HAR application called FlipPin which aims to teach new vocabularies on a real environment. To use FlipPin, users point the handheld device to objects marked by fiducial markers. Then, three-dimensionally registered sprite sheet animations illustrate the action of a verb. Users can hear proper pronunciations by pressing the "listen" button and read the translation of the target word by pressing the "translate" button. The application runs on iPad2 tablet computers and uses the ARToolKit for tracking. For more details, we discussed our design, implementation and user studies further in a previous paper (Santos, Luebke, et al., 2014).

Figure 2. The FlipPin interface (left) and the sample real environment (right)

4.1 Designing FlipPin

We tried to observe the five design principles discussed in Section 3 in developing FlipPin. First, we *present context-aware content* by applying three-dimensionally registered content. For example, in Figure 2, we illustrate the music playing (“spielen” is German for “to play”) as virtual musical notes emerging from a real CD player. We *provide content controls* by rendering the content for the closest fiducial marker only. The content then switches to the next content when the user points the handheld device to a different marker. Moreover, we provide controls for toggling the text panels on and off. We made the text panels transparent to minimize obstruction of the view of the real world, while keeping the texts legible. We *preempt technical difficulties* by using fiducial marker-based tracking instead of point cloud based tracking. Point cloud-based tracking may be unstable to use for this type of scene with many movable individual objects as show in Figure 2, right. Moreover, in this scenario, the fiducial markers point the user to the real objects that are linked with virtual content. We *preserve intuitive icons and menus* by using the interface elements of the iPad, such as buttons and labels. Keeping the iPad interface elements allows users to apply their prior knowledge of using the iPad. However, instead of buttons with text labels, graphical icons may be more familiar for the users. Finally, we *promote social interactions* by locating the content in a place where people could study and chat with each other. In our user studies with FlipPin, the real environments that we used were an office (Figure 2, right) and a refreshment area where people eat snacks. We observed that even after using the HAR system, users would tend to discuss the content related to the objects marked by fiducial markers.

4.2 Lessons Learned

Based on our experience of developing FlipPin, we think that the five design guidelines that we derived from guidelines inspired by other fields of application are also useful for making applications for learning support. Such guidelines are important to inform developers of HAR applications given the developing nature of AR technology.

Aside from these five design guidelines, we propose the following guideline for further investigation:

4.2.1 Design Guideline 6: Pay Attention to Manipulability

Manipulability refers to the ease of handling the device when operating a HAR application (Santos, Polvi et al., 2014). One of the unique features of HAR is that it expects the user to handle and pose the handheld device in unconventional ways. We recommend limiting the amount of virtual information presented through AR to prevent fatigue. The rest of the information can be presented using more conventional display methods for handheld devices. We also recommend having interactions that allow users to rest before proceeding to the next subtask. For FlipPin, the users pointed the device to real objects in less than 20 seconds. Then, they put the device down and repeat the word to themselves. In addition, N6 in Table 1 recommends supporting one-handed operations.

5. Conclusions and Future Work

Guidelines are important to design effective HAR applications. However, in learning support, there are limited design guidelines to inform developers. In response, we synthesized five design guidelines based on other researchers’ experiences of designing HAR applications for tourism, navigation and gaming. We then explained how we applied the five guidelines to our own application for learning support. Furthermore, we recommended an additional design guideline based on our experience. We think these guidelines are helpful in designing HAR applications for learning support.

In this paper, we offer the six design guidelines for further investigation. For easier memorization, the six design guidelines could be referred to as the Six Ps. The Six Ps are: **P**resent context-aware content, **P**rovide content controls, **P**reempt technical difficulties, **P**reserve intuitive icons and menus, **P**romote social interactions, and **P**ay attention to manipulability. We hope that these design guidelines would be also helpful to other developers, especially for those who are beginners in HAR development.

Currently, our guidelines focus on usability and easing cognitive load which is important in learning support. To improve on these guidelines, we plan to compare it with existing guidelines for non-AR handheld applications for learning support. We expect these guidelines to grow our understanding of the best practices in the field. We can then modify the Six Ps or add some new guidelines. We also plan to continue developing FlipPin and other learning support systems that use AR. Through user studies, we can find possible improvements on the interface, as well as contribute to the growing knowledge on HAR design, especially in the field of learning support.

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The Development of a Game-Based Formative Assessment Mathematical Algebra Tutorial App

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Abstract: Algebra plays an important role in the domain of mathematics learning. During the process of solving, not only was it to deepen the basic knowledge of mathematics, but it was also to promote learners' ability of analysis and answering questions. However, during the process of solving an unknown quantity, some researchers mentioned that the learners often made some mistakes such as misunderstanding the meaning of algebra, and it could result in a poor learning of mathematical algebra. In addition, it was also proposed in past studies that the technology integration into learning was helpful to improve the learning effectiveness if employing appropriate teaching strategies, such as game-based learning, formative assessment, and mobile learning. Therefore, the technology of mobile application (abbreviated as "app" in the following) incorporating with the strategies of game-based learning and formative assessment is adopted in this study to develop a game-based formative assessment mathematical algebra tutorial app, and it is expected to enable learners' active learning and improve their learning effectiveness.

Keywords: Game-based learning, formative assessment, mathematical algebra, mobile learning, mobile application

1. Introduction

The learners often had some difficulties in answering the questions of mathematical algebra. For example, learners could not understand the setting of questions or the point of words; they could not make connection of concepts of two words or understand the concepts of unknown quantities (Chiu & Mao, 2002). Hence, some learners progressively began to generate exclusion in learning mathematics. However, due to the progressive process of learning mathematics, the exclusion phenomenon would lead to the learners' difficulties of learning mathematics. Voinea and Purcaru (2014) had explored the effectiveness of learning mathematics at different learning levels, and it is found that the interest of learning mathematics is getting declining for the learners at higher grade. Therefore, how to effectively conduct learners to understand the process of answering the application questions is taken into account in this study.

With the advance of information technology, subsequent scholars increasingly discussed the technology integration into mathematics learning and the possibility to improve the learners' interest of learning mathematics. For example, Wu and Meng (2005) had integrated information technology into teaching with the strategy of question answering, and they explored the effectiveness of question answering on learners in elementary school with mathematics learning disabilities. The results show that it could reduce learners' errors in historical process of answering the questions and improve their attitude of answering the questions. Lwo, Laurence and Liu (2012) developed a personalized computer-assisted instruction (CAI), and they explored the effect of this system on learners learning mathematics algebra questions in elementary school. The results indicate that the learners behave more positively while learning mathematics algebra questions. Lin, Hung, Chang and Hung (2014) proposed a problem-solving learning system (PSLS), and the results show that PSLS is appraised well by 95% teachers and learners. Meanwhile, the learners considered PSLS an effective learning tool as learning contents of problem-solving, and they behave more positively.

However, there were a lot of technology-assisted teaching tools, such as audio-video equipment, teaching compact disc (CD), computer software, network communication, and mobile application (abbreviated as “app” in the following) which was popular recently (Chung & Cheng, 2005). Some researchers appropriately combined app and learning, and it also created more possibility of teaching and learning. For example, Lo (2013) had successfully established cloud app of language learning, and it could be used to provide users to learn the "classical poetry". Due to the availability of app rating at app store, Zhang and Huang (2014) had organized and analyzed the rating of education apps at app store. The results indicate that the number of education apps with 5 stars which is the maximum is still less than the half of those with 2 stars. Accordingly, the education apps at app store were considered to be still not complete and need improvement by customers. Moreover, it was also conducted to compare free apps with commercial ones; the results show that the customers were willing to pay for commercial apps if their qualities were good enough. Therefore, it is found that user’s intention to use be affected by the apps quality. Zhang and Huang (2014) also suggest that the mechanisms of feedback and scoring should be established during the development of education apps, and it could enable the learners to review their learning portfolio and promote their learning effectiveness. Therefore, in this study, the technology of app is adopted, and the suggestion of Zhang and Huang (2014) are also taken into account to increase the integrity of system.

Although the technology integration could attract learners’ interest and improve learning effectiveness, it is insufficient to promote learners’ interest and learning effectiveness only with the technology integration. Chou and Wu (2014) discussed the learners’ effectiveness while learning the surface area of composite solids of mathematics with three teaching modes; one mode was an instruction assisted by Google SketchUp with push-and-pull function, another mode was an instruction assisted by Google SketchUp without push-and-pull function, and the other mode was traditional lecture. Push-and-pull function enabled learners to change the surface area of composite solids. The results indicate that the learners’ effectiveness using the mode of an instruction assisted by Google SketchUp with push-and-pull function is better than those using the other two modes, and there is no significant difference for learning effectiveness between the mode of an instruction assisted by Google SketchUp without push-and-pull function and the mode of traditional lecture. Accordingly, there would be impact on the learning effectiveness when information technology integration into mathematics teaching if insufficient influence of information technology (Chou & Wu, 2014). Chung and Cheng (2005) pointed out that making good use of the technology and incorporating with the teaching strategies during the process of teaching and learning would be helpful to the effectiveness of information technology integration into mathematics teaching.

However, there are a lot of teaching strategies, and game-based learning is considered a helpful teaching strategy to attract learners’ interest and enable learners to enjoy learning (Huang, 2006). Moreover, Chen and Chen (2009) also suggest that the feedback mechanism of formative assessment is helpful to assist learners’ mathematics learning, and it could enhance their mathematical ability and promote learning interest. Consequently, it is intended in this study to develop a game-based formative assessment mathematical algebra tutorial app, and it is expected that the intentional app is helpful to facilitate learners’ active learning and promote learning interest and effectiveness.

2. Literature Review

2.1 Game-Based Learning

A virtual environment was provided to game players, and they had to use their own knowledge to solve the questions encountered under a virtual environment (Huang, 2006). Game-based learning was to proceed learning by the way of a game, and teaching would serve as game playing in order to attract learners’ interest and enable learners to enjoy learning (Huang, 2006). Many scholars had combined a lot of fields with a game, and they found that game-based learning could really promote the learning interest (Chen, Chiou, Chen, & Chang, 2013; Chen, Ho, Wu, Wang, & Yan, 2010). Chen et al. (2010) had integrated the mechanism of game level into the natural science learning in elementary school, and the results showed that the majority of learners considered game-based learning to be more interested and helpful for learning. Chen et al. (2013) integrated a game into mathematics learning to help learners to understand the concept of mathematical division. The results indicated that it could effectively promote the learning interest and facilitate positive learning.

In addition, Chen et al (2010) found that the rank of system components to impress learners was scenario, way to play game, subject knowledge, display, and sound effects. Therefore, it was suggested in game design to avoid too much learners' focus on interesting parts and stimulus brought by game playing, and thus the objectives and the contents of teaching were ignored. Consequently, the strategy of game-based learning is employed in this study to develop an app based on the game level, and the suggestions by Chen et al. (2010) are also adopted to avoid more attentions on game playing than on the teaching contents.

2.2 Formative Assessment

Formative assessment was able to facilitate teachers and learners to understand the learning process and improve learning effectiveness (Cowie & Bell, 1999; Scriven, 1973), and it would play an important role in learning (Bell & Cowie, 2001; Black & Wiliam, 1998). Buchanan (2000) also pointed out that an assessment-centered teaching design could correct learners' wrong directions of thinking by the provision of continuous feedback information to learners. Pan (2008) combined the network multimedia and formative assessment to discuss whether or not to enhance learners' motivation. The results showed that the learners presented higher motivation by the combination of the network multimedia and formative assessment. Hwang and Chang (2011) combined the mobile learning and formative assessment, and the results indicated that the learning effectiveness of learners with formative assessment involved was better than those without formative assessment involved.

Moreover, some scholars had pointed out that it was necessary to incorporate some teaching strategies into formative assessment so as to enhance the learning effectiveness of learners (Wang, 2008; Wang, Wang, Wang, & Huang, 2004a; Wang, Wang, Wang, & Huang, 2004b). Buchanan (1998) suggested that "repeat the test" and "correct answers are not given" could be included in the design of formative assessment; when a learner's answer was wrong, an instant feedback was provided to guide the learner to find out the correct answer; using this method was able to facilitate learners' proficiency of answering the questions during the process of practice and actively finding out the answers, and then promote the learning effectiveness.

Incorporating some modules into the Web-based Assessment and Test Analysis system (WATA), Wang, Wang, Wang and Huang (2004a) discussed the impact of three different types of formative assessment strategies on the learning effectiveness of students in junior high school; one was the Formative Assessment Module of the WATA system (FAM-WATA) which included "repeat the test", "correct answers are not given", "all pass and then reward", and "monitor answering history"; another one was the Normal WATA system (N-WATA) which included "repeat the test", and "correct answers are given"; the other one was the Paper-and-Pencil Test system (PPT) which included "answer once" and "correct answers are given". The results indicated that there were significant differences on the learning effectiveness among different formative assessment strategies, and the average score with FAM-WATA was higher than those with N-WATA and PPT. Wang, Wang, Wang and Huang (2004b) also pointed out that the design of self-assessment teaching strategies implemented in FAM-WATA enabled good learning effectiveness.

Moreover, Wang (2008) discussed the impact of three different types of formative assessment strategies on the learning effectiveness; one was the Game Assessment Module of the WATA system (GAM-WATA) which included "repeat the test", "correct answers are not given", "instant hints are given", "monitor answering history", and "all pass and then reward"; another one was the Normal Web-Based Test system (N-WBT); the other one was the Paper-Pencil Test system (PPT). The results showed that the learning effectiveness with GAM-WATA was better than those with N-WBT and PPT, and it also suggested that teaching strategy integration into formative assessment was necessary to promote the learning effectiveness. Consequently, the formative assessment strategies of "repeat the test", "correct answers are not given", "instant hints are given", "monitor answering history", and "all pass and then reward" will be implemented in this study, and it is expected to promote the learning effectiveness.

3. System Structure

3.1 System Architecture

The intentional system is designed for learners and for teachers; a learner can use a smart phone or a tablet to learn the mathematical algebra, and a teacher can use a smart phone or a tablet to query the learners' learning history. The system architecture is shown in Figure 1.

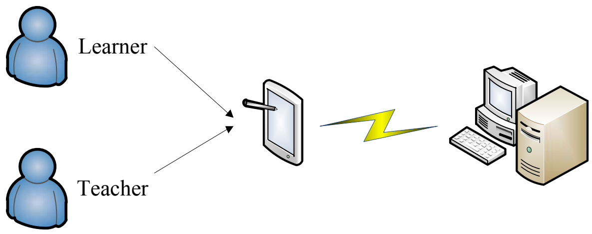


Figure 1. System Architecture.

3.2 Teaching Materials

The contents of teaching materials are selected from a mathematics textbook for sixth grade students in elementary school, and there are eight topics included: "warm-up practice", "average question", "age question", "chickens-and-rabbits question", "catch-up question", "flow rate question", "total review", and "advanced question". Corresponding to these eight topics mentioned above, the intentional App in this study is developed and expected to help learners learning mathematical algebra.

3.3 Game-Based Learning Strategy

The game-based strategy proposed by Chen et al. al (2010) is used in this study, and there are eight game levels designed to correspond to eight topics of teaching materials mentioned above. The learning activities mainly follow the assigned order of game levels, and thus a route animation is designed to inform the learners to click the target game level to advance learning. Therefore, it is illustrated on the map as shown in Figure 2. The inactivated game levels are displayed in gray color; the sphere-like objects denote basic game levels; the pentagon-like object corresponds to the topic "total review"; the six-pointed star corresponds to the topic "advanced question". Furthermore, a toolbar is provided in the upper right-hand corner of the screen, and its appearance can be toggled by mouse click. There are a "Help" button (denoted as a question mark and expressed in text and voice) and a "Close" button (denoted as X) listed on the toolbar.

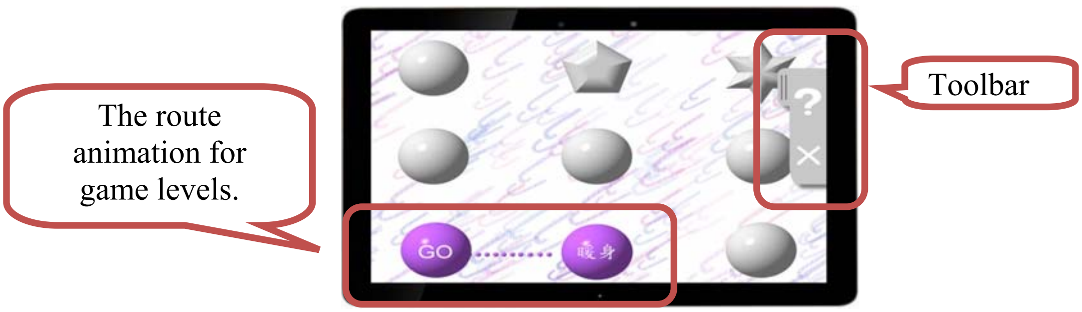
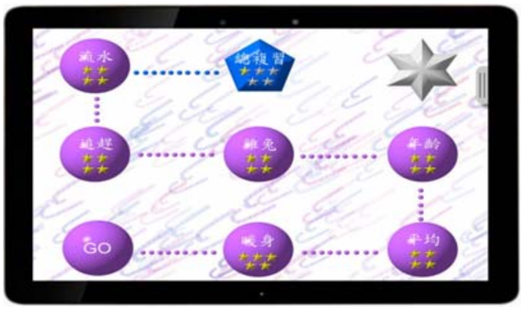


Figure 2. The map of game levels.

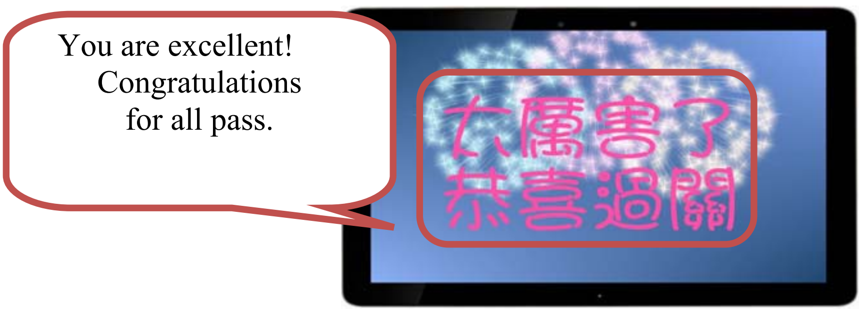
The game level named "warm-up practice" is taken as an example, and there are five game sub-levels corresponding to five questions for this topic. The learners have to follow the assigned order to learn, and they cannot advance to the next game sub-level if not finishing previous ones as shown in Figure 3. The toolbar with the "Help" button and the "Return" button is still arranged in the upper right-hand corner of the screen. Furthermore, the star collection activity is employed in the system to inspire the learners' motivation. All stars will be obtained if the correct answer is given without hints at the first time, but it will result in a one-star loss when the hint is provided after entering a wrong answer.

<u>Figure 3</u>. An example of a game level.

Furthermore, the number of stars within a game level on the map will correspond to the number of its sub-levels as shown in Figure 4. For example, the game level named “warm-up practice” contains five stars corresponding to its five sub-levels. A one-star will be obtained if the correct answer is given without the hints at the first time, but a one-half star will be given if the hints are once provided after entering wrong answers. However, the pentagon-like game level named “total review” will be activated if previous ones are all conquered. The function to access the learner’s personal answering history is also provided by real time recording in the system. Finally, the animation as a reward will be launched to celebrate all pass as shown in Figure 5.



<u>Figure 4</u>. The map of game levels with the star collection activity.



<u>Figure 5</u>. The animation as a reward for all pass.

3.4 Formative Assessment Strategy

A game sub-level within the “average question” level is taken as an example to demonstrate the system design. The question description of a word problem is displayed in the top of the screen, and a toolbar appears in the right-hand side of the screen as shown in Figure 6. There are a lot of buttons on the toolbar, and the function description of buttons is shown in Table 1. Moreover, the area under the question description is available to support handwriting function for the computation details by learners, and its scope is extendable by scrolling up and down. The area to enter the answer is located in the lower right-hand corner of the screen.

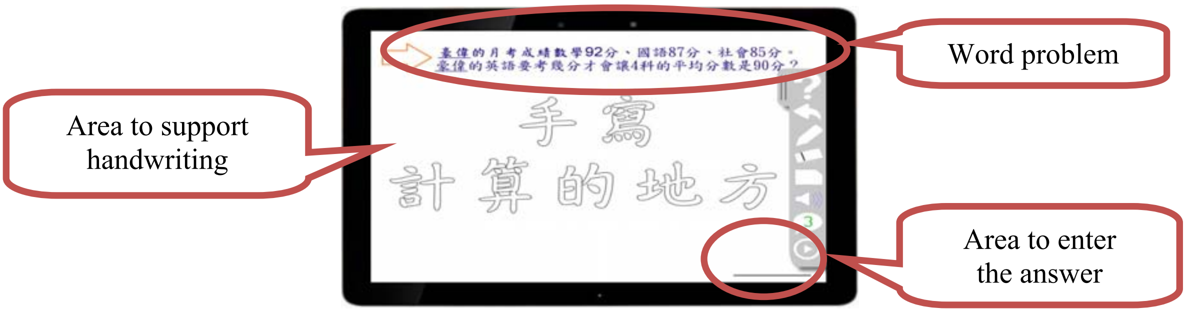


Figure 6. An example of the game sub-level within the “average question” level.

Table 1: The function description of buttons on the toolbar.

Button	Function description
	Provide the operation help expressed in text and voice
	Return to the corresponding game level
	Support handwriting and changing color (the default color is blue)
	Eraser
	Return to the map of game levels
	Speak the question description in voice or turn off the function (the default mode is “on”)
	Provide the hint on demand within three times at most
	Provide the solution with a video after giving the correct answer or three wrong answers

Zhang and Huang (2014) had suggested that the mechanism of feedback and scoring should be established when developing an app, and it could enable the learners to realize their own learning history and promote the learning effectiveness. Accordingly, during the process of learners’ answering the question, the text as a hint is given after entering a wrong answer for the first time as shown in Figure 7; the computation formula as a hint is displayed after entering a wrong answer for the second time as shown in Figure 8; finally, after entering a wrong answer for the third time, the solution video is displayed to guide learners without giving the correct answer as shown in Figure 9. In addition, the animation as a reward is displayed after giving the correct answer as shown in Figure 10. The hints mentioned above are also provided in voice as well as the animation, and their contents are formulated after discussing with the mathematics teachers in elementary school.

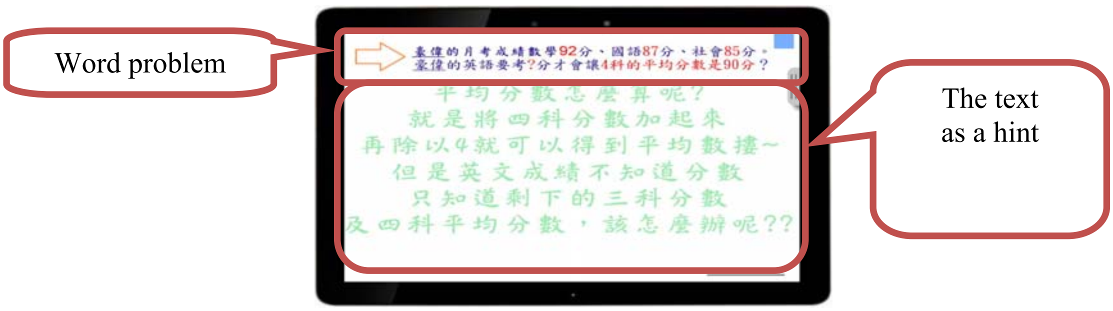


Figure 7. The text as a hint.

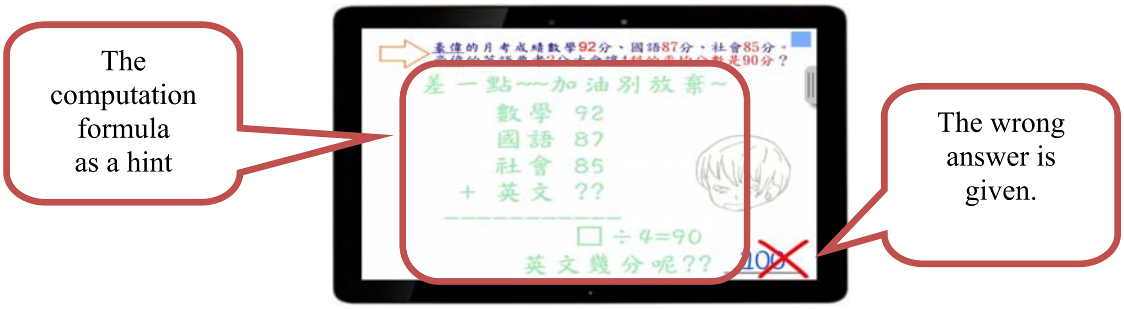


Figure 8. The computation formula as a hint.

Figure 9. The solution video.

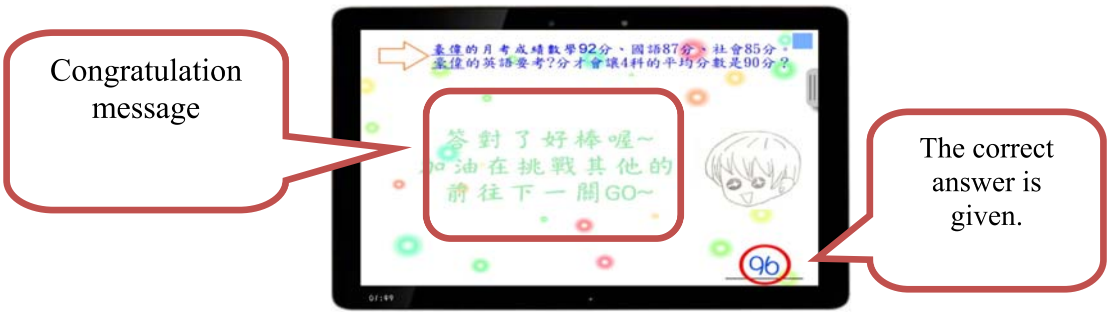


Figure 10. The animation as a reward

Furthermore, the app with the query function for the teachers is also developed to allow them to use a smart phone or a tablet to query the learners' learning portfolio. The learners' current score is illustrated with a bar chart as shown in Figure 11, where the learners' seat number as well as their name is labeled along the horizontal axis and their current score is labeled along the vertical axis. The highest score is 100, and the score computation for each game level is described as follows. There are five questions for the "warm-up practice" level, and their goal is to allow the learners to review the basic mathematical operation. Thus, the score gain is 2 for each question. For five game levels including "average question", "age question", "chickens-and-rabbits question", "catch-up question", "flow rate question", there are four questions respectively for each game level, and the score gain is 3 for each question. For two game levels including "total review" and "advanced question", there are five questions respectively for each game level, and the score gain is also 3 for each question. The score loss is 1 for every time using a hint during the process of answering a question. The score ranking for the learners is shown in Figure 12, and the column titles in the left-to-right order are "Ranking", "Seat number", "Name", and "Score".

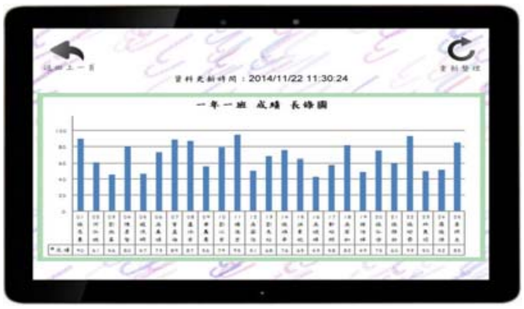


Figure 11. The learners' current score illustrated with a bar chart.

Figure 12. The score ranking for the learners

The personal answering history for a learner is demonstrated in Figure 13, and the column titles in the left-to-right order are "Game level", "Game sub-level", "The n-th time to repeat the test", "Date", "Start time", "Stop time", "Duration", and "Frequency to use the hints". As shown in Figures 11, 12, and 13, the "Refresh" button is arranged in the upper right-hand corner of the screen, and it can be used to refresh the page and update the information on the screen. The update time is also displayed in the top of the screen.

Figure 13. The personal answering history for a learner.

In order to allow learners and teachers to use the proposed system no matter the Internet is offered or not, two switched modes including the offline mode and the online mode are provided in the proposed system. The offline mode can be switched if the Internet is not available or a serious lag, and the learning portfolio for the learners can be temporarily stored in the portable device. When the Internet is available, the online mode can be switched to upload the data temporarily stored in the portable device to the server to update the database and backup. The teachers can download the learners' data from the server to refresh and update the data stored in the portable device by switching to the online mode when the Internet is available, and they can still query the learners' data stored in the portable device under the offline mode when the Internet is not available or a serious lag.

4. Conclusion and Future Work

The game-based formative assessment mathematical algebra tutorial app is developed in this study. During the process of development, the suggestion of Zhang and Huang (2014) is adopted in this study. The mechanisms of feedback and scoring should be established during the development of education apps, and it could enable the learners to review their learning portfolio and promote their learning effectiveness. The suggestions by Chen et al. (2010) are also adopted to avoid more attentions on game playing than on the teaching contents, and the game levels are used to inspire the learners' motivation. In addition, some strategies suggested by Buchanan (1998), Wang (2008), Wang, Wang, Wang, and Huang (2004a), and Wang, Wang, Wang, and Huang (2004b) are incorporated into the formative assessment. The strategies include "repeat the test", "correct answers are not given", "instant hints are given", "monitor answering history", and "all pass and then reward".

The future work is to invite at least two mathematics teachers to test this system, and an interview with the invited teachers will be conducted for forty minutes after the test. The suggestion of the invited teachers will be used to improve and revise the system. Then the teaching experiment is intended to invite two classes of sixth grade students taught by the same mathematics teacher in elementary school. Participants in the experiment are totally 50 students and divided into two groups, the experimental group and the control group. The experimental group uses the proposed app with the strategy of game-based learning and formative assessment to learn, and the control group uses the game-based app without the strategy of formative assessment to learn. The experiment is intended to be conducted in the mathematics course for three weeks, two days a week, and two periods per day. The purpose of this study is to explore the effect of formative assessment strategy on the learners' learning effectiveness.

Acknowledgements

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Effects of a peer-assessment-based mobile physical education learning approach on students' affective perspectives on a university Tai Chi course

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Abstract: The advancement of mobile technologies has encouraged an increasing demand for the support of mobile learning. Researchers have emphasized the need for well-designed peer involvement in order to improve students' abilities in the cognitive, affective and psychomotor domains. Peer assessment has been considered to be an effective learning strategy to improve students' learning performance in past decades. However, few studies have focused on the effects of the peer assessment strategy on students' performance from the affective perspective, especially in Physical Education courses. Therefore, in this study, a peer-assessment-based mobile physical education approach is proposed for developing a mobile learning system for a Tai Chi physical education course in a university. To evaluate the effectiveness of the proposed approach, an experiment was conducted by assigning 42 college students to participate in this learning activity. The students in the experimental group adopted the peer-assessment-based mobile physical education approach, while those in the control group learned with the conventional mobile physical education system. The experimental results show that the proposed approach not only promoted the students' learning interest and motivations, but also improved their learning self-efficacy and socialization.

Keywords: peer assessment, mobile learning, physical education, Tai-Chi, affective perspective

1. Introduction

In Taiwan, physical education is offered as part of the twelve-year national fundamental education as well as at university. The purposes of physical education are not only to train learners in proper exercise habits, but also to enhance their interest in learning, and understanding the individual's physical condition. Teachers have emphasized that a well-designed curriculum plays an important role in physical education, influencing the effectiveness of the teaching/learning process. In particular, motion-based physical education teachers not only instruct learners on sports expertise, but also provide basic operation demonstrations, such that learners will clearly understand the process and knowledge they need to follow in the pre-defined guidelines.

Previous studies have shown that teachers use technology and multimedia as tools in physical education to facilitate learners' learning motivation and enhance their achievement (Leijen, Lam, Wildschut, Simons, & Admiraal, 2009; Papastergiou, Gerodimos, & Antoniou, 2011). Furthermore, multimedia-based teaching models are being widely adopted in ballet lessons to enhance learners' reflective ability. Papastergiou et al. (2011) described multimedia materials presented in the form of blogs that apply to basketball skills to guide the teaching and learning environment. These multimedia materials provided a learner guide (photos) and depiction of the skills, which helped to enhance the learners' self-efficacy. However, the effect of using multimedia in physical education depends on the students' self-discipline ability. Therefore, it has become an important issue to develop effective learning guidance approaches for physical education learning.

The advancement of personal computing technologies such as smartphones, tablet PCs, and wearable devices, has provided an opportunity that enables students to interact with learning systems and their peers in the real world (Kearney, Schuck, Burden, & Aubusson, 2012). This kind of learning approach which allows students to use mobile devices with a wireless network to provide learning materials and perform learning tasks as part of real-world activities has been called "mobile learning" (Lai & Hwang, 2015; Furió, Juan, Seguí, & Vivó, 2015) or "ubiquitous learning (u-learning)" (Chu, Hwang, & Tsai, 2010; Hwang, Tsai & Yang, 2008). Ozcelik and Acarturk (2011) employed the mobile learning approach in a computer course field trip, further showing that mobile learning assists learners in terms of effectively incorporating information into their own practice paradigm. Moreover, Liu and Chu (2010) conducted a mobile English learning activity, also reporting the advantages of the mobile learning approach. Researchers have indicated that mobile learning has great potential for improving students' learning motivation and interest (Chen, Chang, & Wang, 2008; Chu, Hwang, & Tsai, 2010). Researchers have also indicated that proper mobile learning strategies or tools need to be considered to help students acquire the expected learning achievements in real-world environments. This study seeks to explore the difference between traditional and non-traditional mobile-learning strategies regarding physical activity promotion.

To assist students in enhancing their learning outcomes in a mobile learning scenario, peer assessment provides learners with opportunities to develop their own understandings of content, learn from each other, and share their skills and strengths. Moreover, the approach can be used as an aid to learning activities of various courses, such as natural sciences, social sciences, and the humanities (Orsmond, Merrya, & Reilinga, 1996; Falchikov & Magin, 1997; Topping, 1998; Gay, Sturgill, Martin, & Huttenlocher, 1999). Many studies have demonstrated the benefits of peer assessment, which promotes critical thinking, learning achievements and motivation (Chu, Hwang, & Tsai, 2010; van Zundert, Sluijsmans, & van Merriënboer, 2010; Hwang, Kuo, Yin, & Chuang, 2010).

However, despite the value of peer assessment, learners still need to take an active role in the learning process (Tsai, Liu, Lin, & Yuan, 2001). Also, supporting and guiding learners with proper learning strategies and guidance has become an important and challenging issue in developing effective learning guidance models for mobile physical education. To cope with this problem, this study proposes a peer assessment-based approach for mobile learning. Moreover, learning motivation, perceived ease of use and usefulness, and students' self-efficacy are measured to investigate the effects of the proposed approach on the in-field performance of the students from different aspects.

2. Peer-assessment-based mobile Physical education approach

This section further explains how peer assessment is used to engage a student's progress in the cognitive and psychomotor domains. The peer-assessment-based mobile physical education system is developed for conducting physical education activities. Figure 1 illustrates the proposed system architecture, which consists of three modules as follows.

1. Mobile physical education module: students can use their mobile phones to log into the system via a wireless network, and read learning materials and record their learning films. Students can upload their films to the server according to the instructions. The functions of this module contain viewing learning materials, film recording and film uploading.
2. Peer assessment system module: learners can connect the system either on their smartphones or computers to give scores and comments. Learners can also view the scores and comments given by their peers in the system, adjust their movements accordingly, and re-upload their learning videos. The functions of the module include filling in, modifying and viewing the assessment sheets. By discriminating between various learning records, students can learn by considering the motions selected by others, or by rethinking the subject again if they found some ideas or motions to be unfamiliar. It is useful to note that this method of using peer assessment to help students understand the meaning of a subject works for both individual and group settings.
3. Back-end databases module: teachers can observe the students' learning status in the system and check with every learner's personal learning videos and peer assessment results. The module contains databases of the learner's personal information, learning materials, learning videos, learning portfolios and peer assessment sheets.

First, students use mobile phones in a real learning environment, and follow the learning activities provided by the system to learn. During the learning process, the system will provide suitable learning guidance for the students and help them to complete each learning objective. The system also records students' learning films by using the embedded recording function of the mobile phones, and all the films will be uploaded to the server. After all of the films have been uploaded, a peer assessment activity then starts.

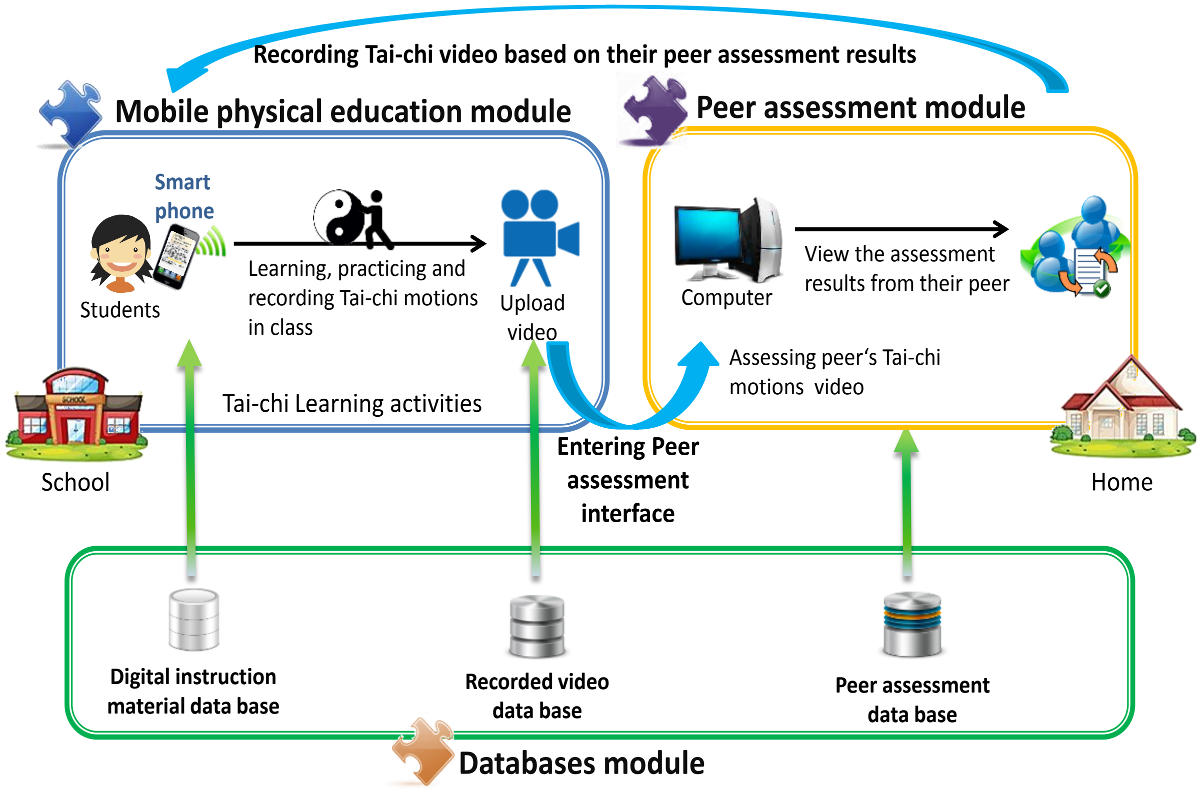

Figure 1. System architecture.

During the peer assessment process, students can use their mobile phones to complete the peer assessment. Moreover, the system will automatically assign two students' films for anonymous assessment. Furthermore, the system uses a five-point Likert rating scheme as the peer assessment sheet, and it will show related information near each assessment item to help students understand the meaning of each item. For example, if students choose 5 points, it means all the movements in the film are correct and good enough. The detailed assessment standard is shown in Figure 2.

Figure 2. System Interface for peer assessment.

After the peer assessment stage, students can then view the scores and advice from their peers, and can record a new film according to the advice. Students can re-upload their films to the system, and the teacher can then log into the system to see all students' films and scores to understand the learning progress of each student.

3. Experiment Design

To evaluate the efficacy of the peer-assessment-based mobile physical education system, an experiment was conducted on the Tai-Chi physical education course in a university in Taipei, Taiwan. A total of 42 undergraduate students (15 male students and 27 female students) participated in this study. The average age of the students was 21 years old. After learning the five basic Tai-Chi motions in the Tai-Chi physical education course, one class was assigned to be the experimental group (n=20) and the other was assigned to be the control group (n=22).

The students in the experimental group were guided by the Tai-Chi peer-assessment-based mobile physical education system, while those in the control group learnt with the conventional mobile physical education system. Both groups of students were taught by the same instructor who has over 25 years of Tai-Chi teaching experience.

Figure 3 shows the procedure of the experiment. It took 6 weeks to conduct the learning activity. In the first two weeks, after learning the five basic Tai-Chi motions in the Tai-Chi course, the two classes were assigned to be the experimental group and the control group. The students were also asked to take the pre-questionnaire including sport learning motivation and sport learning motivation. After the experiment, a post-test was used to test their basic sport knowledge. The students were also asked to finish the pre-questionnaire including sport learning motivation, sport learning motivation, and perceived ease of use and usefulness.

The measuring tools in this study include a self-efficacy measure, a learning motivation measure, and tai-chi skill evaluation. The self-efficacy measure was developed by Pintrich, Smith, Garcia, and McKeachie (1991). The questionnaire for the learning motivation measure was developed by Hwang, Yang, and Wang (2013). The tai-chi skill evaluation was adopted to assess the differences between the two groups after the learning period. The evaluation consists of five basic motions worth twenty points each.

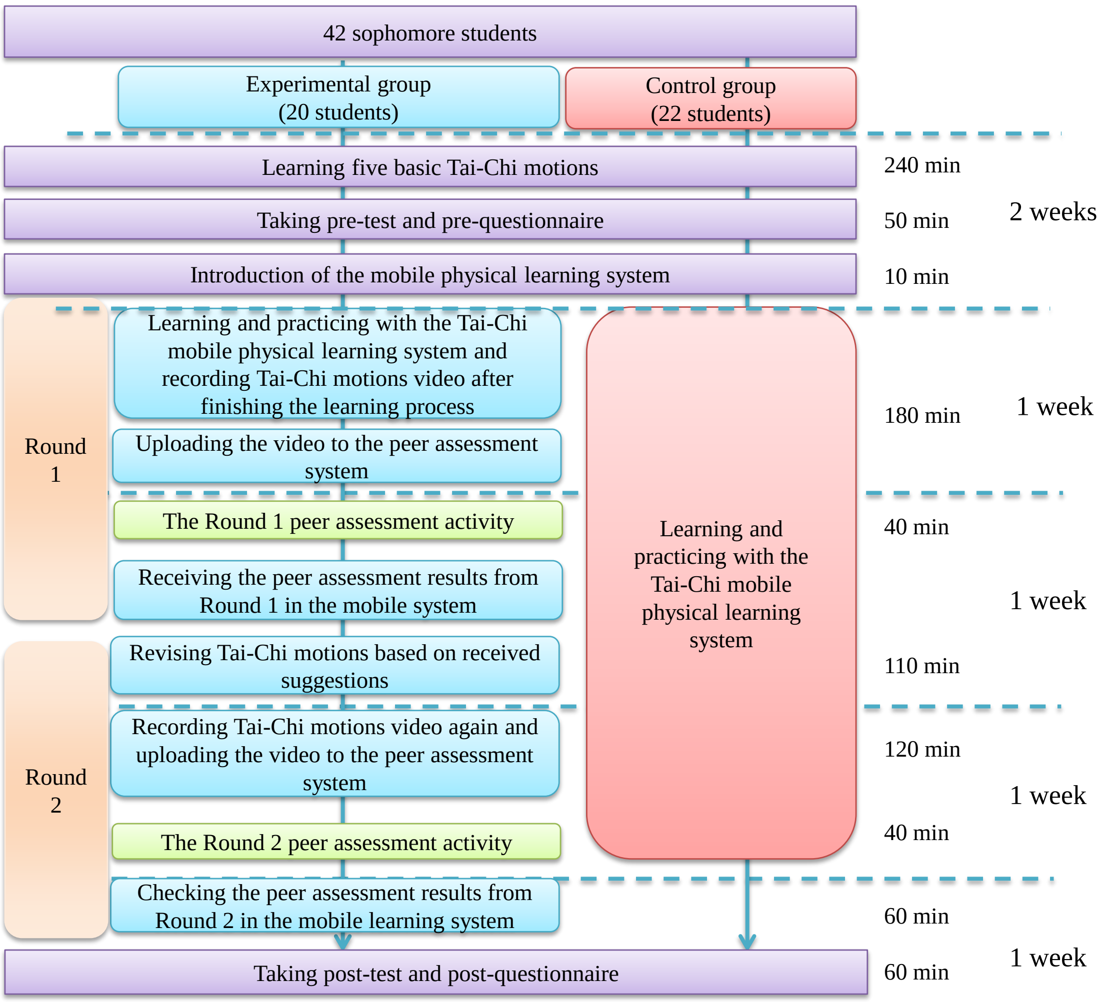

Figure 3. Experiment procedure.

4. Experimental Results

In this experiment, we analyzed the peer assessment mobile learning effect on learning motivations, self-efficacy, and user satisfaction. The major findings are described below.

4.1 Analysis of learning motivations

The questionnaire is presented with a 5-point Likert scale where '5' means strong agreement or positive feedback and '1' represents high disagreement or negative feedback. The results show that the learning motivation of the experimental group students improved after the learning activity. In the learning motivation questionnaire, the experimental group has a significant difference (t=-3.39, p=0.003<0.01) between the pre- and post-questionnaires. In contrast, the t-test results of the control group (t=0.76, p<0.01) showed no significant difference, as shown in Table 1. The results indicate that the learning motivation of the students from the experimental group increased after the learning activity. Further questionnaire analyses showed that the students felt the importance of learning tai-chi (Q1) and they were fond of the content of the class (Q2), as shown in Table 2. The results revealed that the new learning tool effectively stimulated the students and interested them in learning tai-chi based on the comparison of the results of the pre-test and post-test.

Table 1: The paired *t*-test result of the pre- and post-questionnaires of learning motivation.

Groups		N	Mean	S.D.	*t*
Peer-assessment-based mobile physical education group	Pre-questionnaire	20	3.54	0.36	-3.39**
	Post-questionnaire	20	3.91	0.35	
Conventional mobile physical education group	Pre-questionnaire	22	3.61	0.41	0.76
	Post-questionnaire	22	3.54	0.44	

Table 2: The paired *t*-test result of the pre- and post-questionnaires of sports learning motivation for the peer-assessment-based mobile physical education group.

Question		N	Mean	S.D.	*t*
(Q1) I find the content of the Tai-Chi lessons important	Pre-questionnaire	20	3.45	0.60	-2.99**
	Post-questionnaire	20	3.85	0.59	
(Q2) I like the learning content of the Tai-Chi lessons	Pre-questionnaire	20	3.40	0.68	-2.99**
	Post-questionnaire	20	3.80	0.62	

** $p<0.01$

4.2 Analysis of learning self-efficacy

A seven-point Likert scheme was applied in the pre-test of physical self-efficacy. The three sets of values in the one-way ANOVA (Analysis of Variance) test result are provided as follows: the mean value of the test was 4.00 for the peer-assessment-based mobile physical education group and 4.02 for the Tai-Chi mobile learning group (E2). According to the results, there was no significant difference in the physical self-efficacy of the two groups (F=1.70, p=0.19>0.05).

Based on the analysis above, this research further compared the three sets of values of physical self-efficacy before and after learning, as shown in Table 3. The results found that the experimental group (E1) had a significant difference between the pre- and post-tests of physical self-efficacy (t=-2.64, p<0.05). On the contrary, there was no significant difference between the pre- and post-tests of physical self-efficacy in E2 (t=-0.71, p=0.48>0.05). This indicated that perceived self-efficacy significantly improved after learning with the peer assessment-based mobile learning system.

Table 3: The paired *t*-test result of exercise self-efficacy of physical education.

Groups		N	Mean	S.D.	*t*
Peer-assessment-based mobile physical education group	Pre-questionnaire	20	4.17	0.78	-2.64*
	Post-questionnaire	20	4.59	0.72	
Conventional mobile physical education group	Pre-questionnaire	22	4.15	0.78	-0.71
	Post-questionnaire	22	4.24	0.72	

* $p<0.05$

4.3 Analysis of Perceived Ease of Use and Usefulness

To better understand the students' perceptions of the use of the mobile learning system, this study collected the students' feedback on the "perceived usefulness" and "perceived ease of use" of the system. The results indicated that most students gave positive feedback concerning the two dimensions of the mobile learning system. The average ratings for "perceived usefulness" are 3.56 and 2.93 for the experimental group and the control group, respectively; moreover, their average ratings for "perceived ease of use" are 3.81 and 3.59. In comparison with the ratings given by the control group, it should be noted that the students in the experimental group gave higher ratings for "perceived usefulness" and "perceived ease of use", implying that the students who learned with the peer assessment mobile system revealed higher degrees of technology acceptance than those who learned with the mobile learning system.

In terms of perceived usefulness, the *t*-test result (t=3.81, P<0.001) shows a significant difference between the experimental group and the control group. This depicts that the peer assessment mobile learning approach is more effective than the mobile learning approach. The students of the experimental group considered the intelligent mobile system easier to use than a desktop computer. Also, they could learn better by using the intelligent mobile system and the mobile learning system. This implies that most students in the experimental group agreed with the usefulness of the peer assessment learning system approach in terms of improving their learning achievements.

5. Conclusion and future work

This paper explores the impact of using the peer assessment of mobile learning to enhance the positive impact of physical learning. A peer assessment-based mobile learning approach was developed that can provide a richer understanding of how users can more efficiently employ peer assessment to enhance the learning experience. The experimental results showed that the students of the experimental group had significantly improved in their learning motivation. We also surveyed the learners' perceptions of peer assessment-based mobile learning, which were on the whole positive. These results also point to suggestions and references for the design of efficient mobile-supported collaborative learning activities in the future. Further research will be needed to investigate this methodological concern and its practical applications.

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Investigating Correlation between Students' Attitude toward Chemistry and Perception toward Augmented Reality, and Gender Effect

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Abstract: Augmented Reality (AR) is currently recognized as instructional innovation by the way of combining both the real- and virtual world presented via mobile device. In this combination, it benefits student learning by providing contextualized situation and visualizing the complex or invisible scientific phenomena. In this study, a series of AR on chemistry of rate of reaction has been developed and the researchers propose to use the AR as pedagogical tool for facilitating high school students' learning on the chemistry topic. The objective of this study was to examine correlation between gender and students' perception, and their attitude toward chemistry and perception also. 90 tenth-grade students were recruited to interact with the AR in groups. The 25-item attitude questionnaire regarding interest in chemistry lesson, understanding and learning chemistry, the importance of chemistry in real life, and chemistry and occupational choice, was administered to the students as pretest and a series of perceptual items regarding perceived learning, perceived ease of use, flow, perceived usefulness, enjoyment, and perceive satisfaction was administered as posttest, before and after interacting with the AR respectively. The results showed that there was no significant correlation between attitudes toward chemistry and perception toward the AR. In additions, there was also no significant correlation between genders and their perceptions toward the AR. This implied that it is possible to use AR to facilitate chemistry learning of rate of reaction disregarding students' attitudes toward chemistry and gender.

Keywords: Augmented reality, attitude toward chemistry, perception

1. Introduction

Due to the rapid advancement of information and communication technology (ICT) in science education in 21st century, many technologies have become commonplace in improving and advancing the practice of science education because of their potential of bringing about change in ways of teaching and learning (Srisawasdi, 2012). For this reason of research and development in science-based education, the effective use of technology in the classroom teaching process has become an important topic for re-thinking in community of science education. Because of its potential to change the way of teaching and learning, therefore, as part of the change, the integration of pedagogical and technological activities is responsible for improving the process of science learning that often benefit from the application of technology (Srisawasdi, Kerdcharoen and Suits, 2008).

Previous studies indicated many technological tools that could be used to support science learning, such as Microcomputer-based Laboratory (MBL) (Voogt, Tilya and Akker, 2009), computer simulation or simulation (Jaakkola and Nurmi, 2008), web-based inquiry science environment (WISE) (Linn et al., 2003), and Augmented Reality (AR) (Huang, 2011; Cai, 2014). Considering in Thai context, there are only a few of research on development of instructional technology in science teaching and learning. Researchers have been developed and then implemented various kinds of technology for enhancing the learning of science in context of Thai basic education curriculum. Previously research (e.g., Meesuk and Srisawasdi, 2014; Lokayuth and Srisawadi, 2014; Nantakaew and Srisawasdi, 2014 and Kanyapasit and Srisawasdi, 2014) developed and implemented educational digital game to facilitate chemistry and biology learning in high school level. To supporting the construction of conceptual understanding in science, researchers (e.g., Pinatuwong and Srisawasdi, 2014; Srisawasdi and Sornkhatha, 2014; Srisawasdi and Kroothkeaw, 2014 and Srisawasdi and Panjaburee, 2015) have developed effective way of inquiry-based learning by using simulation as pedagogical tool in physics and biology class. Moreover, (e.g., Niroj and Srisawasdi, 2014; Nasaro and Srisawasdi, 2014 and Kamtoom and Srisawasdi, 2014) designed and implemented blended learning environment, a combination of hands-on MBL and online-mediated WISE, to assist student visualizing both observable and unobservable level of natural phenomena. To promote students' science learning through inquiry-based process, (e.g. Piraksa and Srisawasdi, 2014; Meesamrong and Srisawasdi, 2014 and Buyai and Srisawasdi, 2014) utilized a combination of hands-on physical laboratory and computer-simulated laboratory to enhance inquiry-based science learning and promote science motivation for high school students. However, the use of AR for science learning is barely in community of science education in Thailand.

In term of chemistry education, the spatial ability plays an important role in chemistry learning, as students are required to visualize specific microstructures, but the visualization of micro-scale structures is a difficult task for students (Harle and Towns, 2011). Some researchers mentioned that computer animation should be applied for making the students truly understanding and imaging of the chemical phenomena at sub-microscopic level. However, the limitation of computer animation is that it is a virtual which simulates the real world and it may not convince student to believe the presented scientific phenomena. Currently, augmented reality (AR) is recognized as instructional innovation and it is now popularity and more interest among researchers, educators, and teachers. The environment of AR is a combination both real- and virtual world together. Cai (2014) used AR simulation application in chemistry learning and they found that the AR tool has a significant supplemental learning effect for low-achieving students than high-achieving ones. Moreover, students generally have positive attitudes toward the AR and students' learning attitudes are positively correlated with their evaluation of the AR. In additions, AR technology has a positive impact on motivation of learning for student (Di Serio et at., 2013). Learning with AR technology associated with students' positive attitude, motivation, and their genuine interest (Berg, 2005). Moreover, many researchers reported about the relationship between the gender difference and perception of AR. Researcher found that males perform better than females in spatial visualization and orientation tasks through learning with AR technology (Ahmad, 2015). Similarly as Di Serio et at. (2013) reported that augmented reality technology has a positive impact on the students' motivation after learning with augmented reality. In addition Martin et al. (2011) reported that augmented reality is in its initial stage according to its publication impact, and they have proposed that it will probably have significant influences on education in the future. According to the abovementioned, therefore, this study aims to investigate correlation between attitudes toward chemistry and students' perception toward AR, and the gender influences onto perception of AR.

2. Purpose

Accordingly, the aims of this study were to examine the correlation between attitudes toward chemistry and students' perception toward AR in context of chemistry phenomena, and to pilot investigate the efficacy of AR with student's perception related to their gender. Specifically, the following research questions were answered:

1. How were the influences of attitudes toward chemistry on perceptions toward AR after interacting with AR of chemistry of rate of reaction?
2. Are there the gender influences to perception toward AR after interacting with AR of chemistry of rate of reaction?

3. Method

3.1 Study Participants

The participants of this study were 90 eleventh-grade students consisted of 60 females and 30 males (aging between16-17 years old) in the northeastern region of Thailand. They were served in basic chemistry course about rate of reaction and they had no experience with augmented reality applications before.

3.2 Learning activity

In this study, the researchers designed and created a series of AR for using in chemistry learning of rate of reaction. Students were allowed to interact with the AR during a 50-minute inquiry-based lesson. In the lesson, students used mobile phone for observing the chemistry phenomena through a series of AR markers by scanning on the paper, as display in Figure 1.

Figure 1. Students used mobile phone for observing chemistry phenomena through AR marker by scanning on the paper.

3.3 Instruments

This study used two instruments for examining the correlation of students' attitudes toward the chemistry lesson and students' perceptions toward AR. Firstly, The 25-item Attitude Toward Chemistry Lesson Scale (ATCLS) questionnaire (Cheung, 2009), developed in Thai version by Nantakaew and Srisawasdi (2014), was used to measure students' attitudes toward chemistry.

Table1: Subscale descriptions and sample items for the ATCLS questionnaire.

Subscale	Description	Sample items
Interest in chemistry lesson (ICL)	Extent to which student prefer and dislike chemistry learning	- I would like the teaching period of the chemistry lesson more often. - I would like to have fewer chemistry topics in the lessons.
Understanding and learning chemistry (ULC)	Extent to which student developed themselves and relevant in chemistry easily	- I believe that some knowledge in chemistry helps us understand the other science lessons more easily. - Chemistry is a sophisticated and impalpable lesson.
The importance of chemistry in real life (ICR)	Extent to which student thought chemistry about real-life	- I think developments in chemistry improve the quality of our lives. - I think chemistry has a great role in modern life.

Chemistry and occupational choice (COC)	Extent to which student use the information learned in the chemistry classroom for the work in the forward	- I do not believe that chemistry knowledge will be useless after my graduation. - I believe that I do not need chemistry knowledge for my career.

All items were classified into four subscales, consisted of Interest in Chemistry Lesson (ICL) (6 items), Understanding and Learning Chemistry (ULC) (10 items), The Importance of Chemistry in Real Life (ICR) (5 items), and Chemistry and Occupational Choice to Chemistry (COC) (4 items). The sample items and description of each subscale are shown in Table 1.

Another, perception questionnaire (Tao and et al., 2009), developed in Thai by Pinatuwong and Srisawasdi (2014), separated into six subscales, consisting Perceived Learning (PL) (3 items), Perceived Ease of Use (PEU) (2 items), Flow (3 items), Perceived Usefulness (PU) (3 items), Enjoyment (2 items), and Perceived Satisfaction (PS) (5 items). The sample items and description of each subscale are shown in Table 2.

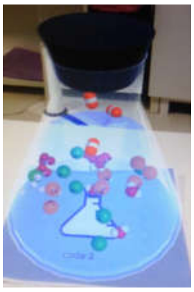
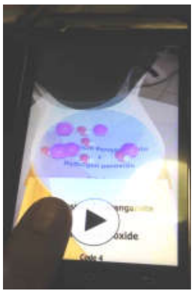
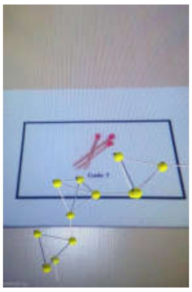
Table2: Subscale descriptions and sample item for the students' perception questionnaire.

Subscale	Description	Sample items
Perceived learning (PL)	Extent to which student can get the new understanding, subjective evaluation of learning by learners themselves.	-The augmented reality increases my learning efficiency. -The augmented reality will help me understand the things I learned.
Perceived ease of use (PEU)	Extent to which using to easy and help to science easier.	-The augmented reality is easy to use. - Using the augmented reality to complete course related tasks are easy.
Flow	Extent to which a state of deep concentration in which thoughts, intentions, feelings, and all of the senses are focused on the same goal	-I was very involved in the augmented reality. - I lost track of time when I played.
Perceived usefulness (PU)	Extent to which students feel happy and attentiveness.	-It is interesting to use games. - I was totally immersed in the augmented reality.
Enjoyment (E)	Extent to feeling of student when used AR.	-I had fun playing the augmented reality for learning science. - I feel relaxed to use augmented reality for learning science.
Perceived satisfaction (PS)	Extent to which the individual awareness of how well a learning environment supports academic success.	-The use of the system makes this learning activity more interesting. - I like to learn new skills by using augmented reality.

3.4 Learning material

In this study, the design of AR technology was related to chemistry concept of rate of reaction. In the AR, it presents 3D model of molecule, and 2D representation of experimental graphs about described theory of chemical reaction will be shown on smart phone screen, which detected AR on the paper marker. The AR engaged student to visualize macroscopic, microscopic, and symbolic representation of chemistry phenomena, and it linked the macroscopic representation from real-life phenomena or laboratory, and also provided information which are three level of representation in chemistry as mentioned. Table 3 illustrates the AR learning material in chemistry of rate of reaction and its descriptions.

Table 3: An illustration of AR learning material in chemistry of rate of reaction and its description.

Topic	Sample of AR	Descriptions
Definitions of rate of reaction		This AR visualizes scientific phenomena of chemical reaction, where the beginning of reaction is fast but it is slow when time up. User could triple touch area of AR display for resetting.
Theories of rate of reaction		This AR visualizes chemistry phenomena about activation energy and activated complex theory. This AR function consists of 3D model and animation. When user uses mobile phone to scan AR markers on paper, it will appear 3D model and also display a button, which can double touch on it, then an animation of experimental graph will appear.
Effect of factor on rate of reaction		This AR visualizes chemical effect regarding nature of substances, surface area, concentration, catalyst and retarder, and temperature. This picture shows the chemical effect of nature of substance. In this picture, when user scans the AR marker, which is match, on paper using mobile phone, the chemical structure of red phosphorus will appear on the mobile phone screen.

3.5 Data Collection and Analysis

This research aims to examine the correlation between attitudes toward chemistry and students' perception toward AR in context of chemistry phenomena, and to investigate the efficacy of AR with student's perception related to their gender. Before their interaction with the AR, the students were administered the pretest questionnaire about attitude toward chemistry lesson in 20 minutes. After that, the students were administered the posttest questionnaire to measure their perception of AR for chemistry learning in 20 minutes. They interacted with the AR in 50 minute during an inquiry-based lesson. Pearson's bivariate correlation was used to examine the correlation and repeated-measure MANOVA was used to investigate the difference of perception among gender.

4. Results and Discussion

4.1 Correlation between students' attitude toward chemistry lesson and their perception

In this part, the results are presented by calculation of statistics on the correlation between students' attitude toward chemistry lesson student before interact with AR and students' perceptions after student interact with AR. Table 4 shows Pearson's correlation of attitude toward chemistry lesson, including interest in chemistry lesson (ICL), understanding and learning chemistry (ULC), importance of chemistry in real-life(ICR), chemistry and occupational choice (COC) in ATCLS, and perceived learning (PL), perceived ease of use (PEU), flow (F), perceived usefulness (PPF), enjoyment (E) and perception satisfaction (PS) in the perception questionnaire. Mean and standard deviation are also presented in Table 4.

Table 4: Descriptive and correlation for attitude toward chemistry lesson and perception toward augmented reality.

Subscale	ICL	ULC	ICR	COC	PL	PEU	F	PPF	E	PS
ICL	1									
ULC	.594**	1								
ICR	.411**	.314**	1							
COC	.486**	.468**	.422**	1						
PL	.136	.238*	-.008	.212*	1					
PEU	.104	.159	-.023	-.029	.480**	1				
F	.048	.233*	-.183	.052	.384**	.455**	1			
PPF	.088	.156	-.035	.052	.551**	.559**	.421**	1		
E	.005	.002	-.082	-.048	.388**	.536**	.231*	.519**	1	
PS	-.002	.067	-.107	.051	.545**	.601**	.386**	.683**	.594**	1
Mean	18.10	30.07	17.83	13.27	13.00	8.54	11.91	12.69	8.69	21.86
SD	3.415	4.146	2.877	2.307	1.398	1.172	1.694	1.633	1.077	1.315

***$p<0.01$*

**$p<0.05$*

The result in Table 4, showed that (1) understanding and learning chemistry (ULC) was related to perceived learning (PL) and perceived flow (F), (2) occupational choice (COC) was related to the perceived learning (PL), (3) importance of chemistry in real-life(ICR) invers correlation with all subscale of perception toward augmented reality,(4) interest in chemistry lesson (ICL) not related with subscale of perception toward augmented reality (PL, PEU, F, PPF, E), (5) understanding and learning chemistry (ULC) not related with subscale of perception toward augmented reality (PEU, PPF, E, PS). So, the augmented reality can use for the most of student even if they have a negative or positive attitude toward chemistry.

The finding from previous study never seen research about revealed that attitude toward chemistry lesson and perception toward augmented reality. But have research about the effect of motivation during interaction with the augmented reality (Di Serio and et at., 2013; Ibáñez et at., 2014). This study indicated that student's perception toward augmented reality via mobile learning does not depend on attitude toward chemistry. Although students may have negative or positive attitude toward chemistry, they can learn chemistry by using augmented reality via mobile phone.

4.2 Comparing students' perception by gender

In this part, the results showed that calculation of statistic on the correlation (repeated-measure MANOVA in SPSS 23.0) between students' gender and students' perception. Table 5 result indicated that the gender does not significantly impact on students' perception toward augmented reality. That means both male and female students can learn chemistry by using augmented reality.

Consider Table 5, the results of participant (30 males, 60 Females) for repeated-measure MANOVA from genders' effect for perception toward augmented reality, six subscales score consists of PE, PEU, F, PPF, PE and PS were significant differences across time.

Table 5: Descriptive and correlation for gender and perception toward augmented reality.

Subscale	Gender	N	Mean	SD	F	Sig.	η^2
Perceived Learning (PL)	Males	30	12.87	1.505	.406	.525	.005
	Females	60	13.07	1.351			
Perceived Ease of Use (PEU)	Males	30	8.50	1.358	.064	.801	.001
	Females	60	8.57	1.079			
Flow (F)	Males	30	11.67	1.807	.937	.336	.011
	Females	60	12.03	1.636			
Perceived playfulness (PPF)	Males	30	12.30	1.822	2.598	.111	.029
	Females	60	12.88	1.508			
Perceived Enjoyment (PE)	Males	30	8.47	1.252	1.935	.168	.022
	Females	60	8.80	0.971			
Perceived Satisfaction (PS)	Males	30	21.27	2.196	2.976	.088	.033
	Females	60	22.15	2.335			

The statistic MANOVA indicated that effect of gender for students' perception on PE (F= .406, partial η^2= .005), PEU (F= .064, partial η^2= .001), F (F= .937, partial η^2= .011), PPF (F= 2.598, partial η^2= .029), PE (F= 0.168, partial η^2= .022) and PS (F= 2.976, partial η^2= .033) was .525, .801, .336, .111, .168, and .088 respectively. In addition to comparison graph between mean value and subscale can simplified for understanding as shown in Figure 2.

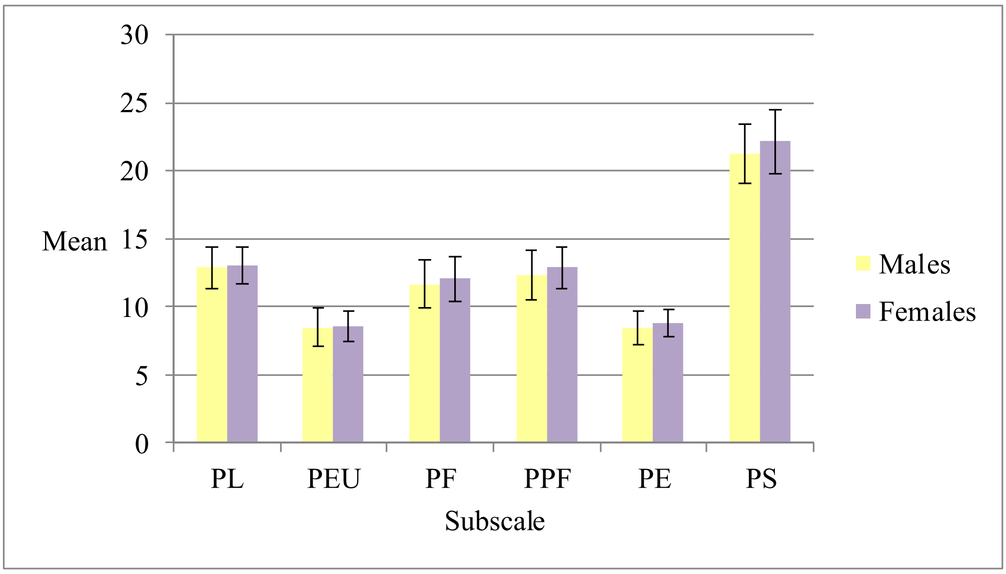


Figure 2. Compare genders' effective between mean scores and subscale of perceptions toward augmented reality.

The finding from previous studies never seen research about revealed that gender and perception toward augmented reality. But there have research about the effect gender with technology (Dorji et. al, 2015). The results pointed out that the students' perception through learning material did not significant to gender, that mean both genders could improve their perceptions toward augmented reality.

5. Conclusion

This study reported impacts of augmented reality investigating correlation between attitude toward chemistry and students' perception toward augmented reality via mobile learning. The augmented reality can use for the most of student even if they have a negative or positive attitude toward chemistry. And students male or female, they can learn chemistry by augmented reality. Moreover, finding highlights the importance of this pilot study are AR help students truly understanding and imaging of the chemical phenomena at sub-microscopic level, saw immediately of phenomena, mixed between result of graph from laboratory and invisible phenomena by their mobile phone and this innovative AR was designed for mobile and ubiquitous learning 1:1. In next study would be more beneficial to combine AR and laboratory activities in teaching rate of reaction, would be analysis data about regression and Structural Equation Modeling to offer more insights on the cause-effect relationships among the constructs.

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A tale of two mobile learning journeys with smartphones and tablets: the interplay of technology and implementation change

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Abstract: This paper describes two mobile learning journeys in the zoo using either smartphones or tablets, and a mobile learning application SamEx, all designed and implemented as part of a research study in a Singapore primary school. Out-of-school semi-formal learning activities such as zoo trips present standard curricular topics where students go out of their schools in order to explore topics of interest in a semi-controlled designed environment. Typically, students observe and connect their observations with prior knowledge or further extend their knowledge on the go or later with their teacher in the classroom. The initial study in 2013 included the whole Primary 3 (P3) level of students, 305 of them, while the subsequent study in 2015 included 321 students. Between the years technology shift was inevitable – the participating school switched from smartphone devices to tablet computers, where each child has a tablet with the option to connect to both a WiFi network and to a mobile broadband network. Furthermore, the changes in the design of the mobile learning SamEx application were carried out in collaboration with the teachers, through a design-based research process. SamEx allows for the collection, organization and storage of media collected by students typically as responses to questions and prompts set up by their teachers. The initial design was oriented towards individual students, to support their individual in-class and homework learning tasks and assignments. The main features added to the application incorporated additional teachers' needs in carrying out curricular topics including inquiry learning and collaborative learning. The paper explores the evolution of both technology and the implementation of the application in the period, and problematizes the notion of inevitable technology change, constant software maintenance and enhancement and the effect of these changes on learning activities and outcomes.

Keywords: mobile learning; e-learning; tablet computers in education; software design

1. Introduction

Mobile learning technologies stimulate student engagement while enabling authentic learning scenarios used as part of diverse educational programs around the globe (Chen, 2013). With the goal of providing a more sustained learning experience for their students, teachers in a Singapore primary school collaborated with a research team in 2012 in a Seamless Learning project in which the goal was the incorporation of mobile learning technologies into the science curriculum. An application named SamEx was developed and has been used as a part of the curriculum since then. The application is constantly improved through a process of iterative design with both teacher and student usage experiences in mind.

SamEx is an educational application for Android platform designed to allow students to post, store and share educational content with their colleagues and teachers either as responses to contextual prompts set up by their teachers or as student-initiated contributions. As a result of the two-year usage, the data on student involvement in form of media contributions, text answers, likes and comments is available for research analysis.

This paper focuses on the comparison of two mobile learning journeys using the data provided by SamEx application. The comparison is characterized by unavoidable technology improvement and insights provided by constant collaboration with the teachers. Analysis is conducted on the data collected from the Primary (Grade) 3 level students in the year 2013 and 2015. In 2013 the students had been using the smartphone SamEx application, while in 2015 the students were equipped with tablet computers running a redesigned and improved SamEx application. Analysis is based on the comparison of two student trips to the Singapore zoo, and characterized by a number of questions specifically designed by teachers for the students to answer on the spot by providing textual, picture, video or audio responses via the application.

Section II provides an overview of the state of the art mobile learning and pedagogical approaches to it. Section III follows with a detailed description of SamEx design. Sections IV and V describe the methodology used and present the results of the data analysis, while Section VI discusses interaction specifics.

2. State-of-the-art

The rapid development of mobile technologies has in recent years encouraged the emergence of a number of novel software applications, and also opened the possibility of transferring many existing applications from desktop PCs to mobile phones and tablets. Moreover, the ease of use, device portability, different connectivity options, built-in camera and various sensors made mobile platforms an ideal environment for many software applications. Used in the mobile educational applications, many of these features have potential of greatly improving user (learner) experience and motivation (Wald, Li, & Draffan, 2014), which could in the end, lead to better learning results. Similarly to Web learning platforms in the late ‘90s, mobile learning applications are “the hot educational topic” throughout the last ten years (Wald et al., 2014).

Although handheld devices, smartphones and tablet computers exist for a number of years now, the real revolution in the field happened in 2007 and 2008, when Apple iPhone and the first Google Android based phones were unveiled. These two, along with Microsoft Windows Phone, are the prevalent mobile and tablet computer platforms today. As soon as the technology stopped being a limiting factor, and tablet or smartphone devices started coming with enough processing power and memory for demanding applications, many studies started actively researching appropriate pedagogical approaches to mobile learning (Sharples, 2013).

Until recent years lectures were mainly designed so that teachers deliver knowledge to the students, who are mostly passive participants in the whole process (Chuang, 2014). Developments in e-learning, and especially m-learning, which is characterized by using mobile phones and unlike e-learning is available on any location, resulted in a more active involvement of students in the educational process.

There is a number of review papers on mobile learning written in the recent years, like (Sharples, 2013), (Wu et al., 2012), (Jacob & Issac, 2008), (Hokyoung & Parsons, 2007) and (Martin et al., 2011). Sharples (Sharples, 2013) gives an overview of the mobile learning field, accompanied with critical review of existing studies and general guidelines for development of future mobile learning applications, without information about specific technologies. Wu et al. (Wu et al., 2012) give a very comprehensive analysis of the field and existing mobile systems. Their study includes papers published until 2011, so a number of new trends and technologies are not included. Jacob and Issac (Jacob & Issac, 2008) made an analysis of learning practices and the accompanying exploitation of mobile devices. They state the advantages and disadvantages of a particular mobile device type in mobile education, as well as the usage of these devices amongst their students, with also no technology-specific information given. Parsons & Ryu (Hokyoung & Parsons, 2007) describe generic software architectures for mobile educational applications and conclude that the best (the “richest”) platform for mobile learning seems to be the client-server architecture. Martin et al. (Martin et al., 2011) analyze the existing frameworks and middleware applications for mobile learning applications and focus only on these two aspects of mobile application programming, without a deep focus on available technologies.

3. SamEx

3.1 System Design

SamEx was designed to support self-directed and collaborative learning activities and provides a participatory platform for students to contribute, share, and give feedback. Students can use it to take a picture to collect data or post information they found to be useful for their learning. These postings are shared with other students who can review, give comments and evaluate by giving "Likes" to the contribution.

SamEx was developed for the Android, Windows 8.1 and Windows Phone 7 and 8 mobile operating systems in the Seamless Learning Curricular Innovation project in a Singapore primary school. SamEx system architecture consists of the following components (Fig. 1): server-side components, web application for system administrators and mobile clients (Android, Windows 8.1, Windows Phone applications for smartphone and tablet devices). The system is based on a centralized data model where clients are not responsible for data processing, and thus focus on the interactions with users. SamEx server-side components are: relational database, web application and web services for communication with mobile clients. All three components allow for seamless data storage and administration for both users and administrators. The key issue in SamEx system design is maintaining a consistent state of the data between the server and client applications.

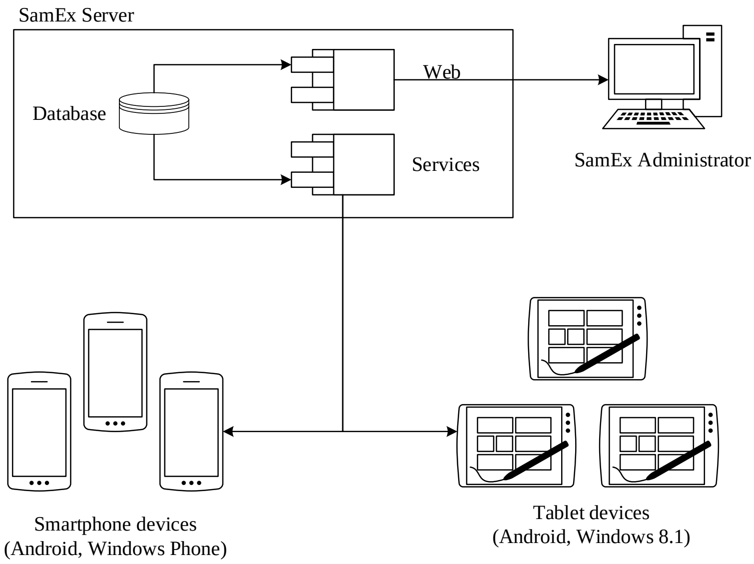

Fig. 1. SamEx system architecture

The generic SamEx mobile client application is built of several layers: a server communication service, a data access layer, and modules for user interaction (GUI). Data is periodically fetched from the server side and stored locally via a background service. A data access layer is implemented over the storage data structures, allowing developers to make easy structural changes without affecting the application logic for the communication with users.

SamEx can be installed on Android or Windows Phone smartphone or tablet devices. Students are given a mobile device with SamEx application preinstalled and preconfigured to immediately act as an active system component. SamEx web application provides an administrative user interface. Teachers and administrators are able to search, filter and sort data, and administer student groups or set up location-based prompts (so called "triggered questions").

Activities in SamEx were designed for primary school students who used SamEx in their school activities. In addition to collecting, storing and accessing multimedia artifacts, SamEx can store contextual users' information for potential educational use. Depending on the current time and users' location, the system allows question prompts to be displayed on students' smartphones potentially facilitating or scaffolding learning tasks. Students can therefore be guided in outdoor mobile learning trails or just prompted periodically in connection with their homework observations or other work they are recommended or required to pursue outside of school. Students can also subscribe to their peers' contributions.

To reward students' activity, SamEx leverages on its own badge system, an extrinsic motivational tool. By collecting media, answering location-aware questions, providing comments to other students' questions and "liking" other students' work, students take part in a game to accumulate points leading to the earning of badges in five categories with four levels in each category. The badges were designed as recognition to motivate student to participate and share in the inquiry process. The content of uploads is not automatically checked for quality, so it is possible for students to upload content just in order to get high badge scores. This is solved by closely examining contributions of students with suspiciously high counts of content.

4. Technology Shift From Smartphones to Tablet Computers

Between the years of SamEx usage a technology shift was inevitable. The participating school decided to switch from smartphone devices to tablet computers, which pushed the evolution of SamEx system. The changes in the design of the mobile learning applications were carried out in collaboration with the teachers and researchers, as part of the design-based research methodology.

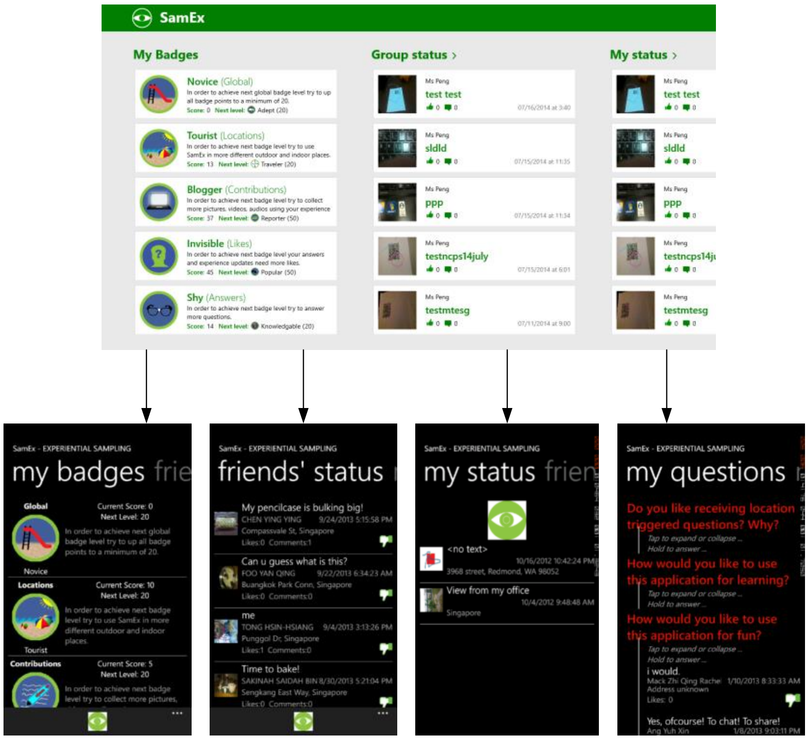

Fig. 2. Badges, my status, group status and questions in tablet (above) and smartphone (below) applications

The foundation of the new application design was the restructured home page for tablets (Fig. 2). In order to improve the application user experience, the new landing page exposes all important features on only one screen: recent statuses, questions and most importantly badge status for the current user. This design reduced the amount of time a user has to spend in the application by laying out the crucial information in a dashboard-like structure. With the new organization of the features, users rarely need to venture deeper into the application because the summary of the most important details is shown right after its launch.

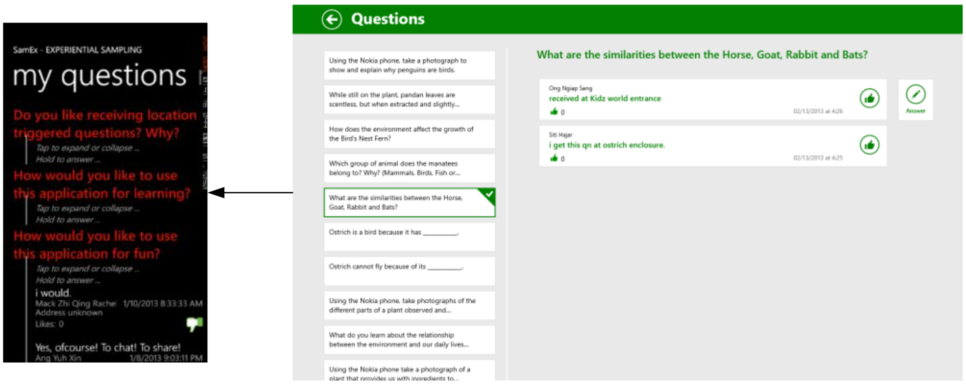

Fig. 3. Questions page in tablet (right) and smartphone applications (left)

Another improvement coming with the SamEx application on tablet devices is the enhanced interaction with media elements. Due to the larger screen, the preview of multimedia artifacts posted by the other students is now much more suitable from the visual perspective. Furthermore, the module for posting a new status now allows previewing, posting or discarding media on the same screen with a clean and user-friendly design (Fig. 4).

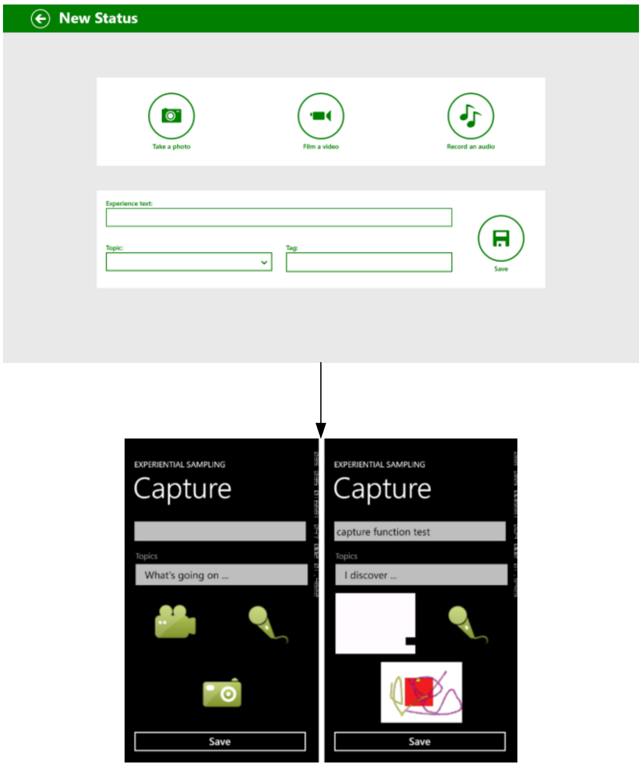

Fig. 4. New status page in tablet (above) and smartphone (below) applications

The SamEx module which gained the most from higher screen resolution on tablet devices is the Group Drawing module (Fig. 5). Students are presented with a canvas where they can draw, re-arrange the multimedia artifacts, add captions and collaborate in creating interactive dashboards. Interactive canvas functionality is much harder to utilize on smaller smartphone screens, which is why this module was not included in smartphone versions of SamEx mobile application.

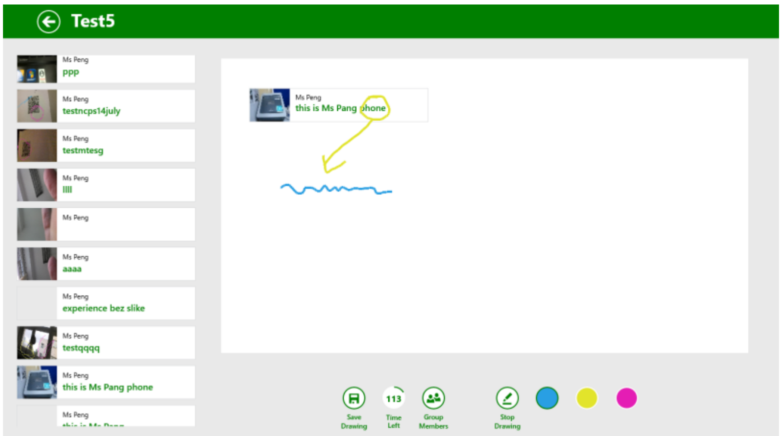

Fig. 5. Group drawing module in SamEx for tablet devices

On the other hand, tablet devices are larger and more robust which makes them difficult to use during highly mobile activities, whereas smartphone devices can easily be carried around in one hand or in students' pockets.

5. Methodology

The students taken into analysis are primary three class students, divided into eight level classes: A, B, C, D, E, F, G, H, both in 2013 and 2015. During both 2013 and 2015 each group had a one day visit to the Singapore zoo. During that visit, students are encouraged to answer predefined questions involving specific zoo exhibits and spots. Some of those questions are triggered via the application as a consequence of the user location change. Students can post their own text or media contributions, read their colleagues' observations and comment and like them. All the data provided by student contributions is collected and stored in the application database for further analysis. The result of SamEx application usage is a rich data set mostly composed of student contributions produced and stored in the period of two years.

Observations in this paper are based on the comparison of the data collected as a result of these two zoo trips. This was decided due to the conclusions of the preceding study where the application usage was the highest during the trips and thus richest in terms of content provided (Boticki, Baksa, Seow, & Looi, 2015). Even though both trips are characterized by almost the same locations visited and almost the same visit duration, the following differences were observed:

- Number of question prompts decreased from 23 in 2013 to 12 in 2015 in order to focus on student involvement in trip activities
- Questions in 2013 require a multiple choice, textual or experience based answer, while questions in 2015 are only experience-based
- Tablets used in 2015 had constant WiFi connectivity and GPS signal, which was not the case with smartphones used in 2013
- Eight group visits were spread throughout two weeks in 2013, while in 2015 the zoo visits were conducted in one week time
- Number of enrolled P3 students in 2013 was 305, while in 2015 a total of 321 primary three students were involved in the study

Taking these differences into account, the methodology of this study is aligned in order to respect and properly analyze these two approaches to the zoo visit. Student contributions taken into the analysis are exclusively the ones corresponding to the dates of the visit of the student's group in order to avoid at home or classroom usage and to only focus on the trip data. Student experiences are filtered in order to avoid repetitive duplicate experiences, due to errors in the system operation mainly due to the lack of WiFi connectivity.

Experience updates submitted by the students are grouped by text, user, and the quantity of audio records, videos, pictures and time. In case more than one experience with the same text and media files have been uploaded in a short time span, they are declared as repetitions, and only one is taken into consideration for the data analysis. Experience updates which contain no text and no media files are disregarded. Audio experiences are disregarded in analysis due to the considerable lack of this type of experiences. Furthermore, data analysis is based on contribution efficiency and frequencies, and not solely on the number of contributions in order to respect differences caused by the different number of question prompts, which will be described in more detail in further text.

6. Data Analysis and Interpretation

The first step in data analysis is the comparison of means of student contribution quantities from the two given years. The results of this step are presented in Table 1. Group 1 represents the cohort of 2013 students, while Group 2 represents 2015 cohort of students.

The variable named *Experiences* presents the total number of any type of student contribution (textual, media or mixed). Experiences can be uploaded either as answers to question prompts or as standalone. *Pictures* and *Videos* represent the number of contributions which include media files. *BaseUsageTime* is a variable which gives the information on total usage time of the application in seconds in the given time frame (during the trip). *QuestionAnswers* represents the number of uploaded answers to teachers question prompts. Question answers can be either textual answers, multiple choice answers or answers in form of experiences. Comments can be added to experiences, while likes can be added to either question answers or experiences. All the variable values are grouped by users.

Table 1 shows raw means are greater in group 1 compared to group 2. As previously mentioned, the number of questions was greater in the year 2013 (23 questions) than in 2015 (12 questions). This difference explains the decrease trend of variable values. However, an unexpected increase in number of question answers is present. Since the number of question answers is lower in 2013 than in 2015, but the total number of experiences is greater, it can be concluded that 2013 students uploaded their own contents more often than directly answering the predefined questions. A substantial difference between groups is present in *BaseUsageTime*. This is partially due to less content upload in general in 2015, and partially due to overall simplicity of tablet usage.

Next step in the analysis is the computation of efficiencies and frequencies based on the previously defined variables. Equations used to calculate these values are following:

Experience Efficiency=Experiences/BaseUsageTime (1)
Picture Efficiency=Pictures/BaseUsageTime (2)
Video Efficiency=Videos/BaseUsageTime (3)
Answer Efficiency=QuestionAnswers/(TotalQuestions/10) (4)
Comment Frequency=Comments/(TotalExperiences/1000) (5)
ExperienceLike Frequency=ExperienceLikes/ (TotalExperiences/1000) (6)
AnswerLike Frequency=QuestionAnswerLikes /(TotalQuestionAnswers/1000) (7)

BaseUsageTime in *(1), (2)* and *(3)* is transformed into hours in order to make the results easier to interpret. The same principle is followed by introducing the factors 10 in *(4)* and 1000 in *(5), (6)* and *(7)*.

Table 2. shows the means of these transformed variables. It can be seen that after these transformations the means are in fact greater in Group 2 in contrast to the initial results. Exceptions are variables *Video Efficiency* and *Picture Efficiency.* This can be explained by the fact that none of the questions in 2015 strictly required students to upload their collected pictures or videos. To query the significance of this difference among groups, an independent samples t-test has been conducted. Equal variances were not assumed for any of the variables except for *Comment Frequency*.

TABLE I. MEANS OF CONTRIBUTIONS FOR GROUPS OF 2013 AND 2015

Measured variable / Group Id		N	Mean
Experiences	1	277	9.47
	2	192	7.95
Videos	1	277	0.36
	2	192	0.19
Pictures	1	277	7.79
	2	192	1.29
BaseUsageTime	1	294	3120.40
	2	247	929.07
Comments	1	68	5.22
	2	51	4.49
QuestionAnswers	1	287	5.90
	2	182	7.62
ExperienceLikes	1	83	14.12
	2	92	12.52
QuestionAnswerLikes	1	32	1.91
	2	137	11.99

The results show that students demonstrated greater efficiency in the second group, by uploading more content in less time and providing a greater frequency of comments, likes and question answers.

TABLE II. T TEST RESULTS FOR CONTRIBUTION MEAN DIFFERENCES BETWEEN COHORTS OF 2013 AND 2015 STUDENTS

	Group	Mean	MeanDiff	Sig(2-tailed)
Experience Efficiency	1	10.5459		
	2	28.2831	-17.74	0.000***
Video Efficiency	1	0.5011		
	2	0.2241	0.28	0.041**
Picture Efficiency	1	8.4991		
	2	4.0708	4.43	0.000***
Comment Frequency	1	2.0417		
	2	2.9425	-0.90	0.305
Answer Efficiency	1	2.5632		
	2	6.3462	-3.78	0.000***
ExperienceLike Frequency	1	5.5223		
	2	8.2056	-2.68	0.165
Answer Like Frequency	1	1.1266		
	2	8.6527	-7.53	0.000***

***$p<0.001$, ** $p<0.05$

7. Interaction Specifics

An important feature of SamEx is question prompts, designed by the teachers in order to motivate and encourage students to participate in SamEx activities. The system allows for three types of question prompts to be created: open-ended (type 1), multiple-choice (type 2) and media (type 3) questions. Media questions encourage students to document their learning process with a photo, video or audio.

The reaction of students to various questions with different content, level of detail and type was analyzed. The questions set for the zoo trip in 2013 were of all three types of questions. The results are unexpected - there was a large number of incomplete or very brief textual answers, while the attached media was of high quality and to the point. Students seemed to gain a lot by making observations based on media questions and produced high quality media content, but failed to give the proper textual explanations along with the photographed artefacts. For example, the question “Using your phone, take a photograph to show and explain why penguins are birds” produced a lot of quality photos and videos, but the majority of students failed to answer the second part of the question. Giving the students too extensive tasks resulted in a lower contribution quality than expected.

Using the observations from 2013, the questions for the zoo trip in 2015 were designed differently. Teachers stopped actively encouraging students to provide media content and focused on shorter, simpler questions. Despite not being explicitly prompted to take pictures, the students continued to provide media contributions along with the textual answers, but with one big difference: the textual answers were now of much higher quality and more focused on the actual question when compared to the previous zoo activities. By giving the students more freedom and more open-ended questions, along with some hints about what to focus on, their answers became more creative while still in line with the learning objectives.

TABLE III. COMPARISON OF QUESTIONS FORMATS IN 2013 AND 2015

2013.	2015.
Using your phone, take a photograph to show and explain why penguins are birds.	How do you think the Stingray breathes in water? Hint: Is it similar to other fish?
Observe the fish and describe at least 5 characteristics that you can see.	Why is the bat a mammal? Hint: Which characteristic(s) of a mammal does the bat have?
Take a video of an insect to show that it is a living thing.	Which group of animals would you classify the hissing cockroach as? Give 2 reasons why.

8. Conclusions

Results of the two groups of students laid out in this paper are challenging when it comes to comparison since the differences between them and the concept of their zoo visits are characterized by a number of differentiating factors. Through the analysis the authors came to a conclusion that the factors which carry the most differences are the number of questions, the type of questions and the use of tablets opposed to the use smartphones.

The number of questions is greater in the year 2013 in comparison to 2015, but students gave better answers in 2015, both in terms of quality and quantity. Teachers decided to decrease the number of questions in 2015 in order to allow students to focus more on the zoo artefacts and exhibits and verbal communication. This proved to be a successful approach, since students react well to a small number of well-defined questions, giving answers which are in most cases correct, concise and often accompanied by media even though not instructed. The better quality answers given by the students prompted their peers to view and respond to the contributions causing the comment and like frequency to rise.

The second factor is the type of questions used. In 2013 students provided adequate answers to multiple type questions and textual questions but the quality was lower in the case of experience-based questions. In contrast, in 2015 students gave high quality experience-based answers. The question type disparity, can be explained by the fact that the questions in 2013 contained more sub-questions and strict rules, while questions in 2015 were more concise and provided optional possibilities of uploading media content which caused a favorable reaction from students.

Informal observations also offer an explanation of a more efficient user interface provided by tablets. As previously described, tablet devices offer the possibility of simpler and more accessible application usage. The smaller number of answers in 2013 can thus be explained with an issue of connectivity and location acquisition which was present in the smartphone version of the SamEx application and caused inconsistent prompts, so the students had to use experiences instead. What is more, graphic interface in the tablet application version offered easier and faster question answering and media attachment which explains the decrease of application usage time. The improved graphic interface on the larger tablet screen also promoted better social interaction between the students as they are able to easily view the answers and experiences contributed by their peers.

An obvious progress can be noticed in the gathered data, mainly in terms of efficiency and quality of the contributions provided by students. Technology shift, application improvement and graphical user interface redesign as well as the change in terms of class organization have proven beneficial for students. Cooperation between the technology and educational expertise through constant iterative redesign gives the expected affirmative results which are expected to further excel in the following years.

Acknowledgment

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The Mediated Effects of Intention behind Internet Use and Online Interaction on the Relationship between Perceived Usefulness and Professional Development

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Abstract: Preschool teachers' attitudes toward the advantages and practical usefulness of Internet instruction and administration influence their perceptions of the development of Internet-based professional knowledge and pedagogical skills. This study examined the impacting factors and mediated effects of their attitudes toward the intention of online professional communications in preschools. This study focuses on preschool teachers' attitudes toward Internet-related applications for professional development based on a survey conducted in Taiwan. The questionnaire comprised four factors, including perceived usefulness, professional development, intention behind Internet use, and online interaction. The sample data was analyzed through partial least squaring, testing indirect effects with the mediated variables. The findings show that preschool teachers feel positively about the usefulness of Internet-related applications in preschools and employ the Internet to advance their instructional knowledge and practical competences. Their preferences about using the Internet and communicating with others about early childhood educational practices play an important mediating role in the impact of the perceived usefulness of the Internet on professional development. The researcher discussed the results and traced the implications derived from this study.

Keywords: Internet, online interaction, perceived usefulness, professional development, intention behind Internet use

1. Introduction

The innovative applications of the Internet help preschool teachers to improve their instructional skills to support young children's learning and development appropriately. Preschool teachers integrate the Internet into their professional practices to strengthen their performance regarding their construction and development of pedagogical knowledge and abilities (Liang, Chai, Koh, Yang, & Tsai, 2013; Thorpe, et al., 2015). More Internet-related opportunities and friendly tools of Internet use assist preschool teachers as they positively engage in online communities through interactive dialogue and exchange about early childhood educational practices (Downer, Kraft-Sayre, & Pianta, 2009). In Taiwan, many preschool teachers use Internet-related applications to interact with others about their lives or working situations. However, most of them ignore possible opportunities to develop professional dialogues within online communities. This results in preschool teachers seldom benefiting from the professional advantages of Internet-related interactions. It is important to clarify the role of preschool teachers' attitudes toward the use of Internet-related applications to share or correspond about early childhood educational issues. Therefore, the researcher explores preschool teachers' attitudes toward Internet application in Taiwanese preschools and online exchanges of professional knowledge and skills.

1.1 The impact of perceived Internet usefulness on professional development

Preschool teachers use the Internet and recognize its usefulness in various situations in preschool. Furthermore, they view the Internet as a tool for enhancing their instructional performance and career advancement (Gialamas & Nikolopoulou, 2010; Vrinioti, 2013). They use Internet-related applications to work efficiently and achieve early childhood educational goals, such as enhancing their management performance, improving the quality of instructional programs, and increasing the development of teaching competence. The Internet provides preschool teachers with more useful pedagogical knowledge and promotes their quality of instruction (Holmes, 2013; Matzat, 2013). Preschool teachers' perceptions of Internet-related interactions are often influenced by the intention behind of Internet use. Their perceptions of the usefulness of the Internet influence their expectations of professional development through online communities. They see the Internet as an important tool to facilitate their attendance of e-seminars to advance their professional development, search for multiple instructional materials, interact with colleagues to resolve teaching questions, and discussion or reflection on professional development. Therefore, the researcher formed the following hypothesis:

Hypothesis 1: Perceived usefulness will positively influence professional development.

1.2 The mediating role of intention behind Internet use

Accessing, searching, and using the Internet helps preschool teachers to develop positive attitudes toward Internet-related assisted teaching and learning activities for young children. Preschool teachers' behavioral intentions regarding engagement of and interaction in online communities influence their preferences about professional development practices. Online communities are an important tool to help preschool teachers communicate with others and exchange their instructional information for young children. Furthermore, they use the Internet to discuss pedagogical and administrative programs and engage a friendly atmosphere to support their professional development (Teo, 2010; Teo, Ursavas, & Bahcekapili, 2012). Preschool teachers with more positive attitudes toward Internet use easily share and discuss professional practices (Liang & Tsai, 2008). They use the Internet to design instructional activities for young children, digitize young children's learning materials, learn additional pedagogical beliefs and ethics for better performance, and promote interpersonal interactions and shared feelings in their classrooms. Preschool teachers' behavioral intentions via the Internet improve their preferences and employment for professional development. Therefore, the researcher formed the following hypothesis:

Hypothesis 2: Intention behind Internet use will mediate the relationship between perceived Internet usefulness and professional development.

1.3 The mediating role of online interaction

The Internet provides preschool teachers with an alternative and friendly tool for social interaction with professional preschool pedagogical groups. They use the Internet to connect with others, to share information, and to resolve problems in online communities (Duncan-Howell, 2010; Reeves & Li, 2012). The Internet helps preschool teachers to work collaboratively and acquire more emotional and professional support to improve their professional identity. They engage in online communities to exchange information and develop the trustworthiness to advance professional literacy (Pianta, Mashburn, Downer, Hamre, & Justice, 2008). Online interactions provide preschool teachers with more access to participate in synchronous or asynchronous discussion activities and to improve sustainable professional development (Kyzar, Chiu, Kemp, Aldersey, Turnbull, & Lindeman, 2014). Preschool teachers use the online interaction to construct social cohesion and enhance their professional reciprocity and exchangeability. Therefore, the researcher formed the following hypothesis:

Hypothesis 3: Online interaction will mediate the relationship between perceived Internet usefulness and professional development.

2. Methods

2.1 Sample characteristics

The sample comprises 341 preschool teachers working in Northern Taiwan. All respondents were informed about the purposes of this study and the procedures for informed consent, and their privacy and confidentiality was protected. The respondents were composed of preschool teachers with various education levels, school types, jobs, years of service, and durations of Internet use. In Taiwan, the preschool teachers are predominantly female and employed in the private sector.

2.2 Measurement Instrument

This study is focused on preschool teachers' attitudes toward perceived Internet usefulness and its effect on their professional development. It also investigates the mediating roles of intention behind Internet use and online interaction in this relationship. A Chinese questionnaire, the "Internet Usefulness and Professional Development (IUPD) Attitude Survey," was administered. Based on the literature review and the theoretical assumptions of this study, the researcher developed the observed variables of the IUPD and consulted and assessed with scholars or experts in the field of Internet-related applications and early childhood education.

The IUPD comprised four factors, including perceived usefulness, professional development, intention behind Internet use, and online interaction. The original survey instrument comprised 20 observed variables (five variables for each latent construct) presented with statements for which the respondents indicate their degree of agreement/disagreement on a 5-point Likert scale (1 = most strongly disagree and 5 = most strongly agree). A description of the four latent constructs is presented as follows:

1. Perceived Usefulness (PU): assessing attitudes on the extent to which preschool teachers believe Internet applications are useful for their early childhood educational practices.

2. Professional Development (PD): investigating the extent of preschool teachers' perceptions of Internet-related applications' capacities to develop their professional knowledge and competence.

3. Intention behind Internet Use (UI): assessing attitudes on the extent to which preschool teachers use the Internet for their daily life activities or work-related practices.

4. Online Interaction (OI): investigating the extent of preschool teachers' perceptions of dialogue and discussion with others in online communities.

2.3 Data analysis

Partial least squares (PLS) combine the statistics techniques with principal component analysis and multiple regression analysis. PLS provides the robust estimation of non-normal data and does so for theory testing and development (Hair, Hult, Ringle, & Sarstedt, 2013). The researcher used the SmartPLS 2.0.M3 to analyze the survey data (Ringle, Wende, & Will, 2005) and evaluated the measurement model and the structural model on the IUPD.

In the measurement, this study estimated observed variables' factor loadings and calculated the statistical significance. The researcher tested the extent to which the sample data supports the hypothesized pattern of relationships between observed variables and latent constructs. Average variance extracted (AVE), Composite reliability (CR), and Cronbach's alpha were used to examine convergent validity and discriminate validity of the latent constructs of the IUPD.

In the structural model, the path coefficients and the measures of explained variances were evaluated. Examinations of the total, direct, indirect effects of the hypothesized relationships between the various latent constructs were used. According to MacKinnon (2008) and Preacher and Hayes (2008), the researcher used the Baron and Kenny approach and the Sobel test to calculate the significances of multiple mediators to test the research hypotheses.

3. Results

3.1 Measurement Model

According to the results of factor loadings per latent construct, the researcher retained a reflective variable only when its loading was greater than 0.700 on the relevant construct. The initial 20 observed variables were reduced to 16 variables. The standardized factor loadings on each variable ranged from 0.737 to 0.888. The researcher used the bootstrapping method based on 5,000 samples to test the level of significance of the standardized factor loadings. The *p* values of statistical significance on the IUPD for all selected variables are less than 0.001.

The AVE, CR, and Cronbach's alpha values of each latent construct of the IUPD range from 0.641 to 0.742, from 0.877 to 0.920, and from 0.812 to 0.883, respectively, as shown in Table 1. The correlation of two latent constructs ranges from 0.290 to 0.505. The correlation coefficient between each construct pair was less than the respective square root of the AVE. These measurements depict the reasonable degree of reliability, convergent validity, and discriminant validity of the latent constructs. The results suggest that the IUPD measurement model has a high degree of internal consistency.

Table 1: The AVE, CR, Cronbach's alpha, and correlation matrix.

	AVE	CR	Cronbach's alpha	(1)	(2)	(3)	(4)
PU (1)	0.671	0.891	0.837	0.819			
PD (2)	0.742	0.920	0.883	0.290	0.861		
UI (3)	0.693	0.900	0.852	0.403	0.473	0.832	
OI (4)	0.641	0.877	0.812	0.505	0.436	0.480	0.800

Note: The square root of the AVE of two latent constructs is given on the diagonal, and the correlation coefficient is given on the below diagonal.

3.2 Structural model

Figure 1 shows the path coefficients and measures of the explained variance in the structural model of the IUPD with the standardized parameter estimates. The PU construct explains 16.3% of variance in the UI construct, corresponding to a standardized regression coefficient of 0.403. The PU construct explains 25.5% of the variance in the OI construct, corresponding to a standardized regression coefficient of 0.505. The UI, PU, and OI constructs jointly explain 28.1% of the variance in the PD construct, corresponding to standardized regression coefficients of 0.338, 0.061, and 0.263, respectively. Except the path from the PU to PD (*t* value = 0.381), all other path coefficients were highly statistically significant ($p < 0.001$) by performing a bootstrap with 5,000 resamplings. The goodness-of-fit (GoF) index is crucial for assessing the acceptable level for the structural model. The GoF value is 0.395, which exceeds the cut-off value of 0.36 for large (Wetzels, Odekerken-Schroder, & Van Oppen, 2009).

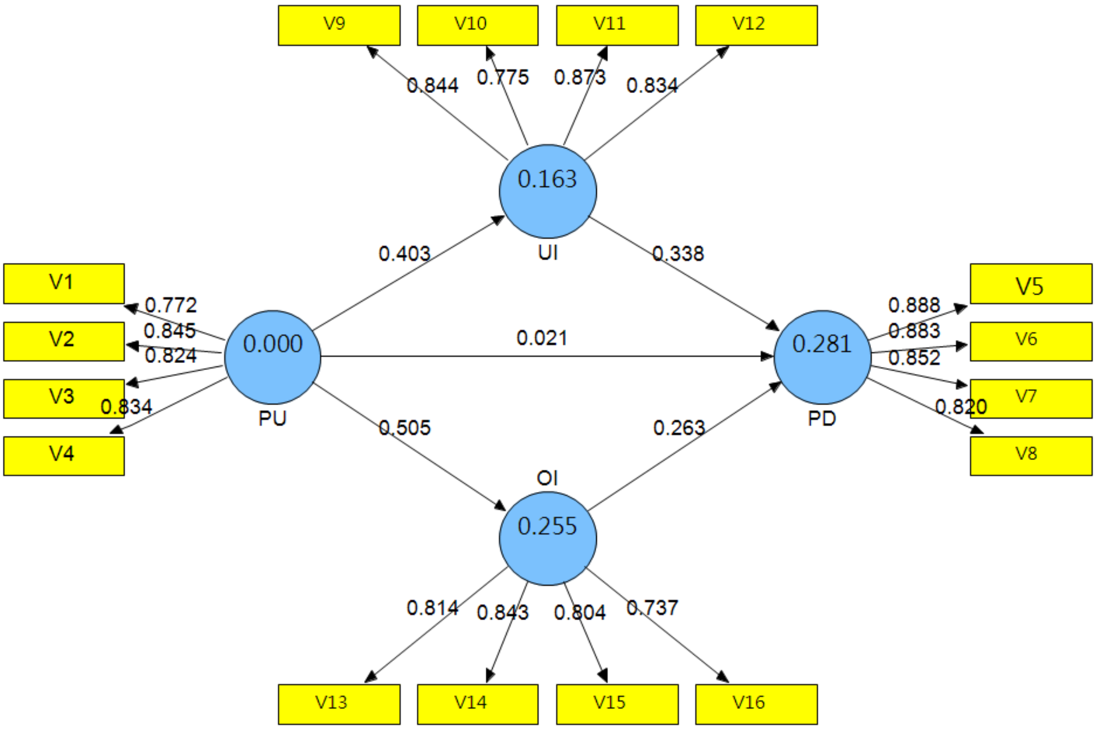

Figure 1. The Structural model.

According to the results, the total effect of PU on PD without the mediators of UI and OI is 0.290 (t value = 5.191, $p < 0.001$), thus supporting H1. After adding the mediators of UI and OI to the relationship between PU and PD, the direct effect of PU on PD decreased to 0.021 and was found to be insignificant (t value = 0.381). The UI and OI completely mediated the relationship between PU and PD. To test the significance of indirect effects in multiple mediator models, the standard error of each path coefficient was calculated by bootstrapping 5,000 resamples. Based on the Sobel test, the indirect effect of UI and OI on the relationship between PU and PD are 0.136 and 0.133, with z values of 4.049 and 3.806 ($p < 0.001$), respectively, thus supporting H2 and H3.

4. Discussion and conclusion

Integrating Internet-related applications into professional development helps preschool teachers to advance their instructional effectiveness and assist young children's learning performance. Considering the trend toward Internet-related development, preschool teachers should focus on usefulness, intention behind Internet use, and connections via the Internet to improve their pedagogical literacy and professional development. This study explored preschool teachers' attitudes toward the usefulness of Internet-related applications for professional development and indicated the important mediated effects of their perceptions of the intention of Internet use and online interactions. The PLS results of the IUPD tested the path coefficients and hypotheses to support H1 to H3.

To effectively employ the Internet-related applications with the development of professional knowledge and instructional competences, preschool teachers should believe in the usefulness of the Internet and take on positive attitudes toward the intention of Internet use and interactive communications in online communities. When they consider that Internet use is an important and friendly tool to effectively improve pedagogical competences, they can present more preferences about Internet self-efficacy and online interaction with other educational partners. These perceptions of Internet-related professional development influence their pedagogical performance, that is, their ability to teach young children by developing appropriate learning activities.

Having positive attitudes toward intentions behind Internet use and social interactions in online communities could help preschool teachers to improve their professional literacy and pedagogical practices. Greater effort is required to improve preschool teachers' perceptions of online professional development in an efficient and meaningful way. They can use Internet-related applications and engage in online communities to exchange professional thoughts and experiences and to cooperatively improve the quality of instructional activities for young children. Future research could reuse or revise the IUPD developed in this study to test preschool teachers' attitudes toward Internet-related applications for professional development. New latent factors or other mediated effects could also be added to explore their thoughts further.

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The effect of integrated movement activities on Children's FMS

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Abstract：The purpose of the present study was to determine the effects of an integrated movement course on the FMSs of preschool children. Purposive sampling was used to select two classes at a public preschool in Chiayi City, Taiwan. The experimental group consisted of 9 boys and 12 girls, and the control group consisted of 11 boys and 8 girls. Both were administered a pretest and a posttest.

There were 5 results as follows:

1. For LS, the experimental group (M = 32.38) performed better than the control group (M = 23.53). For OCS, the posttest revealed no significant difference between the two groups.
2. The experimental group performed better than the control group in running (t = 2.23, P < .05), galloping (t = 8.09, P < .001), leaping (t = 2.96, P < .01), and horizontal jumping (t = 2.96, P < .01).
3. There was a significant difference between the pre- and posttests of the experimental group in running (t = -3.05, P < .01), galloping (t = -7.90, P < .001), hopping (t = -5.19, P < .001), jumping (t = -2.31, P < .05), dribbling (t = -2.71, P < .05), throwing (t = -3.99, P < .01), and rolling (t = -3.47, P < .01), indicating improvement in each of these seven skills.
4. For the control group, there was a significant difference between the pre- and posttests only for sliding (t = -2.88, P < .05); even though they didn't participate in the integrated movement course, their sliding ability improved.
5. The experimental group performed better in the posttests for both the LS (M = 32.31 ＞ M = 24) and the OCS (M = 25.71 ＞ M = 18.81). This indicates that the integrated movement course had a positive influence on both the LS and OCS of the experimental group.

Keywords: Integrated movement activities, The integrated physical education course, FMS

1. Introduction

Childhood is the ideal time for developing FMS, yet teachers need to keep in mind the developmental limitations of their students when planning and selecting interesting activities which are challenging, but not beyond their ability (Li & Chang, 2006; Chang & Chen, 2012). Moreover, the development of FMSs is deeply influenced by a child's everyday interactions with others, especially parents, teachers, and playmates. Thus parents and teachers need to provide an environment and plan activities which promote the acquisition of FMSs (Li & Chang, 2006; Shenouda, Gabel, & Timmons, 2011).

Over 80 percent of preschools in Taiwan have a curriculum which includes games and activities designed to develop physical skills. However, most of these are held only once a week, and few run for more than 40 minutes per session (Chen & Huang, 2005). This indicates that preschools don't give sufficient importance to the development of FMSs, and that educators lack knowledge and ability in this respect (Weikart, 1987/2009).

Huang and Huang (2003) assert that physical education classes in Taiwan are not sufficiently systematic. Ho and Lou (2000) found that most of the physical education (PE) activities at preschools are in the form of group games in which the children spend most of their time passively waiting for their turn or for the game to conclude after being eliminated from the competition. Even when the teacher makes an effort to arrange activities which require continuous participation on the part of all the students, it often happens that the more physically developed students dominate the activity, pushing the less developed ones to the sidelines. Thus teachers need to plan activities which students enjoy and which require everyone to actively participate.

Based on my two decades of experience in early childhood education, very few preschools in Taiwan provide systematic PE classes. This may be because teachers lack training in the physical development of children. Or it may be due to teachers not having enough time to plan more suitable activities, instead falling back on such traditional routines as morning calisthenics and recess on the outdoor playground. In fact, the games most commonly played at preschools in Taiwan tend to be chosen because they are fun or competitive, but if not systematically planned, many such activities have little value with respect to the development of FMSs.

Amongst the related studies carried out in Taiwan during the past decade, few refer to the empirical research previously carried out on the development of FMSs (Shih, Huang, Huang, & Lin, 2006). Huang, Chou, Cheng, and Lin (2005) and Shih et al. (2006) found that a six-week physical education course enhanced the acquisition of FMSs amongst preschoolers. Similarly, Tsai (2010) conducted a 40-minute physical education class for preschoolers twice a week for six weeks, and found that by the end of the course the participants had significantly improved in running, galloping, horizontal jumping, and sliding.

Similarly, Chiu (2013) found that preschoolers who had completed a 12-week physical education course had significantly better scores on the Test of Gross Motor Development-2

(TGMD-2). Also, Barid et al. (2013) designed and conducted a one-hour FMS course twice per week over a span of ten weeks, and found that by the end of the course the participants' FMSs had improved significantly.

In the empirical studies mentioned above, most of the physical education courses continued for between six and twelve weeks, with classes being held twice a week for between 40 minutes and one hour. Although the Temporary Guidelines for Preschool Activities recently adopted by Taiwan's Ministry of Education (MOE) stresses the integration of the different components of the curriculum (MOE, 2013), none of these previous studies attempted to integrate the PE course into the existing curriculum. Therefore, the purpose of the present study was to determine the effects of an integrated movement course on the FMSs of preschool children. It is expected that the results of this study can be used in the design and implementation of preschool curriculums which place more stress on the acquisition of FMSs in an enjoyable manner.

2. Methodology

2.1 Participants

Purposive sampling was used to select two classes at a public preschool in Chiayi City, Taiwan. Each class had a total of 28 children. All of the children were between four and five years old and in good health. One class was designated the experimental group and the other was designated the control group. Both were administered a pretest and a posttest. Of the initial 56 participants, 16 did not participate in all phases of the study; thus only the data for the remaining 40 participants was included in the data analysis. The experimental group consisted of 9 boys and 12 girls, and the control group consisted of 11 boys and 8 girls. At the time the pretest was administered the average age of the participants was four years and one month; at the time of the posttest the average age of the participants was four years and four months. The participants in the experimental group had an average height of 106.5 centimeters and an average weight of 18 kilograms; the participants in the control group had an average height of 106.8 centimeters and an average weight of 17.6 kilograms.

2.2 The integrated physical education course

The teacher of the experimental group integrated the 12 movement skills of the TGMD-2 into the existing curriculum. Each skill was practiced for half an hour, three times over the course of one week.

2.3 Procedures

After selecting the preschool, I contacted the director and explained the purpose of the study and the procedures to be used. Prior to testing, I contacted the participating teachers and explained their role in the research, including the testing procedures and the parental consent forms. The teacher of the experimental group integrated each of the 12 FMSs into the existing curriculum; she also participated in the meetings held by the research team every two weeks over the course of the study to discuss the progress of the research and any problems which had arisen. The teacher of the control group administered the pre- and posttests and conducted the existing PE classes without making any modifications. Both the pre- and posttests were videotaped for the purpose of scoring and discussion.

A Sony DV camcorder was used to film the testing sessions. The evaluations of each participant's performance were carried out by using Windows Media Player to play back the recordings at a slow speed and checking the appropriate spaces on the evaluation forms. The evaluations were carried out by four research assistants with extensive experience using the TGMD-2; each had previously carried out at least 500 such evaluations.

2.4 Data analysis

A dependent sample *t*-test was used to compare the differences between the pre- and posttest scores of each group. An independent sample *t*-test was used to compare the scores of the two groups of participants.

3. Results

Table 1 shows that the pretest revealed no significant difference between the two groups in both locomotor skill (LS) ($t = 1.03$, $P > .05$) and object control skill (OCS) ($t = -.65$, $P > .05$). Table 1 also shows that for LS there was a significant difference between the pre- and posttests of the experimental group ($t = 6.87$, $P < .001$), and that the experimental group ($M = 32.38$) performed better than the control group ($M = 23.53$). For OCS, the posttest revealed no significant difference between the two groups ($t = 1.23$, $P > .05$). However, in the pretest the experimental group had a lower score in OCS than the control group, but in the posttest the experimental group scored somewhat higher than the control group.

Table 1. The LS and OCS of the experimental groups (eg) and control groups (cg).

Item	Group	No.	Mean	SD	*t*
LS pretest	eg/ cg	21/19	24/22.31	6.58/3.37	1.03
CS pretest	eg/ cg	21/19	18.8/20.1	4.95/7.00	-.65
LS posttest	eg/ cg	21/19	32.38/23.53	4.66/3.29	6.87***
OCS posttest	eg/ cg	21/19	25.71/23.16	7.70/5.08	1.23

***P< .001

Table 2 shows that there was a significant difference between the posttests of the experimental and control groups in running (t = 2.23, P < .05), galloping (t = 8.09, P < .001), leaping (t = 2.96, P < .01), and horizontal jumping (t = 2.96, P < .01). In each of these LS the experimental group performed better than the control group: M = 7.14 ＞ 6.63, 5.9 ＞ 2.21, 4.14 ＞ 3.05, and 5.76 ＞ 3.52, respectively.

Table 2. The results of the posttests of the experimental and control groups in each LS.

Item	Group	No.	Mean	SD	t
Running posttest	eg/ cg	21/19	7.14/6.63	.910/.50	2.23*
Galloping posttest	eg/ cg	21/19	5.9/2.21	1.37/1.51	8.09***
Hopping posttest	eg/ cg	21/19	6.14/5.26	1.77/1.45	1.71
Leaping posttest	eg/ cg	21/19	4.14/3.05	1.28/1.03	2.96**
Horizontal jumping posttest	eg/ cg	21/19	5.76/3.52	1.92/.90	4.63***
Sliding posttest	eg/ cg	21/19	3.28/2.84	2.03/1.21	.83

***P< .001, **P< . 01, *P< .05

Table 3 shows that there was a significant difference between the pre- and posttests of the experimental group in running (t = -3.05, P < .01), galloping (t = -7.90, P < .001), hopping (t = -5.19, P < .001), jumping (t = -2.31, P < .05), dribbling (t = -2.71, P < .05), throwing (t = -3.99, P < .01), and rolling (t = -3.47, P < .01), indicating improvement in each of these seven skills.

Table 3. Comparison of the experimental group's pre- and posttests in LS and OCS.

item	No.	Mean	SD	t
Running pretest / posttest	21	6.19/7.14	1.17/ 0.91	-3.05 **
Galloping pretest / posttest	21	2.52/5.90	1.33/1.37	-7.90 ***
Hopping pretest / posttest	21	3.33/6.14	2.08 /1.77	-5.19 ***
Leaping pretest / posttest	21	4.00/4.14	2.17/ 1.28	-0.40
Horizontal jumping pretest / posttest	21	4.62/5.76	2.11/1.92	-2.31 *
Sliding pretest / posttest	21	3.33/3.29	2.76/ 2.03	0.07
Striking pretest / posttest	21	3.43/4.43	1.72 /2.58	-1.62
Dribbling pretest / posttest	21	2.67/3.90	1.62/ 1.73	-2.71 *
Catching pretest / posttest	21	2.71/3.14	1.31/ 1.85	-1.04
Kicking pretest / posttest	21	4.86/5.48	0.91/ 1.47	-1.94
Throwing pretest / posttest	21	2.76/4.52	2.23/2.50	-3.99 **
Rolling pretest / posttest	21	2.38/4.24	1.80 /2.14	-3.47 **

***P< .001, **P< . 01, *P< .05

Table 4 shows that for the control group there was a significant difference between the pre- and posttests only for sliding (t = -2.88, P < .05); even though they didn't participate in the integrated movement course, their sliding ability improved.

Table 4. Comparison of the control group's pre- and posttests in LS and OCS.

item	No.	Mean	SD	t
Running pretest / posttest	19	6.58 /6.63	0.77 / 0.50	-0.25
Galloping pretest / posttest	19	2.42 /2.21	1.35 /1.51	1.71
Hopping pretest / posttest	19	4.89 /5.26	1.76 /1.45	-0.89
Leaping pretest / posttest	19	3.26 / 3.05	1.33 / 1.03	0.78
Horizontal jumping pretest / posttest	19	3.26 / 3.53	1.73 /0.90	-0.84
Sliding pretest / posttest	19	1.89 / 2.84	1.20 /1.21	-2.88*
Striking pretest / posttest	19	3.63 /3.95	2.19 /1.78	-0.55
Dribbling pretest / posttest	19	3.05 /3.63	2.27 / 1.42	-1.07
Catching pretest / posttest	19	2.32 /2.79	1.53 / 1.62	-0.98
Kicking pretest / posttest	19	5.00 /5.00	1.53 / 1.00	0.00
Throwing pretest / posttest	19	3.05 /3.74	2.15 /1.66	-0.97
Rolling pretest / posttest	19	3.00 / 4.05	2.56 /1.75	-1.44

*P< . 05

Table 5 shows that the t-test revealed a significant difference between the experimental group's pre- and posttest scores for both the LS (t = -6.36, P < .001) and the OCS (t = -4.73, P < .001). However, no significant difference was found between the control group's pre- and posttest scores for the LS (t = -1.61, P < .05) and the OCS (t = -1.78, P > .05). It can also be seen that the experimental group performed better in the posttests for both the LS (M = 32.31 ＞ M = 24) and the OCS (M = 25.71 ＞ M = 18.81). This indicates that the integrated movement course had a positive influence on both the LS and OCS of the experimental group.

Table 5. The pre- and posttests of the experimental groups and control groups inLS and OCS.

Item	No.	Mean	SD	t
LS pretest (eg/ cg)	21/19	24/22.32	6.58/3.37	-6.36***/-1.61
LS posttest (eg/ cg)	21/19	32.31/23.53	4.66/3.29	
OCS pretest (eg/ cg)	21/19	18.81/20.05	4.95/7.00	-4.73**/-1.78
OCS posttest (eg/ cg)	21/19	25.71/23.16	7.70/5.05	

***P < .001, **P< . 01

4. Conclusion

Research has shown that the conventional approach to preschool PE classes does promote the development of FMSs. However, integrating movement activities into the overall curriculum brings about better results. Thus it is suggested that preschool teachers participate in school, government, and civic training programs focusing on the design of lively and challenging activities which promote the development of FMSs, and how to integrate them into the school day. By doing so, their students will acquire FMSs more efficiently and enjoyably, and also be more confident as when they enter elementary school.

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Exploring Taiwanese Preschool Teachers' Information Literacy and Searching Behavior in Relation to Internet Self-Efficacy

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Abstract: This paper explores the skills experience and confidence of preschool teachers' engagement with web-based tools in support of learning and teaching. A sample of 287 early-years teachers were examined through path analysis. The results indicated that preschool teachers' Internet self-efficacy (ISE) acts as an important mediator between information literacy standard and searching behavior. In addition, the path analysis revealed that pre-school teachers' authority, multiple and content of information literacy standards are the significant positive predictors for the elaboration scale of searching behavior. That is, preschool teachers with variety information literacy standard and with higher ISE are more likely to express elaboration of searching behavior than those who with lower ISE. The findings of this study also suggest that the government and researchers need to identify effective ways for improving preschool teachers' abilities to utilize the Internet information and their use of appropriate Internet-based tools.

Keywords: Internet Self-Efficacy, Searching Behavior, Information Literacy

1. Introduction

In the past, information was often acquired through books or libraries; in the digital era, more and more individuals now turn to the sources on the Internet to find answers or solutions for the problems encountered in academic, personal, interpersonal, and occupational contexts (Goldman, Braasch, Wiley, Graesser, & Brodowinska, 2012). While the online information is convenient and easy to be obtained, the massive and diverse amount of data available can be overwhelmed and disorientated (Zhang & Wang, 2010). Research has also shown that many Internet users do not emphasize or attend to the quality of the Internet source, even though the information may be presumably inaccurate (Flanagin & Metzger, 2000; Metzger, Flanagin, & Zwarun, 2003).

Information literacy, first introduced by Zurkowski (1974), refers to the competence to identify the requirement of the task, to efficiently locate and select information, to synthesize and effectively use information, and to critically evaluate information and its sources. Consumers who are information literate can save significant time and money because they know where and how to compare and contrast the offers given by different stores; employees with information literacy receive higher payment due to their outstanding ability to find, analyze, and incorporate appropriate information through multiple sources. In other words, information literacy can empower an individual to be successful in daily life (Morville, 2005).

Previous research on information literacy revealed some inconclusive findings, leading to a question that there may be other mediating factors in the information search process. Pharo and Jarvelin (2004) have suggested that the work task, the searcher, the social environment, the search goal, and the search process are five possible factors that influence the searching behaviors. Researchers have examined some emotional factors involved in the process, such as uncertainty (Wilson, 2000), optimism (Nahl, 2004), positive and negative feelings towards the search (Flavian-Blanco et al., 2011; Tenopir et al., 2008), satisfaction (Nahl, 2004), and perceived self-efficacy (Tsai & Tsai, 2003). Because the perceived self-efficacy, among others, has frequently been reported as an influential factor on individual’s information searching behaviors, it may be presumed to be a key mediator in the process of information search.

Internet self-efficacy is conceptualized as the degree of confidence that an individual feels about accomplishing certain task or overcoming the challenges in the Internet context (Wu & Tsai, 2006; Kao & Tsai, 2011). Along with teachers’ perceptions in the web-based context, Internet self-efficacy has been explored with computer usage intentions (Smarkola, 2008), beliefs about web-based learning (Kao & Tsai, 2009), electronic service acceptance (Hsu & Chiu, 2004), gender difference (Tsai, & Tsai, 2010) and other factors. Nevertheless, the knowledge of how Internet self-efficacy affects online searching behavior is still very limited.

Information search is particularly indispensable for preschool teachers. While teachers of other education levels may be able to rely much on textbooks as their core class content, preschool teachers tend to use more self-edited materials due to the nature of the curriculum. The sources of their materials, as reported by Chu (2014), mainly come from the Internet. The information search process and strategies adopted, may determine the quality of teaching materials, as well as the learning outcomes of the students. Accordingly, we aimed to understand and describe preschool teachers’ information literacy and searching behaviors through Internet self-efficacy. The mediating role of Internet self-efficacy in the relationship between information literacy and searching behavior was also examined.

2. Method

The participants of this study were selected by convenience sampling from 30 preschools in the north, middle, and south geographical areas of Taiwan. The final sample included 287 preschool teachers who had previous experience of web-searching.

2.1 Instruments

In order to measure preschool teachers’ self-efficacy level and their web-searching behavior, two survey scales were adopted, including the Internet Self-Efficacy Survey (ISS) and Searching Behavior Survey (SBS).

2.1.1 Internet Self-Efficacy Survey

The Internet Self-efficacy Survey (ISS) was adapted from Kao and Tsai (2009) to investigate preschool teachers’ confidence in using the Internet. ISS was divided into the basic level and the advanced level. The Basic Internet Self-Efficacy Scale measures the perceived confidence in using basic level web-based tools, such as downloading pictures or copying texts online. The Advanced Internet Self-Efficacy Scale measures the perceived confidence in engaging in more advanced online activities, such as purchasing necessaries or participating in online discussions. There are a total of 16 items presented on a seven-point Likert scale ranging from strongly unconfident (1) to strongly confident (7).

2.1.2 Searching Behavior Survey

Based on Wu and Tsai (2005, 2007), the 20-item Searching Behavior is an instrument utilized to investigate the preschool teachers' evaluative standards and searching strategies in the situations of judging online academic information. The SBS consisted of six scales, the first four are searching standards, and the last two are searching strategies. *Multiple Sources Scale* measures the extent to which preschool teachers will validate the correctness of unknown information on the Web by relating to other websites, prior knowledge, peers or other printed materials. *Authority Scale* evaluates the extent to which students will examine the accuracy of unknown information in Web-based learning environments by the ‘authority’ of the websites or sources. *Content Scale* measures the extent to which preschool teachers will assess the usefulness of the information viewed in Web-based learning environments by the relevancy of its content. *Technical Scale* assesses the extent to which students will judge the usefulness of the information viewed in Web-based learning environments by the ease of retrieval, the ease of searching or the ease of obtaining information. *Elaboration Strategy Scale* measures the extent to which students will have purposeful (metacognitive) thinking or integrate Web information from several websites to find the best fit that fulfills their purpose. *Match Strategy Scale* investigates the extent to which preschool teachers will be eager to find only a few websites that contain the most fruitful and relevant information when they search for Web information.

3. Results

A path analysis was performed in order to investigate whether the mediator variable significantly carried the influence of the independent variable to the dependent variable (Sobel, 1982). Some of the variables in the path analysis appeared to have both direct and indirect (mediator) effects. In order to test the significance of the mediator effects, as shown in Figure 1, analysis was performed for the following parameters:

- Authority→ Basic ISE→Elaboration showed a significant mediator effect (β =0.131, p < .01**) indicating partial mediation (due to the significant path between Authority and Elaboration).
- Multiple→Basic ISE→Elaboration showed a significant mediator effect (β =0.158, p < .001***) indicating partial mediation (due to the significant path between Multiple and Elaboration).
- Content→ Basic ISE→Elaboration showed a significant mediator effect (β =0.449, p < .001***) indicating partial mediation (due to the significant path between Content and Elaboration).
- Technical→Advanced ISE→Match showed a significant mediator effect (β =0.502, p < .001***) indicating partial mediation (due to the significant path between Content and Match).

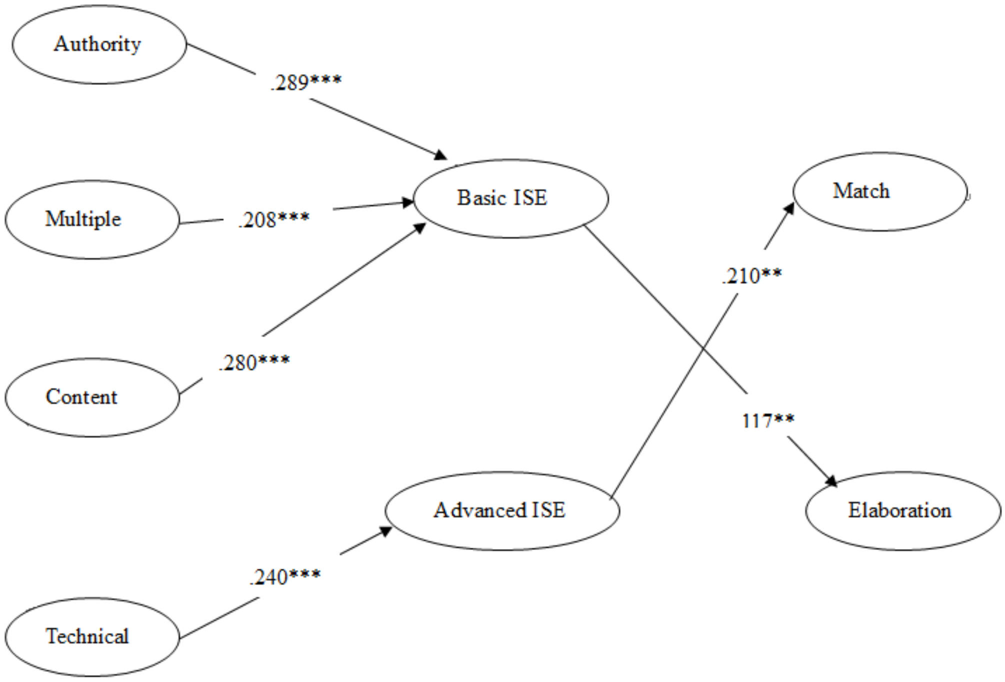

Figure 1. Results of mediation path analysis showing the relationships among Information literacy and Searching behavior

4. Discussion

The main purpose of this study was to investigate the relationship between preschool teachers' information searching behavior and their Internet self-efficacy. The results indicated that pre-school teachers' authority, multiple and content of information literacy standards are significant positive predictors for the elaboration searching strategy while Basic ISE level served as the mediator. Therefore, preschool teachers' various searching behavior should be highlighted in order to improve their Internet self-efficacy. Similar to these positive impacts of mixed information searching strategies, the results of this study indicate that early-years teachers use a variety of information searching behaviors, including advanced and less sophisticated information searching standards and strategies. These can lead to an increase of their Internet self-efficacy within technology enhanced learning environments.

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Improving Elementary Students' Environmental Education Using Dual Interactive Teaching Models

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Abstract: Learning from living with it's subtle and tine aspects are an important startup of Bionic Science in early child' s education. Our research team tries to design and create an educational system to help students learning from nature to nature and explore the power of technology in everyday life. By exploring the theme of urban bugs' eco-development, characteristics, habits, and further convey the concept of prevention to personal health education. Our teaching kits has two highlight features, firstly, the high quality of 3D visual effects, and another is the application of Augmented Reality (AR) app to create the "Immersive" "Interactive" and "Imaginative" learning experience.

Keywords: eLearning, Science Education, Fire Ants, eBook, AR

1. Introduction

In this experimental project, we adopted "Fire ant's ecology journal" as our topic. The teaching model is exploring the bioscience content with an Augmented Reality (AR) app in their hand-held devices first and then read an interactive eBook individually before class. Students/ learners will explore, learn and discover more about Fire Ants in their own campus, which is called "Exploratory Process of Learning".

This teaching models provides; (1) a new interactive e-book with the high quality and unique 3D visual effects and voluntarily interactive learning systems to accomplish "Interactive electronic picture-book in hand-held device" (2) an uploaded app into App Store and make this educative information more popularized from providing this learning material for free in the future. (3) using animations to explain the abstract ecological ideas, and also make it easier for teachers to teach. (4) an unique learning experience for students by using up-to-date technology.

After interviewing with fire ant experts, the contents of interactive e-book content showed the first perspective view as students' to explore fire ants' ecological system. It contained the notion of eusocial insects, the way ants after giving birth; marriage phenomenon flying ants work division status, eating, and death so on interesting ecological phenomenon to introduce eco-ants.

2. Literature Review

2.1 The Flipped Classroom

The method of flipped classroom is inverted typical cycle of traditional teaching where students gain first exposure to new material before class. Students will take more responsibility for their own learning. Significant learning opportunities can be gained through facilitating active learning, engaging students, guiding learning, correcting misunderstandings and providing timely feedback using a variety of pedagogical strategies. Nowadays, this method has been extensive promoted globally and more discusses have been proposed, such as Dr. Mariappan Jawaharlal who is a professor of Mechanical Engineering California State Polytechnic University, Pomona. He established that the key of making the teaching method successful is “IF students review the material before the class. This will happen only if the content is interesting.” (Jawaharlal, 2015) He has been pointed out the dark side of fantasy, more and more teachers to produce a lot of teaching contents for flipped teaching method, indeed the quality and the pervious core content is being used or not that is difficult to proved. Therefore, how to design an interesting teaching material can be the further issue to new generation education.

2.2 The Flipped Flipped Classroom

In 2013, Graduate School of Education, GSE proposed the most recently studies about “Before reading or watching videos, students should experiment first”. The researchers showed that when the order was reversed, students’ performances improved substantially.

3. Result and Discussions

According to GSE’s result, we have been tested our teaching kits in Partial township kids who were fifth grader elementary students as 28 participants. The lesson structure (Figure 1) were that, each participants have 20 minutes to pass and complete 5 questions in the campus by “FindAnts” app (Figure 2) firstly. Secondly, all of participants went through the Interactive eBook (Figure 3) to learn and find out the answers of those questions for another 20 minutes. Thirdly, participants shared their learning and discussed then with teachers in the classroom. So far the data is not big enough yet, it may be too soon to conclude it now. The further teaching program will continue for more partial township kids in Taiwan, and the learning outcomes of these new teaching set will build up for the further modification and product renewing.

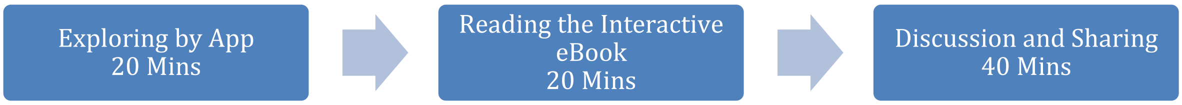

Figure 1. The lesson structure for our teaching sets.

Figure 2. The icon image of App.

Figure 3. The cover image of eBooks.

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Stage Manager: The role of kindergarten teacher in using technology in a thematic teaching classroom

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Abstract: In spite of the different perspectives in defining play, the general agreement is that play is a basic right of children in any culture and it comes in many forms because of the cultural context and the specific discipline. This case study in this paper presents how the kindergarten teachers utilized technology equipment appropriately in children' play-based learning within a thematic teaching context in Taiwan. The result came out positively that the role of teacher is essential. The teacher act as a stage manager, provide enough time、space and proper materials (electronic high-tech equipment) at the right time would expend children's learning.

Keywords: technology, play-based learning, kindergarten teacher, Taiwan

1. Play and Technology in early year learning in Taiwan

Play is a spontaneous and natural ability that children have regardless of their cultural differences. The International Play Association (IPA) put together the Declaration of the Child's Right to Play in conjunction with Article 31 under the Convention on the Rights of the Child of the United Nations. Article 31 states that children all over the world have a right "to rest and leisure, to engage in play and recreational activities appropriate to the age of the child and to participate freely in cultural life and the arts" (Office of the United Nation High Commissioner for Human Rights, 1989). From outdoor to indoor play, from spontaneous play to teacher-guided play, from play for fun to "play to get smart" (Jones & Cooper, 2005), people define play differently depending on what they believe to be its value.

In terms of educational settings, play is a complex activity that allows children to interact with others in social ways, to construct their own knowledge and to relate one subject to another. Developmentally Appropriate Practice (DAP) in Early Childhood Program believed that play is a universal vehicle that children everywhere in the world use to construct their knowledge and to explore the world around them (Bredekamp & Copple, 1997). "Play is the cornerstone for the DAP guidelines for the education of young children in group settings" (Frost, Wortham, & Reifel, 2005). Play is considered a developmentally appropriate practice, especially for young children at the pre-primary level.

In Taiwan, play is listed as one of six content areas in the 1987 National Kindergarten Curriculum Standards document because it is considered as a separate subject rather than as a means for achieving academic goals. Fortunately, throughout the time change, the way of teaching has to be modifying to meet the needs of the young children. A group of early childhood experts and policy makers came to an agreement to revise the National Kindergarten Curriculum Standards into a new form. The new 2012 version of Draft Kindergarten Curriculum Standards clearly states that children learn through play and encourages teachers to integrate play within their whole day learning (MOE, 2013). This can be referring to the Draft Technology in Early Childhood Programs stated by NAEYC (National Association for the Education of Young Children) and the Fred Rogers Center for Early Learning and Children's Media (2011). The Draft suggested that when children interact with technology it should be playful, and teacher has to take the judgment call to determine if a specific use of technology is age appropriate. Young children growing up at ease with digital devices, technology has become pervasive in the lives of many young children. Therefore, to integrate technology into the curriculum or daily routines; it is better to start with what children are interested in and in their play.

2. When play come with technology

In this paper, the case was happened in a four-five years old classroom with two experienced teachers in a public laboratory kindergarten. The design of their thematic curriculum is reflected in the Project Approach, in play-based learning, and in combining them with other learning experiences that integrate knowledge and provide the children with a holistic learning experience. The classroom is set up with learning corners and have several technological equipment (TV, Projector, computers, CD-Player, Cameras). Digital camera is one of the frequently used tools in this classroom. The children can ask for permission to use real digital camera when they needed. The teacher placed an old-fashion camera without batteries in the doll-play corner, the children frequently use in their presented play.

In this case study, on the average they provide 20 to 30 minutes of outdoor play plus 30 to 60 minutes in the learning centers during the morning free exploration time. Learning centers play an important role in giving the children an opportunity to use their imagination to decide what to do after a specific project has been chosen.

Both teachers liked to start their project by brainstorming with the children to find out what they know about the four elements (food, clothing, living, and transportation) that are an integral part of a family's daily life style. The brainstorming sessions revealed that this group of children share many experiences related to shape, especially circular shapes. Then they set up the learning centers to allow the kids to freely explore where circles can be found. They provided plenty of time and a large variety of circle-shaped scattered around the various centers.

Subsequently, a whole series of related activities emerged in connection with each individual element. On November 26, T1 reviewed, with their colleagues, the Circle Project event. Thanks to the changes they had made in the drama center and the opportunity offered the children to explore things freely, their classroom drama center had become the most popular place during morning center time. This led the children to come up with the idea of opening a Circle Restaurant at the Circle Country.

The children want to design they own traffic signs, therefore, the teacher provided real digital camera with supervision, and encourage children to take photo of the signs they seen on camps and the communities. The teachers reflected that these children enjoy playing with the digital camera, and seems learned faster from the signs in the photos they took themselves rather than from the book. Digital cameras not only to take picture for children's portfolio; when it was hold in children's hands, it became a powerful learning tool or as a functional toy for the children.

According to the interview note, the classroom teachers also commented that use of technology in the classroom can scaffold children' ability into a higher level. This can be referred to Vygotsky's view of zone of proximal development (ZPD). When it comes into a classroom environment, children can utilize digital camera to build relationship with their friends and the community (Bonnie B, & Anne S , 2008; NAEYC, 2008). Vygotsky (1976) claimed that play is not the predominant activity during the preschool years, but it is the leading source of development. Play creates the zone of proximal development (ZPD). In a classroom setting, it is commonly observed that young children play individually or in a group setting to act like adults. Children's actions are learned from observing experienced one (teachers, caregiver, or parents) in their daily lives, but are not common roles that the children take at that stage of their lives. Play provides a "context" (Bredekamp & Copple, 1997, p. 14) for young children to practice their newly acquired skills freely and allows them to take on new social roles or solve complex problems that they would not or could not do in real-life behavior.

3. Teacher as stage manager

Spidlberger & McLane (2002) pointed to the benefit of having an adequate amount of adult intervention in children's play "precisely where adults can best assist children in developing new skills and knowledge. In this study, these two experienced-teacher provide various of equipment and enough time and space for children to build up their circle world play. Children want to build a parking lot for all kind of car they made by boxes. They also want to make their own signs to tell their visitors how to drive and where to park. This is the perfect moment where the teacher act as a stage manager (Jones & Reynold, 1992) provide digital camera at the time, to help children to record the signs on campus. As Johnson et al. (1999) suggested, other than being providers who facilitate the children's play, teachers should also be stage manager who "make suggestions to extend the children's ongoing play" (p. 210).

These two teachers also believe that their students' playing time can spontaneously reveal their daily life style and their interests. So they just let the children play without any interference. All they do is observe. A number of episodes observed at the play centers revealed that their students come from families that pursue four basic life styles. This led to the planning of the initial concept web of the circle for their project of the semester. T1 and T2 found out the children were most interested in cooking at the drama play centers, so they added more related props and also asked the parents to provide recycled no-hazard cookware for the children to play. As the number of props grew, so did the number of children wanting to play at the centers, so the teachers had to rearrange things and create more space. In this instance, they had to play the roles of both of stage managers and observers so that the "Circle Project" could be a success and a great learning experience for the kids.

In This case study, It revealed that the teacher as a stage manager perform a vital role to integrate technology gradually by proving appropriate tool (digital camera) at the right time for children to explore and extend their play to a meaningful learning. Technology did not interfere children's learning but accelerate learning and narrow the achievement gap between low-income children and other affluent peers.

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ICT in teaching aids design: Interactive Jigsaw Puzzle

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Abstract: The study is to construct an interactive jigsaw puzzle system. Our goals are to use the information and communication technology in development of child teaching aids. We had designed and implemented the electronic puzzle block. The block used microcontroller to control the patterns and wireless connection to transfer data with computers. Children can rotate and connect the blocks, which can be used to learn geometries in three-dimensional spatial relationships. The change of patterns will attract children's attention, which can increase their motivation and fun in learning.

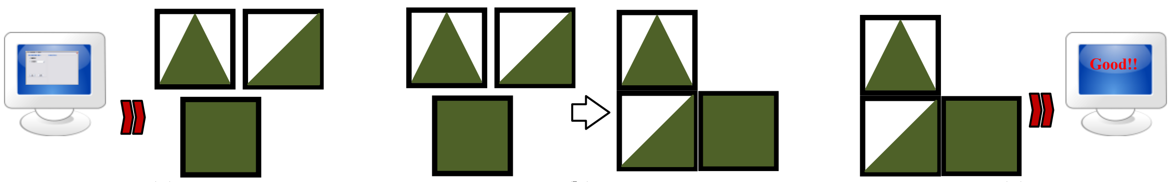
Keywords: ICT tool, e-learning, embedded system, multimedia, Jigsaw Puzzle

1. Introduction

Traditional cardboard jigsaw puzzles had limited patterns and cards. People easily feel boring of the games. Computer jigsaws provide more interesting ways of playing the games. However, children can solely use mouse clicking the icons and cannot learn how to build up the jigsaws by their hands. The study developed an interactive jigsaw puzzle system and the electronic puzzle block. Children can rotate or connect the blocks to learn geometries in three-dimensional spatial relationships.

2. System Architecture

Our system includes two parts: the puzzle block and the console application. Figure 1 is a diagram of how to operate our system. Teachers first select a graph in the console application, as shown in Figure 1(a). The console application separates the graph into several geometric patterns and sends them randomly to the blocks. In Figure 2(b), students then bring the blocks together to build up the graph. In Figure 2(c), the blocks send their neighbor blocks information back to the console application. The console application can automatically compute whether students complete the graph.



(a) (b) (c)

Figure 1. diagram of operation of the proposed system

2.1 Puzzle Block

The puzzle block has three layers. The first layer has 8x8 LED, which is used to display the geometry patterns. The connection ports are located in each side of the layer. They are used to connect neighbor blocks and communicate with them. The microcontroller is located in the second floor, and the third layer contains wireless communication module and batteries. The microcontroller is responsible for communication and display. The wireless communication module is used to data exchange with computer.

2.2 Console Application

The console application can be installed in a personal computer. Several graphs and their component patterns are pre-defined in the console application. User selects one graph, and the console application then sends the component patterns to the puzzle blocks. When each puzzle block sends its neighbors' information back, the console application has to construct their related positions and compute the answer.

3. Results and Discussion

Figure 2 is the blocks with different geometry patterns. Users can rotate them and connect with other blocks at each side. The left photo in Figure 3 is from the console application. The console application can monitor and show blocks' related positions. The photo in the right is the correct result of the blocks.

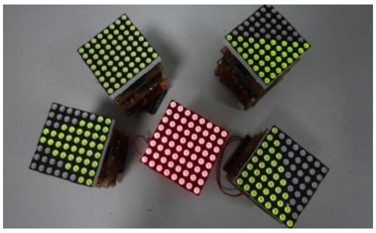


Figure 2. puzzle block can display many geometry patterns

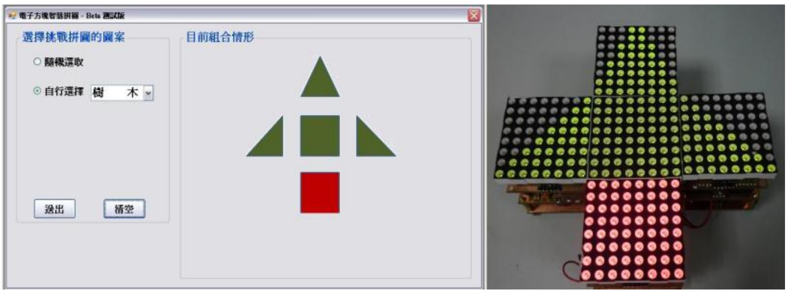


Figure 3. demonstration of system operations

In the future work, we will try to reduce size of the microcontroller and utilize OLED in order to obtain more various and fine patterns. In addition, we also are going to establish function of animation in the puzzle block, that we can develop more interesting games for the system.

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Applying Smart living Concept for Design and Development of Child Tele-Home Care System into Project Oriented Teaching

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Abstract: The pursuit of Smart Living Technology is a recent trend in which Information and Communication Technology is applied to daily life around home and community. Technology-enhanced learning is also increasingly advocated at different school levels around the world. The case study is exploring the use of concept smart living for design and development of Child Tele-Home care system into project oriented teaching. In practical topics making teaching mode, the boot vocational information science students to caregivers in early childhood home care needs to explore the field, cross link both technical resources. The outcome of project example named as "Child Hand-Washing Reminder".

Keywords: Smart Living; Information Communication Technology (ICT); Project Oriented Teaching; Child Care System

1. Introduction

Under modern economic development, elderly population trend of social structure, resulting in the young adult population, become the primary caregivers in the family, Families are also in the infant stage of development suitable to form important field of self-care ability. Through the use of intelligent life, and information and communication technology operations availability closer to the post-industrial age, role as carer for the family, the actual field of user experience, parenting young children into technology design elements, through strengthened interaction with the child in the future of science and technology and education, and to achieve more effective parenting.

2. Objectives

Therefore this case study, for interdisciplinary integration and innovation to school education under the Union plan, focusing on maternal and child care and family support issues,

To cultivate smart living talent, our main tasks can be divided into the following four parts: 1. Innovative Courses: “sandwich" course development and teaching; 2. International Relationship: international education promotion & relationship development; 3. Online Teaching Resources and Social Network Construction: online interactive multimedia platform implementation; and 4. Promotion Activities: hold supplemental activities for inner collaboration and public participation.

Practical integration of universities and higher vocational education of Chinese General practitioners, professional practice topics and early childhood care, introducing the concept of intelligent life core "Field, Design and Technology". The outcome of project example named as "Child Hand-Washing Reminder" design work, research focuses on applications of science and technology education method, and actual child care on the conceptual design of home care systems products.

3. Methods

In consideration of the system is in operation through a network of integration between programs, so the Reminder development tool is Arduino, and programming languages are similar C/C++. The Arduino main characteristic are provided with text editing interface, the Standard toolbar, graphical control interface etc. The most important is Arduino can have good communication with any inductors. The "Child Hand-Washing Reminder" development process is as follows (refer to Figure 1).

Figure 1. The Parts of Project "Child Hand-Washing Reminder" Design.

We explore issues in case study research design. Quantitative and qualitative data were collected using interviews, focus groups, observations, documentary analysis and projects outcome "Child Hand-Washing Reminder" design. In the study, the researchers designed a situation for the children (refer to Figure 2). When the children into and use the toilet, the "Child Hand-Washing Reminder" will confirm whether these children have wash they hands carefully. In the "Child Hand-Washing Reminder", the researchers use well-designed LED to remind children. When children do not wash their hands, the light will continue to shine and remind them by the hanging on the door of LED Reminder. In the study, a total of 108 participants were invited to take part in this study, and almost all the participants were students from Kaohsiung.

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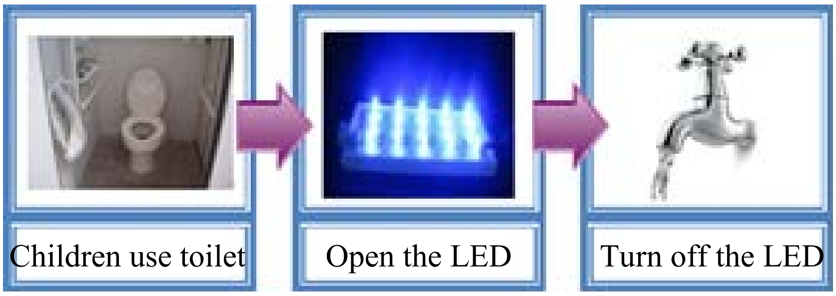

Figure 2. The situation for teach the children hand-washing

4. Results & Conclusion

The four participation of students involved into project oriented teaching program , were guided by the concept of smart living and completed design of the "Child Hand-Washing Reminder".

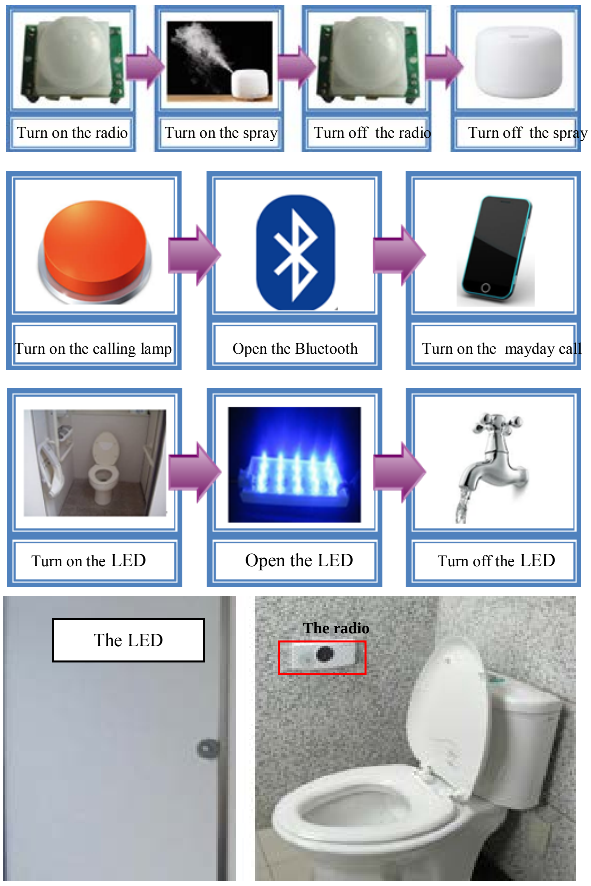

Figure 3. The Framework of Project “"Child Hand-Washing Reminder" Design.

Figure 4. The Parts of Project “"Child Hand-Washing Reminder" Design.

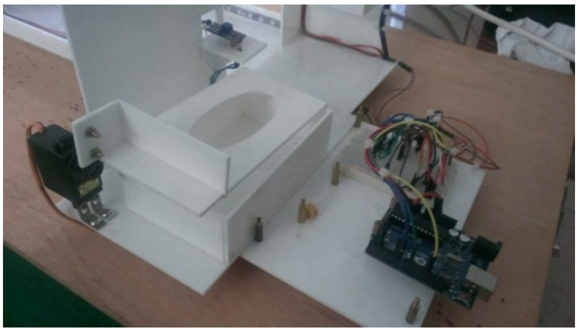

Figure 5. The Parts of Project "Child Hand-Washing Reminder" Design.

More importantly, the study for design the "Child Hand-Washing Reminder " is not only can enhance a child 's willingness to hand washing, but also can interdisciplinary integration and innovation to school education under the Union plan, focusing on maternal and child care and family support issues. In the future, the study also hope to combine more technology elements, and boot vocational information science students to caregivers in early childhood home care needs explore the field, cross link both technical resources to create the best concept of smart living for design and development of Child Tele-Home care system.

Acknowledgements

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The IDC Theory: Research Agenda and Challenges

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Abstract: In this paper, we examine some of the design principles and contextual conditions for fostering interest in learning. We hope to present some initial discussion of the research issues and challenges that need to be addressed in working towards iterating and refining the IDC theory. Explorations of facets of this theory are intended to motivate further research work and to derive practical implications such as design principles to impact learning and educational practices. We hope to further contribute to the understanding and promotion of interest-driven, creation-focused and habit-oriented perspectives towards a broader vision of what learning and education should be about in Asian countries and societies.

Keywords: Interest; Creation; Habits; Interest-based learning environment

1. Background

Consider the current situation in most of Asia, especially in the East Asian countries and regions. In school learning, developing students' interests towards disciplinary domains is an essential agenda for developing learners to have the knowledge skills and dispositions for careers and work in the 21st century. Students may view the subjects they learn in school as difficult and unrelated to reality. The abstract and synthetic curriculum content in schools does not allow them to meaningfully apply and utilize knowledge in real-life problems. Thus, it is necessary to involve students in interest-driven activities and to make connections between education and reality to increase students' attitudes and achievements towards subjects like STEM (McCrea, 2010). Students are also not motivated to study schools subjects in the humanities like literature, as they fail to see the relevance to their lives, or they perceive that it is difficult to get top grades for such subjects in high-stakes examinations.

Nevertheless, Asian researchers who desire to bring about a significant impact on transforming education have been faced with a great barrier of resistance: a considerable part of formal education in Asia remains "examination-driven" (Kirkpatrick & Zang, 2011a, b; Koh & Luke, 2009; Pong & Chow, 2002). Across Asia, educational practice is largely governed by the short-term goal of obtaining high scores on public examinations. This leads to over-emphasizing the mastery of disciplinary content, resulting some severe drawbacks: learning and teaching are tuned towards producing good examination performances; many students do not enjoy learning; it is difficult for students to develop positive attitudes towards the disciplinary domains.

The twenty-first century, however, marks an era of exponential change. Our world demands productive citizens to have a lifetime of creative and critical thinking, and to deliver new values, innovations, and productivity to thrust social and economic development. Have our schools found the right ways to prepare the young generation for the twenty-first century education? How to help them to develop interest towards the disciplines by building their interests, harnessing their positive habits and fostering their creativity within social contexts? The IDC theory makes a strong case for the roles of interest, creation and habits that enable and foster learning these skills and competencies, and acquiring these dispositions. While various researchers and policy groups have formulated frameworks for describing the skills, competencies and dispositions needed for the 21st century, the relationships and roles of interest, creation and habits in these frameworks need to be further examined and studied.

This paper presents some facets of a research agenda and challenges in the building of interest-based learning environments that provide opportunities for creating and for forming habits and routines. We consider three dimensions arising from the literature study (identity, attitude, and interaction) as basic principles for students to establish their interests. We will then discuss creation and habits together with the goal of building and advancing interest-driven learning environments in schools. Students need to learn through creation so that they develop the innovation mindset; they also need to develop good disciplinary habits of thinking and generic habits of learning. We postulate that approaching the balance between creation and habits as akin to the challenge of how to move up the innovation adaptivity corridor (Schwartz, Bransford & Sears, 2005). Efficiency and innovation are seen as two dimensions of adaptive expertise, and should be approached in tandem to move up the corridor to be adaptive experts.

2. How to drive interest in education?

In many Asian countries and regions, students are evaluated with regularly administered, standardized tests. Schools are also appraised based on how well their students have performed on those tests. With these evaluative methods in place, schools are understood as a place where students compete to acquire as much knowledge as possible and unfortunately, their academic achievements are often linked to their social identities. While we recognize the importance of schooling and standardized tests for education evaluation, one possible avenue to value-add in learning could be to create a different interest-driven learning environment, especially targeting for identity, attitude and interactions.

Identity is the story that we create for ourselves (Polman & Miller, 2010) and for students, their identity is embodied by their skills, academic achievements, interests, aspirations, that they are proud of – both in and out of school. As we develop and pursue interests in different contexts, our experiences develop identities that may influence how we project ourselves in the future (Penuel & Bell, n.d.). This includes acts of social positioning and identification that take place within classrooms (Bricker & Bell, 2008; Hegedus & Penuel, 2008; Wortham, 2004). Research in the anthropology and sociology of education has described how students' diverse social identities both influence and are shaped by schooling (e.g., Cazden, John & Hymes, 1972; Mehan , 1996; Varenne & McDermott, 1999). Research also indicates that one's identity affects their interests, motivations, and beliefs (Brickhouse, Lowery & Schultz, 2000; Carlone, 2003; Painter, Jones, Tretter & Kubasko, 2006).

To drive interest-driven learning in education, we need to also look into student attitudes towards these subjects. Attitude refers to emotion, cognition and intention (Myers, 1993). It is viewed as individual's beliefs about an object (Fishbein & Ajzen, 1975). Student attitudes towards science are influenced by interest and emotion (Mamlok-Naaman, Ben-Zvi, Hofstein, Menis & Erduran, 2005). They find science abstract and complex (Piburin & Baker, 1993), boring and impractical because teachers focus on memorizing content (Nolen, 2003). Similarly for mathematics and engineering, students find knowledge complex and difficult to learn (Bingolbali, Monaghan & Roper, 2007). The lack of learning support in learning mathematics also decreases students' interests in learning; leading to negative attitudes (Stone, Alfeld & Pearson, 2008). Current engineering and mathematic courses emphasize theoretical understanding over practical application. Dewey (1913) wrote: "Things indifferent or even repulsive in themselves often become of interest because of assuming relationships and connections of which we were previously unaware. Many a student has found mathematical theory lit up by great attractiveness after studying some form of engineering in which this theory was a necessary tool."

Despite the inherent challenges involved, students do enjoy the study of science and mathematics. They understand these subjects as essential for engineering. They have positive attitudes towards engineering due to its contribution to society, and are willing to engage in engineering-related careers (Hilpert, Stump, Husman & Kim, 2008). However, students want to learn science in a practical way (Osborne & Collins, 2000). When students practice science knowledge and understand its applications in their daily lives, their interests in science may increase (George, 2006). Similarly students have a positive attitude towards mathematics. Students want to learn mathematics because it relates to their future careers and lives. Students' achievement in mathematics is also determined by the extent they are anxious about mathematics (Walsh, 2008).

At the core of Vygotsky's Cultural-Historical theory (1978) is the idea that interactions between children and their social environment nurture children's development. These interactions involve the people around them, cultural artifacts, such as books or toys, along with culturally specific practices, in the classroom, at home or on the playground. Children construct their own meanings, knowledge, skills and attitudes based on these interactions. “A child’s greatest achievements are possible in play, achievements that tomorrow will become her basic level of real action and morality” (Vygotsky, 1978). Interaction supports development through imaginary situations where children take on roles, and rules while acting out their imagined scenarios. To Vygotsky (1978), these scenarios create the "zone of proximal development” and most effective learning happens here - when new skills and concepts are taught just on the edge of emergence.

During interaction, multiple pathways and outcomes are possible to allow for a greater range of experimentation and opportunities for observations, testing, failure, and success as the purpose and pathways that drive engagement and persistence are authored by the learner. Children develop exploratory as well as explanatory drives in interaction: they actively look for patterns, test hypotheses and seek explanations, leading to increased complexity in thinking, learning and understanding (Gopnik et al, 1999).

Thus, the learning environment as a site for identity development is likely to take on significance for students if it unifies the classroom and the outside life in a way that allows students to bring and explore their interests, their cultures, and their communities as part of curricular activities (McDermott & Webber, 1998). Hence, framing a learning environment that takes into account the identities and attitudes of students with multiple pathways of interactions would be beneficial for students through their school life and beyond.

3. How creation leads to an interest-based learning environment?

One long lasting line of research in creation as learning has been in the area of knowledge building. Tan, So and Yeo (2014) reports knowledge creation practices in schools, and asserts that schools should focus on developing students’ capacity and disposition in knowledge creation work. New programmes of research like Makerspace (Good & Krull, 2013) provide another perspective to knowledge creation. However, the epistemologies of knowledge building and creation are not resonant with those of prevailing school cultures, hence the challenges of incorporating and translating knowledge building practices to actual practices in schools persist in many countries and regions of the world that have attempted such approaches. One of the challenges to having students create knowledge and artifacts is that students engage in problem-based or project-based learning and inclined towards the completion of tasks with less consideration for learning. What learning tasks and situations, interactions and mechanisms need to be in place so that students doing staging or performance lead to learning? What are needed from the perspective of IDC is to study the types of school practices, pedagogical and collaborative patterns, and interaction protocols that can bring scaffold the Imitation-Combining-Staging loop of creation.

In schools, face-to-face classroom situations can host a broad variety of pedagogical patterns (e.g. think-pair-share, IRE, jigsaw, gallery walk) of student-student and student-teacher interactions. But the modularity of class periods, typically ranging from 35 to 90 minutes, imposes a premium in contrast with those (such as knowledge building activities) whose characteristic timescales are measured in days or months or even years. Of particular interest to teachers and administrators are such teaching practices that would not only carry the burden of content (e.g. science, math, foreign language) but also enhancing participating students’ development of so-called 21st century skills. For instance, in the design-based research work on GroupScribbles (Looi, Chen & Ng, 2010), students engage in rapid collaborative knowledge improvement patterns by posting their initial ideas on a common space (imitating), reading and building one each other ideas (combining), and creating group products or artifacts or presentations (staging). Questions that lend themselves to more work include: how to define success to find collaborative patterns that are efficacious for short/rapid and slower/longer-term knowledge creation and improvement? How to achieve success? Which patterns are most adoptable? How to support teachers to implement patterns? How to design pedagogical principles customized for unique needs? What are the determinants of learning? What are the favorable socio-cultural conditions, that is, how do we know learners have moved up the optimal adaptivity corridor?

4. What is the role of habits in learning?

The notion of 'Habits' is a broad term. One can think of disciplinary or professional habits of mind which a learner can aspire to attain. The literature mentions scientific habits of mind which postulates that learning science should be about helping learners to develop these habits of mind. In Dewey's own words, ''the future of our civilization depends upon the widening spread and deepening hold of the scientific habit of mind ... the problem of problems in our education is therefore to discover how to mature and make effective this scientific habit'' (1910, p. 127).

The habits loop points towards nurturing habits of creation and life-long attitudes towards being creators, so that these become dispositions shaping one's responses to learning situations, thereby generating interest in students. These become internalized as routines which help us to learn and perform better. The flip side of habits is to interpret habits as non-innovative routines on the efficiency dimension of the optimal adaptivity corridor. There needs to be opportunities to nurture innovation, so that the learner can also progress along the innovation corridor by their sustained interest in learning.

Habits can also refer to the routines by which we live life and we go about doing our study and learning. There is a flip side to such habits. Carey (2014) discusses what were thought of as "good" study habits in fact hampers learning. For example, students are usually told by their teachers or parents to always study in the same quiet space and time, and to create a ritual of studying. Carey points out some research studies that suggest that subtle variations in the routine such as going to a different room, or library, or coffee place; alternating the space or between light background music, silence, or the drone of people talking, might actually improve learning. The plausible explanation is that when we are studying, we are also registering cues from the world around us at a subconscious level, and weaving them into what is being learned. Different contextual cues make the connections richer, and are further strengthened if the material is reviewed in a different context than when it was initially learned. Each alteration of the routine further enriches the skills being rehearsed, making them sharper and more accessible for a longer period of time (Carey, 2014).

5. From IDC Theory to Practice: Research Agenda and Challenges

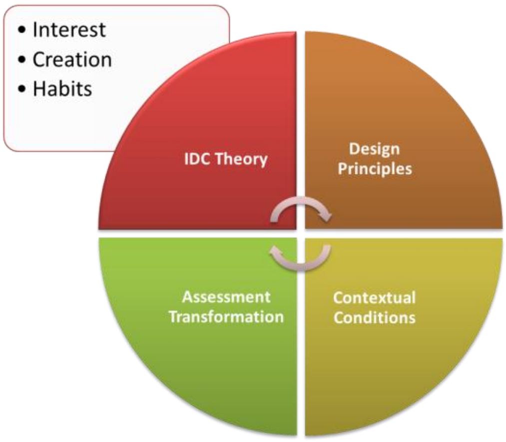

Figure 1. From IDC Theory to Practice: Research Agenda and Challenges

The work to probe elements of an IDC theory will bring us to a better understanding of the theoretical landscape with the vast variety of perspectives spanning psychological, neurological, developmental and socio-cultural accounts of interests, creation and habits. The goals would be to bridge across the various perspectives, and distill design principles which can be applied in an Asian setting.

From a theoretical perspective, we want to hear more stories and research into IDC that suggest alternative frameworks for interests, creation and habits that fall outside of the generic loops presented in the concept papers in this workshop. For example, the creation loop postulates imitation as one essential component in the process of creating; thus, are there creation cycles in which imitation is not part of the process? We need evidence and stories to be found from research, practice or our observations or insights that show the importance and relevance of interests, creation and habits.

Evidence is also needed from industry/real world that shows the impact of learners who are successful in their own ways because of their interests/creation/habits; or such stories.

5.1 Design principles to promote and optimise interest and creation in learning

The design of IDC learning environment could be an entry point for learning to happen in formal and informal context, supporting meaningful engagement of student interests. The underlying motivation applies equally well to the structuring and design of any system, be it mechanical, institutional, or social. It appears that interest-driven learning draws on the earlier concepts – in enabling applied learning as the emphasis on interest, creation and habits, in an authentic learning environment. By capitalising on and catering to students' varying abilities and interests, students develop skills and competencies that go beyond routine cognitive tasks, such as the ability to critically seek and synthesise information, the ability to create and innovate, and the ability to self-direct one's learning (Dede, 2010).

What are the design principles for fostering disciplinary habits of thinking, and effective habits of learning? A key habit of learning is to adopt the creators' habits of mind -- a growth mindset that encourages the belief that one can learn to do anything, and for individuals to become engaged citizens and agents of change (Dweck, 2006). The notion of habits is also encompassing, covering habits or learning and re-learning; automaticity to allow focus on learning; a range of habits ranging from scientific habits to social media habits to dispositions and routine ways of thinking and acting.

What are the design principles for providing opportunities for learners to model, to adapt and to perform in the creation loop? From a research perspective, we need to understand the interplay between individual creativity and collaborative/collective creativity, much akin to work in CSCL which seeks to understand the mutuality of individual and group/community cognition. "Things indifferent or even repulsive in themselves often become of interest because of assuming relationships and connections of which we were previously unaware. Many a student has found mathematical theory lit up by great attractiveness after studying some form of engineering in which this theory was a necessary tool" (Dewey, 1913).

5.2 Contextual conditions to promote interest learning in students

To motivate interest-driven learning in schools, we need to identify how school-based education builds, hampers or affects the foundations for interest-based learning, and on how interest-based learning builds the foundation for strong school-based learning. From a learning sciences perspective, the relevant research question is: what are the design principles for triggering, immersing and extending the development of learners' interest? There are also challenges are when students develop their identities, attitudes and interactions in the school curriculum, namely, that will require internal motivation from students, how to support learning objectives outside of learners' interests, and the impractical levels of resources and flexibility in supporting the divergent interests of individual students (Edelson & Joseph, 2004). The challenge of coverage faces the tension from having to cover a national or state curriculum. Nonetheless, many education systems expect students to achieve a large number of learning objectives. What is needed is to connect objectives to interests and to help teachers and students establish relevance. School practices need to be transformed to enable students to create knowledge in classrooms as in "knowledge building approach." interpret or solve problems from new perspectives, and be creative in the innovation sense.

Interest-driven learning is important to sustain learning. Increasing students' exposure to resources, mentors, inspiring projects, and opportunities — in school, but also in libraries, museums, clubs, and digital spaces — will result in interest-driven learning (Barron, 2006). In postulating her conjectures, Barron (2006) postulates that interest led learners to choose, create, and seek out learning opportunities; Interest driven activities were likely to be boundary crossing, that is move across settings of home, school, work, community, and online; as learning opportunities expanded they increasingly became connected to a sense of present and possible future selves; learning opportunities dynamically developed, for example expertise was often taken up by others which resulted in new learning opportunities. From an Asian perspective where formal education is prominent, pertinent issues are: How about informal learning strengthen formal learning and vice versa? How do we reinforce knowing and knowledge by frequent inter-contextual use? (Looi et al, 2010; Tabak & Nguyen, 2013).

5.3 Transforming assessment to drive IDC theory in education

Assessing the processes and products of creation poses a challenge to mass education, as they require more time-consuming labour intensive processes. Designing rubrics for assessment, nurturing a culture of self-evaluation and self-regulation, and peer-assessment are examples of strategies that have been reported in the literature that attempts to address assessment at scale. Indeed, assessments usually face a trade-off between efficiency of administration and grading, and authenticity of the assessment task. For example, MOOCs pose a challenge to supporting creation processes for learners because of the challenges of assessing such student products and assignments at scale.

6. Conclusion

Although much of the discussion in this paper has emphasized the implications of the IDC perspective on learning in schools, learning environments also permeate the diverse learning spaces from formal to informal learning environments (via notions of seamless learning and inter-contextuality). There is much work on research into informal learning that can also shed light on the roles of interests, creation and habits in fostering learning in spaces like science centres, community clubs, the home, or virtual or cyber communities. Brown (2005) postulates a hybrid model of learning, where we combine the power of interest-based participation in niche communities of practice with a “minimalist” core curriculum for teaching the rigorous thinking and argumentation specific to that field. For students in school, finding and joining such communities could well happen outside formal schooling, as has happened as guilds and interest groups.

Ultimately, more work and research needs to be done to depict the goal and vision of a future of Lifelong Interest-Driven Creators. Indeed, how lucid is this vision in terms of what does the future look like if this vision is a reality? How do schools become transformed? How do spaces for learning look like that resonates well with the IDC theory? What are the unique characteristics in an Asian context? Are such notions utopian scenarios, or in what ways things may not quite work out, and they may turn into dysfunctional scenarios?

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The IDC Theory: Interest and the Interest Loop

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Abstract: Numerous studies have shown that learning is enhanced when students show interests in the subject matter. However, educators continue to grapple with the challenges, or simply do not recognize their potential roles, in the development of students' academic interest. This conceptual paper is written under the auspices of the Interest-Driven Creator (IDC) initiative, a theoretical synthesis effort carried out by a group of educational researchers in Asia. The intention is to co-construct a holistic developmental/design framework to guide the students in fostering their learning interests, capabilities in creation, and learning habits – the three anchored concepts of the IDC theory. This paper focuses on delineating a three-component "interest loop" to guide the design of a coherent learning process that encompasses a series of learning tasks. The three components are: *triggering interest*, *immersing interest*, and *extending interest*. Underpinned by the rich literature on interest development, we will propose suitable design strategies for each of the three components, namely, *curiosity*, *flow* and *meaningfulness*, respectively. We will then explicate their respective design considerations/principles to maximize the intended effects.

Keywords: Conceptual paper, Interest-Driven Creator (IDC) Theory, interest development, curiosity, flow, meaningfulness

1. Introduction

Interest has been recognized as a key condition in (effective) learning. Indeed, according to Schiefele's (1996) meta-review on studies that have quantified influences of interest on learning, about 10% of the variability in learning can be accounted for by factors related to interest. Thus, learning could improve by promoting student interest in the subject matters to be learned. In other words, when the affective domain prevails, students may learn more effectively and efficiently by paying greater attention and exerting greater efforts, surpassing the expectations on cognitive outcomes required in school.

Notwithstanding, educators continue to grapple with the challenges, or simply do not recognize their potential roles, in the development of students' academic interest (Lipstein & Renninger, 2007) within the formal schooling system. In particular, the mainstream examination-driven education and the assessment modes in Asia that emphasize duplication of knowledge over 21st century competencies favor teachers' classroom instructions and students' self-learning strategies which can be characterized as "working hard" and "working smartly" (as posited by Wong, Jan, Toh, and Chai (2012) based on their study on Singapore students' conceptions of learning). "Working hard" means behaviorist drill and practice of pre-packaged knowledge acquired through transmissionist means. "Working smartly" means evaluation of the system requirement (such as guessing the examination questions or figuring out tactics to score high, typically without the need to internalize the knowledge or skills to be assessed) to outcompete ones' peers. Such instructions or learning strategies are typically boring to the students, particularly to the young generation who are born and raised in a fast-moving, technology-based lifestyle, where they are accustomed to searching for, evaluating, remixing and producing timely and relevant multimodal information (Clapper, 2014) at their own discretion.

The Merriam–Webster Dictionary defines "interest" as "a feeling of wanting to learn more about something or to be involved in something," and the Oxford Dictionary adds that interest is "a quality of exciting curiosity or holding the attention" or "an activity or subject which one enjoys doing or studying." The "feeling" referred to in the first definition is the emotional state of a person; the "quality" mentioned in the second definition is a cognitive state, which engages the person; and the "activity or subject," such as singing, sports, science, or philosophy, indicated in the third definition, is the person's interest if the person enjoys the activity or studying about the subject.

In the contemporary educational psychology field, interest is defined as an interaction between a person and an object (i.e., a particular content to learn) within the environment (Boekaerts & Boscolo, 2002; Hidi & Baird, 1986; Renninger & Wozniak, 1985). The potential for interest is in the person but the object and the environment define the direction of interest and contribute to its development (Hidi & Renninger, 2006). In his person-object theory of interest, Krapp (2002) described interest as a relational construct that consists of an enduring relationship between a person and an object. This relationship is reified by specific activities, which may comprise concrete or hands-on-actions and abstract mental operations.

Research on interest dates back to the 1800s. James (1890) pointed out that interest plays an important role in directing attention and behavior; and Dewey (1913) asserted that interest boosts learning and elicits effort. However, interest research has flourished only in the last few decades, demonstrating that interest increases knowledge (Alexander, Jetton, & Kulikowich, 1995; Kintsch, 1980; Schraw, Flowerday, & Lehman, 2001), generates positive feelings (reference), and reduce the cognitive load within learning situations (Hidi, 1995; Schnotz, Fries, & Horz, 2009). In addition, interested learners proactively raise curiosity questions (Renninger, 2009), anticipate subsequent steps when processing work (Renninger & Hidi, 2002), develop more types and deeper levels of strategies (Schiefele, 1991), are resourceful when a question cannot be immediately answered (Renninger & Shumar, 2002), persist in constructive and creative endeavors (Izard & Ackerman, 2000), promote self-regulation (Sansone, Thoman, & Smith, 2000), increase self-efficacy (Hidi, Berndorff, & Ainley, 2002; Zimmerman & Kitsantas, 1997), and value the opportunity to reengage in the task or a similar task (Flowerday & Schraw, 2003), among others. How can we make school subjects such as reading, writing, mathematics, science, and history as students' interests?

This conceptual paper is written under the auspices of the Interest-Driven Creator (IDC) initiative, a theoretical synthesis effort carried out by a group of educational researchers in Asia. The intention is to co-construct a holistic developmental/design framework to guide the students in fostering their learning *interests*, capabilities in *creation*, and learning *habits* – the three anchored concepts of IDC theory. This paper focuses on delineating a three-component "interest loop" to guide the design of a coherent learning process that encompasses a series of learning tasks. The three components are: *triggering interest*, *immersing interest*, and *extending interest* (Figure 1). Underpinned by the rich literature on interest development, we will propose suitable design strategies for each of the three components and explicate their respective design considerations or dstil design principles to optimize the intended effects. We will then discuss about how such an "interest loop" can be integrated into the school schedule with the ultimate aim of nurturing lifelong learners.

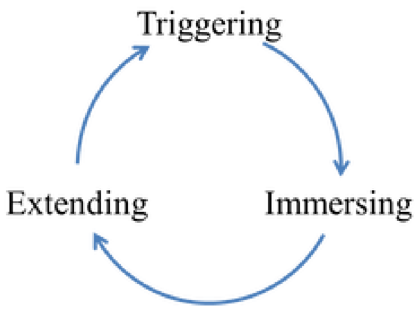

Figure 1: The interest loop

2. Development of Interest

The meaning of interest may range from a single, situation-specific person-object relation (e.g., reading a stimulating text) towards the enthusiasm with respect to a particular domains (e.g., interest in physics) (Schiefele, 2009). Accordingly, two major notions of interest have been identified, namely, situational interest and individual interest (e.g., Hidi, 2000; Krapp, 1999; Silvia, 2006). A developmental view of interest sees that interest can be cultivated, being initially aroused, maintained, and then further deepened and broadened – as a transformative trajectory from situational interest to individual interest. Hidi and Renninger (2006) characterized four phases of interest development: triggered situational interest, maintained situational interest, emerging individual interest, and well-developed individual interest. Situational interest is an affective reaction (e.g., the eagerness to know more) involving focused attention triggered by environment stimuli. Situational interest may not persist over time, and thus it must be maintained to develop a more stable interest. Individual interest refers to an enduring predisposition for reengaging with particular activities or subjects. Thus, individual interest, similar to what people generally know about the term interest, will sustain over time. After triggering and maintaining situational interest with environmental stimuli, individual interest emerges and could be further developed.

3. The Interest Loop in Interest-Driven Creator (IDC) Theory

In this section, we will propose suitable learning strategies for the three components of the interest loop. The three strategies can be characterized by three keywords respectively: "curiosity" for triggering interest, "flow" for immersing interest, and "meaningfulness" for extending interest. While this proposed trajectory can be loosely mapped to the first two or first three phases of Hidi and Renninger's (2006) interest development model (i.e., triggered situational interest, maintained situational interest, and emerged individual interest), our intention is to explicate the design guidelines for initial interest development that will eventually be harmoniously integrated into the full learning journey of IDC (i.e., to connect the interest development process with the "creation loop" and "habit loop" of IDC). Put it another way, within the context of IDC Theory, the "interest loop" begins with triggering of the students' situational interest, with the aim of nurturing emergent individual interest as the end; the "habit loop" would then take over from here to assist the students in the final step of establishing well-developed interest. The respective design considerations of the three components and their theoretical underpins will be explicated next.

3.1 Triggering Interest – "Curiosity"

"Triggering interest," the first component in the interest loop, concerns designing an activity that induces initial interest in learning a particular object. Providing incongruous and surprising information, for example, can intrigue students. Neuroscientists found that a specific area in the brain can be stimulated to evoke sniffing in rats, what is known as "seeking" behaviors that are present when the animal is searching, or investigating. Panksepp (1998) argued that the types of feelings that characterize the arousal of this system in humans would be described as intense interest, engaged curiosity, and eager participation. Such a behavior in humans has been found to produce feelings of invigoration, as if something very interesting and exciting is going on (Heath, 1963; Panksepp, 1998). In turn, minimal cognitive processing is likely to trigger situational interest, especially in early phases of interest development (Hidi & Renninger, 2006). Thus, we see arousing curiosity as the general design strategy for triggering interest.

Berlyne (1954, 1960, 1966) categorized different types of curiosity into two dimensions: one dimension ranging between perceptual and epistemic curiosity and the other dimension ranging between specific and diversive curiosity. Perceptual curiosity, aroused in animals and humans by visual, auditory, or tactile stimulation, increases the perception of stimuli. Epistemic curiosity, mainly evoked in humans by conceptual puzzles and gaps in knowledge, is a desire to know. Specific curiosity enables investigating the details of a particular piece of information or exploring in-depth the experience with a particular activity. Diversive curiosity, motivated by feelings of boredom or longing for stimulus variation, leads people to seek new stimuli or opportunities regardless of source or content.

Arousing specific epistemic curiosity is closely related to triggering interest because curiosity is not only for obtaining information that dispels uncertainties at the moment, but also for acquiring knowledge (Berlyne, 1966). According to the knowledge-deprivation hypothesis (Berlyne, 1954; Loewenstein, 1994), the emergence of epistemic curiosity (or situational interest in general) is the consequence of a knowledge gap between what a person knows and what (s)he desires to know. If we regard what a person desires to know in a particular domain as a knowledge "reference point", and when this reference point exceeds the person's level of knowledge, then curiosity, the drive for acquiring new knowledge, arises to remove the discrepancy. In addition, as satisfying curiosity is a pleasant experience (Csikszentmihályi, 1990; Izard, 1977), people voluntarily expose themselves to curiosity-inducing situations. To students, posing questions that foreground the students' knowledge deficit, presenting riddles or puzzles, exposing to a sequence of events with an anticipated but unknown outcome, violating expectation that motivates a search for explanation, etc., arouse their curiosity.

Curiosity, particularly epistemic curiosity (which is often connected to triggering situational interest), is a well-studied topic within the educational psychology field. Distilled from literature, a list of design principles for triggering interest by generating curiosity is given below,

(1) *Awareness of knowledge deficit*: According to the research findings of Rotgans and Schmidt (2014), students have to be *consciously* aware that a knowledge gap to understand the problem-at-hand has to exist, in order to provoke situational interest. Being confronted with only captivating learning materials is not sufficient for the stated purpose. Nevertheless, Rotgans and Schmidt (2014) also cautioned that in the everyday reality of classroom practice, students are typically confronted with far less intriguing problems. For example, a student who simply has no interest in mathematics may perceive a complicated math formula as knowledge deficit, but the topic may still fail to arouse situational interest. This leads to design principle (2) as posited below.

(2) *Novelty and complexity*: The context or problematization of the designed activity should be something new, complex, surprising, unexpected, or otherwise not understood (Litman & Jimerson, 2004; Silvia, 2005, 2006). Yet it should be concrete and vivid. However, both too low and too high levels of complexity may reduce interest. Too low levels of complexity may be deemed as a lack of challenging element to intrigue the students. Too high levels of complexity may result in cognitive overload. This leads to the specification of design principle (3) as below.

(3) *Perceptions of competence*: Design activity that the students feel competent in their ability in resolving the curiosity stimulus (Arnone, Small, Chauncey, & McKenna, 2011; Millis, 2001; Silvia, 2005), both in terms of (a) their competency in dealing with the complexity of the problem and (b) the skills required to carry out the task.

(4) *Cautious use of seductive details*: Teachers often spice up their instruction by adding enjoyable, emotional, but unimportant information/element (e.g., dazzling multimedia presentations, fun games, etc.) to make the process fun (Harp & Mayer, 1997; Wade & Moje, 2000). Garner, Gillingham, and White (1989) referred to such sources of seemingly motivating but unrelated to the content to be learned as 'seductive details'. Such design elements could render cognitive overload in students; thus distracting them from important information and impede knowledge construction (Meyer, Rose, & Chall, 1998; Schank, 1979; Shen, McCaughtry, Martin, & Dillion, 2006). For this reason, teachers are advised to design "interest triggering" activities with the core consideration in promoting the construction of the targeted knowledge, while treating seductive details as peripheral.

(5) *Creation of positive and psychologically safe learning environments*: In enacting the activity, encourage students to tinker with their ideas, 'good' or 'bad'. Teachers should not intimidate students by making them feel that they risk being embarrassed by the teacher or by their peers for giving 'bad' or 'wrong' answers or even opinions (Brookfield, 1995; Clapper, 2014).

(6) *Arrangement for student presentations of findings:* Depending on the nature of the designed activity or the knowledge to be learned/constructed (particularly for those open-ended curiosity questions without standard answers), students may be required to present their findings to the class toward the end of the interest triggering activity. Based on the findings of Rotgans and

Schmidt's (2011) study, such a synthesizing activity as the "highlight of the day" would further uplift the students' situational interest, perhaps due to the "sense of audience" and the elevated sense of achievement.

Nonetheless, it is important to note that such interest triggering activities are not necessarily effective in holding interest over a longer period of time (Magner, Schwonke, Aleven, Popescu, & Renkl, 2014; Mitchell, 1993). As noticed by Rotgans and Schmidt's (2011, 2014) series of studies, students' situational interest triggered by curiosity would be decreasing with the increase of knowledge. This seems to be counterintuitive with the common argument made by general educational psychologists that the relationship between interest and knowledge is a positive linear one (e.g., Alexander, 2003; Schraw & Lehman, 2001; Silvia, 2005). The main reason is that such past accounts typically refer to interest development as a whole, i.e., from situational interest to individual interest, or did not always distinguish the two types of interest in their relevant studies. Rotgans and Schmidt's studies were however focusing on situational interest. Situational interest, particularly in the form of epistemic curiosity, is about "thirst for knowledge" (Lynch, 2006; Rotgans & Schmidt, 2014; Shernoff & Csikszentmihalyi, 2009), which can be satisfied by being "quenched" with knowledge. If the perceived gap is closed because of knowledge gains, there is no additional impetus for further knowledge to be acquired and, hence, situational interest would be reduced (Rotgans & Schmidt, 2014). Thus, in order to maintain the students' interest beyond the triggering activity, it is crucial to facilitate the students in advancing to "immersing interest".

3.2 Immersing Interest – "Flow"

"Immersing interest", the second component in the interest loop, pertains to designing learning activities that engage the full attention of the students. We contend that the main design strategy related to this component is enabling students to experience "flow" (Csikszentmihályi, 1990; Csikszentmihályi & Rathunde, 1993). Flow refers to an experience of intense emotional involvement, being completely engaged in the activity for its own sake, thus feeling a sense of control or mastery, fully enjoying tackling the task at hand, being unaware the passage of time, losing self-consciousness, and experiencing great gratification that the activity is intrinsically rewarding. Mihály Csikszentmihályi aptly described the phenomenon where "The ego falls away. Time flies." (quoted by: Geirland, 1996) When students experience flow, they seek out increasingly greater challenges while devoting more attention to stretch their skills to confronting such challenges, resulting in personal development as well as feelings of efficacy. When flow activities are collaborative, engaging in such tasks with immersing interest enables building positive social relations with others by caring for and benefiting others. Thus, as Pintrich and Schunk (2002) stated, "… the flow experience requires skill, expertise, concentration, and perseverance, not just hanging out and feeling good." (p.284)

To enable students to experience "flow", the key design consideration includes providing concrete goals, offering immediate and clear feedback, giving flexibility to exercise some choice and control (i.e., student autonomy), balancing skill levels and challenge (cf. Table 2 in Pintrich, 2003, p. 672), and both the skill and the challenge must be above a critical threshold (Hoffman & Novak, 1996). In particular, entering flow requires the establishment of an equilibrium between perceived action capacities and perceived action opportunities (cf. Massimini & Carli, 1988). If challenges posed by the "flow" activity begin to exceed skills, one first becomes vigilant and then anxious; if skills begin to exceed challenges, one first relaxes and then becomes bored (Nakamura, 2002). Considering individual differences within a class, teachers should advise and assist students who are experiencing anxiety or boredom during a "flow" activity to adjust their levels of skills and/or challenges in order to re-enter flow.

Notwithstanding, flow experience and instructional design (in traditional sense) bear major differences in orientation. Instructional design is typically concerned with learning and achievement (regardless of whether individual students have established their interest in the target domain), while flow essentially foregrounds emotion and attitude (regardless of the effectiveness in learning about the target domain) (see: Chan & Ahern, 1999). Still, we argue that it is possible to reconcile the two seemingly disconnected objectives in the design of flow activities, particularly if teachers manage to trigger students' situational interest pertaining to the target domain prior to engaging them in a flow state in tackling challenges on the same domain. With students' situational interest being maintained through the “flow”, they are perhaps one step away from developing individual interest on the target domain through “extending interest”.

3.3 Extending Interest – “Meaningfulness”

“Extending interest”, the final component in the interest loop, relates to designing an activity to extend student interest in the domain after immersion in the learning activity. Extending interest also predisposes students to re-engage in similar activities should the opportunities arise. This should be the latest point of time where meaningfulness and self-directed learning is injected to the interest loop-informed learning process. The intention is to assist the students in transforming their maintained situational interest into emergent individual interest. Meaningfulness, or personal value, refers to students’ perception of target domain as being relevant to their daily lives (Schiefele, 2009). Studies (e.g., Dohn, Madsen, & Malte, 2009; Harackiewicz, Barron, Tauer, Carter, & Elliot, 2000; Mitchell, 1993) showed that perceived meaningfulness of the learning tasks was a crucial factor in maintaining situational interest, and perhaps even triggering the development of individual interest. In addition, Hidi and Renninger (2006) argued that conditions that support interest development not only need to generate positive feelings but also entail a shift from more external support to more internal support. Thus, for example, unlike during the “triggering interest” state where curiosity questions were imposed by the teachers, students who are engaged in the “extending interest” state may begin to generate curiosity questions on their own. Such questions (or other self-set challenges) enable students to connect their present understanding of content to alternative perspectives that challenge them to reconsider what they do know and to seek additional information (Renninger, Sansone, & Smith, 2004). As a result, students may redefine and exceed task demands with an emerging individual interest (Lipstein & Renninger, 2007), as well as deepening and broadening their knowledge or skills about the target domain in the future. In addition, students would re-engage in such activities in the way that they intended, without feeling any pressure to produce a performance that meets some standard of excellence (Brophy, 1999).

In light of the above explication, Schiefele (2009) distilled several conditions for inducing individual interest, which can be treated as design principles of “extending interest” for the teachers, in the context of IDC framework. First, highlight the practical implications of subject content and its relation to students’ everyday life (Mitchell, 1993); constructivist learning activities such as problem-based learning or authentic activities should help to increase students’ interest (Cordova & Lepper, 1996; Hickey, 1997). Second, assist individual students to associate the content or the “extending interest” task with their already existing or natural individual interests (Assor, Kaplan, & Roth, 2002; Meece, 1991), e.g., encourage students who are football fans to apply statistics skills to the statistical analysis of the performances of their favorite football teams. Third, express the teachers’ own interest in the subject being taught (Bergin, 1999; Schunk, Pintrich, & Meece, 2008) – interest is contagious and can best be conveyed if the teacher functions as an interested model. To accomplish these three conditions/principles, we contend that teachers should gradually relinquish their controls over the students, empower them in, say, self-directed or self-regulated re-engagement in the domain or the activities, and embodiment of their natural individual interests into the learning process.

In short, we position “extending interest” as the means to pave the way for students to develop individual interest out of the situational interest that teachers assisted them to trigger and maintain through “triggering interest” and “immersing interest” activities. In other words, this is where the individuals’ affective (interest-related) goal would converge with or become compatible with the core cognitive (learning-related) goal of the subject matter, and better still, to be compatible with one's preferred values and ideas of the growing self (Deci & Ryan, 1985; Krapp, 1999).

4. Discussion and Conclusion

Cognizant that 'interest is the mother of learning', we delineate a design framework for interest development in the students within the context of the IDC Theory. Curiosity-driven learning, flow experience and meaningful learning were the learning strategies being identified for realizing "triggering interest", "immersing interest" and "extending interest" respectively. Nevertheless, when it comes to concrete learning design, there may or may not be clear distinction among the three components/states. Instead, they can be seen as a continuum of various types of activities that support the students to walk through the early process of interest development. Moreover, the design considerations or design principles being laid out in the subsections of 3.1-3.3 are not necessarily restricted to the respective learning strategies. For example, while we emphasize meaningfulness only in the "extending interest" component, it does not mean that curiosity-driven learning and flow activities could not be designed in a meaningful manner. Another example is that "cautious use of seductive details" is discussed under the "triggering interest" component; yet this principle should apply to the designs of all other learning activities and learning environments. A novice "interest loop" designer may start with adhering to the delineated framework in this paper. Once (s)he becomes adept in the design skills and gain experience in enacting interest loops, (s)he may instead exercise flexible and differentiated designs to optimize the effectiveness of such activities. In particular, when such interest loop activities are repeated according to the school schedule (thus affording plenty of opportunities for reengagement) and when the student interest shifts from a situational interest to an individual interest, triggering interest will no longer be needed. Also, with the appropriate design of a school schedule, not only a learning interest will be developed, the learning interest may also become a learning habit (the last anchored concept of IDC), and, hopefully, a lifelong habit.

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The IDC Theory: Creation and the Creation Loop

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Abstract: Undertaken by a group of researchers in Asia, the Interest-Driven Creator (IDC) initiative is a collective endeavor intending to construct a holistic design theory for technology enhanced learning in the future. The IDC Theory hypothesizes that, with the support of technology, *driven by interest,* our students can be *engaged in creation* of knowledge or things, and, by repeating this process in their daily learning activities to foster their *learning habits,* our future generations will become *lifelong interest-driven creators*. Therefore, *interest*, *creation*, and *habit* form the three anchored concepts of the IDC Theory. Creation, the second anchored concept, is the core of learning because it makes learning productive, creative and achieving. This conceptual paper focuses on describing the three components of the *creation loop*, which consists of *imitating*, *combining*, and *staging*, and how they may support the development of creation capability.

Keywords: Conceptual paper, Interest-Driven Creator (IDC) Theory, creation capability development, imitation, combination, stage

1. Introduction

Learning must involve learners and learning activities. But what does a learning activity constitute? This is the subject of the second anchored concept—*creation*. In the IDC Theory, we view that learning is creating, and creating is learning. In the long history of human development, our ancestors learnt by creating, and, through learning, they created. Creation or creativity is not some mysterious capability only limited to a small group of people who are labeled as geniuses. Humans are natural and genuine creators—using and creating tools; observing how other people do things and then mimicking themselves; communicating with each other via gestures (initially in the ancient times), then via oral language when oral language was developed, then via written language when written language was developed, and, now, via digital media. Every act is a different act, combining what a person knows already to what that person perceives from various senses: visual, audio, tactile, and others. From ancient times to modern times, humans have been progressively creating knowledge and things. Now this process goes increasingly faster. Unfortunately, this natural acceleration process of creation has been distorted by formal education since the Industry Revolution, and particularly by examination-driven education in Asia. Nevertheless, with technological support, this natural creation process can resume, propelling schools toward forward-looking education in the twenty-first century.

Given this view of learning, we assert that creation consists of three components—*imitating*, *combining*, and *staging*—forming the *creation loop* (Figure 1). Each of the three creation components can be standalone activity (e.g. reading involves imitating and is usually a standalone activity) or group activity (e.g. complex tasks such as inquiry learning projects involve all three components and are typically group activities).

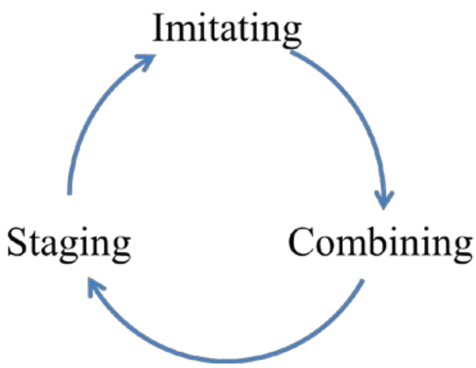

Figure 1: The Creation Loop

2. Imitating: the beginning of learning and creation

The present-day emphasis on creativity and innovation can easily devalue the imitation role in learning. Learning, as well as creation of ideas and things, however, begins with imitation. Meltzoff and Moore (1977) found that newborn babies, as young as 41-minutes old are able to imitate basic manual and facial gestures from an adult. Toddlers, before they develop their language, also demonstrate imitation behavior. Nadel (2002) sets up a playroom with two copies of everything. In the room, when one child picks up an umbrella, the other child picks up the other umbrella. When the first child starts spinning the umbrella, the second child spins her too. Such reciprocal imitation behavior goes on endlessly.

For adults, imitation behavior produces even far-reaching effect. Dawkins, in his book The Selfish Genes, describes how social practices, languages, ideas, as well as belief systems are being transmitted from generation to generation, producing different cultures throughout the world. The term 'meme' used in the book has become a word in the Oxford English Dictionary, referring to a type of behavior passed on from one member of a group to another by non-genetic means, especially copying or imitating. Indeed, unlike other species, we are able to learn by imitation -- the basis of human culture.

2.1 Neurological basis for imitation learning

It is natural to predict that some innate mechanism must be present in human brain to allow spontaneous imitation behavior. Actually, humans are born to imitate. Scientists finally found the neuro mechanism of imitation. The groundbreaking discovery of a special class of brain cells, called mirror neurons, possibly provides a unifying framework for understanding learning, language, empathy, and possibly more other human mental abilities. The potentially far-reaching implications of mirror neurons explain why Ramachandran (2000) claims that mirror neurons will do for psychology what DNA did for biology.

Mirror neurons were discovered more than 20 years ago (Pellegrino, et. al., 1992; Rizzolatti & Fabbri-Destro, 2010). In experiments with monkeys, Rizzolatti and his colleagues noticed that some neurons in the monkey brain fired equally when the monkey performed an action, for example, reaching for a peanut, and when someone else performed the same action. These copycat cells and their mechanism were hard to imagine at the beginning. Later experiments with humans via functional magnetic resonance imaging (fMRI), which can examine the entire human brain at once, suggest that a much wider brain areas demonstrate mirror properties in humans than previously thought (Gazzola & Keysers, 2009).

Actually, when we are listening to other people, we are mirroring the speakers with their tongues as if we are simulating their speech by talking to ourselves the same speech (Fadiga, et. al., 2002). This is possibly the way our brain understand other people's speech, hypothesized by Liberman and Mattingly (1985). Likewise, reading will also invoke mirroring mechanism. Watching videos for some actions and reading sentences describing the actions, such as "grasp the banana" and "bite the peach," will activate the same specific areas of brains for controlling the movements of the hand and of the mouth, respectively. This suggests that mirroring process may help us understand what we read by internally simulating the actions we just read. It may also suggest that when we read a novel, mirror neurons in our brains simulate the actions described in the novel, as if we were doing those actions ourselves (Aziz-Zadeh, et. al., 2006).

In sum, mirror neurons fire when an individual bites an apple, sees an apple being bitten, hears an apple bitten, and even just says, hears and reads the word "bite" (Iacoboni, 2008). Thus, mirroring is an incessant neuron mechanism as we use our own senses—sight, hearing, etc.—to get information about the world around us.

However, to understand other people's minds, we need to identify their intentions (goals to achieve) because behind an action there could be possibly different intentions. Yet, mirror neurons are able to code differently the same action for different intentions (Fogassi, et. al., 2005).

Taking all these lines of research, it suggests that some part of our brain is "no longer 'private' but a part of our social brain, processing the states of others as if they were our own." (Keysers, Kaas & Gazzola, 2010). We do not need to analyze what and why other people are doing and feeling, we simply simulate in our brain, involuntarily and automatically, what they do and what they intend to do, then we understand their minds and feelings. Thus, empathizing people around us is natural to us because we tend to see other people similar to us, not different from us. Mirror-neuron mechanism may also indicate how humans survive and grow in a complex social world.

Despite excitement about the discovery of mirror neurons, some scientists express doubts on mirror neurons research in humans (Pascolo, et. al., 2009; Hickok, 2009). Nevertheless, mirror neurons research is still at its beginning stage, the continual advancement of mirror neuron research has already led us to rethink about learning, social relationships, and our very selves. Ramachandran (2000), for example, proposed that mirror neurons and imitation learning constituted the driving force behind 'the Great Leap Forward' in the history of human development.

2.2 Spectrum of imitation learning

Going beyond mimicking somebody's actions, voices, gestures, or manner, imitation can be viewed as a spectrum of learning activities with multiple forms and levels of interpretation. Imitation requires something or someone that serves a model for imitation, and the imitation process consists of two sub-processes: observation of the model and production based on the observation. The word 'observation' used here is not only by watching; it is used in a general sense: inputting information by our senses (sight, hearing, etc.) from the situation as well as reading text or watching video. Production is about outputting—delivering information, performing actions, or making things after observation—resembling the model to some degree.

Modeling, a form of imitation learning, takes somebody as a model and attempts to understand and follow the model's ideas, methods, manners, or ways of making things. Bandura (1986, p.19) argued that "virtually all learning phenomena, resulting from direct experience, can occur vicariously by observing other people's behavior and its consequences for them." Modeling is indispensable in learning how to master complex skills. For example, to learn their mother language, children must need to expose themselves to the utterances of adults who serve as their models. It is too costly to learn through trial and error. Learning hunting or swimming may even cause fatal mistakes if children learn by trial or error. We need competent models to follow.

Obviously, a source of competent models is expert or teacher. Modeling, the first step in the teaching process of cognitive apprenticeship (Collins, et. al., 1987) refers to an expert's demonstration so that learners can observe how the expert performs the task. Modeling enables the expert to externalize the usual internal process of performing the task, helping the learners to build a conceptual model of achieving the task.

In general, there are three aspects of imitation learning to be considered: what constitutes a model, types of observation, and degree of resemblance between the reproduced product and the model. A model can be somebody or some tangible thing. It can also be a character in a story book or movie, a method described in a book, depicted in a picture, illustrated in a video. Observation is about perceiving and examining either in physical reality or through printed or digital media.

For the degree of resemblance, if the outputted product replicates the model with high degree of resemblance, it is a pure form of imitation. Note that such high-resemblance imitation learning is usually demanded in learning about sports, learning to dance, or learning speech sounds of a language. If, on the other hand, the outputted product bears little resemblance to the model, yet the product is still found valuable, then one may call this imitation process *creative imitation* or simply *creation*. Thus, what turns an imitator to a creator depends on the degree of resemblance between the product and the model.

From a socio-cultural perspective of learning, learning means learning to be a member of the community. Learning to be is about enculturating into the practices of a field often via legitimate peripheral participation via apprenticeship (Lave, 1991; Brown, 2005). Being a legitimate peripheral participant becomes akin to observing and "imitating" the practices of the core member of the community. Joining the community and moving from the peripheral to the core would involve cycles of imitation and engaging the real work of the community through creation practices and staging practices through scaffolding by the more knowledgeable members of the community.

3. Combining: the mechanism to move from imitation to creation

At this point, it is interesting to review how the word 'learn' is defined in dictionaries. In the Merriam–Webster Dictionary, it is defined as "to gain knowledge or skill by studying, practicing, being taught, or experiencing something" or "to cause something to be in your memory by studying it." In view of these two definitions as well as both the argument on modeling by Bandura and the mirroring mechanism in the brain, as described above, it seems that learning is essentially imitating. Since humans are born to imitate in the brain, humans are born to learn too.

But what constitute "studying, practicing, being taught, or experiencing something?" If, in the imitation process, we address more on the production sub-process, the disparity of the product from the model, and the value of the product, then we shall move from imitation to creation. This explains why the IDC Theory regards that learning is creating and vice versa.

Actually, the taxonomy of educational objectives by Bloom and his colleagues (1956) has already delineated how we can move from imitation to creation. There are six levels in the taxonomy—*knowledge*, *comprehension*, *application*, *analysis*, *synthesis*, and *evaluation*—moving through the lowest level to the highest. The movement is even clearer if we look at Anderson and Krathwohl's revision of the taxonomy (2000)—*remember*, *understand*, *apply*, *analyze*, *evaluate*, and *create*. The revision switches Bloom's *synthesis* and *evaluation* to *evaluate* and *create,* respectively. For Anderson and Krathwohl, they put *synthesis* at the highest level, and, like us, they view it (we use the word 'combination') as *creation*. For the first three levels, from *remember*, *understand* to *apply*, they represent imitations with different levels of outputting the product. For example, *remember* concerns least with the outputted product while *apply* concerns most. For the last three levels, *analyze*, *evaluate*, and *create*, perhaps we can look at them in different ways. In order to create (to synthase, or in our words, to combine), we need to *analyze* what we have and *evaluate* what elements to retain and what to get rid of. Then, with some planning and probably with some new ideas and elements of our own, we *combine* them with all the retained elements to form something new.

Indeed, everyone can create, just as creating novel speech 'on the fly' when talking with somebody (Andreasen, 2006). And we never cease to create, but genuinely original creation is rare. Most creations are re-creations, and new things are built on from the old things. What is 'new' and what is 'old' depend on an individual's brain or a specific community's brains. Actually, when perceiving new information from the environment, we always make sense of this new information (possibly through mirroring in our brain) and combine it with our own background knowledge (what has had already in our brain) in order to create another piece of new information as our outputted product.

The notion of learning as creation has many adherents in various frameworks and approaches to learning; ranging from learning by doing, knowledge building, constructionism, tinkering, and the more recent Makerspace movement. These take somewhat different perspectives and nuances to learning as creation, but there is one common underlying idea—combination—putting different ideas and things together to form something novel and valuable to the community.

Assessing the processes and products of creation poses a challenge to mass education, as it involves more time-consuming but thoughtful deliberations of them. Designing rubrics for assessment, nurturing a culture of self-evaluation and self-regulation; peer-assessment, etc., are strategies that have been reported in the literature. Assessments usually compromise between efficiency of administration and grading, and authenticity. For example, MOOCs pose a challenge to creation because of the challenges of assessing created products and assignments.

4. Staging: sustaining, improving and advancing creation

Maslow's hierarchy of needs, from lower level to higher level, presents five levels of needs: the *physiological* needs, the *safety* needs, the *love* needs, the *esteem* needs, and the needs for *self-actualization*. We may conjecture that our imitation behavior, which aims at how we are similar to others, tends to meet the two lower-level needs—*safety* and *love*—so that, just like everyone else, we can be recognized as a part of the community. On the other hand, our creation behavior, which aims at producing something new and valuable to the community, tends to meet the two higher-level needs—*esteem* and *self-actualization*—so that we are not only a part of the community, we are, with our own creations, able to contribute something valuable to the community. But we need a stage to demonstrate and prove the value of our creations.

Shakespeare said: "All the world's a stage, and all the men and women merely players." The world is your stage. Imagine when you are playing a role in this stage, you have opportunities to demonstrate the value of your existence through your creations. If you are a student in school, for example, the community around you is your stage. When you talk to one of your classmates about your idea (i.e. your creation), then your classmate becomes your stage; when you talk to a small group of classmates, then they become your stage; when you talk to the whole class, the whole class becomes your stage; when you talk to a large online community, then the online community is your stage. In this process, your creation gets recognized by your community. At the same time, the feedbacks received from the community sustain, improve and advance your creation. Of course, the same argument applies to creations by a collaborative group of students. To excel, staging is essential, whether the creations are individual or group products.

Staging is an indispensable component of creation process. One implication is the design of learning tasks that require performance and staging on the part of learners – learners create artifacts or stage their performance that can matter and not just be thrown away. The knowledge building paradigm posits advancing knowledge in the community; articulations of learning as being authentic, problem-based or project-based learning point to providing a context or stage for learners to be engaged in such authentic learning experiences. Staging also has implications for assessment and learning; solving a quest or problem in a virtual world or in a well-designed game-like environment is not only staging, but a demonstration of competencies in both the domain and non-domain – which may hold more validity in just doing traditional forms of assessment like paper-and-pen tests. Assessment itself is learning.

5. Summary

In this paper, we describe the three-component creation loop. Imitating, the first creation component, talks about learning through observing others, adopting examples, or absorbing information through any means to mimic or emulate somebody or something that serves as a model. Combining, the second creation component, refers to synthesizing the thoughts or things of others and the self's own to form something new or different. Staging, the third creation component, mentions about displaying products, presenting new thoughts, or demonstrating achieved outcomes to others.

Imitating is the beginning of creation; combining the core of creation mechanism; and staging the platform for advancing creation.

6. Future Work

Also, we shall investigate further community creation vs individual creation. Since creative thinking is an important 21st century skill, we shall explore teaching creativity in schools.

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The IDC Theory: Habit and the Habit Loop

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Abstract: Researchers, educators and parents have long acknowledged the importance of cultivating students' good habit for learning. However, educators and parents continue to grapple with the challenges in helping students form new good habit and break old "not-so-good" habit. The research literature on learning habit formation is still limited in informing the teaching and learning practices in schools and beyond. This conceptual paper is written under the auspices of the Interest-Driven Creator (IDC) initiative, a theoretical synthesis effort carried out by a group of educational researchers in Asia. The intention is to co-construct a framework to guide the practitioners in fostering students' learning interests, capabilities in creation, and learning habits – the three anchored concepts of IDC theory. This paper focuses on delineating a three-component "habit loop": *cueing environment, routine,* and *satisfaction*. This paper will discuss the implications of the habit loop for student's interest-driven creation. Cultivating students' learning habit is fundamental to education but it is not a well-explored area. The paper raises some questions with the aim to stimulate further discussions among educators, researchers, parents and policy makers.
Keywords: Interest-Driven Creator (IDC) Theory, learning habit, habit loop

Introduction

Learning involves a persistent and stable change in what a person knows or does. Forming useful and productive habits learning is important for education and learning. Habit formation is often related to interest and persistence. Learning driven by interest with process mimicking in the creation process will produce no lasting effect on students unless it is repeated regularly in daily learning activities to accumulate its effects. To exert a long-term impact on student learning, a natural way is to cultivate creation with interest as a habit, desirably a lifelong habit.

Habit

Habit is a routine of behavior that is repeated regularly and tends to occur unconsciously. "Habits are the result of automatic cognitive processes, developed by extensive repetition, so well-learned that they do not require conscious effort" (Ronis, Yates, & Kirscht, 1989, p. 219). Oxford Dictionary (2014) defines habit as "a settled or regular tendency or practice, especially one that is hard to give up" and "an automatic reaction to a specific situation". Cognitive scientists often talk schema and automaticity when discussing cognitive processes involved in habit formation (Anderson, 1992; Schank & Abelson, 1977).

Building up good habit is a fundamental issue for people's life. People's behavior is largely affected by their habits. Thus, habits, to some degree, define who people are. Many philosophers, psychologists and educators have emphasized the importance of the habit. The notion of *habits of mind* encapsulates many prior discussions (Costa & Kallick, 2008). The pioneering psychologist and philosopher William James (1890) wrote, "All our life, so far as it has definite form, is but a mass of habits." "Any sequence of mental action which has been frequently repeated tends to perpetuate itself; so that we find ourselves automatically prompted to think, feel, or do what we have been before accustomed to think, feel, or do, under like circumstances, without any consciously formed purpose, or anticipation of results." "We are what we repeatedly do," Greek philosopher and scientist Aristotle famously proclaimed. "Excellence, then, is not an act, but a habit." The same goes for the reverse: problems and failure can become habits too. Those who have formed good habit have higher chance to excel in various aspect of life.

Types of Habit

Habits can be divided into three types depending upon the nature of activities. The first type is motor habits which refers to the muscular activities of an individual. These are the habits related to our physical actions such as, standing, sitting, running, walking, doing exercise, maintaining particular postures of body, etc. Many motor habits are health related. For example, drinking a lot of water, doing exercise regularly, eating less oily food and more vegetables and fruits, brushing teeth in the morning and evening. A study on developing healthy habits (eating, drinking or exercises) found that automaticity increases and fits an asymptotic curve with repeated behaviors in a consistent context (Lally, van Jaarsveld, Potts, & Wardle, 2010).

The second type is intellectual habits which are related to psychological process requiring our intellectual abilities such as good observation, accurate perception, logical thinking, using of reasoning ability before taking decisions and testing conclusions, etc.

The third type is habits of character. Some of our characters are expressed in the form of habits. For example, helping others who are in need, trusting people, being honest, talking in a friendly way, time management, being considerate by opening the door for people instead of barging through it first, not interrupting or talking over people, hard working, keeping our dress clean and tidy, etc. These habits will have essence of feelings and emotions; hence these are also called as emotional habits.

Learning Habit and Habit for Interest-Driven Creation

Students will experience success, difficulties, challenges and failures throughout their life. Helping next generation to succeed in the future is at the heart of educators and educational researchers. Cultivating students' good learning habit is to nurture them to excel in the future. The influential Chinese author and educator Yeh Sheng-t'ao stated that "what is education? To answer it in a simply way, just need one statement: nurturing good habits".

Students' future achievement includes things like marks, literacy, numeracy, effort, persistence, engagement, participation, collaboration, exploration, creation, etc. Some study habits, especially those habits related to persistence with regard to learning goals are directly related to students' academic performance, such as preparing the learning content before coming to the class and reviewing and reflecting what have learned after the class. According to Azikiwe (1998), "good study habits are good assets to learners because the (habits) assist students to attain mastery in areas of specialization and consequent excellent performance, while opposite constitute constraints to learning and achievement leading to failure". A recent study found that one's habits are related to whether one has growth or fixed mindset (Yan, Thai, & Bjork, 2014). For example, a student with growth mindset may be intrinsically motivated to learn and tend to have a habit of restudying.

Some researchers attempts to cultivate students' good learning habit to make them as life-long learner with 21st century competencies such as critical and inventive thinking, self-regulated learning, problem solving and collaborative learning etc. Such 'habits of mind' (or 'habits of thought', as John Dewey originally referred to them) require little or no effort on the part of the child to initiate or sustain them and would include inclinations to take responsible risks, persistence, manage impulsivity and think 'outside the box' when in problem-solving situations (Whitebread & Wingham, 2013). Costa and Kallik (2008) explains how habits of mind may be cultivated in children. They show how children can be taught, at home and at school, how to 'habituate' effective problem solving strategies and techniques into their mental repertoire so that they develop the propensity for skilful problem-solving in a variety of life settings. Good learning habits can be formed in student' schooling but can be sustained lifelong.

Educators hope the students can form good habits at the early stage of their life so that they are more likely to have a successful and productive life. Students' achievements due to good habit have a cumulative effect on future success. Therefore, those students who have had developed good learning habit earlier continue to sustain and increase the learning gains while those students who haven't had good learning habit have a harder time catching up – essentially, the stronger get ever stronger while the weaker only get weaker, due to habit. This is consistent with the research findings that suggest that prior learning performance of an experience is a good predictor of future learning (Jonassen & Grabowski, 1993). This exactly illustrates Nathaniel Emmons's saying that "habit is either the best of servants or the worst of masters".

In education context, the term 'habit' is widened from the commonplace definition meaning an oft-repeated action or an established practice or custom requiring little thought (such as brushing teeth or adding sugar to one's coffee) to mean unconscious mental propensities or processes, revealed as behavioural tendencies and dispositions as the student engages with the events and challenges of everyday life.

“Habit”, the third anchored concept of IDC theory in our paper, speaks of nurturing habits of creation. If students learn with interest incessantly and habitually (as when following a school timetable that regulates daily routines), and their learning process emulates the creation process, then students will become creators, lifelong IDCs. Habit does not only substantiate the effect of learning, it also decides whether students are creators because shaping who they are is demonstrated by their daily repeated behavior, which in turn, is governed by their habits.

Educational researchers and instructional designers investigated the relationship between interest and habit and how motivation promote learning (i.e., result in more time spent on learning tasks) in the context of habit formation. The notion of interest encapsulates much of what is called motivation and volition (Keller, 2008). To cultivate interest-driven creator, there is a need to (a) determine those habits that contribute to interest driven creation, (b) identify current and desired habits of learners, (c) determine which learning habits of learners require additional support and development, (d) develop an instructional design framework that foster the habit of interest driven creation.

Mechanism of Habit Formation and the Habit Loop

To cultivate good habits of students we need to have a deep understanding of habit formation. A habit is a regularly repeated behavior pattern: a routine that is practiced frequently and hard to stop. Habit formation is the process by which new behaviors become automatic (Bargh, 1994). While the link between habits and learning is widely recognized, there is much less research that investigates how learning habits are formed in various circumstances with different learners. One of such research is Lally, van Jaarsveld, Potts, & Wardle’s (2010) study on how to promote habit formation. They explored on strategies to initiate a new behavior, support context-dependent repetition of this behavior (cueing environment), and facilitate the development of automaticity. Lally and her Colleagues also provided the assumption that repeating a behavior in a consistent setting increases automaticity. Moreover, the term, habit, refers to a behavior that is done automatically with little thought.

Durhigg (2012) considered that a habit can be thought of as being composed of three parts: a cue, a routine and a reward. Adapting from Durhigg (2012)’s framework, we proposed a habit formation framework in the context of education and learning which consists of three components: *cueing environment* (arrangement of place, time, people, or incidents), *routine* (repetitive pattern of activities), and satisfaction, forming the habit loop (Figure 1).

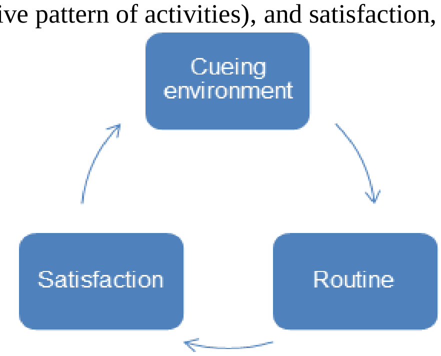

Figure 1: The Habit Loop

Cueing environment. In the habit formation process, first, there's a cue, or trigger, that tells your brain to go into automatic mode and let a behavior unfold. Cuing environment is important because it could provide learner perform the behavior consistently and then cue environment could trigger the learning behavior (Lally, & Gardner, 2013). Habits are formed when actions are tied to a trigger by consistent repetition so that when the trigger happens, you have an automatic urge to do the action. When a habit is triggered, the actor may sometimes do it without consciously knowing doing it. For example, brushing teeth is a habit. When most people wake up from their beds in the morning, they go to the bathroom and brush their teeth automatically, without asking themselves whether they want to brush teeth in that morning. Occasionally, the action is so automatic that people may forget later in the day that they brushed their teeth. An appropriate cue should be easy to identify by a learner and to influence habit formation and supporting the development of automaticity.

Psychologists have found that habits are cued by context (Wood, & Neal, 2007). Furthermore, there are two forms of contextual cues: direct and motivated cuing. First, direct cuing refers to repeated association between routine and environment. Such continuity may facilitate the encoding of learning patterns in students’ procedural memory. For this reason, habits can be developed via providing a constant environment, for example, reading in the same room at the same time, maybe with a favorite hot tea. Second, motivated cuing refers to the rewarding experience in the past. In other words, previous successful experiences may become a cached motive to do the same thing (Daw, Niv, & Dayan, 2005). For doing so, the cuing environment should include a supporting mechanism, for example, setting feasible plans before solving a complex learning task, like creating. On the other hands, some research also showed that a good everyday habit could be disrupted when specific contexts were changed (Wood, Tam, & Guerrero Witt, 2005).

Routine. The behavioral patterns we repeat most often are literally etched into our neural pathways. Through repetition, it's possible to form (and maintain) new habits in which new response mechanisms, called scripts or schema by cognitive psychologists, are formed. “Any sequence of mental action which has been frequently repeated tends to perpetuate itself; so that we find ourselves automatically prompted to think, feel, or do what we have been before accustomed to think, feel, or do, under like circumstances, without any consciously formed purpose, or anticipation of results.” (Duhigg, 2012). A good way to start forming a new habit should keep it easy and simple. The previous study found complex behaviors took longer time to become habits (Lally, van Jaarsveld, Potts, & Wardle, 2010).

People’s behaviors and actions can be goal-directed or habitual. Goal directed actions are rapidly acquired and regulated by their outcome. Habitual actions are reflexive, elicited by antecedent stimuli rather than their consequences. If people engage in goal-directed behavior on routine basis it may become habitual. A habit may initially be triggered by a goal, but over time that goal becomes less necessary and the habit becomes more automatic. Performance of instrumental actions in rats is initially sensitive to post-conditioning changes in reward value, but after more extended training, behavior comes to be controlled by stimulus–response (S-R) habits that are no longer goal directed. The research shows that it is possible to change goal-directed behavior with habitual behavior if people are engaged in certain behavior repeatedly or on a routine basis.

It is interesting to note that neural science research nicely complements both behavioral and cognitive learning research. Scripts and schema represent the cognitive treatment of automated responses, and mental models represent the cognitive treatment of a goal-directed non-automatized behavior. Roughly speaking, from the perspective of Piaget’s perspective, the formation of mental models is a kind of accommodation on process and the formation of schema is a kind of assimilation process. Neural science provides an explanation of what is happening in the brain as those processes develop and habits form, and behavioral science provides a way to observe and measure the associated conditions and results.

Some research showed that the number of repetitions required to form a habit depends on the complexity of the task (Lally, van Jaarsveld, Potts, & Wardle, 2010). For example, it will take 18 or fewer days for easy tasks (e.g. riding a bicycle, drinking more water) and up to 254 days for more complex tasks (e.g. going to the gym). Ericsson, Krampe, and Tesch-Römer (1993) argue that it takes as long as 10 years to develop very high-level performance of complex tasks. Moreover, van Merriënboer (1997) distinguishes recurrent tasks (e.g., those that are performed more or less the same way regardless of surrounding circumstances) from non-recurrent tasks (e.g., those that require modifications in performance depending on variations in the circumstances). Recurrent tasks are more amenable to the formation of automated responses and the development of habits, whereas non-recurrent tasks typically require the activation of mental models to perform some aspects of the task, and, as a result, are not so easily automated. The literature on habits of mind could be interpreted in part as referring to how a person develops coping mechanisms to respond to non-recurrent tasks.

Satisfaction (reward). Through the routine behavior and action, people feel their needs get fulfilled or have a sense of satisfaction or achievement. Our brain likes satisfaction, fulfillment, achievement and enjoyment, which helps us remember the "habit loop" in the future. Reward or satisfaction in the new habit possibly increases a positive feedback loop that helps the repetition of the new behavior in the future (Neal, Wood, Labrecque, & Lally, 2012; Lally, & Gardner, 2013). Because Rothman (2000) also noticed that “the feeling of satisfaction indicates that the initial decision to change the behavior was correct (p. 66)”, the role of satisfaction as a reinforcer of cue-response associations.

In other words, habits are automatic behavioral which responses to environmental cues, develops through repetition of behavior in consistent contexts, and reinforces a learner’s satisfaction. In short, to create a habit, a learner needs to repeat the behavior in the same situation. Hence, we can adopt that the habit loop may provide a mechanism for establishing new behaviors, and learning habit formation is a desired outcome for many interventions.

Cultivating Habit for Interest-Driven Creation

We have discussed the importance of cultivating interest-driven creator in previous paper. Developing habit is related to developing interest, for example, developing reading habit is also developing interest in reading. Once students have the interest, they will have attention and concentration and will make sincere efforts. While we, educators, are more concerned with the development of complex cognitive behaviors than simple repeated behaviors, it is challenging to unpack the underlying mechanism of how a certain cognitive action becomes an automatic behavior, and is eventually sustained to become a habitual routine behavior in a long term. The formation and execution of habits involving complex cognitive behaviors is more than the simple chain of stimulus and response since one's habit is highly related to the influence of affective aspects and cognitive control. The recent literature on technology adoption, for instance, has highlighted the role of habit, emotion and environmental cues to explain the habitual continuing use of information technology (De Guinea & Markus, 2009; Lee, 2014). This view is dramatically different from the traditional theoretical view on the continued use of technology (e.g., Technology Acceptance Model) that emphasizes the role of intentional and reasoned actions. De Guinea and Markus (2009) argue that the habitual use of IT is less driven by intentional actions but is more driven by triggers in environmental cues.

Start from manageable behavior. To make students be interested in creation, students need to have a good start. Educator need to get students at a manageable pace to. Students will be overwhelmed if they are to form too many new habits within short period of time. Success is more likely when students are focusing on only one or two changes which is manageable for them at a time. Forming habits of complex behaviors may reach the levels of automaticity more difficult than forming simple ones (Verplanken, & Wood, 2006). This is due to the fact that complex behaviors involve more thinking processes (Wood, Quinn, & Kashy, 2002). For this reason, when developing students' habits, it is easier for them to start with creation activities which are not too complex. We can take a spiral progressive approach to get students engaged in more complex creation activities at a later stage.

Create a cueing environment (a reminder). for example, if a student start to engage in knowledge creation work at a fixed time for a fixed length of period, we should provide a cueing environment which make them not hesitating from the beginning. It is ok to remind students at the beginning of habit formation by clarifying the goal of the learning activities with the students. If the student knows the purpose of the activity, he/she can focus on the learning and the study will be goal directed which can become habitual later.

Another cue could be the educator himself/herself. Teachers can be the role model of students as interest-driven creator. Previous research on mirror neurons shows that observing other people's behaviors may facilitate unintentional and non-conscious mimic behaviors (Rizzolatti, Fadiga, Gallese, & Fogassi, 1996). The finding suggests that students should be situated in a learning environment with good behaviors. In classrooms, teachers should become the role models so that students can mimic what routines we want them to do. Besides, the teachers should also setup a norm that is conducive to develop crowd habits in classrooms.

It is helpful to view the process of habit development, especially for more complex forms, as the interplay between one's agency and situational resources. That is, one's will alone is not sufficient to develop and sustain routine behaviors in a long term, unless situational opportunities and resources are provided as affective and cognitive support. Situational resources act as triggers in a cueing environment. For instance, the design of an immersive simulation in classrooms (Lui & Slotta, 2014) demonstrates the possibility of using technology as a trigger for collaborative inquiry activities. The large public display on the classroom walls provides a situational cue where students can easily monitor the collection of ideas and the current status of the community knowledge. When entering the room with the situation cue, the students are engaged in actions where they can easily check and monitor ideas. Further, the immersive simulation on the large display may be able to trigger routine behaviors for students to check what questions are posted and to contribute ideas for collective knowledge advancement.

When we shift our focus of habit formation from the inside of one's mental activity to the interplay between individuals and environmental cues, designing and embedding triggers in environments becomes a central issue. The criticality of environmental cues in habit development suggests the need to design tools and platforms that effectively provide relevant triggers. With that, we can explore how the recent development of emerging technologies can help provide effective and meaningful triggers to students. For instance, the recent use of wearable technologies has demonstrated the potential of detecting, capturing and analyzing data generated by individuals with a wearable device. Data is seamlessly collected in an unconscious manner, hence reducing one's cognitive load of tracking and monitoring. Data from such wearable devices can prompt individuals to evaluate their performance, and in some cases can provide motivational triggers to alter certain habitual behaviors. Such applications for raising self-evaluation and self-regulation have been proposed mainly in the field of healthcare systems, including the visualization of eating habits and the sensor-based system to monitor dietary habits (Faudot, Lopez & Yamada, 2010; Shuzo et al. 2010). However, the application of such wearable and data-based technologies for educational purposes is in its infancy. Perhaps, learning analytics is the most actively researched area that concerns with the use of the vast amount of data for enhancing teaching and learning (Siemens, 2013). Considering that many online crowd-based learning platforms leave a vast amount of learner's habitual data such as reading, writing, and study patterns, such data can be automatically detected and made meaningful to users as motivational triggers to reinforce positive habits or to develop new habits.

Get students engaged in the behavior on a routine basis (do the same thing at the same time everyday or on regular basis). It is essential for students to practice the new habit regularly until it becomes a routine in their life. Postponement or interruption should be avoided because it weakens the habit formation. The routine schedules in schools provide such possibility as educators can get students engage in knowledge creation work in a fixed time slot.

The Fostering a Community of Learners (FCL) (Brown, 1992) is a classic example of classroom implementation where students were able to develop a habit of sharing their ideas and interest horizontally in a classroom and also vertically across different grades (Collins, Joseph, & Bielaczyc, 2004). FCL employed a dramatically different structure where students are engaged in crosstalk and reciprocal teaching to discuss across different topics, to work in different groups, and to co-teach each other for understanding. Such built-in activities and structures influenced the emergence of a classroom culture where students were able to freely share ideas and ask questions. This culture is a huge deviation from the traditional classroom culture where individual students often engage in fixed activities. What makes FCL successful is the fact that the routine activities of sharing and discussing ideas function not as simply procedural activities, but were operated as a system with the interdependent activities that the underlying objectives are articulated (Bielaczyc & Collins, 1999). That is, both teachers and students as community members were aware of why they are engaged in certain procedures, thereby creating the shared understanding about their actions.

Reinforce students' satisfaction. The sense of satisfaction can help students engage in new behaviors in the habit loop. If students are satisfied by the experience of a new routine, they typically attempt to facilitate behavioral changes, and vice versa. Specifically, we consider that the satisfaction of the habit loop will increase the strength of the habit formation, whereas low satisfaction will gradually weaken it. Satisfaction may be boosted by reinforcing un-existing wanted habits, or disrupting existing unwanted habits. Regarding the former, the satisfaction of habit loop can potentially help students form new good habit, such as, inculcating the reading habit (Asraf, & Ahmad, 2003), or becoming an amateur astronomy (Azevedo, 2013); regarding the latter, satisfaction can also help students break old "not-so-good" habit, such as, weight loss (Finch, Linde, Jeffery, Rothman, King, & Levy, 2005), and smoking cessation (Baldwin, Rothman, Hertel, Linde, Jeffery, Finch, & Lando, 2006). That is, the satisfaction of habit loop can apply a habit formation approach in designing behavior change interventions.

The key to students' satisfaction is to create successful learning experience as often as possible. Fortunately, educators and researchers have already provided several feasible ways to doing so. Generally speaking, successful learning experience can be achieved by cognitive and affective scaffolding. Cognitive scaffolding may support students to complete difficult learning tasks, such as questioning, providing hints, explaining, coaching, and modeling (see van de Pol, Volman, & Beishuizen, 2010), while affective scaffolding may encourage students to finish tasks and prevent possible negative emotions, such as anonymity (Cornelius, Gordon, Harris, 2011) or information hiding (Cheng, Wu, Liao, & Chan, 2009). In particular, teachers should provide low-ability students with additional assistance, so that students can acquire the satisfaction in the habit loop of interest-driven creation.

Conclusions and Discussions

Building good habit is important and fundamental for education, be it in school or out of school. It will have in-depth impact on student's life-long learning and will nurture them as interest-driven creator. There are so many intervention projects in schools which use innovations to transform students learning experiences. However many these interventions' impact on school practices is limited. More research is needed in addressing the fundamental issues on education. Nurturing good habit is one of them.

Can habit formation be cultivated by educators? The answer is yes. As discussed in the paper, the mental processes and dispositions for habit can be taught and practised, so that they become habitual ways of working towards thoughtful, purposeful, self-regulated action in facing the challenges of life. Having said this, there are many issues remains to be addressed when cultivating students habit in interest-driven creation.

The first issue is time. The widely touted theory, highlighted in a 1993 psychology paper and popularized by Malcolm Gladwell's book Outliers, says that anyone can master a skill with 10,000 hours of practice. One can say that habit formation is the basis for becoming an expert in a particular area. If we are able to get students accumulate considerable amount of time on a regular basis if not daily, students are more likely to form a habit and become an expert in the area later. However it is not realistic to expect students to be an expert in too many areas because forming habits takes time but students' time is not unlimitedly as they need to do other activities as well. Therefore educators and researchers need to prioritize the learning habits we would like students to form. It is found in the literature that researchers and educators tried various innovations in teaching and learning to help students learn better. Do we need to take step-by step approach to address more fundamental learning habit (e.g., reading) first? If yes what are those more fundamental and important learning habits that we want students to form so that they can be successful in learning?

The second issue is the satisfaction (reward) out of the new learning practices. as many learning habit we would like to students to may not have immediate impact on students learning which is measured by traditional exam, how to make students more satisfied through the new learning experiences? More research is needed in this area to reinforce the students' satisfaction from the new learning experiences.

The third issue is the relationship between interest and habit in the IDC theory. We need to tab on students interest in cultivating their learning habit. If we provide a cueing environment for students' habit formation, is this in align with their interest? What if students do not have this interest at the beginning? Or can they develop interest after we introduce them the new learning practices?

The fourth issue is the balance of educator's effort and students' effort in habit formation. The intrinsic motivation is important for habit formation. Educator and parent can provide cueing environment and provide scaffold and support. How much scaffold and support is needed? How to increase students' intrinsic motivation for the habit formation?

Last but not least, for cultivating students' interest-driven creation habits, do educators, parents, or researchers, as students learning designers, need to form habit in interest-driven creation or designing learning environments for cultivating and developing interest-driven creators? If yes how?

We may not have immediate answers for all these questions and there could be more issues need to be addressed. More research and discussions are needed in exploring this under-explored area. We raise the questions here to stimulate more in-depth discussions among educators, parents, researchers and policy makers.

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Promoting Students' Interest in Learning Through Play in a Makerspace

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Abstract: Makerspaces have been increasingly popular in education to achieve interest-driven creation and learning. In this paper, we describe background of makerspace, uncover its advantages in stimulating intrinsic motivations and natural curiosity of learners, and propose a framework to operationalize makerspace. We target to investigate learning affordances, contextual conditions (e.g., community-building mechanisms, infrastructural settings), dos and don'ts around the development of such ground-up initiative in Singapore. Our assumption is that such design of learning environments and/or pedagogies could be avenue to promote and optimise "interest", "creation" and/or "habit" in learning

Keywords: Makerspace, student-centred learning, playful learning, interest-driven, intrinsic motivation

1. Introduction

In Singapore, students are evaluated with regularly administrated, standardized tests. Schools are also appraised based on how well their students have performed based on these extrinsic goals and expectations. With these evaluative practices in place, schools are understood as a place where students compete to acquire as much knowledge as possible. Rather than developing proactive learners, Torrance (2007) and Sadler (2007) caution that these "assessment for learning" practices not only deter learning, but also promote learning as "criteria compliance in pursuit of grades" (Torrance, 2007).

While Singapore has been consistently among the top ranking countries of International evaluation studies, Government leaders recognize and acknowledge the apparent lack of thinking skills and creativity among students (Tan and Gopinathan, 2000). Education evaluation practices remain characterized by high-stakes and standardized testing notwithstanding the rhetoric of education reforms to promote active learners with a creative and critical thinking culture within schools (Tan & Gopinathan, 2000; Tan, 2001).

Because of the emphasis on the extrinsic goals and expectations of the school, the intrinsic motivations and natural curiosity of children may have been extinguished inadvertently (Honey and Kanter, 2013). Research-based evidence, however has found that this natural interest to learn could be rekindled by designing learning environments that are supportive (Honey & Kanter, 2013).

A makerspace could be an entry point for learning in an informal context, supporting meaningful learning and engaging student interest. This underlying motivation applies equally well to the structuring and design of any system, be it mechanical, institutional, or social. In this respect, the concept of a makerspace poses interesting challenges to the design of schooling: What if, instead of training our students to grow up to become helpless consumers of knowledge (in all its forms), we could nurture in them the spirit of intellectual curiosity, a thirst for understanding, equipped with an extensive 'toolbox' of intellectual devices with which to create a better world for themselves? Here, the vision recalls the ideals of education as articulated by critical sociologists of education (see, e.g., Freire, 1970/2000; Giroux, 1983; Marcuse, 1964/1991; Young, 1971), and located within more contemporary critiques of the neoliberal standardised 'consumer' model of education (Apple, 2001; Klees, 2008; McGregor, 2009; Olssen, 2004; Pick & Taylor, 2009).

This paper proposes that a makerspace as an avenue for students to establish their interests, to regain their individual agency, and to possess the knowledge, skills, and means to accomplish their designs. In next sections, we will start with the background of maker movement and introduce how the makerspace has been employed in education in recent years. Then we elaborate on the characteristics of a makerspace in the sense of interest-driven creation and propose a framework to operationalising a sample makerspace. Finally, we suggest our future developments in advancing makerspaces in Singapore schools.

2. A Makerspace as a learning environment to promote and optimise interest and creation in learning

2.1 Background of the Maker movement

The roots of the contemporary movement may be traced back to German hacker groups such as the Chaos Computer Club (CCC) (Maxigas, 2012), fused with American hacker (Thomas, 2002) and maker culture (Anderson, 2012). The driving philosophy of the movement of these grassroots networks is driven by a "Do-It-Yourself ethic" that is self-directed, hands-on, with flexible goals (Schrock, 2014; Gauntlett, 2011) that is a result from a shared interest in making, generally employing democratic rather than "top down" organizational practices (Schrock, 2014).

In typical implementations, makerspaces consist of both traditional and digital media, tending towards open or minimally guided exploration with a focus on student authorship of ideas. These spaces encourage experimentation that entails a positive experience that "arouses curiosity, strengthens initiative, and sets up desires and purposes" (Dewey, 1938). Its approach is a student-centered, project-based learning style that stems from the pedagogical tradition of learning by making and through apprenticeship (Maker Media, 2013). Learners may respond to design prompts requiring them to make objects with particular functionalities, or to solve a practical challenge. Using the design method, learners analyze problem contexts, creatively generate prototype solutions to these problems, then iteratively improve on prototypes until a satisfactory solution is reached. The task is a deeply cognitive one, often requiring makers to continually evaluate the system of components during cycles of 'de-bugging' when their designs almost inevitably fail to work initially.

2.2 Makerspaces in Education

Makerspaces can create an engaging and empowering learning experience for all students. Making enriches the educational experience of students who do not learn effectively in a mainstream curriculum, or who are motivated by different interests, developing skills such as curiosity, creativity, and the ability to learn on one's own (Cavallo, et al., 2004). Its highly collaborative environment allows students' interest to be connected, both in and out of school, by identifying, developing and sharing broad framework of projects and kits (Kalil, 2013). Makers engage collaborate and give guidance to peers. They are open to sharing and exhibition, instead of competition. These interactions create new opportunities for different learning experiences (Dougherty, 2013).

Makerspaces allow educators to experiment with different pedagogical approaches, to counteract education in schools that is characterized by rote learning, standardization, high-stakes testing and the narrowing of school curriculum (Baker, et. al. 2010; Rose, 2010). These alternative approaches include scientific inquiry and the everyday, "thinking with our hands," and authentic learning by participating in real life scenarios.

In recent times, literature in the international context (e.g., Honey & Kanter, 2013; Dougherty, 2013) point to makerspaces as ideal learning context to build up on intrinsic motivation. In this view, makerspaces offer advantages over conventional learning activities (e.g., Bennett & Monahan, 2013; Petrich, et al., 2013) because:

- Conventional classroom activities are often constrained within the boundaries of teacher –centred instruction, content knowledge, and exams. Activities in makerspaces, give students the opportunity to design and make objects of their own initiative. This provides the opportunity for students to express their own intentions through making.
- Through makerspaces' emphasis on the iterative design, appreciating failure as a means of feedback for improvement, and the benefits of play, we anticipate that the activity structures of makerspaces may afford the creation of new learner identities that conventional classrooms fail to develop. For instance, makerspaces eschew the prospect of making as a means to attain an extrinsic goal, but instead, that making is an intrinsic goal in itself.

3. Building interest in Makerspaces through play and tinkering

3.1 The Makerspace as an informal learning space

Because learning in formal classroom setting emphasize routine tasks and instructions, the motivations of a learner lean towards extrinsic factors (Saonsone & Harackiewicz, 2000).

Research has found that informal learning environments often are instrumental for sustained science learning of individuals (National research council, 2009). Informal contexts such as hobbies, non-curricular activities and summer programs can afford enriching experiences that can set interest in a subject. If such moments of situational interests are further reinforced, they can open up extended pathways of learning through intrinsic motivation (Quinn & Bell, 2013).

3.2 The role of intrinsic motivation in a makerspace

Similarly, one of the first theorists to use the precise term 'intrinsic motivation' - Hunt, wrote that humans find being at the helm of one's environment to be inherently motivating (Hunt, 1961; 1965). Likewise Bruner (1961, 1966) suggested that the contextualization of learning was instrumental in generating students' interest of the larger world outside of their classrooms – and this was done by demonstrating to students the relevance and utility of skills that were taught.

There is also evidence that students derive high levels of intrinsic motivation and learning efficacy when they are faced with topics that they are most interested in. Asher (1981) Asher, Hymel, & Wigfield (1978) for instance, established that students' capacity to remember was highly correlated with past measures of their interest in the topics. In comparable fashion, Anderson, Shirey, Wilson, and Fielding (1987) demonstrated that grade-school children's memory for sentences was better predicted the interest value of the sentences.

Considering the above theoretical frameworks, it appears that makerspace draws on the earlier concepts – in enabling applied learning as the emphasis on doing and making, in an authentic learning environment. By capitalizing on and catering to students' varying abilities and interests, the makerspace paves opportunities for them to design and create objects based on their interests, with an emphasis on authorship of ideas. In doing so, students develop skills and competencies that go beyond routine cognitive tasks, such as the ability to critically seek and synthesize information, the ability to create and innovate, and the ability to self-direct one's learning (Dede, 2010).

3.3 Learning through play and tinkering

It has been argued that instructive teaching that is routine and repetitive in nature becomes a chore to learners (Hidi, 1995) and that interest and motivation levels could be increased if learning tasks were more like play and recreational activities (Shernoff, et al., 1999). Lepper & Cordova (1992) also reported a series of studies that demonstrated enjoyable and making learning fun resulted in increased interest and learning.

The concept of experimental play is an integral aspect of the maker movement. The central notion is that makers experiment and play to better understand the functions of that object. Through experimentation and play, they explore what they can do and learn as they explore (Dougherty, 2013).

We situate this understanding within the extant literature on the importance of play, to locate and trace evidence of learning through students' participation in a makerspace – as an informal learning environment designed for tinkering and making. To do so, we will draw on the work of Vygotsky (1978), Holzman (2009), Goldberg (2009), Piaget (1973) and Papert (1980).

Insights on play were first advanced by Lev Vygotsky (1978) in the early twentieth century. At the core of Vygotsky's Cultural-Historical theory is the idea that interactions between children and their social environment nurture children's development. These interactions involve the people around them, cultural artifacts, such as books or toys, along with culturally specific practices, in the classroom, at home or on the playground. Children construct their own meanings, knowledge, skills and attitudes based on these interactions. "A child's greatest achievements are possible in play, achievements that tomorrow will become her basic level of real action and morality." (Vygotsky, 1978) As a result of play, the learner will develop skills, interest and a sense of purpose (Vygotsky, 2004).

The concept of play has been explored in experimental schools to understand the kinds of learning environment and performance postures it affords (Holzman, 2009). Opportunities were created to emphasize performance and students take on roles of writers, scientists, historians, test artists, mathematicians, and so on. Games were created to help learning and visitors and itinerant participants were asked to join in to give freely their expertise, ideas (Holzman, 1997). Holzman (2009) observed that through play students and teachers leant to "speak other languages". Students had studied the theoretical significance and practical importance of the various roles they had taken on from performing as mathematicians, scientists, biologists. Similarly, Goldberg (2009) saw that to play "car shop," children might talk about the nature of the repair, who will play the owner of the car, who will act as the receptionist, and who will play the mechanic. Such play planning serves as the precursor to reflective thinking. The basis of learning is through play and discovery – "to understand is to discover, or reconstruct by rediscovery, and such conditions must be complied with if future individuals are to be formed who are capable of production and creativity and not simply repetition" (Piaget, 1973).

In a makerspace, the concept of play and tinkering is emphasized, as opposed to a routine following of instructions, as seen in formal classroom settings. Tinkering is a playful style of designing and making, where one is constantly experimenting, exploring new ideas in the process of creating something. Tinkering draws on constructionist theories of pedagogy (Papert & Harel, 1991); often identified as an important theory of learning within the maker movement. Tinkering affords an expansive view of learning. Constructionism emphasizes discovery, inquiry, and constructing knowledge by engaging with materials. Through tinkering, learners understand a particular subject, through iterative design and testing, especially in seeing how the artifacts change over time. Tinkering emphasizes the iterative approach, where "mistakes" or "failed" attempts pave the way for new ideas. This is an important process in making, where a range of solutions can be derived by field of possibilities. These principles are central to the development of tinkering within the maker movement context.

4. Operationalizing of A Makerspace

To operationalize our makerspace, we have adapted Stanford University's d.school problem-framing framework to generate activities, as outlined by Bennett & Monahan (2013). (See figure 3.2) (IDEO, n.d.).

This framework helps educators to first consider the setting, to set the design problem in a context that can be understood by the learner. Similar activities have been carried out by the New York Hall of Science Design Lab and they have found that thinking about the setting of the problem has deeply engaged participants in problem-solving. As participants contextualize the problem, they will start to ideate and begin brainstorming for solutions to solve the problem. Research has shown that actively engaging students in design projects can help them develop deep analytical understanding of the knowledge and principles of a domain that will support the mastery of self- guided inquiry skills that are difficult to teach (Crismond, 2001; Johnsey, 1993; Roth, 1995). At the same time, this design- based framework serves to promote engagement and allow for multiple points of entry into STEM learning in an informal context that is the makerspace.

Sample Activity: Singapore's Jubilee Celebration activity

Think about something you could build for Singapore's Jubilee celebration that would make people proud. How would you use an LED and/or a motor in the city to make your creation do something to spread pride in Singapore? Using the materials below, to build models with circuits to add to Singapore's Jubilee celebrations. Materials: cardboard boxes, index cards, aluminum foil strips, binder clips, paper clips, markers, scissors, watch batteries, motors, LEDs and any other items that you can find easily.

Figure 1: The goal of the activity is defined by the learner, promoting a sense of agency

Designing the activity

Generating Authentic Design Problems Think of a subject and encourage students think about the characteristics and problems they might encounter in such situations/settings	
Settings (places or situations that students might encounter or be interested in) Example: Local park	**Characters** (at least 3 – 6 characters who might be part of this setting) Example: Animals, Parents, kids, pets
Potential Problems (at least four problems to solve in this setting) Example: Litter, habitat disruption, animal behavior, safety of equipment	**STEM Concepts and BIG Ideas** (Ideas that need to wrestle with to solve this problem) Example: Interdependence of organisms; life cycle, failure in structures

Figure 2: This chart to help teachers plan for activities that would meet their content goal (Bennett & Monahan, 2013)

5. Conclusion and Future Work

In this paper, we describe background of makerspace, uncover its advantages in stimulating intrinsic motivations and natural curiosity of learners, and propose a framework to operationalize the makerspace as a site to nurture interest-driven creation and learning. Our objective of this development tranche is to establish makerspace in Low Progress Learner (LPL) context; and to generate guidance and rules to build makerspaces that can be applicable and replicable to more school contexts in Singapore. We target to investigate learning affordances, contextual conditions (e.g., community-building mechanisms, infrastructural settings), dos and don'ts around the development of such ground-up initiative in education. Specialized to address learning needs for students afforded by makerspaces, we need to identify how learning activities shape students' pro-STEM attitudes, such as acquiring personal context for STEM, motivation for learning STEM, enjoyment of STEM experiences, acceptance of scientific enquiry as a way of thought, as well as developing interest in pursuing a STEM related career.

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Examining Relationship between Biology Attitudes and Perceptions toward Mobile Augmented Reality of Photosynthesis and Impact on Gender Difference

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Abstract: New possibilities for teaching and learning provided by augmented reality (AR) have been increasingly recognized by educational researchers. In science education, AR allows learners to visualize complex spatial relationships and abstract concepts and experience natural phenomena that are not possible in the real world in way of the mixed reality. Due to the abovementioned benefits, a mobile AR represented photosynthesis process has been designed and created for enhancing biology learning by the researchers. 101 eleventh - grade students aging 16-18 years old were recruited to participate in this study, to investigate the relationship between attitude toward biology and perception toward mobile AR and compare the perception towards augmented reality tool within the disparity of gender. They were 71 females and 30 males, and all of them were administered with 25-items biology attitude questionnaire and 18-items perception toward mobile AR. The results of this study suggest that students' perception toward augmented reality technology was not defined by their attitudes toward biology, and the disparity of gender did not effect to perception toward learning with mobile AR technology. This implied that any gender could learn biology of photosynthesis with the use of AR technology, and they could participate to learn biology through mobile AR disregarding biology attitude.

Keywords: attitude, perception, augmented reality, biology education

1. Introduction

Due to the nature of conceptual biology of photosynthesis, the process of photosynthesis is much complicated and difficult to understand by students. In national science curriculum of Thailand, the photosynthesis concepts were placed into lower primary education until upper secondary education, and researchers found that student often hold many alternative conceptions or misconceptions of photosynthesis (Pinatuwong and Srisawasdi, 2014). Regarding to the previous researches such as Kose (2008), and Svandova (2014), these previous studies revealed that most students still have the misconception, for example in the chloroplast only have chlorophyll (Kijkuakul, 2006), and photosynthesis is the same process as plant respiration (Svandova, 2014). They need a special assistance from researchers, educators, or teachers to facilitate their learning on how photosynthesis works for improving meaningful learning in biology.

In context of Thailand, the way to teach biology of photosynthesis in science class is using lecture incorporated textbook, work sheet, or slide presentation. Laboratory work which is perhaps the most essential element and exiting thing about science, but it requires time, effort, experience and expense Thai students generally can be test takers but cannot succeed biology learning with text reading as a result of having difficulty to understand the process of photosynthesis without visualizing the dynamic process and biological mechanism of plant photosynthesis. Sometimes the pictures in text book are inadequate to understanding of biological process of plant.

At present, the technologies has been greatly developed and widely used in improving quality of education. Concurrent with the rapid growth of computers and technologies in the practice of the science education community, contemporary technology-based approaches to science learning offer ample opportunities for students' innovative learning environments for conceptual development (Srisawasdi and Panjaburee, 2015). Suits and Srisawasdi (2013) mentioned the affordabilities of instructional visualization technology, which could support perceptions of students to visualize scientific phenomena both observable and unobservable levels of representation. In recent years, augmented reality (AR) technology is gaining popularity within society and becoming more ubiquitous in nature (Johnson, Smith, Levine, and Haywood, 2010). According to Chang, Morreale, and Medicherla (2010), several researchers have suggested that students can strengthen their motivation for learning and enhance their educational practices with virtual and augmented reality. Several educational uses of AR have already been documented in the literature. AR technology has been used to develop students' understanding of science, including environmental science (Hsiao, Chen, and Huang, 2011), micro-biology (Chen, 2006) and biomedical science (Rasimah, Ahmad, and Zaman, 2011). The use of AR in the classroom has repeatedly been shown to increase student motivation (Billinghurst and Duenser, 2012; Johnson, et al., 2010; Tarng and Ou, 2012). According to the benefits of AR in education, the researchers interest to utilize the AR for enhancing biology of photosynthesis because AR could be used to visualize the photosynthesis process by combining virtual data with real world data which can provide users with access to rich and meaningful multimedia content, that is contextually relevant and can be easily and immediately acted upon (Billinghurst, Kato, and Poupyrev, 2001).

2. Literature Review

2.1 Augmented Reality (AR)

Augmented Reality or AR is the technology blended real world and virtual realistic together via software or other connected devices and then real - time display on the mobile - phone, computer or projector. So player can interact with the image or anything in AR directly. AR can display for 3D, animation, or audio visual based on the designing of programmer. In the current augmented reality is considered as an efficiently pedagogy applications (Cheng and Tsai, 2012). For educational contexts, AR research is relatively in an early stage, there have been a number of research studies that evince cognitive and emotional effects of AR applications on student learning process and outcome. AR technology can enhance learners' understanding of complex objects or situations by presenting a variety of views through 3-dimensional stereoscopic images and virtual simulation infused with the real environment (Han et al., 2014).

2.2 Gender Effect on Science Learning

In the last decades there were many evidences of gender gap in science learning. Soyibo (1999) studied about the different of genders' performance on the biology test. The results showed that the girls had higher score more than the boys significantly. The effects of science interest and environmental responsibility on science aspiration and achievement was investigated by Chiu (2010), the finding showed the positive integrating effect for boys but negative for girls. On the other hand, there were many researches indicated that no significant difference in science learning between the disparity of gender (Piraksa, Srisawasdi and Koul, 2014; Plant et al., 2009)

2.3 Biology Learning of Photosynthesis

Due to the complexity and abstraction of photosynthesis concepts, most of students often hold alternative conceptions about the biology phenomena. In Thailand mostly instructional about photosynthesis were taught by regular classroom. There were some research about teaching photosynthesis with technology such as Pinatuwong and Srisawasdi (2014) used analogy-based simulation for biology learning of light reaction phenomenon, the result showed that the student could perceive this technology even they were positive or negative attitude toward science learning and Nasaro and Srisawasdi (2014) used sensor-based laboratory learning environment incorporated predict-observe-explain (POE)-based ubiquitous learning in photosynthesis topic, the result explicit that the intervention could promote students' self-efficacy and perceived ease of use on the learning. There have no research about augmented reality on photosynthesis yet. So we think the new technology for biology learning cloud improve student attitude toward science and it could develop conceptual understanding in biology topic.

3. Purpose

The aim of this study was to examine relationship between attitude toward biology and perception toward mobile augmented reality application of photosynthesis, and to investigate impact of gender difference on their perception toward the mobile augmented reality.

4. Methods

4.1 Participants

The study was conducted in a large-sized urban public high school located in the northeastern region of Thailand. The total participants consisted of 101 students in their age ranging from 16 to 18 years. 71 of them were female (about 70%) and rest of them was male (about 30%). All of them have ever learned about photosynthesis in regular biology class and the never know about augmented reality. The students who participated in this study were voluntary. They were given no preferential reward for participating.

4.2 Learning Material

In this study, a series of mobile AR of photosynthesis have been designed based on common misconceptions about photosynthesis hold by students. A number of researchers, both international and national journals, were reviewed and then the researchers summarized all common misconceptions. Then, a story board has been created by the researchers and it was sent to computer programmer. The AR app. used in this study was displayed in Figure 1.

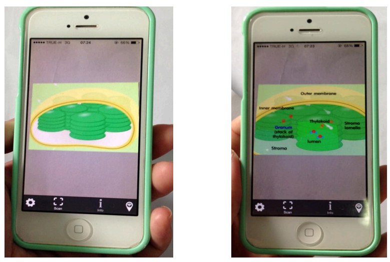

Figure 1. An illustration of mobile AR application: microscopic - represented animation in the mobile AR app (left); and mechanism representation of plant photosynthesis (right).

4.3 Procedure

In the step of pilot study using mobile AR tool in this study, before the leading to the topic of chloroplast in the AR - tool participants took a twenty-five item 5 point questionnaire for determining the attitude toward biology lesson that have already taken the reliability for Thai version (Pinatuwong and Srisawasdi, 2014).The questionnaire was developed including 6 items of interested in biology lessons (IBL), 10 items of understanding and learning biology (ULB), 5 items importance of biology in real - life (IBR), 4 items biology and occupation choice (BOC) toward biology lesson (Ayyildiz and Tarhan, 2013). The students were informed to take the questionnaire for 15 minutes as pretest. Before interact with AR - tool, teacher orientated about using mobile AR application and then student were allowed to interact with the AR by using android phone, iOS phone, or tablets for reading the AR pictorial code for 30 minutes, as displayed in Figure 2.

Figure 2. An illustration of learning activity of photosynthesis through mobile AR application

At the end, the second questionnaire was used to survey the perception to created AR tool. This questionnaire was composed of 18 items including perceived learning (PL), perceived ease of use (PEU), Flow (FL), Perceived playfulness (PP), Enjoyment (EJ), Satisfaction (ST) developed from Tao, Cheng, J.C. and Sun (2009). All students took the questionnaire for 15 minutes as post-test. Data from two questionnaires were analyzed by using Pearson's correlation in SPSS version 21.0 and the perception toward AR tool of each gender were compared by using MANOVA statistic in SPSS 21.0.

5. Result and Discussion

5.1 Correlation between Biology Attitude and Perception toward Mobile AR

The first analysis was Pearson's correlation of IBL, ULB, IBR, BOC toward biology lesson with PL, PEU, FL, PP, EJ, and ST (see Table 1). The results explicated that correlation among PL, PEU, FL, PP, EJ, and ST, illustrates positive correlation significantly (p-value < 0.01), these were like the correlation of perceptions towards technology among IBL ULB, IBR, and BOC (p-value < 0.01). There was no significant correlation between variables of attitudes towards biology and variables of perceptions towards technology; Pearson product moment correlation among BOC, PL, r = 0.203, p-value < 0.05, PEU, r = 0.246, p - value < 0.05, and ST, r = 0.256, p-value < 0.01, nevertheless. Mostly, these finding advise that participants' attitudes towards biology lesson was not controlled by their perceptions towards augmented reality, except some part such as the perceptions about perceived learning, perceived ease of use, and satisfaction depend on the attitudes toward biology about biology and occupation choice; if student prefer to work or use the biology knowledge to created their occupation in the future they would have a good perceptions. The results showed like that because the augmented reality about chloroplast in this version prefers to use the internet for playing the AR code. While the school area had poor internet signal, student might have difficulty to interact with it. This study indicated that augmented reality suitable for supported biology lesson. Cai et al. (2014) created AR marker about composition of substances and tried it out with junior high school, the result presented that augmented reality could enhance learning significantly and most of the students have positive attitude towards augmented reality.

5.2 Perception between Males and Females

The result of this study shows that the disparity of gender did not effect to students' perception toward instructional technology in augmented reality on photosynthesis. Furthermore, any gender could perceive toward this technology Moreover, the mean score in each area of perception of male was

Table 1: Descriptive statistics and Pearson's correlation between biology attitudes and perception toward instructional technology in augmented reality.

Pearson correlation	IBL	ULB	IBR	BOC	PL	PEU	FL	PP	EJ	ST
IBL	1									
ULB	.559**	1								
IBR	.456**	.471**	1							
BOC	.624**	.483**	.394**	1						
PL	0.182	0.126	0.195	.203*	1					
PEU	0.153	0.176	-0.032	.246*	.427**	1				
FL	0.078	0.18	-0.014	-0.01	.408**	.486**	1			
PP	0.044	-0.009	0.083	0.072	.570**	.329**	.593**	1		
EJ	0.147	0.081	0.081	0.144	.451**	.311**	.430**	.586**	1	
ST	0.141	0.034	0.183	.256**	.632**	.356**	.348**	.628**	.555**	1
Mean	18.34	31.01	18.15	13.67	11.95	7.29	10.23	11.2871	7.81	19.86
SD	3.22	3.57	3.08	2.64	2.02	1.54	2	1.86192	1.36	3.27

*** p - value < 0.01,*

** p - value < 0.05*

similar to females' mean score, satisfaction has the highest mean score of any area of perception (about 20 points). The PL and PP were estimated 15 points, and PEU, FL, EJ have about 10 points. The satisfaction, perceived playfulness, flow, and enjoyment connect to the interest-driven creator theory (IDC), especially the interest loop, there were linked with the triggering, immersing, and extending, component of interest loop. This finding indicated that the instructional technology in augmented reality on photosynthesis can promote the students' interested.

6 Conclusion and Implication

Overall finding of this investigation suggests that students' perception toward augmented reality technology was not defined by their attitudes toward biology, and even though they have disparity of gender but it did not effect to perception toward augmented reality technology. The result showed all participants have the same perception to augmented reality. The participants have satisfaction toward this technology highly.

This was the pilot study. In the next study we prefer to use augmented reality on refutation text combine with the model-based inquiry pedagogy to promote a deep understand in the concept of photosynthesis and the critical thinking skill. The reason for chosen the refutation text is, challenge to misconception that usually consists of two main parts, the first part is a message that is all misconceptions and the second part is a text by clearing misconception which scientific explanation. Reading refutation text could foster effective conceptual change more than reading regular text (Sodervik et al., 2013). In the pedagogy of the next study, we will allow student to predict about phenomena that occur in process of photosynthesis by drawing or explaining on their worksheet. After that they interact with learning materials and the last they must be draw, explain or create their understanding in the same worksheet. This instructional can prompt student to create or organize their knowledge like the creating loop of IDC theory that consist of imitating (draw or explain after interact with AR material), combining (organize their knowledge) and staging (picture or description on worksheet).

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