ENHANCING CRITICAL THINKING USING PROBLEM BASED LEARNING IN A MATHEMATICAL CLASSROOM

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ABSTRACT

This paper is set out to explore the implications of Problem Based Learning (PBL) in enhancing critical thinking skills in a mathematics classroom. Semi-structured interview and observation sheets were used as tools to gather information from the participants. 30 undergraduate students from the field of engineering participated in this study. The teacher acts to facilitate the learning process rather than to provide knowledge. It was found that PBL is an approach that fosters critical thinking by challenging students in groups and seek solution to real world problem. Discussion and teaching each other creates a platform for students to experience a learning style that is conducive for critical thinking to grow. In addition, it was also found that the students learned better and more in a small groups, they became confident and more motivated as they begun to solve problems. Therefore, problem based learning is an approach that can help develop students’ better understanding in mathematics as it enhances critical thinking as well as problem solving skills.

Field of Research: Problem Based Learning (PBL), Critical Thinking, Mathematics

1. Background

In mathematics classroom, critical thinking has been identified as an important component in making sound judgement. (National Institute of Education, 1984). Students who has critical thinking skills are more capable in solving mathematics problems. Future employers also place a high priority on seeking critical thinking skills in prospective employees. The Minister of Education in his 2006 Ministerial Message stated: “The way we assess our children’s achievements in learning must be in response to developments and changes in the world.” (Y.B. Datuk Seri Hishamuddin Hussein, in 2006 Ministerial Message, NST, January 18, 2006)

In a study done by Burbach, Matkin, & Fritz, 2004, students find it hard to understand the concept and therefore merely memorize the formula and apply them without having a clear understanding of how and when to use them. As a results of this, most of these students do not perform well in the exams and most importantly they are unable to relate these
mathematical concepts with the real world. Memorizing formulas unable to provide sufficient understanding of the concept. Reeder (2011) stated that understanding concepts seems to be more of a point on a continuum rather than the final destination for the students’ overall learning. Mathematics is a subject that needs clear understanding of concepts, rational thought and thus making decision and conclusion. Even though many realize the important of critical thinking, the exists a difference of view as to how critical thinking should be taught. (Brookfield 1997). Teaching through the traditional lecture format, has been criticised for its emphasis on the learner's passive receipt of knowledge rather than learning to think critically. (Maudsley 2000). In this study, Problem-based learning (PBL) has been used as an approach to promote critical thinking.

*Thinking is skilled work. It is not true that we naturally endowed with the ability to think clearly and logically without learning how, or without practicing.* -A.E. Mander

2. Theoretical Framework

The main theory that underpinning PBL is a constructivist approach. Constructivism emphasises in encouraging students to use techniques than constantly challenge them to create more knowledge and then reflect on what they have learnt. Constructivism transforms the student from a passive recipient of information to an active participant in the learning process. In Problem Based Learning (PBL) is a student centred learning where it gives important on the process of learning by which the students themselves will come up with the solution and the teacher will act as a facilitator. It enables students to be a part of the learning process by which the students themselves organized their own learning.

The PBL method was develop to stimulate the students, help the students to apply their knowledge to solve real life problems and also to motivate them to keep on learning. (Barrows, 1986). The most important is how it helps students to think, create, analyse and apply their knowledge to solve the problem. The key element of PBL is the small group learning which has all the criteria for collaborative learning (Dolmans and Schmidt 2006). The main idea behind PBL is that the learning process starts with a problem, a query that the students want to solve (Bound, 1985). In PBL, the problem steers the learning and is posed so that the students discover that they need to learn some new knowledge before they can solve the problem (Woods, 1995). In this sense, PBL is in keeping with the constructivist philosophy of learning.

3. Critical Thinking

Thinking is an mental activity which includes deducing, dreaming, internal dialogue, imagining and any kind of these activity can be taught and improved (Sharp, Splliter,2005).

Critical thinking on the other hand is reflective and so it is not the same as just thinking. It is...
metacognitive. It involves thinking about your thinking while you are thinking in order to make your thinking better (Paul 2004) in his definition on Critical thinking.

In Robert Ennis’s classic definition from his book A concept of critical thinking (1962), “Critical Thinking is reasonable, reflective thinking that is focused on deciding what to believe or do”. Aspects of Critical Thinking According to Ennis (Lipman,2003) are reasons, focus, inference, situation, clarity, and overview. People are generally become independent-minded, highly motivated, open minded and humble if they are able to think critically.

Utami Munadar (1999) definition on critical thinking is the ability to find several possible solution to a problem where the focus is on quantity, efficiency and the different forms of answers based on the data available.

There are many instruments test are available to test a person’s critical thinking. However these test typically assess the outcome of judgement but not the reasoning behind it. In relation to this the individual who are taking the test may not provide the accurate response according to the available answer but the reason behind the choice may be equally sound (Kennedy,Fisher & Ennis,1991)

Examples of such instruments are Watson Glaser Critical Thinking Appraisal (WGCTA), the Cornell Critical Thinking Test (CCTI), the California Critical Thinking Skill Test (CCTST), Carlifornia Critical Thinking Disposition Inventory (CCTDI), the New Jersey Test of Reasoning Skills, and the Ross Test of Higher Cognitive Processes.

While there have been numerous studies on the general college population, there are relatively few that are particularly for mathematics classroom. In 1932, Harold P. Fawcett, designed an experiment to test the usefulness of geometric and proof practices and how extensive work in geometry can lead to proficient and successful “transfer” of ideas and thought processes as they relate to the world outside of the classroom His work were later published in the National Council of Teachers of and Mathematics, The Nature of Proof (1938) has brought the idea that students could learn mathematics through critical thinking.

The study also presents the students responses to the heterogeneous nature of PBL teams. The findings of this research study serves as a guide lines of what teachers need to consider when bringing students together in order to cultivate critical thinking using PBL in a mathematics classroom.

4. Problem Based Learning

Problem based learning was first implemented in medical school program at McMaster University in Hamilton, Ontario, Canada in 1960 by Howard Barrows. The reason of this was because it was found that these students could memorize great amounts of detail but they are were not good at applying this knowledge in clinical settings. The PBL method was develop to stimulate the students, help the students to apply their knowledge to solve real life problems and also motivate them to keep on learning.(Barrows,1986).Another study done by
(Schmidt, 1983) discovered that students do not often use the knowledge learned appropriately.

Over the years, PBL methods showed huge success in instilling interest on the subjects hence motivates students to learn more as it helps promoting in-depth thinking and makes learning meaningful.

5. Statement of Problem

Students need to think critically in order to make sound judgement and decision on what they learned and be able to apply these principles learned in their daily lives. Based on observation and the students’ exam results, it was found that students are unable to “see” maths and how is it relevance to their lives and thus they scored fairly low in the examination. Learning activities are teacher centred where students are given a set of exercise and directed to obtain the correct answer. The students are passive and do not explore many ways of solution. According Tatang Herman (2006), this kind of learning activities only accommodate low-level thinking skills, such as memorizing and applying the formula. According to Alan Schoenfeld, (1992), majority of students do not think mathematically, they basically just follow directions and manipulate diagrams and perform what they think they should do. He added that critical thinking in mathematics education is self-directed mathematical thinking based on clear understanding of mathematics concept and how does it reflect on the surroundings. Students will be able to make sense of what they learned if they are able to think mathematically.

6. Research objective

The aim of the study is to explore the role played by Problem based Learning in enhancing critical thinking in Mathematics Classroom.

7. Research Question

The research questions are as follows:

1. How does the implementation of Problem Based Learning helps in students’ Critical thinking.

2. What are the students overall perceptions of using PBL approach to enhance Critical Thinking in mathematics?

8. Method

The sample consisted of 20 undergraduate engineering students. They were divided into group of 5. A duration of four weeks were allocated for this study. Every week there was one hour meeting facilitated by the researcher. Topic chosen was on probability. The steps of PBL is based on the stages suggested Barrows and Tamblyn (1980).
Figure 1: Diagram showing the PBL overall process.

To answer the research question 1, the researcher took up the role of non-participant observer. Observation were recorded as field notes and analysed. For each categories of the critical thinking skills, the researcher assigned a number of activity statements.

**Group 1:**

<table>
<thead>
<tr>
<th>Critical Thinking Skills</th>
<th>Activity Statements</th>
<th>week</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analyzing and Interpretation</td>
<td>Student should be able to break the whole into parts. Able to sort things out.</td>
<td>1</td>
</tr>
<tr>
<td>Evaluation and Inference</td>
<td>Drawing conclusion that are supported by evidence.</td>
<td>2</td>
</tr>
<tr>
<td>Explanation and Predicting</td>
<td>Envisioning a plan and its outcomes</td>
<td>3 and 4</td>
</tr>
</tbody>
</table>

Figure 2: Adapted from B.K. Scheffer and M.G.Rubinfeld (2000)
To answer research question 2, a semi structured interviews were used to gain elicit rich qualitative information. Two students in each of the groups were randomly selected to be interviewed at the end of the fourth week. The student’s responses were tape-recorded, transcribed, and analyzed.

9. Data Collection and Analysis

The questions in the non-participant observation which was to answer the research question 1 focused on the following critical thinking skills.

(i) Analyzing and interpretation
(ii) Evaluation and Inference
(iii) Explanation and predicting

9.1 Analyzing and Interpretation

It was observed that at the beginning stage, students were quite unfamiliar of what to do, they were unable to list down relevant information and unwilling to work together. As the PBL process continues, the students became comfortable with each other. They began to relate of what they know in relevance to the problem. At the end of the one hour, they manage to scrutinize the problem given to them.

9.2 Evaluation and Inference

The following week, they students worked individually and gathered information from various resources and come up their own suggestions of how to resolve the problem. In week two meeting, they managed to discuss with each other and draw conclusion on what method to use to solve the problem. There was a setback in one of the group, as one of the student started to argue and refuse to corporate. However the group members manage to talk to him and persuade him to work together.

9.3 Explanation and predicting

At the end of week four, they presented their findings and overviewed the whole process that they have undergone in that four weeks.

9.4 Semi Structured Interview Analysis

Two students were randomly selected from each group and a total of 10 students were interviewed at end of week 4.
Table 1: Sample of the interview questions and answers obtained from student A.

<table>
<thead>
<tr>
<th>No</th>
<th>Researcher</th>
<th>Interview</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>What is your opinion about studying mathematics?</td>
<td>Very challenging. Must always revise. When you manage to solve it you feel you are somebody, intelligent and nobody can fool you. Feel proud.</td>
</tr>
<tr>
<td>2.</td>
<td>How do you find the current method of teaching mathematics in your classroom?</td>
<td>It is O.K but I want the teacher to give more examples because I always have difficulties.</td>
</tr>
<tr>
<td>3.</td>
<td>What kind of difficulties you face in solving mathematics?</td>
<td>If the question not straight forward then I have to think and most of the time I don’t know where to start to think and also I don’t understand the mathematical terms. This makes it more difficult. I have tremendous difficulties in analysing the question from the beginning.</td>
</tr>
<tr>
<td>4.</td>
<td>Do you agree that higher order thinking skills are needed to solve mathematics problems?</td>
<td>yes</td>
</tr>
<tr>
<td>5.</td>
<td>Why is that?</td>
<td>Simply the question need thinking skills. I think hardly you will find questions that does not require thinking skills .You have to think hard for solving the questions , first we must write the steps.</td>
</tr>
<tr>
<td>6.</td>
<td>In your opinion, would you have benefited more if you solve the problem in a group rather than if you have done it by yourself.</td>
<td>Yes, I agree.</td>
</tr>
<tr>
<td>7.</td>
<td>Can you elaborate on that</td>
<td>This is mathematics not like memorizing subjects. Mathematics you need support in terms of idea and also creativity of other people. That will lead you to the solution and also will make you love maths. This also will make you want to solve other problems in maths.</td>
</tr>
<tr>
<td></td>
<td>Question</td>
<td>Answer</td>
</tr>
<tr>
<td>---</td>
<td>--------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>8</td>
<td>Okay, now since you have undergone PBL approach, so what can you say about it.</td>
<td>Well teacher..(pause) it is good if we don’t have any beginning knowledge of the subject.</td>
</tr>
<tr>
<td>9</td>
<td>What do you mean by beginning knowledge?</td>
<td>Like you see, in step one and two of PBL when you give us the problem..i was totally blank…no idea.then slowly i just wrote down what I think its relevant.</td>
</tr>
<tr>
<td>10</td>
<td>Does this step helped you?</td>
<td>First I thought it’s just waste of time but after I go back and look again I can actually come up with something and teacher that really challenge me to think harder.</td>
</tr>
<tr>
<td>11</td>
<td>Where did you look to find more information regarding the problem and what’s your opinion on this?</td>
<td>Oh..i just “googled” When I google there are plenty of information, there are just sometimes too much information. So you really must read and also understand these information and carefully select what you want. Learn continue</td>
</tr>
<tr>
<td>12</td>
<td>So how did this benefit you?</td>
<td>I read so many examples teacher and also surprise that now I know so much about the topic. New knowledge, before this I did not know even it exists..”oh my god “</td>
</tr>
<tr>
<td>13</td>
<td>What was your role in this assignment?</td>
<td>Oh I was the coordinator teacher.</td>
</tr>
<tr>
<td>14</td>
<td>And what did you do ?</td>
<td>I manage the team.i mean worked with the others so that our plan to solve the problem carried out well.</td>
</tr>
<tr>
<td>15</td>
<td>Can you tell me what you benefited from being a coordinator?</td>
<td>First teacher I was afraid, also shy but I want to complete the task so I brave myself and made sure everyone come for the meeting and we discuss the problem together.</td>
</tr>
<tr>
<td>16</td>
<td>To lead your team mates what kind of skills you need.</td>
<td>I need to “push” them .Sometimes</td>
</tr>
</tbody>
</table>
17. In which step would you say that PBL helping you to think critically and can you give an example to support your answer

Well actually the most is in the beginning part where you have to list down what we know, and also when you are looking for the information, must think carefully and make the right judgement.

18. How does your group played a role in enhancing critical thinking for you

When I reach “khalas” teacher my friends push me then I think harder. It is very good this way

10. Discussion

Problem based Learning (PBL) is motivating, challenging, and fun approach which has been the outcome from the process of working together towards resolving a problem. Based on the observation done, it is also found that critically thinking skills is nurtured by PBL through the process of solving, particularly within brain storming sessions where students actively explore the problem and list down what is known to them. Other sessions like sharing, discussion and teaching each other creates a platform for students to experience a learning style that is conducive for critical thinking to grow. Students develop greater understanding and self regulation through. It was reported in *The Critical Thinking Consortium 2013*, that teachers cannot think for their students but they can create conditions that they can “switch on” their thinking cap and get actively involved in learning mathematics through critical inquiry. It was also found that students develop their critical thinking through reasoning, interaction, self-assessment and justifying their results. The implication is that the implementation of PBL must be carefully examined that is the role of the facilitator who is conducting the student learning especially in triggering the students critical thinking need. The problem designed has to have the elements of engaging students’ curiosity and hence initiate learning. With all these carefully taken into considerations PBL can be an approach which can successfully enhance students’ critical thinking and therefore students can perform better in mathematics.
References


