What Happens in Project-based Learning?

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Abstract:

There is an accumulating literature over the last decade on collaborative learning in various types of settings, from more focussed learning tasks to open enquiry to problem-based projects. Project-based teamwork was valued as students were required to work together for knowledge sharing, knowledge building and problem-solving, and thus provide them with opportunities to be acculturated as members of a knowledge community. Over the last couple of years, it has also become extremely popular in Hong Kong schools to assign group projects to students. This was often justified on the grounds that project work promotes the information retrieval and self-directed learning abilities of students; collaborative learning is good and students should learn to collaborate with each other. However, as a pedagogical strategy, very little is known about the actual impact of group projects on learning in Hong Kong and whether the assumed advantages and expected learning outcomes do come about. Is group-based projects the panacea for the evils of teacher-centred delivery?

This paper explores the question "what happens in project-based learning?" based on the observations made during the SLITS (Self-directed Learning with Information Technology Scheme) project. The project involved 40 groups of students working on projects of their own choice, each group being facilitated by a teacher. There were several key findings from this study: 1. Participation in such a project may not necessarily lead to deep learning; 2. Learning to collaborate in a group is in itself an important part of the problem-solving process; 3. There are different models of collaboration and only those models which engage the students continuously in interactive decision making during the learning process would lead to collaborative knowledge building; 4. Effective collaboration is in itself crucial for sustaining motivation and interest in the learning process; and 5. Facilitation is required for guiding both the collaborative as well as the enquiry processes. This paper will report on these findings as well as describe the key features of good collaboration and good facilitation identified through the study.

Project-based Learning, Collaborative Learning and Knowledge Construction

Project work is a complex cognitive and metacognitive process that requires both hands-on and minds-on learning, that is, concrete subject-based knowledge and abstract high-order thinking skills (Puntambekar and Kolodner, 1998). Project-based learning is action-oriented and focuses on doing something rather than learning about something (Moursund, 1999). In projects, students engage in a complex process of learning, enquiry and knowledge construction. The result is an *artifact*-- a product of student knowledge that can be shared and critiqued. The resulting artifact becomes a product for review and reflection (Guzdial, 1998). Projects can bring with them real world contexts that involve issues and topics which, if properly chosen, help to situate

and promote authentic learning as well as improve transfer. In project-based learning, students construct knowledge by manipulating and extending ideas and information. Further, because of its scale and complexity, project work are often organized on a group collaborative basis. This allows students to exchange information, share and jointly improve ideas and make joint decisions in the learning process.

Project-based learning encourages collaboration as well as cooperative learning (Moursund, 1999). Cooperative learning is more than just arranging students to work and cooperate in a group activity or project (Adams and Hamm, 1996). It refers to strategies for managing tasks and activities that often implicate a group working together (Crook, 1994). Cooperative learning is an "old idea in education", and is often justified on grounds of improved student academic achievement and group cohesiveness (Slavin, 1980). The line is thin between cooperative and collaborative learning, but one characteristic of research in the "collaborative" tradition is a greater interest and concern in cognitive processes, whereas studies on cooperative learning "help to define a motivational and organizational structure for an overarching program of group work" (Crook, 1994). In collaborative learning students construct knowledge socially in small group, in which the locus of authority shifts from teacher to student groups (Bruffer, 1999).

Collaboration is often seen as an essential element to enhance learning effectiveness when organizing project-based learning. Collaborative learning provides opportunities for students to critique, justify, and more importantly, to build knowledge as a team. The creation of a community of learners will provide a setting and mechanisms for learners within that community to achieve what they cannot working individually (Bereiter, in press). Project work requiring a process of enquiry, on the other hand, involves students in complex cognitive processes that serve as a catalyst for higher-order learning. The enquiry process "makes covert abstract processes visible, public and manipulable [and] serves as a necessary catalyst for reflective metacognitive activity" (Puntambekar and Kolodner, 1998). Project-based learning is an iterative process of building knowledge, identifying important issues, solving problems, sharing results, discussing ideas and making refinements. Through articulation, construction, collaboration and reflection, students gain subject-specific knowledge and also enhance their metacognitive caliber.

The Project Enquiry Process and Computer Supported Collaboration

Based on a review of a number of recent enquiry-based learning projects, Guzdial (1998) developed a five-stage model of project progression. The different stages of project progression do not represent a linear sequence for the students. Learners clearly need to loop back to previous stages at several points in the process. Therefore, finding the best ways to support each stage of a project and to encourage integration, review and progress is critical for a project-based learning environment. The five stages are:

1. Initial Review: to understand the problem, design a solution process and conduct research, often by inventing a prototypical solution or potential solution to drive the investigation and design process,
2. Decomposition: to define the components of a solution and look at examples and cases,
3. Composition: to assemble the solution artifact by meshing the pieces and making

sure all of them are compatible with one another,
4. Debugging: to test the artifact, to learn if current knowledge is complete, inappropriately structured, incomplete, or incorrect, to correct problems and to learn from failure,
5. Final Review: to reflect on the failure and success of the project and on what is finally accomplished. It is an important opportunity to develop metacognitive skills.

In "Scaffolded Technology Tools to Promote Teaching and Learning in Science," the authors put forth the essential elements for project-based technology-supported teaching and learning of science (Krajcik, Blumenfeld, Marx and Soloway 1998) as:
1. a driving question, encompassing worthwhile content that is meaningful and anchored in a real-world problem or question;
2. investigations that allow students to ask and refine questions, debate ideas, make predictions, design plans and / or experiments, gather information, collect and analyze data, draw conclusions, and communicate their ideas and findings to others;
3. artifacts that allow students to learn concepts, apply information, and represent knowledge in a variety of ways as they address the question or problem;
4. collaboration among students, teachers, and others in the community; and technology that supports students in data gathering, data analysis, communication and document preparations.

One activity that occurs throughout all the learning stages is collaboration, which can be further divided into collaboration among group members and between groups (Puntambekar et.al., 1997). Intra-group collaboration requires collective knowledge construction and critical discussion of the various issues involved in the topic. Here, issues are addressed, problems identified, solutions evaluated and design direction finalized. During inter-group collaboration where groups display their design models, learners will be engaged in the exchange of ideas and experiences, questioning of other groups' models, justification of their own design rationale, and reflection upon the functions and structures of their design.

Fostering constructive collaboration among learners is often high on the agenda in project-based learning. Aside from developing students' interpersonal or teamwork skills, collaboration plays a pivotal role in extending the boundaries of knowledge construction. The self-explanation effect, as cognitive science studies have shown, helps student learn better and learn more by asking them to explain what they know (or think they know). When students work collaboratively and hold productive discussions, they stand at the outer edges of their understanding and are pushed to move one step ahead toward a deeper knowledge. When learners work together, they engage in three major learning interactions: articulation, conflict and co-construction (Crook, 1994). The act of communication transforms all the parties involved (Pea, 1994). In a conversation, the act of speaking requires a structure and a coherence that may lead to a recognition of the gaps in understanding or forge new connections between formerly disconnected knowledge. The interaction between speaker and listener(s) in a conversation amplifies this process as they attempt to reconcile the differences in their perspectives, opinions and experiences. Such conversations may result in new knowledge, reorganized knowledge, and an awareness of a need for additional understanding and/or a motivation to improve current knowledge (Edelson, Pea and Gomez 1995). According to Vygotsky's theory of zone of proximal development,

collaborative learning efforts in project work should propel knowledge co-construction through the creation of synergy and the presence of diverse expertise in collaborative settings.

In parallel to the increasing interest in collaborative learning as a pedagogical setting as well as organizational learning, there has been a lot of work in recent years in the design of network environments to support collaborative learning. CSILE (Computer-supported Intentional Learning Environment) was the first of such environments designed for use at school level and supports sustained, collaborative enquiry for knowledge construction (Scaradamalia and Bereiter, 1991). Through the use of a communal database, notes and procedural facilitation whereby learners become more aware of the progress and synthesis of ideas, knowledge as a communal artifact is being built and pursued to deeper levels. Conscious, cooperative development of shared knowledge is the focus of CSILE. The basic idea of a knowledge-building environment is that knowledge is brought into the environment and something is done collectively to it that enhances its value. The goal is to maximize the value added to existing knowledge - either the public knowledge represented in the community database or the private knowledge and skill of the individual learner.

Another environment, the DDA (Design Discussion Area), was designed to promote and support collaboration and collaborative learning on problem-based Learning and case-based reasoning (Kolodner and Nagel, 1999). Reflection plays a central role in problem-based collaborative learning. Students work together to generate questions for enquiry, address challenges, design and run experiments, test and analyze solutions, share insights and reflect on what has been learned. Contextualized learning takes place in case-based reasoning. Discussions are anchored and students talk about what they need to learn and what the anticipated difficulties. In turning their experiences into cases requires, students need to make connections between goals, implementations, and results, while the need to report the cases to the class requires them to make sense of and reflect on their experiences and knowledge.

The SLITS project

SLITS (Self-directed Learning with Information Technology Scheme) is a project conducted by the Centre for Information Technology in School and Teacher education (CITE) of the University of Hong Kong. It is designed as a joint project between the University sector and the school sector to explore new models of organizing learning that could better equip learners for the challenge of life in the information age. Conventional classrooms organize learning around prescribed curricula and the teacher plays a key role in guiding students through a relatively closed set of materials. While there are opportunities for students to interact in the classroom, generally that interaction is only very peripheral to the learning process. There is little opportunity or need for students to gain access to people and resources outside of the school environment. This project attempts to breakthrough this closed process and places the learners at the centre of the learning process. One hundred and sixty secondary 5 students from 20 schools were recruited to participate in groups of 4 on self-selected topics. The group members come from different schools and each group is assigned a teacher who will act as a facilitator through the process. The study activities will be conducted over the summer vacation for a period of about 10 weeks. About 20 expert

advisors who work in areas related to the students' project themes, mainly university academics and professionals, are invited to advise the students. Advisors are not expected to be giving answers to the students but to direct them to useful information sources and to provide feedback and expert advice to them at critical moments of the students' work, notably on their interim and final reports. The aims of the project are to explore how learning may or may not take place under such circumstances and the kinds of training and support that would be necessary to both students and teachers to make the learning experience a successful one.

SLITS is distinct from many other similar projects in that the collaborating students do not even come from the same school and they are grouped together based on their self-declared interest. Thus the learning groups will not start with a natural sense of community embedded in normal classroom settings, and students' intrinsic interest become the key motivation. Further, as most of the group members are new to their assigned teacher facilitators and the teachers are normally also novices in relation to the study interests of the group that they facilitate, the interests and interactions of the group members occupy center stage in determining the development and outcomes from the self-directed learning activities from each of the learning groups.

Information technology (IT) played an important role in the project. One obvious function of IT was to act as productivity tools for students during the learning process. Many of the participating students were not familiar with even the basic office suite applications. The project also provided training on the use of these tools as well as the use of basic internet tools and information search skills. A major research goal of the project was also to design and evaluate a web-based environment that gives scaffolding support to students engaged in self-directed knowledge co-construction activities, structuring different thinking and collaboration support throughout the different stages of the learning process. The web-based environment also provided communication support for the teacher facilitators and advisors to contribute to the group communications. For various reasons, the web-based environment turned out to be not popular with the project participants. However, this paper will only focus on the collaboration process and its relationship with the learning outcome.

Main findings from SLITS

The study started out to look at (1) how the students' conceptual and metacognitive understanding developed through the project enquiry process; (2) the patterns of collaboration amongst the students and the problems and issues that may arise there; and (3) how the learning outcome may be affected by the collaboration and facilitation process. These questions could only be answered through a close inspection of data that reflects the thinking processes and experiences of the students. We started the analysis by reviewing the students' logbooks, reflection diaries and final reports and tried to delineate the students' understanding of the problem and their approach/method of solution, aspects of collaboration as well as key aspects of their experiences throughout the 5 stages of enquiry as described above.

During a first pass through the data, we were amazed by how much reference was consistently given to descriptions and comments on collaboration, irrespective of whether the group has been "successful" or not. It is conceivable that collaboration constitutes only part of the enquiry process and thus the quality of the final project report reflects another aspect of the learning outcome. However, we found that success as perceived by the students was always experienced as happy and collegial and was perceived as a key motivating factor and most memorable aspect of the learning experience. The “unsuccessful” groups, which either did not complete the project or lost a number of members during the process and struggled to a finish with only one or two persevering souls were all characterized by failing communications and a lack of collaboration. Another prominent observation at this initial stage of analysis was that the groups that produced the best project reports in terms of depth of enquiry and originality were those that had very positive collaboration experiences.

A second pass through the data focussed on the collaboration process, the patterns of collaboration and the roles assumed by different team members. It was found that where the groups worked in a purely cooperative mode, identifying the role or responsibility at an early stage and expecting that a collation of the individual pieces of work at the end to be the main interactions between group members, such groups had difficulties even in sustaining the cooperation and often results in member dropouts or complete group breakdown. On the other hand, it was observed that equitable sharing of workload was not a critical factor in the collaboration. The most important factor appears to be whether the group members were able to jointly discuss, review and make decisions pertaining to the progress of the project at the different stages of enquiry. These groups often held meetings where they shared the results of their labour and sought feedback and confirmation from other group member to decide whether there is a need to modify or fine-tune their workplan. This participation from all group members in the decision-making processes during the enquiry process seemed to have contributed greatly to the members’ ownership of the problem, the method of enquiry as well as the final product. Further, such regular review and monitoring helped the students in these groups to develop deeper conceptual understanding as well as better metacognitive awareness and a higher level of understanding of the nature of knowledge as defined by Bereiter (1999). Such differences observed in the collaboration process in fact parallel strongly the distinction between collaboration and cooperation by [Dillenbourg, 1999 #208]. According to Dillenbourg, the main difference between collaboration and cooperation is in whether the division of labour was a “horizontal” or “vertical”. When one partner works on the task level and the other the meta-communicative level, this leads to a “horizontal” division of labour into reasoning layers, and is typical of collaborative situations. The vertical division of work, on the other hand, partitions work into independent sub-tasks as is typical in cooperative situations.

Further in-depth analysis of various cases of “successful collaboration” reveals that even when collaboration does take place in having joint decision-making throughout the various stages of the enquiry process, how the group perceives and handles differences in opinions, whether conflicts in opinion is seen as a threat to the social cohesion of the group determined largely whether the collaboration led to enhanced learning.

In the remainder of this paper, three case studies are reported to illustrate these findings. Case 1 reports on a team that went through very difficult times as a result of two members dropping out of the project. The project was finally completed with the joint effort of the remaining two members. Case 2 is an account of a four-member team that experienced a happy and collegial collaborative relationship. The team was a good example of strong social bonds acting as a key motivating factor for the group to work together, but the mode of operation changed from collaboration at the beginning towards cooperation in the later stages of the enquiry process. Case 3 reports on the collaboration experience of a group who maintained a highly collegial and interactive mode of operation throughout the course of the project. The depth of interaction and level of knowledge building resulting from such intense collaborative relationships are possibly the major contributing factors to the remarkable learning outcomes exhibited by this group.

Case 1, The Struggling Survivors

The project topic chosen by this group was "the impact of the June 4th Incident on Chinese in Hong Kong and the Mainland". This was the only group that produced a typed report with massive chunks of clipped newspaper and magazine reports pasted on while most other groups produced a final report on the web. A closer examination of the report was essentially a collection of news reports on individual Chinese dissidents. There was neither indication of why these particular individuals were selected to be presented nor any comments on those reports. There was not even attempts at categorizing the individuals or views. There was a stark absence of any indication of the learners' own views and attitudes towards the topic in the report. The report reflected that the learners had a general recognition of the details of the events but a rather low level of analysis. It is not apparent that the experience of doing the project helped them to understand more or changed their views about the June 4th incident.

This group was also unique that it started out with four members but two of them, including the leader, quitted during the course of investigation. The two persevering members then worked diligently on information search, conducting interview, data analysis and information collation in order to produce a complete study in a final report. According to this team, they relied heavily on telephone communication and could afford to have face-to-face discussion for no more than four times. Most of the work was done on an individual basis.

Problem exploration and focus refinement

From the log books, it showed that the four members started out with a variety of interest areas that includes unidentified flying objects, spirits and computer. The topic was suggested by the group leader, who later on quitted the project when he took up a summer job. According to the two remaining team members, they all supported this choice of topic as they were all very young when the event occurred and they wanted to gain a deeper understanding of the incident from a more macroscopic perspective. The focus refinement process was fairly long for this group. They kept narrowing down their focus and did not finalize the exact focus until after the first round of data collection. In this stage, their decision was greatly influenced by the direct advice provided by their teacher facilitator:

> *After we set the topic to look into the June fourth event, we wonder if the topic might be a bit too sensitive. This made the topic more difficult to handle. … Our teacher facilitator also reminded us on the sensitive aspect of this topic. … We asked our facilitator how to deal with it. He suggested that we should set our focus on the area that does not related to the political aspect of the event … mainly to look at the impact (but avoid the process).* (B1-58, 60)

Facilitation in this stage channeled the group to conduct the investigation in a specific direction. Once the focus was set, all four members parted and conducted information search independently. The whole group did not set a time to meet again. They had little contacts with one another except a few phone calls, most were initiated by the two remaining members who managed to see the whole project through.

Designing enquiry method and data collection

The design of the enquiry method overlapped with the previous stage in the second meeting. The group tried to identify different sources of materials they could make use of, for example newspaper cutting, magazine articles and information on the web. The teacher facilitator also provided direct instruction to the group in the second meeting on

> *… He made suggestion on some reference books we could refer to. He also taught us how to get hold of certain resources. … Through him, we learnt about the various means of looking up possible information.* (B2-76)

In the record of one of the students' log book, it contained the following account:

> *Our teacher suggested that we could interview people who were Form 5 and Form 7 students in 1989. He said we could try to find out the impact of the event on them over the ten years. He also suggested that we could interview some journalists and politicians.*

In response to his suggestion, the group set off for their independent information search process. Through infrequent telephone contacts, they shared about what they found from library, Internet and other sources. However, no one appeared to be enthusiastic about the project and the group did not make much progress until they realized that time was running out.

Up to this point, the group had little "conversation" about information they have collected on the topic. The group worked independently and only made infrequent telephone contacts. There was a long period of "no communication" among the group. By then, one of the members was totally out of touch with the group and the group leader announced his withdrawal. The two remaining members were determined to finish the project, being motivated by their sense of responsibility and interest in the topic.

Data Analysis and final report production

With only two people left to finish the task in a few weeks, the two felt exhausted and worried. Given the physical distance between their homes, telephone was the key communication means between them. They communicated to each other the kinds of materials they gathered over the phone and tried to decide on what would be relevant to the topic. However, they considered the lack of face-to-face communication to be

detrimental as the description over the phone was too limiting and was not adequate in creating a sufficiently common understanding. In the final stage, they met for three to four times during the last few weeks to sort and regroup the materials they had on hand. During these meetings, usually one person led the discussion and made suggestions on the relevance of the materials. This was considered by the pair as an efficient and timely way to finalize their decision on what to put in the final report.

After sorting through the materials, they then divided up the work for writing up of the final report, which was done independently. They were not happy with this arrangement and was aware of the adverse impact this made both on the quality of work and their own learning.

> *Each worked on a part and then put them together would definitely help in saving time. However, the quality of the final report would be affected. Since we wrote the two parts independently, there was little integration across the sections. … When we worked on the materials in our writing process, each of us might have put in our own interpretation. The other party would not know what you meant by certain expression. Each part was segregated, unequal to an integrated piece of work.* (B2-188, 190)

Due to the time constraint, the students did not get to critique and review each other's work. They wrote up the parts independently and relied on the telephone for checking on each other's progress. They collated and put their typed up sections together the day before the report deadline.

In the final presentation, the task was taken on by one of the members, the more outspoken member in their interaction. Unlike the other groups, this group focused on sharing their struggles and working experience in the enquiry process rather than the research findings. They considered the experience they went through in the enquiry and collaboration process as a more valuable learning gain than the factual information they obtained from their investigation.

> *I think the greatest gain from my participation in the project was the experience itself. For instance, the experience of report writing. Just the experience though. I did not pick up the part about the steps of report writing. Gaining a better idea of what a project is like. I also came to meet new friends and know more something about the university … and benefit from its facilities.* (B2-256)

Both of them focused their learning on the skills, all the 'how to', they acquired from the enquiry process and related themselves to the nature of learning about the topic itself only at the level of recognizing the facts and expanding their knowing of these facts. They considered the struggles they went through in the enquiry process as more worthwhile sharing with others than what they had put in the final report. They were not satisfied with the quality of the final report for there was not much insights and integration between the sections. The lack of communication within the group was seen as the main factor of the low level of integration of the sections which in turn affected the quality of enquiry and final output.

Case 2, The Happy Collaborators

The project topic chosen by this group was "the impact of Japanese culture on youths in Hong Kong". This group worked in a highly interactive and collaborative manner throughout the whole enquiry process and was the only group that made intensive use of ICQ as an important channel of discussion and decision making in the process. Three of the four members had access to Internet at home while one did not. The three communicated with one another frequently through emails, ICQ and telephone contacts besides face-to-face meetings. As for the member who did not have access to the internet, the group leader made use of telephone calls to keep her informed of the discussion and suggestions made by other members in the ICQ and email communication. They also kept their teacher facilitator closely informed of their progress and obtain suggestions and endorsement from her on their products at different stages through emails, ICQ, telephone calls and face-to-face meetings.

The group considered their major learning gains to be the acquisition of better computer and IT skills through the sharing of knowledge and ideas among group members, personality building through their association and interaction with the group, and questionnaire setting skill through the design of research instrument process.

Problem exploration and research focus refinement

In a semi-structured interview, the members recalled the moments of difficulty they encountered in the initial stage of topic setting. The role of the teacher facilitator was considered very crucial. They had meetings at the teacher facilitator's school for three times during the first two stages in order to narrow down the research topic. They considered the facilitator's input at this stage crucial in breaking the ice since they were strangers to each other then.

> *Her presence and involvement was very significant in the initial stage. … From the point we knew nothing about one another, till the facilitator guided us in the conversation, setting topic and instructing us what we would have to do then.* (D76, 78)

After deciding to focus on cultural issues, they then searched for information on this area separately in order to sharpen their focus. The idea of researching on cultural issues was further polished and narrowed down with the urge of the facilitator. Her questioning skill in guiding the group through the topic setting stages was seen as a motivating force to learning. They believed that

> *When it comes to learning, you tend to learn more when you are questioned.* (D270)

They asserted that the level of learning achieved simply by listening to their teacher's delivery in the classroom is lower than that induced by problem solving. The exchange of ideas at this stage was simply an expression of individual interests. After much probing and questioning from the facilitator, they came to an agreed topic. The notion of finding a "common" interest recurred many times in the interview and there was a tendency to avoid confrontation of ideas. They preferred going by the socially 'safe' way, and decision-making tended to focus on finding the set of common denominators in the list of ideas each shared. They each attained a better understanding of the topic

through library search and extensive reading. Up to this point, their communication contributed to knowledge expansion through the sharing of information.

Research design and data collection

The research method course provided by the SLITS staff and suggestions made by the teacher facilitator helped the group to come up with the idea of data collection through a web-based questionnaire. The group considered the design of questionnaire as the most time-consuming task in the whole project. The group leader wrote in his reflection diary, "*Designing questionnaire is even more difficult than preparing for examination.*" They felt that questionnaire setting is cognitively more demanding since they cannot simply retrieve information from their heads to give an answer, as in the case of taking examinations. Instead, they had to create from scratch meaningful questions that could result in relevant information for the study.

They met many times and had frequent ICQ discussions. After much effort, they finally came up with the first draft questionnaire. One member typed it up and sent it to the leader via email. He then sent the document to the teacher facilitator for review. Feedback was sought on the phone. In response to her comment, the group revised the questionnaire to accommodate more open responses. They put the questionnaire on the web and made invitation to friends to fill in the questionnaire through their ICQ network. They encountered some technical problems in the process but two of the members who were more familiar with IT applications worked together and solved the problems. They shared their skills and IT knowledge through various contacts on ICQ and supported each other throughout the process.

Later, in the data collection process, they were unable to solve some technical problem in the web environment and in order to complete the survey on time, they finally decided to go by a traditional way of conducting survey by interviewing strangers at the Japanese comics exhibition. The students took it as a gain in personality building through the fieldwork experience. This gave them enriched practical experience and broadened exposure, which would unlikely be attainable from classroom learning or through reading books. Their burgeoning friendship and intra-group accountability became the main motivation in bringing the project to a successful completion.

Data analysis and final report write-up

As soon as the survey was completed, the group started analyzing all the data they have obtained. The analysis was to base on the following sources: references (magazines, comics and books on Japanese culture) they have individually collected earlier and data collected through the questionnaire survey. Information selection was based on relevance considerations and the group leader's decision. In this group, the role of the group leader was

> *to encourage the members to throw in their ideas and I (the leader) am responsible for analyzing and deciding which are good ideas or input my opinions at times.* (D59)

He was also the mediator among group members as well as between the group and the teacher facilitator. Both the group leader and group members were very comfortable with such a decision-making mechanism. With this mutual understanding of the role of the leader, there was little disagreement or confrontation among the group. This

contributed to the efficiency in decision making but reduced the opportunities for building on one another's ideas for knowledge co-construction. Both the group leader and group members had very clear perceptions of their own roles in the collaboration process. Besides decision making, the leader was praised by the group members for his strong initiative in maintaining a close and frequent communication within the group. The leadership style in this group enhances the collegiality and efficiency. Everyone was encouraged to put his or her best effort into the project. However, the reliance of the group on the leader to be the key decision-maker meant that the quality of the final product depended very much on the leader's understanding of what is relevant and meaningful.

They completed about two hundred survey questionnaires and shared the data input by each typing in the results of fifty questionnaires independently. The group then met together to analyze the data in the questionnaire. Given that the questionnaire were basically designed to captured attitude as expressed on a Likert scale, they simply calculated the percentage and displayed the results in the form of pie charts for the items.

By the time they finished the data analysis task, they were left with only one week to finish up the final report and to prepare for presentation. They then decided to split up responsibilities to work on different tasks according to each individual's strength and ability. Completed sections were sent to the group leader who pieced them together. During the process, the partially completed task would be sent to all members for verification and feedback. When the group was asked about this experience of independent work, they were not positive:

> *I believe to be able to work together as a group is better for we can input more ideas. When I am done with my part, I kind of wonder if they like it. I always have to send my file to them to let them check it and tell me if they think it is pretty. It would be more convenient to get their immediate feedback if we can work on the tasks together.* (D344)

They felt that this mode of working during the last stage of the project resulted in a lower quality report for the group. To arrive at an agreement and to be endorsed by all members in the group were considered as the most important goals in their interactions. The tendency to maintain social harmony seemed to have its strengths and weaknesses: it was easy for the group to come to an agreed decision but with little integration and modification of ideas. There was little knowledge co-construction in this group. The kinds of change that resulted from interactions tended to be at the surface level, such as the colour or size of graphics, etc. Stimulating metacognitive activity should be a major outcome of a collaboration relationship. However, both the final report and the ICQ log of this group did not reflect high levels of metacognitive activity. It was mostly at a knowledge sharing and accretion level.

Case 3, The Deeply Interactive Collaborators

The project topic chosen by this group was "the causes of anti-social behaviour in adolescents". Similar to the group in Case 2, this group also experienced learning gains in various skills areas. However, they emphasized the learning gains experienced through their changing conceptualization and re-definition of the project topic. Like the

members in the other two groups, open communication and social harmony were seen as crucial motivating forces for a successful collaborative learning experience. Their report, in the form of a webpage, exhibited an exceptional depth of analysis which integrated their understanding of the problem, the findings from a questionnaire survey they conducted and to compare and contrast that with what they read on the topic from different media and reference sources.

This group, comprising three girls and one boy, exhibited high levels of collaboration and collegiality throughout the enquiry process. Their collaboration pattern was characterized by frequent interactions that took place in face-to-face group meetings and telephone contacts among themselves and between the group and their teacher facilitator, sometimes also with the expert advisor. The frequent interactions involved intensive metacognitive exchange of ideas which kept evolving into new forms of shared values and opinions.

Problem exploration and focus refinement

In this initial stage, the group had infrequent meetings to explore and locate a research topic. The activities involved sharing of interested areas by individuals, brainstorming possible ideas, conducting information search on possible topics, narrowing down the focus, negotiating an area of common interest and coming up with a consensus for the research topic. All these activities were carried out at a group level except the information search which was conducted individually.

In this group, three of the members were interested in studying a topic in the field of psychology whereas the remaining member intended to study something related to the application of information technology. Finally, they decided to go with the majority interest in the choice of research topic but to incorporate the individual interest in the work process by paying more attention to using IT. Such integration of ideas and skills and the practice of building on one another's strength through frequent solicitation and consultation of ideas enabled them to build up a collegial learning environment and put their knowledge and skills together in creating a joint artifact.

Despite carrying out information search on their own, frequent conversation over the phone and the diligent coordination work done by the leader have kept everyone in the group informed of one another's progress and got everyone prepared for the meetings. Moreover, agenda setting was not limited to the leader's role. All the members also played their part in it.

> *At the end of each meeting, we will discuss about what are the things to be worked on in the next meeting.* (A18)

Such communication enhanced both individual accountability and group accountability among the team. It ensured that every team member would stay informed and contribute their ideas and efforts to the project. They tried to understand and negotiate meaning and understanding so that they could be clear about each other's views and the knowledge bases they worked from. Thus they were able not to simply select common ideas to follow through but to actually negotiate and arrive at a new problem definition and refinement.

After identification of the research focus, they began their individual information

search according to the agreed topic and scope. This was followed by a vigorous exchange of ideas, concerns and a critical evaluation of the relevance of the materials each member collected. During these meetings, each presented their understanding of the materials they collected and relevance to their topic, the problems and constraints encountered and responded to other members' opinions. Afterwards, they arrived at a common agreed topic. This negotiation process enabled them to gradually create a shared understanding and a common knowledge base about the topic. This helped them to build up a common research framework to investigate the different factors affecting young people's personality and how such factors may contribute to their rebellious behaviour. There was a developing symmetry of knowledge and goals among the group members which provided a new reference for further knowledge co-construction.

Enquiry method and questionnaire design

After locating the topic, the group sought advice from their expert advisor, who was invited by the project to provide expert consultation on the topic. The group was directed to conduct the study by means of survey questionnaire and was advised to narrow down their focus factors by referring to newspaper clippings related to the set topic. Another phase of individual information search followed and the group identified four major factors, namely family, peer, self-image and mass media, from their newspaper clippings and other reference readings. They located these four factors by doing frequency count on the occurrence of serious rebellious behaviors recorded in these materials. This preliminary analysis has set forth the basis of the working mode they adopted thereafter such that further task sharing was organized around these four factors. The preliminary questionnaire design and data analysis were shared equally; each member responsible for one factor based on each member's personal interest. However, the design of the final web-based survey was done as joint effort. They discussed about what to put in the questionnaire, by collating ideas from their readings, setting the focus questions and the target group to be surveyed, and then typed up the questionnaire as a group. Everyone contributed ideas on the questions and the graphic design in the questionnaire. Constant feedback was sought among group members. Everyone contributed to and agreed on the final version which was then endorsed by their teacher facilitator. When they were asked about their own views on the limitation of their questionnaire content, the leader acknowledged that the four choices indicated in the responses of each question actually limited the respondents' answer. However, she pointed out that it was a deliberate act out of group consensus that such design would facilitate their task sharing in accordance to their interest and ability in tackling the data. Such decision reflected their awareness of their ability and other constraints in the enquiry process, as well as the inadequacy of their work.

Data collection and data analysis

After the questionnaire was finalized, each member was responsible for conducting twenty surveys and to perform further information search on the specific factor under their charge from newspaper clippings and reference readings. The working mode for the group at this stage was independent. After completing the individual quota, the group met as frequently as possible to compile that data, select useful information and restructured their responsibility according to the four factors set earlier.

Data analysis was done at both an individual and a group level. They analyzed both reading materials and data collected from the survey. Reading materials collected individually were reviewed at group meetings. One member recalled how they came to

consensus on the relevance of materials collected to the survey data:

> *We collected the materials on our own. We then group the information together, see if it is related to the topic. We also referred back to the content of our study. We would ask among ourselves if this is useful and whether we agree with what the writers say. If we think it's useful, we will mark down the reference and include it in our report.* (A117)

The following brief account described the procedure of their operation in this stage:

> *We divided up the whole questionnaire into four areas and each of us analyzed the one area that we are responsible for in all the questionnaires we have completed. Then we exchanged our parts, reviewed and made suggestions to each part.* (A392)

Beginning from this stage, they started critiquing their own work instead of other member's work. They were in closer contact than before in terms of paying attention to each other's understanding and belief instead of other people's work as in the earlier stages. This process involved personal interpretation and evaluation. At this stage, when being questioned and challenged by other group members, they considered it a personal gain:

> *A lot of time, we tend to look at things from only one angle but fail to see the other perspectives. Others' opinions can trigger us to think and re-think. We may realize that others are right and our own view might be too narrow.* (A198)

> *We tend to hold on to our own ideas. As a result, we may have filtered away some information based on our own choice when we search for information or when we interpret and write up the report. … That's too subjective.* (A199)

Recognition of the importance of multi-perspectives in dealing with knowledge and the ability to be aware of one's interpretation and judgement of information gathered were seen as the positive outcomes of the jointly critical collaborative process. This was also seen by the team as an effective way to attain consensus on the findings.

Production of Final Report and Presentation

In fact, the critique element in the group's interactions persisted through to the last stage. After every one has finished analyzing and writing up their own part for the final report, they critiqued each other's work at group meetings by going through the following steps:

1. Analyze and write up the findings of the section they are responsible for individually
2. Exchange of the first draft of the analysis in a group meeting
3. Critique on each other's work
4. Make suggestions on changes
5. Modify work
6. Agree on the finalized version
7. Type into the computer to make up the final report

This rigorous critical process required a higher level of understanding of the topic matter and the team reported the following advantages in reviewing and critiquing each other's work:

> *Sometimes, you may get too involved with your own writing and after putting all the information together, it may turn out that the others cannot understand what you tried to say. Therefore, other people can kind of remind you what is missing out and you learn to look at it from someone else's position. … Think about what the others can understand and what not.* (A188, 190)

> *Whenever somebody raises an opinion, it can be a stimulation to my own thinking, no matter it is a right idea or not. Sometimes, you may even come up with a new idea out of that stimulation.* (A195)

Their presentation was a joint effort with responsibility shared among members.

> *Each one is responsible for the particular section one has analyzed and written in the report. We also critique on one another[']s performance] and give suggestions to one another.* (A394)

Preparation work was done as individual tasks but with group input to ensure integration and coherence of content to enhance the quality of both the report and the presentation. The group worked together on the homepage, the charts, newspaper clippings and the graphic design to bring about a final product that represented an intergrated group effort.

They considered the requirement for the project to be presented publicly to have a positive impact on their learning:

> *You tend to have deeper impression of what you have said and done. If no presentation is required, the materials may end up in the form of bits and pieces. When you need to prepare for presentation, you would think carefully how to group and regroup the information.* (A324)

The articulation of acquired understanding consolidates ideas and requires the learners to reorganize their knowledge before the information can be shared verbally and meaningfully with other people. Such impact also supported the team's preference of having face-to-face meeting rather than talking to one another over the phones or through emails. Articulation is the basis of communication and face-to-face discussion enhances the directness and instantaneous nature of feedback from every member, who pointed out that the readiness and instantaneous responses from each member promotes the vigor and collegiality of the group and keeps them progressing through the many stages.

According to their sharing in the interview, the students' perception of learning can be categorized into knowledge-based and skill-based. The re-definition of the research topic and their conception of "rebellious behavior" was seen as topic driven and they relegated it to the category knowledge-based learning. On the other hand, they considered the learning through the collaborative process to be skill-based and rated that as of much higher value as they believed such skills would have greater application

in their future learning and working environments.

This group worked closely with their teacher facilitator at almost all stages in the project. The facilitator's style of intervention and guidance is highly commended.

> *I think we are very lucky to have a facilitator who is very open. She gave us a lot of room to try out different approaches freely. This is very crucial to us for we would like to explore the topic from our own perspective.* (A256)

> *She gave us indirect guidance. … She usually guided us with questions to make us think. She would ask, "What do you think is the significance of these materials? Are they useful?" (We thought through her question.) … Sometimes, we may get stuck with some points. She would then intervene. She would put in further guideline when the group is stuck and when we run out of ideas. … Since she takes only a guiding role, we can apply our own approach to conduct the study. With greater freedom to deal with the problem, we tend to have more thorough consideration.* (A230)

Conclusion

In studying the work process and the final products from the projects and in reading logbooks, reflection reports and interviewing students participating in the SLITS project, it is apparent to us that a process of collaboration is a critically important element in enquiry learning. Collaboration as an interactive process where joint decision making is an essential component, as distinct from cooperation, provides an important source of affective collegiality which provides for a powerful motivating force to take the learners through the stages of uncertainty and help them to persevere through the long enquiry process. The endorsement and support from fellow members are also important as unlike ordinary school learning where one has ready feedback and model answers, it is not easy to judge the quality or validity of one's enquiry product.

Another important finding from this study is that for the collaborative process to be truly productive in bringing about knowledge co-construction, there must be deep cognitive levels of interaction which includes explanation, and critical evaluation of each other's ideas. Such interactions perceivably lead to dissonance and is a potential threat to social harmony. How groups can understand and work out a group dynamics that is amiable to such dissonance to become strengthened by such interactions is not a simple matter.

As Dillenbourg (1999) pointed out, collaboration is neither a mechanism nor a method. The challenge to educators is to study in greater depth the possible mechanisms that can evolve from people working together and to design pedagogical methods that would foster deeply interactive collaborative learning.

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