STUDENTS' PERCEPTIONS ON THEIR ABILITY TO ENGAGE CRITICAL THINKING IN A PROBLEM-BASED LEARNING ONLINE ENVIRONMENT

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ABSTRACT

This paper reports the evaluation of students' perception on their capability to engage critical thinking in a problem-based learning online (PBL online) environment. The learning process intervention was took place throughout the second semester of 2008/2009 academic year, at the Universiti Malaysia Sabah, Malaysia. Thirty science physics students from the School of Science and Technology (SST), and twenty pre-service science teachers from the School of Education and Social Development (SESD) which then form ten collaborative groups (4-5 members in each group) were involved. The samples followed all the PBL learning activities (i.e., learner-centred, self-directed learning, inductive learning, collaborative and interdependent learning). Data were gathered through an open-ended questions and a semi-structured focus group interviews after the students finished with the learning activities by the end of the semester. The findings in general can be categorised in three themes: critical thinking improved; managed to engage in critical thinking; and managed to generate related ideas. In the mean time, majority of SST students agreed that: it does mind activation and brainstorming; and they were able to think in terms of cause and effect. Whilst SESD students agreed they can: think more freely and; answer in more acceptable ways.

Keywords: Problem-based learning; Online Learning; Critical thinking

INTRODUCTION

The development of Problem-based learning (PBL) has been discussed extensively by Savin-Baden (2000) since 1070's. Boud and Feletti (1997, p. 2) characterize PBL as "a way of constructing and teaching courses using problems as the stimulus and focus for the student activity". It's been pioneered in medical school at the McMaster University, Ontario, Canada. Since then, PBL strategies have been used successfully with a variety of learners in a variety of context (see Duffy & Cunningham, 1996) including distance learner (Adelskold, Aleklett, Axelsson, & Blomgren, 1999), higher education (Ahlfeldt, Mehta, & Sellnow, 2005), medicine (Albanese & Mitchell, 1993), teacher education (Albion & Gibson, 2000), nursing (Baker, 2000), K-12 settings (Fosnot, 1988), engineering (Jayasuriya & Evans, 2007), doctoral education (Candela et al., 2009) and economic (Son & VanSickle, 2000). PBL strategies are becoming well established as a method and an area of study within the field of instructional design. Knowledge in this millennium is increasingly characterized by creative integration of information and learning from diverse disciplines. For these disciplines, PBL is probably the most extensively used tool (Ward & Lee, 2002), and many educational institutions worldwide have used PBL in educational reform and curricular innovation (Tan, 2004). Various studies using PBL in many disciplines (e.g., science, chemistry, biology, marine, and management) suggest that PBL works especially well for complex, multi-disciplinary subjects like medicine. Koh, Khoo, Wong and Koh (2008), for example, reported that trainee doctors who learnt via PBL in a medical school showed enhanced social and cognitive competencies, such as coping with uncertainty and enhanced communication skills (Koh et al., 2008), and Colliver (1993) likewise reported gains in clinical skills (see also Blake, Hosawaka, & Riley, for more work on medical schools, 2000)

Although research indicated that the use of PBL in several context and other disciplines is engaging, and enabling students to develop a number of cognitive skills (e.g., Albanese & Mitchell, 1993) until now, little research has been done about to seek the students' perception about PBL. With respect to improvement of education in higher education especially the science students and pre-service science teachers and the enhancement of the students' engagement it is important to know how good PBL classroom practices can be enhanced and what are the views of students about effective PBL discussion and working together. Hence the purpose of this study is to explore the students' perceptions about PBL that been implemented in a physics course to better know what is the real engagement deal between PBL and students particularly in critical thinking.

PBL MODEL AND PBL ONLINE ENVIRONMENT

In this study, the researcher employed a model based on a combination of three models: that used by McMaster University (Barrows & Tamblyn, 1980); the Torp and Sage Model (IMSA, 1998); and the model used by Pastirik (2006). The main purpose of choosing a hybrid model was to ensure students explores their own learning, especially in terms sharpening their analytical skills, improving their critical justification in making decision, being a creative observer, and practicing their communication skills. All of these characteristics can be sharpened through these established learning models. Thus these PBL models were modified to suit undergraduate students.

There are five main stages that consist in this PBL which are: i. problem presented; defined the problems which is messy-structured and multifaceted situation; ii. student recognizes learning issues and potential sources of knowledge and information; iii. engage in independent study by gathering and analyzing essential scenario information; iv. student then meet with the small group, they critically discuss the practical application of the information to the scenario; and v. student then critically reflect on both the content learned and the process.

These theories are important in this study to maintain the key features of PBL and which, at the same time, can be applied to undergraduate level physics students in Malaysia. This is because the learning process that is embraced in these PBL models also needs to be acceptable in Malaysia, and to promote the soft skills that are deemed important in Malaysian institutes of higher education. Hence, the researcher integrated these models in an online environment in order to create new PBL online model to address the research questions for this study.

PBL online basically mean merge the pedagogy (which is in this case is PBL) and deliver entirely or partly by the use of online and the World Wide Web (Savin-Badin 2006). It is also an approach that claimed works online when integrated with a proper and rational technology (e.g. BlackBoard, LMS, and a Web-based courseware management and delivery platform) (McLinden et al., 2006) or as students learn through web-based materials that include text, simulations, videos, demonstrations and resources (Savin-Baden & Gibon, 2006). In King's (2008) works no print materials were provided, where students only can access materials directly from the course website. Whereas in Savin-Baden and Gibbon's (2006) case this category of mixed PBL tends to focus around a particular site through which students are guided by the use of strategy problems, online material and specific links to core material. While at one level the use of the site is student led, the materials provided necessarily support the learning they undertake in face-to-face PBL groups. An example of such a site is the SONIC project (Savin-Baden & Gibbon, 2006). The latest report on combining PBL and online learning is to put the aid of collaboration tool in the learning activities as suggest by Savin-Baden and Wilkie (2006), where it will lead to focused on team-oriented knowledge-building discourse and reduced the teacher- centered learning. Savin-Baden (2006) defined this milieu as PBLonline where students working in teams on a series of problem scenarios that combine to make up a module in collaboratively way to solve problem. Students will work in real time or asynchronously using technology. Synchronous collaboration tools are critical for the effective use of PBLonline since tools such as chat, shared whiteboards, video conferencing and group browsing are central to ensuring collaboration within the PBL team.

CRITICAL THINKING AND ROLE OF COGNITIVE DEVELOPMENT IN CRITICAL THINKING

Brookfield (1987) defines critical thinking from the perspective of a process, as it embraces the whole process of identifying and challenging assumptions, and searching other ways of thinking and acting. Gathering information uses all our senses, verbal and/or written expressions, reflection, observation, experience and reasoning to come up with solutions or products.

The role of cognitive development in definitions of critical thinking ranges from simple statements about an individual's ability to create logical conclusions based on reasoning, to more complex definitions which take into consideration a person's emotions, personal feelings, and cultural biases. According to Erwin (2000a), critical thinking is a wider expression describing reasoning as open-ended practice, having no limit in range of solutions. Critical thinking demands learners improve the quality of their thinking by skilfully and masterfully taking charge of its very structures and by imposing intellectual standards upon them (Brookfield, 1987; Paul, 1990; Shurter & Pierce, 1966).

Cognitive development plays a significant role in a person's ability to think critically. Piaget proposed that cognitive development consists of the development of logical competence, and that this development consists of four major stages (Piaget, 1979, 1983, 1981; University of Alberta, 2008), culminating at around age 11 or 12, when a person enters the *formal operational stage*, and becomes capable of advanced logical thought about abstract concepts. This is the ultimate stage of human cognitive development according to Piaget (1979, 1983, 1981), but other theorists argue that Piaget's theories are faulty. Vygotsky, for example, says that an individual's higher mental functions develop more through social interaction, and that humans learn from their interaction and communications with others (Daniels, 1996; Newman & Holzman, 1993). Vygotsky thus assumes intellectual development is continual without an end point (as cited in Erwin, 2000b). Likewise, Riegel (1976) proposes a fifth phase to Piaget's four phases of cognitive development, dialectical reasoning, saying that dialectical reasoning is when a person's mental processes move freely back and forth among all the Piagetian stages. According to Erwin (2000a), biological and cultural developments are interrelated, and do not develop in isolation, cognitive skills like evaluation and development are complicated, and are affected by social and cultural contexts.

Critical thinking involves higher order thinking, and Bloom, Englehart, Furst, Hill, and Krathwohl (1956) have produced one of the most often cited documents in establishing educational outcomes based on higher order thinking: the so-called Taxonomy of the Cognitive Domain. According to this model, erudition and knowledge is composed of six successive levels arranged in a hierarchy: remembering, understanding, applying, analyzing, evaluating and creating.

Research over the past 40 years or so suggests that the first four levels are indeed a true hierarchy; that is, knowing at the knowledge level is easier than, and subsumed under, the level of comprehension and so forth up to the level of analysis. However, there is some debate as to the relationship of synthesis and evaluation with the other levels; it is possible that these are not set at an appropriate level in the original taxonomy, or they represent two separate, though equally difficult, activities (Seddon, 1978).

Huitt (1992) suggests that there is an equivalent-but-different relationship between critical thinking or evaluative thinking. Huitt classified techniques used in problem-solving and decision-making into two groups roughly corresponding to the critical dichotomy. One set of techniques tended to be more linear and serial, more structured more rational and analytical, and more objective-oriented. These techniques are often taught as part of critical thinking. The second set of techniques tends to be more holistic and parallel, more emotional and intuitive, more creative, more visual, and more tactual and kinaesthetic; these techniques are more often taught as part of creative thinking. This dissimilarity as well matches up to what is sometimes referred to as left brain thinking (viewed as analytical, serial, logical, objective) and right brain thinking (viewed as global, parallel, emotional, subjective) (Springer & Deutsch, 1993).

The literature suggests critical thinking is very important in developing cognition. It allows us to evaluate, explain, analyze, synthesize, and restructure our thinking, decreasing thereby the risk of acting on, or thinking with, a false premise (Ennis, 1987; 1991; 1996). In thinking critically, students use their command of the elements of thinking to adjust their thinking successfully to the logical demands of a type or mode of thinking. As students come to habitually think critically, they develop their special traits of mind; intellectual humility, intellectual courage, intelligent perseverance, intellectual integrity, and confidence in reason (Ayersman & Reed, 1995).

METHODOLOGY

The intervention done in this study was administered in Semester II during the 2008/2009 academic year at the School of Science and Technology (SST) and at the School of Education and Social Development (SESD) University Malaysia Sabah (UMS), Malaysia. The sample consisted of students from the Bachelor of Physics and Electronic Programme (science physics students) and also from the Bachelor of Education with Science Programme (pre-service science teachers) student who were taking Modern Physics course during the semester. There were 50 students who took part in the study. The students were separated into two main groups. One group formed the PBL group for SST (N= 30) and the rest formed the PBL group for SESD (N=20). The students learned in collaborative groups of 4-5 students, and there were a total of 10 groups involved all together (6 group from SST and 4 groups from SESD).
Table 1 show the group sample for the study.

Table 1 *Group sample for the study*

Group	
Science Physics Students (SST)	30 students
Pre-Service Science Teachers (SESD)	20 Students

The intervention was conducted over 16 weeks. During the intervention the entire learning activities delivered by using Learning Management System (LMS) provided from the Educational Technology and Multimedia Unit (ETMU) from the Universiti Malaysia Sabah. The researcher prepared and organised the LMS followed the PBL learning activities (including the problem's design) approach to fulfilled the learning and teaching activities via online learning. Thereupon students can access the LMS anywhere and at anytime they prefer suite to their own period and space. The university's library also provides student with five hundreds computers that have the Internet connection at a computer lab known as The Mega Lab. Thus, those who did not have their own computer can use the computer at the lab.

There were five problems need to be solved by each group. Students were engaged in variety of synchronous and asynchronous PBL learning activities, such as chat rooms; forum; sending and receiving e-mail from group members and facilitator; uploading their own materials to be used by other friends; downloading materials from the Internet; sending assignments and also get feed-back from facilitator. Since there were no fix times during the learning process, they can choose their own flexible time to carry out all the activities by online. A facilitator guided the PBL groups cognitively in collaborative atmosphere all the way throughout the semester, in a very minimum direction.

Data were collected through an open-ended questionnaire they completed, and a semi-structured focus group interview after the intervention finished. The survey consisted of questions about the PBL online approach used during the intervention. In addition a focus group interview was conducted a week after the intervention completed. One of the main objectives of this survey and interview was to seek students' opinions about how their ability to engage in critical thinking been affected.

FINDINGS AND DISCUSSIONS

The data finding suggests that as far as the PBL online approach is concerned the students were positive in their feedback about the approach. Feedback for the physics science students and pre-service science teachers is first presented combined and any differences between the cohorts then discussed.

Table **2** shows the themes that been categorised upon the open ended questionnaire and focus group interview of students' perception on their ability to engage creative thinking in a PBL online physics course. The themes been formed by a question which is: *How has your ability to engage in creative thinking been affected?* And also from focus group interview questions based on their perceptions after experiencing PBL online.

Table 2 *Themes of students' perception on Their Ability on Engaging Critical Thinking in a PBL Online Physics Course Environment.*

Generally
i. Critical thinking improved;
ii. Manage to engage in critical thinking;
iii. Manage to generate related ideas
SST
i. Mind activation and brainstorming;
ii. Able to think in terms of cause and effect
SESD
i. Think more freely;
ii. Answer in more acceptable ways
Other Perspective (Negative)
i. Their critical thinking is not improving;
ii. Had headache

The findings from this study can be categorised into several themes: in general; SST's feedback; and SESD's feedback. As shown in Table 2, analysis of the data indicated that students felt they learned and gained three principle learning outcomes: *i. Critical thinking improved; Managed to engage in critical thinking* and *ii. Managed to generate related ideas.* Here the researcher provides more detail to support this finding.

i. Critical thinking improved

The need for students to use critical thinking during the intervention is really vital since it helps them to unravel problem assigned to them. A participant remarked that:

> My critical thinking is increased. I have to think critically to solve the problems. Thus I can train myself to have more way to solve problems (R7, SST, M, *questionnaire*).

Besides being better able to engage in critically thinking, some students also stated that they learned that they had to carefully synthesize information found from the Internet, and that they needed to process such information to solve their problems:

> It is improving my critical thinking. When I am finding some latest information, or some definition, I have to read the entire file that I downloaded and digest it. In this process, I improve my ability to engage in critical thinking (R12, SESD, F, *questionnaire*).

ii. Managed to engage in critical thinking

There is also mixture of creative and critical thinking noted by a participant that is useful to solve physics problems. One participant noted:

> My ability to engage in creative thinking is increase rapidly where I always use the critical thinking to solve the problem that use the concept of physics. (R4, SESD, F, *questionnaire*)

They also felt that the intervention helped inspire them to learn more from the information resources they used, in order to get to know options for solutions of their problems. This, it seems, was related to the nature of the question or problem posed:

> As the question given are quite challenging, it really makes me to learn more and more either learning it through the Internet or search information from reference books to know the actual solution for the problem which really engage my critical thinking. (R11, SST, M, *questionnaire*)

An interesting point was made by one student, who said that PBL skills like critical thinking are important when searching for suitable sources, since there are rather too many sources of information, and that one needs to be more critical about choices of information sources.

> It is very important to think critically during the process of searching the knowledge through the internet. There are large amount of knowledge in the internet. The same topic may have different point of view from different perspectives and angles. Hence, the critical thinking is useful in analyses the information that receive and summarize the entire huge concept to a way which fitted our level. (R10, SESD, M, *questionnaire*)

iii. Managed to generate related ideas

A participant was able to deal with the ideas where she became a more critical thinker by tracking related and associated information and sources of knowledge:

> I was able to work with critical thinking. I was able to generate related ideas and information. I try to find out a lot of information about the problem given to help me think critically to solve the problem. (R5, SST, F, *questionnaire*)

One student also indicated that he felt that the intervention helped him to relate the specific issues or problems that they were dealing with, with other ideas and, in particular, to everyday life and activities:

> After involved in PBL, I am able to think critically about the problem in physics and relate it with the activities in daily life. (R6, SESD, F, *questionnaire*)

This is an interesting finding, since it suggests that this student was given a problem to solve, as and a result of the learning, discussion and the interaction that happened during the intervention, he tried to think in many, creative, ways.

As above, in addition to these common themes, there were some differences between the SESD and SST student cohorts. For example, the SST students noted that they felt the intervention *i. Mind activation and brainstorming;* and that they were ii. *Able to think in terms of cause and effect*

i. Mind activation and brainstorming

Using this instructional method means that students must activate their mind and use brainstorming in order to reach a significant acceptable solution for their problems. A participant stated that:

> In this activity, I found that I really tried my best to understand and solve the problems given. Hence, it does activate my mind to work and think harder. (R1, SST, F, *questionnaire*)

ii. Able to think in terms of cause and effect

PBL causes the students to think in terms of cause and effect in a very effective way.

> Finding the cause and effect by searching every possibility. (R9, SST, M, *questionnaire*)

Some students stated that they felt they had to think and consider any side effects of the solution to their problem:

> The critical thinking is the most important things while solve this problem because we have to think the side effect if we choose the solution for the problem. (R10, SST, F, *questionnaire*)

However, some SESD students pointed out that they were able to *i. Think more freely* and *ii. Answer in more acceptable ways*:

i. Think more freely

Since no longer being driven by a text book, their thinking become more expansive and the way they considered knowledge and learning become open and wider, as noted by a participant:

> I can think freely because not need to be influence by the textbook. (R5, SESD, M, *questionnaire*)

ii. Answer in more acceptable ways

A participant also remarked that the difficulty of problems actually can be handled and she become more confident responding to such problems in more logical and common sense way:

> I can answer question with logic and in accepted way. Before this, I don't think that I can deal a problem such solving a problem about radiation, X-ray, solar energy etc. But right after entering my first discussion with my group member, I realize that I can think and find a solution about a question that I felt I will never answer in my life. (R9, SESD, F, *questionnaire*)

There were some negative responses from some students: *i. Their critical thinking is not improving* and one of the students even said that she *ii. Had headache* after the intervention using this approach.

i. Their critical thinking is not improving

In some other ways, a participant denied that their critical thinking improved by saying it is not enough since she still was not sure about the course itself. She was confused and struggling a bit with the learning contents during the intervention:

> My critical thinking still not improve enough, because lack of knowledge about this course. I'm still explore the formula but did not able to create others formula or idea. (R19, SST, F, *questionnaire*)

ii. Had headache

One participant even commented that she had headache while solving the problem

> I have headache. (R20, SST, F, *questionnaire*)

In general, the students were of the same opinion, noting that they felt their *critical thinking improved*. This is because they *managed to use their critical thinking* in *generating related ideas* in solving their course problems. Some of the science students said that these learning activities helped in *activation and brainstorming* of ideas, and as a result, the activities helped them to *think in terms of cause and effect* for every problem they considered. As for the pre-service teachers, they said they felt that they now *can think more freely* and were able to *answer each question in more acceptable ways.* However, in another different view, there were some criticisms, with some students saying that *their critical thinking did not improve*, with one student saying she *had headache* when trying to solve confusing physics problems. This is similar to work reported by Norman and Schmidt (2000), who described PBL is a more challenging environment of learning, and need more effort and attempt from student to make it a successful learning outcome.

Furthermore students reported feeling really comfortable learning through online. The massive amount of information available from the Internet played important role in developing their critical thinking, as they had to synthesise and analyse their results and consider carefully what they needed to report in their final findings. This is in line with work by Chan Lin and Chi Chan (2007) who report that students have to use divergent thinking when a variety of sources and information are accessible for analysing problems. Consequently, the present study suggests that students' were able to engage in critical thinking using PBL online. Thus, it seems that critical thinking in science can be nurtured by emphasizing the solving of problems, with less rote learning.

CONCLUSIONS

The purpose of this paper was to report the students' perception on their ability engaging critical thinking in a PBL online environment in a physics course. In conclusion it is clear that students gained positive engagement trough PBL online specifically to theirs' critical thinking. The findings came up with several themes focused on their critical thinking improved, managed to engage in critical thinking, and managed to generate related ideas. Majority of science physics students agreed that it does mind activation and brainstorming and they also able to think in terms of cause and effect. Even as pre-service science teachers agreed that they can think more freely and can answer in more acceptable ways. However, minor feedback stressed that their critical thinking is not improving and had headache while facing the PBL online. Therefore this finding should be able to give a few clear descriptions and ideas to educators and lectures on what is the real deal happen between students and PBL online especially when it comes to their critical thinking.

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