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Online discussion and critical thinking skills: A case study in a Singapore secondary school

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Studies have shown that electronic discussion can be used effectively to teach critical thinking and can achieve greater understanding. The use of online discussions is common in polytechnics and universities, and many schools in Singapore have begun to introduce online forums for discussion beyond the classroom. This research investigates lower secondary school students' critical thinking in an asynchronous online discussion environment. The findings show that the students in this age group have only minimally exhibited critical thinking skills during the online discussion. However, investigation into students' perception of online discussion shows positive attitudes. Some enhanced scaffolding strategies for online discussion participants and guides on designing good questions are recommended to foster critical thinking skills in this environment.

Introduction

Critical thinking is a vital topic in modern education. All educators are interested in teaching critical thinking to their students (Schafersman, 1991). The Singapore Ministry of Education's vision of a "Thinking School, Learning Nation" has aimed to inculcate thinking skills onto the students to become lifelong learners. The old thinking and perception of Singaporean students being passive, less vocal, lacking initiative in class, and lacking creativity in thinking are diminishing gradually in the new education era. Modern teachers have recognised that learning by book and memorisation by words and facts are no longer a learning pedagogy. The introduction of the "Teach Less Learn More" approach has implications for students applying thinking skills more skillfully as they do their independent discovery of the subject matter. In a traditional classroom, critical thinking is stimulated when the instructor asks open ended, thought provoking questions which require students to tap into their analytical thinking skills and apply their knowledge to the problem (Bruning, 2005). However, the problems of limited class time and large class size have constrained students' participation and contributions of thoughts in class. Thus in class discussion outcomes tend to be superficial, having little impact on students' critical thinking. Teachers are facing challenges in designing innovative pedagogical approaches with the objective to set young minds thinking and to promote critical thinking. This study investigates online discussion in relation to developing critical thinking skills in a secondary school context.

Asynchronous online discussion forums, or simply online discussions, have the potential to improve teaching and learning experiences in traditional classroom setting (Cheung & Hew, 2005). The desirable characteristics of the online discussion are mainly 1) its asynchronous nature, where discussion can be done outside classroom at anytime and anywhere, 2) its ability to store all the discussion dialogue / threads for analysis later, 3) its web based nature that tears down the barrier of shyness in face to face contexts, and 4) its more time allowance for participations that has allowed expression in words clearer and more "thought of".

Taking on the affordances of asynchronous online discussion, many higher education institutions use these environments to facilitate teaching and learning, and there is extensive research in this topic. Greenlaw and DeLoach (2003, p.36) introduced electronic discussion as a method for developing critical thinking skills for undergraduate economics students. Students in the masters course in the National Institute of Education, Singapore, have used discussion forums in the *Blackboard* system to discuss, reflect or critique topics in their respective subject matters. For example, a study by Cheung and Hew (2005) investigated quality of thinking by pre-service teachers (undergraduates) during online discussion. However, our study is conducted with a sample of school students from the lower secondary level in Singapore to investigate the their critical thinking skills in an online discussion environment. The following questions are addressed: what is the quality of thinking being exhibited by the secondary students? What are their perceptions about online discussion? These initial questions have formulated the research questions stated below.

Purpose of the research

There has been little research done into how a group of Singapore secondary students would actually participate and contribute in an online discussion environment. Our study is targeted to secondary students, in this case, from secondary one, as subjects to investigate their critical thinking skills during the online discussion. It is noted that this investigation is not to justify the suitability of online discussion for secondary or primary students, nor to find out the appropriateness of online discussion to coach critical thinking. Instead, the study focuses on how such forum may be used to assist secondary students in becoming "critical thinkers" by presenting a case study that investigates the perceptions and forum postings of a class of students. Guidelines that may help facilitate critical thinking skills development are proposed at the end of this paper.

Research questions

The following research questions guided this study:

1. What is the quality of thinking, i.e. surface or in depth level, demonstrated by secondary one students during asynchronous online discussions?
2. What are the students' perceptions about using asynchronous online discussion for learning and thinking?

- a. Do students perceive that they think more in online discussion as compared to face to face classroom discussion?
- b. Do students perceive that they learn more in online discussion as compared to face to face classroom discussion?

Literature review

Asynchronous online discussion

The discussion forum is one of most popular technologies used in the delivery of online learning, has its origins in the early days of the Internet where it was used by academics of American universities to promote discussion and collaboration. Unlike text, audio and video conferencing, the discussion forum is an asynchronous technology, which does not require all participants to be online simultaneously. One of the strengths that the discussion forum provides to the online learning community is the ability to allow learners from a variety of time zones to interact at a time that suits the individual learner. (Corich, Kinshuk and Hunt, 2004, p.2)

The asynchronous and interactive nature of the online discussion are probably two of the strongest reasons for educators finding it useful and incorporating it into their online lesson packages. Students are able to participate in the discussion at the comfort of their home, at anytime and anywhere. Asynchronous communications allow students to have more participating time to reflect on what others have said and how they wish to respond (Kaplan & Kies, 1994), in contrast to a classroom based discussion where there is often insufficient time for students to frame their responses to the questions raised, thus often resulting in shallow and less critical contributions (Hew & Cheung, 2003). Online discussion enables interactions among the participants that include students and the teacher as moderator. Literature reviews on asynchronous online discussion have discussed positive uses of online discussion as outlined above, but also show some shortcomings such as the loss of face to face interactions, which have energy and immediacy that is important to some faculty and students (Meyer, 2003).

Critical thinking

As the focus in this paper is investigating students' critical thinking in the online discussion environment, a literature review on critical thinking is very relevant. Lochhead and Clement (1979, p.1), provided an insight on thinking: "We should be teaching students how to think. Instead, we are teaching them what to think." In fact, critical thinking has become an important skill students should have in order to succeed in the world. As teachers impart more content knowledge to students, it would be counterproductive for students to simply memorise and learn more of these content facts. Learning methods have to be changed to acquire, understand, and evaluate information instead of to memorise. Becoming a critical thinker who is able to analyse and reason is probably the key to the door of the thinking world.

By critical thinking, Schafersman (1991, p.2) means:

Correct thinking in the pursuit of relevant and reliable knowledge about the world. Another way to describe it is reasonable, reflective, responsible, and skillful thinking that is focused on deciding what to believe or do. A person who thinks critically can ask appropriate questions, gather relevant information, efficiently and creatively sort

through this information, reason logically from this information, and come to reliable and trustworthy conclusions about the world that enable one to live and act successfully in it.

Often most people and students do not think critically. They do not think through questions; they remain silent; they do not voice firm opinions; and they do not challenge the status quo. It is a very common scenario in Singapore classroom. Children are not born with the power to think critically (Schafersman, 1991). Thus, critical thinking should be taught especially in the primary and secondary education when pupils are still young.

Asynchronous online discussion and critical thinking

A literature review in this area indicates that critical thinking could be taught through online discussion (MacKnight, 2000). However, in a study conducted by McLoughlin and Luca (2000), analysis of forum participations by students in a project management course showed that most of the forum messages were superficial – comparing and sharing information. The forum did not appear to foster significant higher order thinking. In another study conducted with pre-service teachers, the relatively low rate of critical thinking (16.7%) exhibited was a matter of concern (Hew & Cheung, 2003a).

Although online discussion allows for giving and accepting feedback and for greater reflection, MacKnight (2000) notes that it is important for online participants to be aware of the significance of their responses and learn to ask good questions of themselves and of others. One important thing that she has mentioned is the technique of asking good and right questions. Questions that focus on the fundamentals of thought and reasoning would form the baseline of critical thinking. Equally important is also the role of the teacher in the online discussion environment to be able to engage in a line of questioning that will continue to drive ideas, and thus help students to develop and apply critical thinking skills (MacKnight, 2000). Technology is henceforth dead without appropriate pedagogical strategies. This study will discuss scaffoldings and strategies to promote critical thinking in the later section.

In order to conduct an investigation on students' critical thinking skills, a measuring instrument for thinking skills needs be developed or adapted.

Evaluation framework for thinking

There is extensive literature on the study of cognitive processes for online learners and how cognitive skills can be evaluated. This section will discuss one thinking framework by Hew and Cheung (2003b). Drawing from various models and works of Henri (1992), Swartz & Parks (1994), and Newman (1997), Cheung and Hew (2005) tabulated a generic thinking model to evaluate the quality of students' thinking skills with respect to levels of information processing. This model could be used to simply indicate whether thinking skills exhibited by the students were surface or in depth nature according to Cheung and Hew (2005). Table 1 provides a summary of the definitions and indicators of the model.

Table 1: Framework for evaluating thinking skills in online discussions
(Extracted from Cheung & Hew, 2005)

Critical thinking - Assess the viability of the alternative solutions (Swartz & Parks (1994))		
Surface	←	→
<ul style="list-style-type: none"> • Does not justify conclusions or judgments made • Stating that one shares the conclusions or judgments made by others without taking these further (Henri, 1992) • Does not spell out the advantages or disadvantages of a suggestion, conclusion or judgment. (Henri, 1992) • Sticking to prejudices or assumptions (Newman et al, 1997) 		<ul style="list-style-type: none"> • Justifies conclusions or judgments made • Stating that one shares the conclusions or judgments made by others and supporting them with relevant facts, experience or personal comments (Henri, 1992) • Identifying the advantages or disadvantages of a suggestion, conclusion or judgment. (Henri, 1992) • Making valid assumptions based on the available indicators.

The "surface" level includes 1) making conclusions or judgments without offering justifications, 2) sticking to prejudices or assumptions, 3) stating that one shares the conclusions or judgments made by others without taking these further, and 4) failure to state the advantages or disadvantages of a suggestion, conclusion or judgment. The "in depth" level involves 1) making conclusions or judgments supported by justification, 2) setting out the advantages or disadvantages of a suggestion, conclusion or judgment, 3) stating that one shares the conclusions or judgments made by others and supporting them with relevant facts, experience or personal comments, and 4) making valid assumptions based on the available indicators.

This study has used the above model for evaluating the quality of thinking among the students in the online discussion environment. The reasons are that the rubric or the model is simple (a measurement of In depth and Surface level), and the measuring criteria are comprehensive and credible (drawn from experts in thinking). The model well matches the purpose of this research.

Methodology

Background to the study

As part of their core curriculum, the secondary one students study a short module named *Infocomm Studies IS100: Computer Fundamentals*. One part of the lessons is to discuss students' thoughts, solutions or recommendations on a few real life IT problems or case studies. These topics are generally ill-structured problems that provoke thinking. Instead of having the discussion done in the classroom, it is done via a discussion forum online using the school in house learning management system, *IVLE* (Integrated Virtual Learning Environment).

Sample

The subjects for this research are boys aged 13-14 in their first year of secondary school enrolment in Singapore, in a class numbering 35. The students came from different primary schools before joining secondary education. Some students had experience with a forum in primary school, and some had little or no experience with online discussion.

Procedures

In this study, the 35 students were divided into 6 smaller groups of 5-6 students in each group. The discussion spanned a period of 2 weeks to give students sufficient time to post and make responses to postings. Instead of setting one single discussion topic for the 6 groups of students to discuss, the teacher set 6 different discussion topics, all ill-structured problems, so that each group had a unique topic to discuss among its members. The rationale for dividing into separate group discussions was that if all groups discussed the same topic, the discussion would begin to “sound along the same lines” (Hew & Cheung, 2003b, p.363). There could be a tendency for participants in a group to take an easy way out by reading a response from another group and typing it out as their own after making minor modifications.

All 35 students were briefed, in a face to face session, on what they were to do. In the briefing, guidelines were given to them to ensure that they could participate better. Details of the briefing, rules, instructions and other guidelines are given in Appendix A. Efforts were made to ensure meaningful and insightful discussions. A face to face demonstration was used to ensure that students understood the meaning of critical discussion (Appendix B).

The study took into consideration the scaffolds needed for the relatively inexperienced participants to ensure they participated effectively. It was a student centered environment, with the teacher monitoring the discussions but not participating actively in them. If participants breached etiquette and responded with harsh or vulgar language, the tutor would need to react and remind students (privately) about computer etiquette (Berge, 2001). It is important to not give too much direction as learners will often rebel if the structuring of the conference is excessive (Berge, 2001).

Data collection

After the end of the two weeks of discussions, all six groups' online discussion threads were printed out. Of the 6 ill-structured problems posted, four of them were case analysis problems. Knowing the type of problems posted to each group was important, as that could affect how the interaction, participation, and the quality of thinking among students could be demonstrated. This study had chosen four problems of a similar type, case analysis problems (Jonassen, 2000), and use their discussion threads for analysis. There is no particular reason on why the other 2 groups are not using the case analysis problems. The researchers only found out after the study that problems of different types cannot be analysed together, thus the four groups that used the same problem types (Appendix D) comprised those subjected to analysis.

Instrument

The thinking model by Cheung and Hew (2005) was used to evaluate the level of information processing of students in this study. All the message postings were individually summed into main ideas. Each posting could contain one or more than one message ideas. Each message idea was then critically evaluated whether it was

a surface or in depth level information processing based on the model criteria. The main idea of the message in this study was also referred to as the “message unit” that Cheung and Hew (2005) defined, as a single idea that was conveyed by the participants. All the surface and in depth level of information processing instances from each group were then added to find the total number of each level. A higher number classified as in depth level would imply a higher occurrence of higher order thinking. Figure 1 illustrates an example on how 5 postings by one sample group were “scored” into either surface or in depth level of information processing. To check the reliability of the instrument, we invited two coders to analyse two forums which had 27 messages. These two forums were not from this study. The percentage of agreement was 81%.

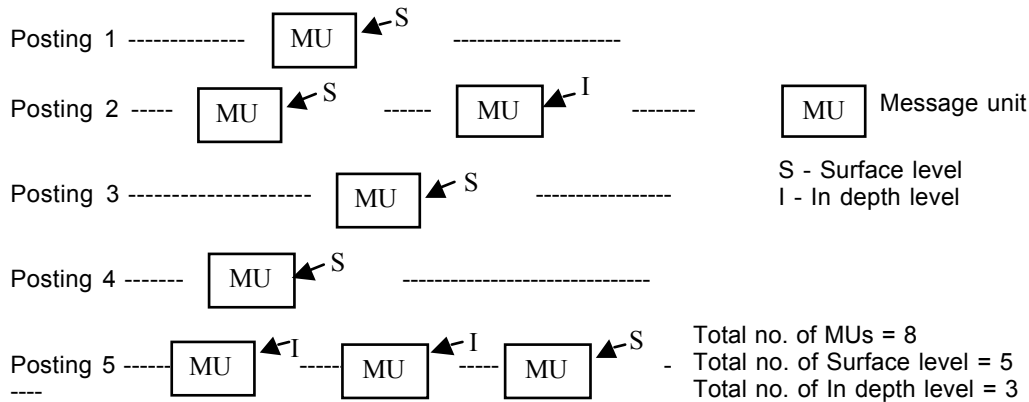


Figure 1: An example on how 5 postings of a group are “scored”.

In addition, an online survey was conducted using a Likert scale questionnaire to evaluate the students’ attitudes, perceptions, or opinions about using asynchronous online discussion (Appendix C). One open ended question was also included to allow students to record their comments on asynchronous online discussion.

Findings

Evaluation of critical thinking

Research question: What is the quality of thinking, i.e. surface or in depth level, demonstrated by the secondary one students during the asynchronous online discussion?

The four groups of forum that were classified as case analysis problems were examined. The entire four group postings were analysed and interpreted critically based on the thinking model. Table 2 shows the posting results of each of the four groups in the forum. Details on the case study topics are given in Appendix D.

Each posting corresponds to one thread in the forum. The total number of postings for each group includes the posting and replying threads in that group. However, each participant can do more than one posting. To illustrate, for example, in group “DSL, cable or wireless”, there are altogether 6 (4 from this group, 2 from other groups) participants who either post or reply in the forum. Any participant could do multiple postings and replies. In this case, the 6 participants made 10 postings.

Table 2: Posting results of the four groups discussing case analysis problems

Participants	F13 – F18	F19 – F24	F25 – F30	F31 – F35
Group	Operating system	Online collaboration	Transmission media	DSL, cable, or wireless
No. of participants allocated in each group	6	6	6	5
No. of participants who did postings (in this group)	3	5	4	4
No. of participants who did postings (from other groups)	2	0	1	2
Total no. of postings in each group (note that each participant can do more than one posting)	5	5	7	10
No. of message ideas / units from the total postings in each group	6	12	7	10
No. of in depth level of information processing in each group	2	9	5	4
No. of surface level of information processing in each group	4	3	2	6
Total no. of message ideas / units in all groups	35 (Add up no. of message ideas from each group: 6 + 12 + 7 + 10)			
Total no. of in depth level	20 (Add up no. of in depth level from each group: 2 + 9 + 5 + 4) or 57% (20/35)			
Total no. of surface level	15 (Add up no. of surface level from each group: 4 + 3 + 2 + 6) or 43% (15/35)			

For each posting, message unit(s) / idea(s) was / were identified. Note that one single posting could contain more than one message unit. For example, in the “Online collaboration” group, there were 12 message units identified in the 5 postings. Based on the thinking framework (Cheung & Hew, 2005), the message units were analysed to determine whether they were “surface” or “in depth” in level of information processing. The percentage of each level of information processing was then calculated. For example, in the “Online collaboration” group, 9 message units were in depth level whilst 3 messages were surface level type of information processing.

From Table 2, it can be seen that about three-fifths (57%) of the thinking skills exhibited were higher level information processing. This result showed that students had supported their posted comments / conclusions or the comments / conclusions made by others with relevant facts, and personal experience (see below, posting example 1 from Group Transmission Media) and also were able to identify advantages and disadvantages of a suggestion (see below, posting example 2 from Group DSL, Cable, or Wireless). The sentences in the examples here are corrected for spelling errors, and student names have been changed for confidentiality.

Posting example 1

Topic : Transmission Media
From : Ferris

I agree with Nicky. A wireless transmission media is better than a hardwired transmission media. The wireless transmission media is much more convenient. I think that company's with low budget should buy hardwire transmission media as it is cheaper. From experience, I do not think walls cause any obstruction to the wireless transmission media.

I do not think that wireless technology will affect our health; I think that it is all just superstition. Wireless technology uses Bluetooth, which are radio waves, which is harmless.

Posting example 2

Topic : Re: Wireless network
From : Kim

Shawn, I totally agree with you. Having wireless networks with us is so useful since there aren't enough computers for all the students to use at the same time. Having a wireless device like a palmtop is useful to us as we will then be able to check our SMB (Student Message Board) or IVLE (Integrated Virtual Learning Environment) at the earliest possible time. Announcements put on the SMB will be immediately informed through this wireless connection. Palmtops are also portable, so you can bring it to school (if the school allows) and you can check for announcements during our free time like recess.

But Shawn, we should also think of the cost. Wireless devices are not cheap and not everyone would want to fork out money to buy one. Also, will the school also allow such devices to be brought by students? For example, if we were able to store some stuffs into our storage systems, then some mischievous students may store stuffs like games and this will interrupt and affect the whole class.

On the other hand, 43% of all the thinking skills exhibited were surface level information processing. This result indicated that there were many students whose postings standard did not meet the criteria for higher order thinking. There were students who did not justify their postings and judgments, or stick to assumptions, for example one student simply said: "Yes, I agree with what you said." and another student assumed: "... I also think that radio transmission will damage our health." These examples were one sentence answers with no elaboration or supporting details. Some students stated that they shared the judgments made by others but without taking further (see posting example 3 below) and some also failed to spell out the advantages of a suggestion (see posting example 4 below). These two examples of low (surface) level information processing were taken from Group DSL, Cable, or Wireless:

Posting example 3

Topic : Re: Wireless network
From : Ken

I agree....it is better to use wireless network..it make work easier for people.

Posting example 4

Topic : Online Collaboration
From : Wee

... White board is a Video conference feature in which another window on the screen displays notes and drawings simultaneously on all participants' screens ...

In summary, analysis of the students' asynchronous online transcripts revealed that 57% of all the thinking skills exhibited by the students were in depth level information processing. These students had most probably spent time thinking and composing their answers / comments after some research or reading, before posting. They had justified and supported their judgments made. 43% of all the thinking skills exhibited by the students were of surface-level information processing. These students, however, were most probably inexperienced at "playing the forum game" and could have lacked initiatives to research for more information on their postings, thus resulting in superficial level postings. They did not justify and support their conclusions.

Perception of asynchronous online discussion

Of the thirty-five students, two did not turn up in class to do the survey; nine did not participate in the forum, reasons are mainly "no time" and "forgot all about it", thus they were not required to complete the survey; and hence only twenty-four students participated in the survey.

Research Question raised: What are the students' perceptions on using asynchronous online discussion for learning and thinking?

- a. Do students perceive that they think more in asynchronous online discussion as compared to face-to-face classroom discussion?

The survey result showed that about 92% of students agreed or strongly agreed that they think more in the asynchronous online discussion environment.

- b. Do students perceive that they learn more in asynchronous online discussion as compared to face to face classroom discussion?

The survey result shows that about 84% of students agreed or strongly agreed that they learnt more in the online discussion environment.

In summary, most of the students have perceived online discussion as useful in terms of learning and improving their thinking skills. In the open ended questions, a majority of students gave feedback that online discussion was easy to use and would like to use it beyond classroom discussion, but a minority felt that it was time consuming and would have preferred classroom discussion. Other positive comments on online discussion were that it was educational, as it could improve the students' problem solving skills and thinking skills through the discussion. Highlighted here are two of the students' remarks:

I feel that asynchronous online discussion is useful. It lets us interact with each other. It lets us have the higher order thinking skills. (from Heng)

I feel it is educational and improves on my skills in solving computer related problems. (from Chuan)

Having reported that, we would like to make it explicit to the readers that the survey results might not be fully accurate due to 9 participants failing to respond to the survey. Responses from this slightly more than 25% of the sample population could have affected the results.

Discussion and implications

As the results revealed, a slightly higher percentage (57%) of students' thinking skills exhibited were in depth level information processing in the online discussion environment. Although the result may imply that secondary students are also capable of contributing critical postings in online forum, as is found for tertiary students, it is not to a large extent and this matter is analysed further below.

In this study, the sampled students were from one of the top high schools in Singapore. They were the high achievers from the primary schools and generally were perceived to be higher ability than an average secondary student from a normal mainstream school. Thus, they could be expected to perform well with critical thinking skills. Unfortunately, many of the students were not displaying critical thinking skills in posting their recommendations or responses to others in each case study. Only slightly more than half (57%) of the instances of thinking skills were classed as in depth level, whilst about 43% of thinking skills were surface level information processing. Assessment on their postings revealed that the information they posted was often superficial, conversational and less critical as compared to the thoughtful and quality postings. As the figure of 43% could be regarded as somewhat disappointingly high, this study needed to explore possible contributing factors behind this lack of critical thinking. The following factors, based on the researchers' observations, experiences and encounters with the students, are suggested.

1. Students did not fully understand the case analysis problem. They would give up attempting the postings or would not be able to provide quality postings.
2. Students did not do sufficient research or reading before postings. They chose only concepts that they were more familiar with and discussed only these. Thus comments on unfamiliar concepts were not elaborated and were superficial.
3. Students lacked discipline and experience in forum discussion. Although they were briefed initially on how to justify and support their opinions before posting (see Appendix A, Guideline 6), some students did not follow the rules, or simply did not know how the "game" (forum) should be "played".
4. The scaffolds provided before the beginning of the discussions were not clear to students or were insufficient. If the students did not fully understand the guidelines such as knowing how to post their thoughts and views with elaboration and explanation to support their postings, students would not be able to give good quality postings. The teacher could be at fault by not providing the necessary scaffolds accordingly to the students' needs.
5. Students did not treat the discussion seriously, thinking that it could be just another chat room environment where students would engage informally. This could be due in part to the participation rules not being strongly enforced by the teacher, as there was no consequence even if the students did not participate. As a

result of their misconception and attitude towards learning, they would be less motivated to participate critically and aggressively.

6. Students lacked skills (critical thinking) in giving constructive comments. Students were liable to respond with very straightforward answers without putting in much thought. This could be because their prior knowledge and experience were limited, or because they did not independently research on their own for a better solution to the posted problem / question.

In addition to the above six factors, we believe the critical thinking framework (Cheung & Hew, 2005) may not be comprehensive enough to include all the in depth critical thinking indicators. As a result, we might not be able to identify some of the critical thinking online messages. We believe there are some other factors that would affect the quality of student critical thinking such as the sampled students being young, inexperienced, lacking in discipline, initiative and independent study skills, and having a "not so serious" attitude to online learning. Consequently, these attributes would also affect students' quality of postings.

This study reveals the need to scaffold the lower secondary students on how to justify their statements with appropriate examples or supporting information. Teachers cannot take for granted that the students will know to do critical online discussion by themselves even if the students are from the top school. The teacher's role as a facilitator in the forum is important. Understanding the thinking framework and the various criteria of what surface or in depth level of information processing are, allows the teacher-facilitator can monitor better the progress of a class by scaffolding students into critical thinking. This practice is important for the future conduct of online discussion.

The outcomes of this study could imply that scaffoldings given at the start of the study might still be insufficient. Certain measures and strategies were therefore proposed below and should be enforced seriously.

Recommendations

To provide students with a forum facility for communications is insufficient. The teacher's role in scaffolding the online discussion environment is vital to the success of a constructive discussion. In the present study, the teacher did nothing to moderate the whole discussion such as to respond with words of encouragement or ask probing questions to scaffold students to think and reflect further. There are various roles for online tutors mentioned in the literature. Berge (2001), for example, remarked that one of the most important roles is the pedagogical role that he described that the moderator should use questions and probes for student responses that focus discussions on critical concepts, principles and skills. Based on the experience conducted in the study and literature reviews, this study has contributed and presented some strategies that could facilitate in depth thinking among students in the online discussion environment. However, investigating strategies necessary to facilitate and scaffold learners to promote interactions, participations, and collaborations was not within the scope of this study. Strategies that could be studied and perhaps

performed by teacher to facilitate critical thinking and interactions among students may include:

1. Advise students not to be repetitive on ideas from others but to provide more insightful comments based on their own knowledge and personal experience (Cheung & Hew, 2005)
2. Advise students to justify their conclusions (Cheung & Hew, 2005)
3. Advise students to clarify all suggestions with supportive examples or details (Cheung & Hew, 2005)
4. Offer timely feedback, foster independent thinking and present alternative viewpoints through argumentation (McLoughlin, 2000)
5. Stimulate the discussion by asking pertinent, probing questions that hold students accountable for their thinking (MacKnight, 2000)

It is important for online participants (teacher or students) to learn to ask good questions of themselves and of others. MacKnight (2000) remarked that questions that focus on the fundamentals of thought and reasoning form the baseline of critical thinking. Scriven and Paul (n.d.) stated in the Foundation for Critical Thinking website, that a well-cultivated critical thinker should raise vital questions and problems, formulating them clearly and precisely. The teacher is responsible for scaffolding students and coaching of learning by modeling questioning techniques that promote critical thinking. One such questioning technique is the use of *Socratic questioning*. Table 3 below suggests illustrative examples of questions for exploring ideas and statements in depth.

Table 3: Socratic questioning techniques
Extracted from ChangingMinds.org Website, Syque (2002-2006)

Six types of questions (that Socrates asked his pupils)	
1. Questions for clarification	a. What do you mean by ____? b. Could you put it another way?
2. Questions that probe assumptions	a. What are you assuming? b. Is this always the case? Why do you think the assumption holds here?
3. Questions that probe reasons and evidence	a. What would be an example? b. Could you explain your reasons to us?
4. Questions that probe questions about the questions	a. To answer this question, what questions would we have to answer first? b. Does this question ask us to evaluate something?
5. Questions that probe implications and consequences	a. What are you implying by that? b. What effect would that have?
6. Questions about viewpoints or perspectives	a. Can anyone see this another way? b. What would someone who disagrees say?

From the survey findings, the results indicated that most of the students perceived that they have improved in term of learning and cognitive level. This implies that online discussion could be perceived and recommended as an effective tool to teach critical thinking and to enhance learning experiences.

Limitations and future research

We should note that there are some limitations to this study. One limitation is that we analysed the online messages according to Cheung and Hew's (2005) critical thinking framework. If we adopt another framework, the finding of this study could be different. Secondly, all subjects were male students. Consequently, we urge that further research should examine students of both genders. Thirdly, this study included only lower secondary male students. Future studies to examine other levels could be done. Another recommendation is to conduct future investigations not only on critical thinking, but also on creative thinking and caring thinking.

Conclusion

This study has investigated secondary students' quality of thinking in an asynchronous online discussion environment. The results have shown 57% of recorded instances of thinking skills exhibited by the students were in depth level information processing and 43% were surface level. Most students perceived online discussion as an appropriate platform for learning and thinking. However, supporting an effective discussion that could foster critical thinking in the online discussion environment would require participants to formulate their postings by raising good, appropriate questions which could prompt further thinking about the subject matter. Teachers must act as facilitators to provide students with sufficient scaffolding including the coaching of questioning technique such as those used by Socrates as recommended in this paper. Knowledge about information processing levels, whether surface or in depth, can assist teacher-facilitators to scaffold students into critical thinking. The idea of monitoring class progress with abilities to demonstrate critical thinking skills is pedagogically more important than the absolute figures obtained in this study.

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Appendix A

Guidelines for participating in asynchronous online discussion

The briefing included the following main guides:

1. Each member of the group must post at least one message (i.e. suggestion, comment) that is relevant to the problem; incorporate ideas gathered / learnt in the f2f lesson and assigned readings.
2. Each member of the group must respond to at least one posting from the student in the same group.
3. Students are however, encouraged to post and respond beyond the requirements stated in 1) and 2). For example, they can post more than 1 posting.
4. Students are encouraged to read other group(s) postings and if desirable, could respond to other group.
5. Students are encouraged to reply to their classmates' online enquires within 48 hours, so as to avoid the problem of delay between message postings. (Cheung and Hew, 2005). Online discussion would last for a duration of 2 weeks.
6. Your messages must provide supporting information for examples, justifications, clarifications, and elaborations. Follow guidelines proposed by Cheung and Hew (2005).
7. No abusive or insulting messages are allowed.

The study adhered to the above 7 basic guidelines the author has recommended. It was assumed that even after encouraging for more postings, students might not be able or want to participate as told since it was still optional to post more than the required number of messages.

Appendix B

Teacher's demonstration on how critical discussions could be conducted online

Since this study focused on finding whether critical thinking has occurred in the discussion, the teacher had demonstrated how discussions could be conducted in a more critical manner by explaining to the students through an example of "How to connect your computer to the Internet?" The example was elaborated as below:

Ask a problem: "What will you do if you need to use an Internet from home?"

1. Possible non-critical (surface) reply: "Use a modem to connect to Internet." or better: "Use a dial up or broadband modem to make connection to Internet."
2. Possible critical (in depth) reply: "There are many ways you can do it such as using a dial up modem, DSL, cable or even wireless modem. Using dial up access is inexpensive but slow in surfing Internet whereas broadband access is more costly but gives faster surfing speed. Depending on your needs and budget, you may connect your computer to Internet in any of the methods."

Based on the thinking rubric from Table 1, the above first reply was classified as surface level of information processing as the author did not spell out the advantages and disadvantages of a suggestion. The second reply, however, identified the advantages and disadvantages of a suggestion. Hence, an in depth critical thinking skill was exhibited from the author in the second case.

Appendix C: Discussion forum survey

Students' Perception on asynchronous online discussion

Name: _____ Class: _____ Index Number: _____ Date: _____

Have you participated in the Online Discussion Forum for Infocomm Studies (IS100)?

- No. If no, please state why in the box below and return this form to the teacher.

- If yes, please fill in the below section and return this form to the teacher..

Dear fellow student,

Online discussion forum is often explored as an alternative choice for discussion beyond classroom. It is changing the way students participate and learn in classroom. This survey aims to discover how students use asynchronous online discussion in their studies and to collect their views and perceptions on using asynchronous online discussion for learning. Your answers to these questions will be of great benefit in helping to shape the use of asynchronous online discussion in education.

Thank you for giving us your valuable time to complete this questionnaire.

Tick the relevant boxes to indicate your level of agreement with the following:

Items		I totally agree	I mostly agree	I mostly disagree	I totally disagree
Cognition (think more)	1. I analyse what other participant(s) has/have written in the forum and think about what I want to feedback and write.				
	2. The asynchronous* nature of asynchronous online discussion allows me more time to critically think about what to write and discuss in the forum. (* means need not to happen at the same time)				
	3. I feel that I have used my mind more often in asynchronous online discussion than in the class discussion.				
Learning (learn more)	4. When I write down my discussion, I am generating my thoughts in words. This makes my thinking visual. I have learnt better this way than in verbal discussion.				
	5. I have learnt a great deal of knowledge from other participants' views / postings either in the same or other group.				
	6. I interact through online discussion with other participant(s) to come out with good comments. I have learnt more through small group collaboration.				
	7. The more time allowance that asynchronous online discussion provides gives me time to do some research such as surfing online for information or reading relevant text materials before I discuss my responses in the forum. I have learnt more this way.				

	8. State your feedback on using asynchronous online discussion for learning i.e. <ol style="list-style-type: none"> a. your good / bad experience b. do you prefer asynchronous online discussion than Classroom Discussion or via versa c. suggestion for improvements in Asynchronous Online Discussion d. others 	
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Appendix D: Case analysis problems

Case study - Operating system (F13-F18)

Your team members are employed as analyst at Soap-n-Suds, an international manufacturer of laundry soaps. The company currently uses an early version of the Windows operating system on its 5,000 desktop computers. Next year, the company plans to upgrade the operating system and, if necessary, its desktop computers. The vice-president of information technology has asked your team to compare the latest desktop versions of the Windows operating system, the Mac operating system, and the Linux operating system. Comment on what is the initial cost of the operating system per computer? What are the memory and storage requirements? Will the operating system require the company to purchase new computers? Are training costs involved? Which one is best at avoiding viruses, spam, and spyware? Which operating system is easier to use? Why? Can Microsoft Office run under the operating system? Share your findings.

Case study - Online collaboration (F19-F24)

Your cousin owns a major architectural firm on the west coast. The company specialises in designing condominium complexes for retirees throughout the United States. One of her biggest expenses is the cost of her sales force and architects traveling to meetings with customers. She recently learned about the collaboration features of Microsoft Office. She is aware that you are studying about computers and has asked you to examine online collaboration as an alternative to some or all of the face-to-face meetings with customers. What are the advantages and disadvantages of collaborating online? What is a whiteboard? How are online messages set up? What is Net Meeting? Does collaboration require additional hardware? Discuss your findings.

Case study - Transmission media (F25-F30)

You work as an intern in the Information Technology department for the Star-Journal, a local newspaper. The newspaper's board of directors recently approved a budget for redesigning the interior of its century-old building as part of an inner-city rehabilitation project. Your manager has been asked to recommend the type of transmission media (hardwire or wireless) to use for the newspaper's local area network. He has asked you to comment the advantages of hardwiring the building versus using wireless transmission media. Which transmission media would have a greater startup cost? Which transmission media do you think is the most secure? Do the walls in the building present a problem for a wireless network? Does a wireless network present any health hazards? Discuss your findings.

Case study - DSL, cable, or wireless (F31-F35)

Your school offers free student-intern assistance to the county government. The county in turn assigns a manager to each team of students, who is responsible for defining the project assigned to the student team and ensuring that dates are met. Your team has been assigned to the manager of communications in the information technology department. Next year, he plans to select an ISP – DSL, cable, or wireless – to handle all Internet communications in the county buildings. Determine the advantages and disadvantages of their all the ISP. Include such features as start-up costs, e-mail disk storage, speed, online protection, and recurring costs. Share your recommendations.

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