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**INCORPORATING WIKI TECHNOLOGY IN A TRADITIONAL
BIostatISTICS COURSE: EFFECTS ON UNIVERSITY
STUDENTS' COLLABORATIVE LEARNING, APPROACHES
TO LEARNING AND COURSE PERFORMANCE**

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ABSTRACT

Aim/Purpose	To investigate the effectiveness of incorporating wiki technology in an undergraduate biostatistics course for improving university students' collaborative learning, approaches to learning, and course performance.
Methodology	During a three year longitudinal study, twenty-one and twenty-four undergraduate students were recruited by convenience sampling and assigned to a wiki group (2014-2015) and a control group (2013-2014 and 2015-2016), respectively. The students in the wiki group attended face-to-face lectures and used a wiki (PBworks) weekly for online- group discussion, and the students in the control group had no access to the wiki and interacted face-to-face only. The students' collaborative learning, approaches to learning, and course performance were evaluated using the Group Process Questionnaire (GPQ), Revised Study Process Questionnaire (R-SPQ-2F) and course results, respectively, after testing.

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Findings	Multivariate analysis of variance results revealed that the R-SPQ-2F surface approach score, surface motive and strategy subscores were lower in the wiki group than in the control group ($p < 0.05$). The GPQ individual accountability and equal opportunity scores (components of collaboration) were higher in the wiki group than in the control group ($p < 0.001$). No significant between-groups differences were found in any of the other outcome variables (i.e., overall course result, R-SPQ-2F deep approach score and subscores, GPQ positive interdependence score, social skills score, and composite score). Looking at the Wiki Questionnaire results, the subscale and composite scores we obtained were 31.5% to 37.7% lower than the norm. The wiki was used at a frequency of about 0.7 times per week per student.
Recommendations for Practitioners	Using wiki technology in conjunction with the traditional face-to-face teaching method in a biostatistics course can enhance some aspects of undergraduate students' collaborative learning (individual accountability and equal participation opportunity) and approaches to learning (with less surface learning). However, use of a wiki does not improve course performance.
Keywords	statistics, education, social media, group processes, learning

INTRODUCTION

Statistics education is an integral part of the university curriculum worldwide. In the medical and health science disciplines, the ability to understand, analyse, and interpret statistical data and critically appraise research findings are essential core skills of students (Astin, Jenkins, & Moore, 2002; Giesbrecht, 1996) and the foundations of evidence-based practice (Sackett, Rosenberg, Muir Gray, Haynes, & Richardson, 1996). However, many statistics educators often express frustration about the difficulties in teaching statistical concepts to medical and health science students. They have found that it is difficult for students to develop statistical understanding and competence (Garfield, 1995), perhaps because abstract concepts of statistics are difficult to understand and apply (Mills, 2002) or because many medical and health science students have anxiety about statistics that may adversely affect their course performance (Onwuegbuzie & Wilson, 2003).

Studies have suggested that the use of computer stimulation methods with support from the course lecturer can enhance university students' learning of statistics and hence their performance (Garfield, 1995; Mills, 2002). Based on constructivism theory, computer-assisted instruction allows students to learn together by actively constructing and making sense of their own knowledge (Mills, 2002). In addition, timely feedback provided by lecturers online can lead students to engage in corrective activities and thus help them to overcome statistical misconceptions (Garfield, 1995). Moreover, sharing of perceptions and understanding of statistics in an electronic format may reduce students' anxiety level (Onwuegbuzie & Wilson, 2003; Rock, Coventry, Morgan, & Loi, 2016). As such, the integration of computer technologies with the traditional face-to-face teaching method may enhance teaching and learning of statistics amongst undergraduate medical and health science students.

Indeed, an increasing number of educators has incorporated the use of information technologies in their statistics courses for students' learning and assessment (Dani, 2007; Neumann & Hood, 2009; Su & Beaumont, 2010). Web 2.0 tools provide an ideal computer-supported collaborative learning environment that helps students better adapt from rote learning to active collaborative learning (S. K. W. Chu, Chan, & Tiwari, 2012). In particular, it has been proposed that the wiki platform is useful in promoting collaborative learning amongst university students because of its information-sharing and straightforward interactive features (Schaffert et al., 2006), easy authoring of Web content, and open access function (Dani, 2007). This online platform combines reading and writing within a Web browser, allowing students to edit text, create or link to webpages easily, and construct and share knowledge and ideas readily. It has commonly been used in group projects and blended learning

courses (S. K. W. Chu, 2008; S. K. W. Chu & Kennedy, 2011; Dani, 2007; Neumann & Hood, 2009). However, to the best of our knowledge, only one study (Neumann & Hood, 2009) has quantitatively assessed the effects of using wikis on students' collaborative learning specifically in a university statistics course. Fifty-two undergraduate students were tested. They joined either a wiki group or control group at the beginning of the statistics course. Students in the wiki group analysed a data set and communicated the results by jointly writing a report using a wiki. Students in the control group analysed the same data set but wrote an individual report. Results have shown that students' cognitive and collaborative engagement and class attendance were enhanced when a wiki is used to support learning. However, the assessment performance was the same between the two groups.

Furthermore, a recent study (S. K. W. Chu et al., 2017) has shown that the effectiveness of wikis for group-based learning in higher education was discipline specific. The level of participation and core actions on the wikis depended on students' technical backgrounds and previous learning experiences. So, it is plausible that wikis may have differential effects on health science students' participation and collaborative learning but no study has examined it thus far.

Based on the preceding evidence, we hypothesised that a wiki may be useful in supplementing the face-to-face mode of teaching and learning in undergraduate statistics courses to enhance exercise and health science students' collaborative learning and thus their course performance.

Moreover, Vaughan (2008), through using a naturalistic inquiry approach to gather survey and focus group interview data, found that wikis, because they promote peer collaboration, could support a deep approach to learning. However, the teaching approaches and assessment framework must be designed to promote peer collaboration. This topic is particularly important for teaching and learning statistics because an understanding of many statistical concepts (e.g., central limit theorem) and the development of statistical reasoning and thinking require a deep learning approach (e.g., motivation and extra time spent on exploring a particular statistics topic) rather than a surface learning approach (e.g., not studying a topic in depth and passing examinations by remembering answers to probable questions) (Biggs, Kember, & Leung, 2001; Garfield & Ben-Zvi, 2007). Therefore, we postulated that wikis may help exercise and health science students engage in deep learning. A longitudinal study was warranted to consistently confirm the effectiveness of wikis on enhancing students' deep approach to learning statistics.

The Wiki Questionnaire is a commonly used tool to evaluate the pedagogical value of wiki technology (E. H. Y. Chu et al., 2013; Hazari, North, & Moreland, 2009). It is a 20-item questionnaire which is used to collect information about the students' perceptions of the value of wiki technology. Studies have shown that this instrument is reliable and valid (Hazari et al., 2009). It comprises four constructs: learning/pedagogy, motivation, group interaction, and technology. Each construct measures a different dimension of wiki-based learning. The learning/pedagogy construct assesses information about students' perception of interest in the course, retention of course contents, active learning attitude, and the use of course material to meet learning objectives. The motivation construct assesses students' perception about motivation to use a wiki by investigating criteria such as time, effort, benefits, recommendations for use of wiki, and preference toward the use of wiki. The group interaction construct assesses students' interaction within a group, consensus building, cooperative, and collaborative learning. The technology construct assesses students' perception about user interface, ease of use, technical issues, and comparison between wiki and WebCT or other course management tools (Hazari et al., 2009).

The pedagogical use of wiki technology in exercise and health science undergraduate courses was uncommon in the Institute of Human Performance at the University of Hong Kong. Most of the course contents were delivered through face-to-face lectures and laboratory experiential learning. Incorporating wiki technology into a biostatistics course for exercise and health science undergraduate students was an innovative teaching and learning approach.

This study aimed to investigate the effectiveness of incorporating wiki technology into a traditional biostatistics course offered by the Institute of Human Performance on improving exercise and health science undergraduate students' collaborative learning, approaches to learning and course performance.

Ethical approval was obtained from the Human Research Ethics Committee of the University of Hong Kong. Written informed consent, basic demographic information, and relevant personal information (e.g., age and gender) were obtained from each student at the beginning of the biostatistics course if they wished to take part in the study.

METHODS

STUDY DESIGN

In this longitudinal study, a quasi-experimental design was adopted but without randomization of participants. Bachelor of Science in Exercise and Health students who enrolled in the Research Design and Analysis course offered by the University of Hong Kong in 2013-2016 were recruited by convenience sampling ($n = 45$). As shown in Figure 1, from 2013 to 2016, twenty-one and twenty-four exercise and health science undergraduate students were assigned to a wiki group (2014-2015) and a control group in two cohorts (2013-2014 and 2015-2016), respectively. The students in the wiki group attended face-to-face lectures and used a wiki (PBworks) weekly for online group discussion for 13 weeks, and the students in the control group had no access to the wiki during the intervention period. The students' collaborative learning, approaches to learning, and overall course performance were evaluated using the Group Process Questionnaire (GPQ), Revised Study Process Questionnaire (R-SPQ-2F) and course results, respectively, after testing. Figure 1 shows the flow of the study.

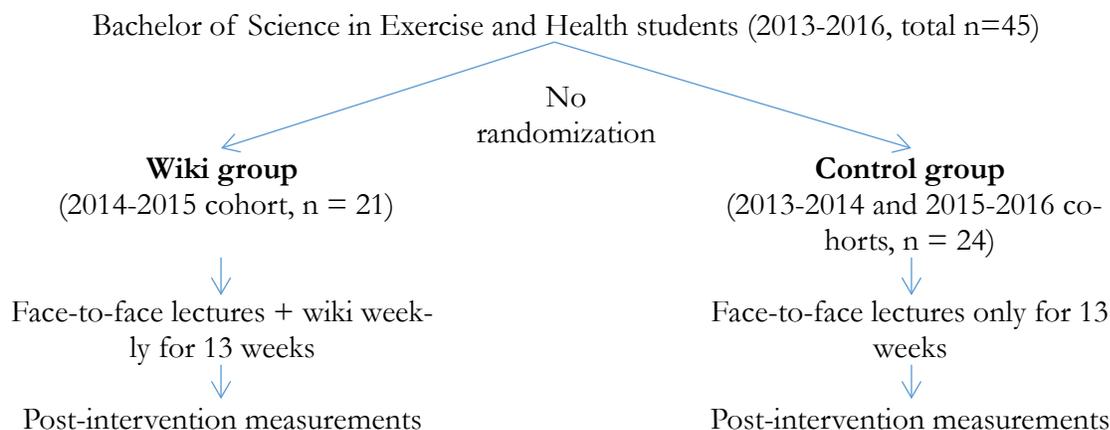


Figure 1: Flow of study for three cohorts of Bachelor of Science in Exercise and Health students over three years.

STUDY PARTICIPANTS

All Bachelor of Science in Exercise and Health students who enrolled in the biostatistics course named “Research Design and Analysis for Exercise and Health” offered by the University of Hong Kong in academic years 2013-2014, 2014-2015 and 2015-2016 were invited to participate in this study voluntarily (i.e., convenience sampling). This biostatistics course was delivered by the same lecturer (the first author) across the three academic years, and the medium of instruction was English. The students from 2014-2015 were assigned to the wiki group (i.e., they attended face-to-face lectures and used a wiki weekly for online group discussion), and the students from 2013-2014 and 2015-2016 were assigned to the control group (i.e., they attended weekly face-to-face lectures and had no access

to the wiki platform). Students in the control group who used any wiki-based online platform in other courses during the study period (a total of 13 weeks per academic year) were excluded from statistical analysis. Overall, 45 final-year and pre-final-year undergraduate health science students (between 18 and 25 years of age) voluntarily participated in the study. Of those students, 21 (13 male and 8 female) were assigned to the wiki group and 24 (15 male and 9 female) were assigned to the control group.

INTERVENTION

Wiki group – The wiki online learning environment

A wiki-based platform (PBworks) was set up as an online teaching and learning environment to support the wiki group participants' collaborative learning and supplement the face-to-face teaching sessions. The course lecturer uploaded some practical questions (e.g., case studies) about the application of biostatistics in real-life situations biweekly on the platform. Statistical concepts were also discussed online. Students were prompted to participate in the online intergroup and intragroup discussions every week and to co-construct knowledge (e.g., suggest answers to the practical questions) based on the statistical concepts learned in class. The lecturer also gave written feedback on performance to the students weekly via the wiki-based platform.

Control group

The students in the control group attended weekly face-to-face lectures and had no access to the wiki platform. However, they could continue to use information technologies (except for the wiki) to assist their learning in other courses. Practical questions (e.g., case studies) about the application of biostatistics in real-life situations were formally discussed in class biweekly in contrast to the wiki group. Students formed small groups to discuss the questions face-to-face and they received feedback and guidance from the course lecturer in class and via e-mail from time to time during the study period. This was to ensure that the course activities and levels of interaction (lecturer-student, student-student and student-content) were similar between the two groups.

DATA COLLECTION PROCEDURES

To minimise response burden, questionnaires were administered at the end of the course by only the course lecturer and three teaching assistants. All of the students, regardless of group assignment, were evaluated on the basis of the following outcomes. The assessors were not blinded to the group allocation.

PRIMARY OUTCOME MEASURES

Course performance: Lecturers' assessment of students' work

In the biostatistics course, students were engaged in a variety of assessment activities throughout the semester. These consisted of (wiki-based) group projects, in-class or online participation, and a final examination. The assessment components for the two groups were basically the same. The total marks (overall course result) earned by the students were analysed and used to reflect the students' learning.

Collaborative learning: Group Process Questionnaire

The Group Process Questionnaire has commonly been used to measure the quality of the group work and collaboration of the team members of a project group at our University. It was developed on the basis of the conceptualisation of Johnson, Johnson, Holubec and Roy (1993) and Kagan and Kagan (1994) and is presented in the Appendix. It consists of 16 questions and measures 4 domains, including positive interdependence, individual accountability, equal opportunity, and social skills. Re-

spondents were invited to rate the questions on a 6-point Likert scale from '1 – strongly disagree' to '6 – strongly agree'. For those negative questions, the rating was reversed (i.e., from '1 – strongly agree' to '6 – strongly disagree'). The reason for using a 6-point scale, instead of a 7 point scale, was to avoid a neutral response. The sum of the item scores within a specific domain was used to derive the domain scores (range, 4 to 24), and the sum of the domain scores was used to derive the composite score (range, 16 to 96). Higher scores generally represented more favourable attributes in a particular domain. Both the domain and composite scores were used for analysis. This questionnaire was administered to both wiki and control groups at the end of the course.

Learning approaches: Revised Study Process Questionnaire

Given its good psychometric properties, the Revised Study Process Questionnaire was used to evaluate the students' approaches to learning (Biggs et al., 2001). This instrument has two main scales (i.e., deep approach and surface approach) with four subscales (deep motive, deep strategy, surface motive, and surface strategy). It presents 20 questions to measure respondents' attitudes towards their studies and usual ways of studying. Respondents rated the questions on a 5-point Likert scale from '1 – this item is never or only rarely true of me' to '5 – this item is always or almost always true of me'. A summation of specific items produced a deep approach score (range, 10 to 50), surface approach score (range, 10 to 50), deep motive subscore (range, 5 to 25), deep strategy subscore (range, 5 to 25), surface motive subscore (range, 5 to 25) and surface strategy subscore (range, 5 to 25). A higher score or subscore represented a greater tendency to use that particular approach to learning in general (Biggs et al., 2001). All of these scores were used for analysis.

SECONDARY OUTCOME MEASURES

Students' perceptions of the wiki: Wiki Questionnaire

The students assigned to the wiki group also filled in a 20-item Wiki Questionnaire, which was used to collect information about the students' perceptions of the value of wiki technology. Studies have shown that this instrument is reliable and valid (Hazari et al., 2009). It comprises four constructs: learning/pedagogy, motivation, group interaction, and technology. Each construct consists of five questions. Respondents rated the questions on a 5-point Likert scale ranging from '1 – strongly disagree' to '5 – strongly agree' for each item. The sum of the item scores within a particular construct formed the subscale score (range, 5 to 25), and the sum of the subscale scores formed the composite score (range, 20 to 100) (Hazari et al., 2009). All of the subscale and composite scores were used for analysis.

Students' use of the wiki: Wiki activity log

The learning process of the students throughout the course was documented using the wiki. All of the students' online activities were tracked by the data log function in the wiki. The students' identity numbers were used to link data. The total activity count of each student throughout the course was analysed.

DATA ANALYSIS

The G*Power software 3.1.0 (Franz Faul, University of Kiel, Germany) was used to estimate the sample size. According to both our previous pilot study and a study from Neumann and Hood (2009), the students in the wiki group engaged more with other students and performed better on the test than the students in a no-wiki control group (effect sizes ranged from 0.47 to 0.89). Due to our small class size, a rather large effect size of 0.89 was used for the between-groups comparison of the primary outcomes in this study. To achieve a statistical power of 80% with the two-tailed alpha level set at 5%, a minimum of 21 students per group for the current longitudinal study was required. Therefore, data for the 2013-2014 and 2015-2016 cohorts was combined for analysis. We did not

anticipate any dropout because the biostatistics course was mandatory (a core course) for all health science students at our university.

Data were analysed using the IBM Statistical Package for Social Sciences (SPSS) 20.0 software (IBM, Armonk, N.Y., U.S.A.). Descriptive statistics (mean \pm standard deviation) were used to describe the demographic data, overall marks of the students, wiki activity log and survey results (i.e., all of the outcome variables were treated as continuous data). The assessment results and students' responses to the Group Process Questionnaire and Revised Study Process Questionnaire were compared between the two groups using multivariate analysis of variance or independent-samples *t*-test, as appropriate. Effect sizes (partial eta-squared for multivariate analysis of variance and Cohen's *d* for the *t*-test) are also presented. By convention, partial eta-squared (η_p^2) values of 0.01, 0.06 and 0.14 represented small, medium and large effect sizes, respectively. For Cohen's *d*, values of 0.20, 0.50 and 0.80 indicated small, medium and large effect sizes, respectively (Portney & Watkins, 2009). Since only the wiki group responded to the Wiki Questionnaire and had the wiki activity log data, no between-group comparisons were performed for these outcomes. A significance level of 0.05 (two-tailed) was adopted for all of the statistical tests.

RESULTS

STUDY POPULATION

Forty-five final-year and pre-final-year undergraduate health science students (between 18 and 25 years of age) voluntarily participated in the study. Of those students, 21 (13 male and 8 female) were assigned to the wiki group and 24 (15 male and 9 female) were assigned to the control group. No differences were found in any of the demographic characteristics (i.e., age and sex) between the two groups. None of the students had repeated the course. None of the students in the control group used a wiki in our course or in other courses during the study period. The average attendance rates for the face-to-face lectures were 61.5% and 62.5% in the wiki and control groups, respectively. No student dropped out of the study.

PRIMARY AND SECONDARY OUTCOME MEASURES

The students' overall course results, wiki activity log and questionnaire responses are presented in Tables 1 and 2. To summarise, the results of multivariate analysis of variance revealed that the R-SPQ-2F surface approach score, surface motive, and strategy subscores were lower in the wiki group than in the control group ($p < 0.05$), and the GPQ individual accountability and equal opportunity scores were higher in the wiki group than in the control group ($p < 0.001$). No significant between-groups differences were found in any of the other outcome variables (i.e., overall course result, R-SPQ-2F deep approach score and subscores, GPQ positive interdependence score, social skills score and composite score). The total marks earned by the students in the wiki group and control group were 66.05% and 72.36%, respectively. Since there was no significant between-group difference in the overall course result, it indicated that students in both groups achieved/ learned similarly (Table 1).

Table 1. Group differences in outcome variables for Study Process and Group Process questionnaires

	Wiki group (n = 21)	Control group (n = 24)	P-value	Effect size
Overall course result, %	66.05 ± 13.49	72.36 ± 5.17	0.054	d = 0.618
Revised Study Process Questionnaire				
Deep approach score (range, 10 to 50)	29.29 ± 6.13	26.17 ± 6.11	0.095	$\eta_p^2 = 0.063$
Deep motive subscore (range, 5 to 25)	14.86 ± 3.44	13.46 ± 3.62	0.193	$\eta_p^2 = 0.039$
Deep strategy subscore (range, 5 to 25)	14.43 ± 3.06	12.71 ± 3.26	0.076	$\eta_p^2 = 0.071$
Surface approach score (range, 10 to 50)	23.81 ± 6.30	29.63 ± 5.77	0.002*	$\eta_p^2 = 0.195$
Surface motive subscore (range, 5 to 25)	10.57 ± 2.89	13.79 ± 3.46	0.002*	$\eta_p^2 = 0.208$
Surface strategy subscore (range, 5 to 25)	13.24 ± 3.87	15.83 ± 3.53	0.023*	$\eta_p^2 = 0.114$
Group Process Questionnaire				
Positive interdependence score (range, 4 to 24)	12.24 ± 2.19	13.50 ± 2.26	0.065	$\eta_p^2 = 0.077$
Individual accountability score (range, 4 to 24)	13.55 ± 1.80	10.40 ± 1.76	<0.001*	$\eta_p^2 = 0.449$
Equal opportunity score (range, 4 to 24)	15.24 ± 2.41	12.20 ± 2.13	<0.001*	$\eta_p^2 = 0.319$
Social skills score (range, 4 to 24)	11.71 ± .61	11.20 ± 1.75	0.437	$\eta_p^2 = 0.014$
Composite score (range, 16 to 96)	52.91 ± 6.16	49.07 ± 7.63	0.072	d = 0.554

Values are mean ± standard deviation unless specified otherwise.

*Denotes a significant between-group difference ($p < 0.05$).

Looking at the Wiki Questionnaire results, the subscale and composite scores we obtained were 31.5% to 37.7% lower than the norm (Hazari et al., 2009). Our students perceived lower wiki learning/pedagogy-related satisfaction, less motivation to use the wiki, less group interaction in the wiki-based learning, and lower wiki technology-related satisfaction than those students who participated in a study by Hazari et al. (2009). The wiki was used at a frequency (wiki activity log) of about 0.7 times per week per student (Table 2).

Table 2. Outcome variables for Wiki Questionnaire and Wiki activity log.

	Wiki group (n = 21)	Norm (Hazari et al., 2009)
Wiki Questionnaire		
Learning/pedagogy score	14.06 ± 5.15	22.12 ± 9.51
Motivation score	14.76 ± 4.47	23.70 ± 9.47
Group interaction score	15.82 ± 5.54	24.83 ± 8.70
Technology score	17.06 ± 3.29	24.90 ± 8.72
Composite score	61.71 ± 17.36	95.55 ± 36.40
Wiki activity log, n	8.59 ± 5.95	---

Values are mean ± standard deviation unless specified otherwise.

DISCUSSION

In this study, the researchers attempted to explore the effectiveness of incorporating wiki technology into a traditional biostatistics course on improving health science students' collaborative learning. Our findings supported our hypothesis that a wiki was useful in supplementing the face-to-face mode of teaching and learning in undergraduate statistics courses to enhance students' collaborative learning in certain aspects. This outcome is shown by significant differences in the GPQ individual accountability score and equal opportunity score between the wiki group and control group. However, no between-group differences were found in the GPQ positive interdependence score, social skills score, and composite score. Our results were similar to those of previous studies (e.g., Dani, 2007; Hazari et al., 2009; Neumann & Hood, 2009; Su & Beaumont, 2010) and are discussed below.

In our study, we showed that a wiki (PBworks) could promote some components of collaborative work between student group members because students' equal participation opportunity and individual accountability were higher in the wiki group than in the control group. Perhaps, this was because all the students in the wiki group had individual wiki accounts, which gave them equal opportunity to participate in the online group discussion and co-construct knowledge. In addition, because we logged the students' participation in the online group discussions, they could not rely on others to work for them on the wiki platform. Documenting each student's contribution to the collaborative process using the wiki's automatic data log function could have improved their individual accountability (Trentin, 2009). In addition to the wiki activity log, lecturer's timely evaluation and peer evaluation on wiki could have also improved students' individual accountability (Trentin, 2009).

Having said this, we found that using the wiki might not have enhanced student group members' social skills, positive interdependence, and overall level of collaboration (as reflected by the GPQ composite score) which are components of collaborative learning. These negative results were anticipated because our students did not interact face-to-face much after lectures; instead, they worked together online. It has been widely acknowledged that face-to-face interaction is an essential element that makes cooperation work (Johnson & Johnson, 1999). Collaborating online (on the wiki platform) might not have improved the social skills, positive interdependence, and thus the overall level of collaboration of the students.

Our results also revealed that students in the control group used more of a surface approach to learning (surface motive and strategy) compared with the students in the wiki group; however, the R-SPQ-2F deep learning approach scores did not differ between the two groups. These results hinted that using wiki in conjunction with face-to-face teaching could facilitate undergraduate students to

use more than a surface approach to learning biostatistics. This finding was primarily in line with a previous study that suggested that wikis could enhance a relatively deeper approach to learning amongst undergraduate students as they encourage students to engage in reflective learning practices (Vaughan, 2008). Students had more opportunities to work with their peers on the wiki platform, which could have improved their learning motives and strategies to deeper learning levels (Garfield & Ben-Zvi, 2007). For example, students could have spent more time discussing the statistical concepts on the wiki platform after class as suggested by Biggs et al. (2001). Certainly, further study is needed to establish the link between collaborative learning and the surface and deep approaches to learning biostatistics amongst undergraduate health science students.

Despite the potential benefits of using a wiki in the biostatistics course, our students perceived lower wiki learning/pedagogy-related satisfaction, less motivation to use the wiki, less group interaction in the wiki-based learning, and lower wiki technology-related satisfaction than those students who participated in a study by Hazari et al. (2009). The Wiki Questionnaire learning/ pedagogy score, motivation score, group interaction score, technology score and composite score were 36.4%, 37.7%, 36.3%, 31.5% and 35.4% lower in our students compared to the norm (Hazari et al., 2009), respectively. These discrepancies might have been explained by our students' inadequate voluntary exposure to wiki technology (0.7 time per week on average). Differences in group personality, local constraints, objectives of the project and other contextual factors as outlined by Dooly (2008) may also explain the different findings between our and Hazari et al.'s (2009) studies. Future studies may incorporate more wiki-based assessment components and thus encourage the students to use wikis more frequently. In addition, the course lecturer may better design the learning materials to encourage truly collaborative learning among students. For example, case studies could be better designed to encourage students to take responsibility for their learning and take charge of learning specific concepts. Student groups are required to set their own goals and plan their learning activities at the beginning of the course (i.e., student-centred learning). Peer feedbacks could be solicited through discussion boards, emails or even oral presentations throughout the course (Dooly, 2008).

Looking at the overall course results, no significant difference was found between the two groups. Although the finding was in some contrast to our hypothesis, our results were in agreement with previous studies that reported no difference in statistics course results between blended learning (Web-based and face-to-face instruction) groups and traditional learning (face-to-face instruction) groups (Utts, 2003; Ward, 2004). However, course results cannot fully reflect learner outcomes (Garfield & Ben-Zvi, 2007). Woo, Chu, and Li (2013) suggested that online feedback could elicit revisions using the wiki platform and that this would lead to a better assessment result. Future studies may structure the wiki technology properly in the statistics course curriculum (Hazari et al., 2009) and provide timely and more frequent feedback (Garfield & Ben-Zvi, 2007) to improve students' overall course performance.

This study had major limitations. We adopted a quasi-experimental design (without randomisation or formal baseline measurement) that might have weakened its internal validity. Future research should use a true experimental design (randomised controlled trial) to establish a causal relationship between the application of wiki technology and undergraduate students' collaborative learning, approaches to learning and performance in biostatistics courses. Furthermore, our results could be generalised only to undergraduate students in the health science discipline. We are unsure whether the application of wiki technology is also effective for university students in general. Regarding the Group Process Questionnaire, since the rating was reversed (i.e., from '1 – strongly agree' to '6 – strongly disagree') for the negative questions, this could have introduced some bias. Further study may keep the rating scale consistent and only reverse the responses to negative questions. Another limitation of the GPQ and R-SPQ-2F is, when interpreting the questionnaire scores, there are no cut-off points to differentiate low, medium and high levels of collaborative learning or surface/ deep learning approaches. In addition, the GPQ may not be able to detect unhealthy competition among group members which indicates a lack of collaboration. Finally, we examined only one online teaching and learning plat-

form, the wiki, in this study. Future studies may also compare the effects of different online platforms (e.g., wikis, Moodle and blogs) on students' collaborative learning, attitudes, motivation and learner outcomes. Moreover, qualitative analysis of the posted edits and comments on an online platform (e.g., a wiki) and students' learning experiences may also be warranted to evaluate the manner in which peer feedback influences collaborative learning amongst university students.

CONCLUSION

Incorporation of wiki (PBworks) technology into a traditional university biostatistics course can enhance components of students' collaborative learning (individual accountability and equal participation opportunity) and approaches to learning (less of a surface learning approach), but not their overall course performance, positive interdependence or social skills. Although the perceived benefits of using wikis for our health science students were not as good as previously found in other studies, this might have been due to inadequate exposure to the wiki technology. Future studies may encourage students to use wikis more frequently, provide more frequent online feedback to students and adopt a true experimental study design to confirm the benefits of incorporating wikis into statistics courses for university students.

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CONFLICT OF INTEREST

Nothing to disclose.

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APPENDIX. THE GROUP PROCESS QUESTIONNAIRE

Group Process Questionnaire

This questionnaire measures the quality of group work and collaboration among members of a group. It is based on the conceptualization of Johnson, Johnson, and Holubec (1993) as well as Kagan (1994)

回顧這次專題研習的過程，你有多同意以下是你的小組經驗？

Looking back on the working process as a group, how much would you agree to the following experiences?

非	不	有	尚	同	非
常	同	點	算	意	常
不	意	不	同		同
同		同	意		意
意	Disagree	意	Somewhat	Agree	
Strongly		Slightly	Agree		Strongly
Disagree		Disagree			Agree
1	2	3	4	5	6

Positive Interdependence

1. 組員齊心合力，共同完成目標。

The group works together to complete the target

2. 我們互相分享資料。

Groupmembers share information with each other.

3. 組員之間，互相競爭，鉤心鬥角

There is unhealthy competition among group members.

4. 各人只顧自己，不理其他組員。

Each group member just cares for himself/herself without thinking of others.

Individual Accountability

1. 組員各有職責，人人都有貢獻。

All group members have their own roles and contribute to the group.

2. 每個組員的職責清楚，沒有人可以偷懶。

The role of each group member is clear and no one can just be lazy.

3. 有些組員依賴他人，自己甚麼都不做。

Some members rely on others and do not contribute to the group.

4. 有些組員把工作推卸在別人身上。

Some group members do not do their own work and rely on others to do their work.

Equal Opportunity

1. 我們的工作分配公平。

The distribution of work in our group is fair.

2. 每個組員有同等的參與機會。

Every group member has an equal chance to participate

3. 有的組員做得太多，有的組員做得太少。

Some members do too much, others too little

4. 有的組員霸佔了大部分的工作機會。

There are members who take over the bulk of the work

Social Skills

1. 組員之間互相幫助，相處融合。

We help each other and get along well in the group

2. 我們互相關心，希望每人都能有進步。

We take care of each other and hope to improve together.

3. 組員之間互不尊重。

There is little respect within the group.

4. 我們常常無法解決爭執。

We are often unable to resolve disagreements.

BIOGRAPHIES



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