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Critical Thinking Skills of Students in Online Tutorials Based on Problem-based Learning for Mathematics Curriculum Analysis

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Abstract

Critical thinking skills are one of the abilities required for students to be skilful in analysing, synthesising, concluding and decision making. Postgraduate programmes typically have no valid information regarding student's critical thinking skills. This research's objective was to access students' critical thinking skills in an online tutorial for a mathematics curriculum analysis course by using problem-based learning (PBL). PBL was used for this research because research indicates that this method could stimulate students' critical thinking skills through problem solving. This study included approximately 40 students using an online mathematics curriculum analysis tutorial application in January, 2013. To obtain data on the students' critical thinking skills, researchers observed the discussion forum of the online tutorial. The data were qualitatively analysed. Overall, the students' critical thinking skills were good. The students' best results were in the Compare and Contrast category, namely approximately 91.25%, and the lowest result was approximately 70.625% for the group Creating category. The results indicated that students had the capability to make a decision properly accompanied by a relevant argument and evidence. In addition, the students had properly conducted investigations to reach their decision.

Keywords: critical thinking skills, problem-based learning, tutorial online

Introduction

Critical thinking skills are learners' most important ability. Critical thinking has become an attractive topic in modern education, and all educators are interested in teaching their learners to think critically (Cheong, 2008). Johnson (2002) defined critical thinking as observing systematically for the thinking process itself, meaning that we observe by using evidence and logic. Critical thinking skills are very important because this ability affects the resulting decision. R. Swartz and D. N. Perkins (Hassoubah, 2004), stated that critical thinking (1) aims to reach the critical valuation regarding what would be accepted or what would be done by a logical excuse; (2) uses the valuation standard as the result of critical thinking in the decision-making process; (3) applies the standard and composes multiple strategies and provides a meaningful rationale; (4) researches and collects reliable information for supporting evidence of a valuation.

To obtain information regarding the critical thinking skills of postgraduate students at Open University Indonesia, the researchers developed a problem-based learning (PBL) model for an online tutorial of a Mathematics Curriculum Analysis course. A high level of critical thinking was required to understand this subject matter because the expected competency was a student-owned ability to analyse the school mathematics curriculum and its learning problems. Additionally, these critical thinking skills were also needed so that the students could research alternative solutions for mathematics curriculum problems based on theoretical study as well as results from the relevant research.

PBL was used in this study because the previous research indicates that this method could stimulate the students' critical thinking skills through problem solving. PBL is a motivating, challenging and exciting problem solving process (Barrows, 1997). Savery (2006) stated that PBL could develop a specific skill including critical thinking. Savery added that PBL could enhance student's ability to (1) analyse and solve a complex problem; (2) find and evaluate the problem by using appropriate resources; (3) cooperate; and (4) effectively communicate by using intellectual knowledge and skill. By examining the definition, it appeared that critical thinking skills could be improved through PBL.

The students' critical thinking skills would be observed through the discussion forum on a PBL-based online tutorial application. Wee (Morin, 2012) stated that critical thinking skills could be obtained through the problem-solving process of PBL learning, particularly in group brainstorming settings. According to Arends in Trianto (2007), discussion occurs in the situation between an educator and learners or between a learner and other learners who converse and share ideas and opinions. However, Samani (2007) said that discussion is a sharing of opinion among two or more persons that aims to obtain an agreement regarding the perceived problem.

With the development of the Internet, discussions can be performed online. Arends in Trianto (2009) stated that online discussion provides enough time and space for students to think so that critical thinking skills can be improved. In developing critical thinking skills, the student must be able to respond to a question that directs the student to think, to interact and to reflect during the online discussion activity. Thus, online discussion is a method that provides a problem that learners solve together in an online group. In further activities, learners were instructed to use critical thinking in solving existing problems.

Critical Thinking Skills

Critical thinking is reasonable and reflective thinking that relies on decision making about what must be trusted or performed, according to Ennis (Hassoubah, 2004), while Paul and Elder (2003) state that critical thinking is an individually taught process to reach a conclusion.

They added that critical thinking skills could be sorted into eight functions where each function represents the crucial part of a learner's thinking and resultant quality: (1) Question at issue: awareness of questioning something that was needed; (2) Purpose: any appropriate needs for the objective or result was accomplished through the inquiry process for objective identification; (3) Information: answered the question using the proper information and utilised this information as a material for developing ideas and synthesising new thinking; (4) Concepts: a theory, definition, rule or law that directs thinking or action. The concept is a construction of the human mind that describes a frame of thinking and action; (5) Assumptions: statutes whose truth need not be proved; (6)

Points of view: the differentiation of someone's viewpoint in reasoning and thinking. It was a part of critical thinking that involved interpretation and understanding processes; (7) Interpretation and inference: combining new information with the existing viewpoints, concepts or assumptions. Interpretation was required to understand the data and to draw conclusions; (8) Implication and Consequences: the result of reasoning and thinking because critical thinking was not a single entity but a process to generate something.

With technology and information development, critical thinking could be part of the learning process. Critical thinking is a mental activity in evaluating opinion and drawing a conclusion, so it could be used in building trust and making decisions (Gilster in Astleitner, 2010). Critical thinking is the most important ability when using the Internet because through the Internet, there is incorrect, incomplete information, so the learners should be able to readily criticise the information (Reinman in Astleitner, 2010).

PBL

According to Savery (2006), PBL is learning that centres on learners by empowering them to conduct research, integrate theory and practice, and apply knowledge and skills for developing appropriate solutions for a defined problem. PBL centres on the learner's pedagogy. This learning focus is active and collaborative and engages learners' knowledge of real-world or case problems (Tambourish, 2012).

A PBL educator must give learners the freedom to take responsibility for learning. According to Kauffman (1998), the facilitator role in PBL was effective when the educator: (1) stimulated the communication of educator and learners; (2) provided ample opportunity for learners to independently find what they needed in the learning material instead of pushing knowledge from the teacher; (3) intervened only when the learner's discussion had veered off the determined path; (4) functioned as a resource person for the learners instead of the final decision maker; (5) provided additional value for the learners who searched for extra material for learning about other opportunities.

Each type of learning has advantages and disadvantages. According to Hajriana (2010), PBL's advantages were (1) use of PBL would make learning meaningful. Learners who learned to solve a problem would apply their own knowledge or try to find out the required knowledge. Learning could be more meaningful and expandable when learners dealt with a situation where the concept should be applied and (2) integration of their knowledge and skill simultaneously and apply them within the relevant context. Their learning would be suitable with real conditions and not theoretical, so the problems would be in applying concepts. Theory would be found at once during the learning; (3) PBL could improve critical thinking skills, raise initiatives for working, provide internal motivation for learning, and develop international relationships. The PBL's disadvantages were (1) requirement of complex learning preparations such as tools, problems and concepts; (2) difficulty finding relevant problems for learning (a given problem would have to meet the criteria for a good problem); (3) PBL takes a long time.

The application of PBL's model on online mathematics curriculum analysis course tutorial

The online tutorial of Open University Indonesia was an internet-based tutorial service offered by Open University in which students participated through an Internet network. The online tutorial activities were comprised of: (1) dissemination of initiation material from tutor to student, which amounted to 8 times (once weekly); (2) at least 3 student assignments, and (3) question/answer activities between tutor and students and among students.

The application of the PBL model on an online mathematics curriculum analysis tutorial was conducted based on Arends's theory (Trianto, 2007), which outlined the application steps of PBL in learning. Five phases were needed for implementing PBL. They were: (1) orienting the learners towards the problem; (2) organising the learners for learning; (3) guiding the individual in group inquiry; (4) developing and presenting student work; (5) analysing and evaluating the problem solving process. From these phases, a PBL-based online tutorial was developed as follows:

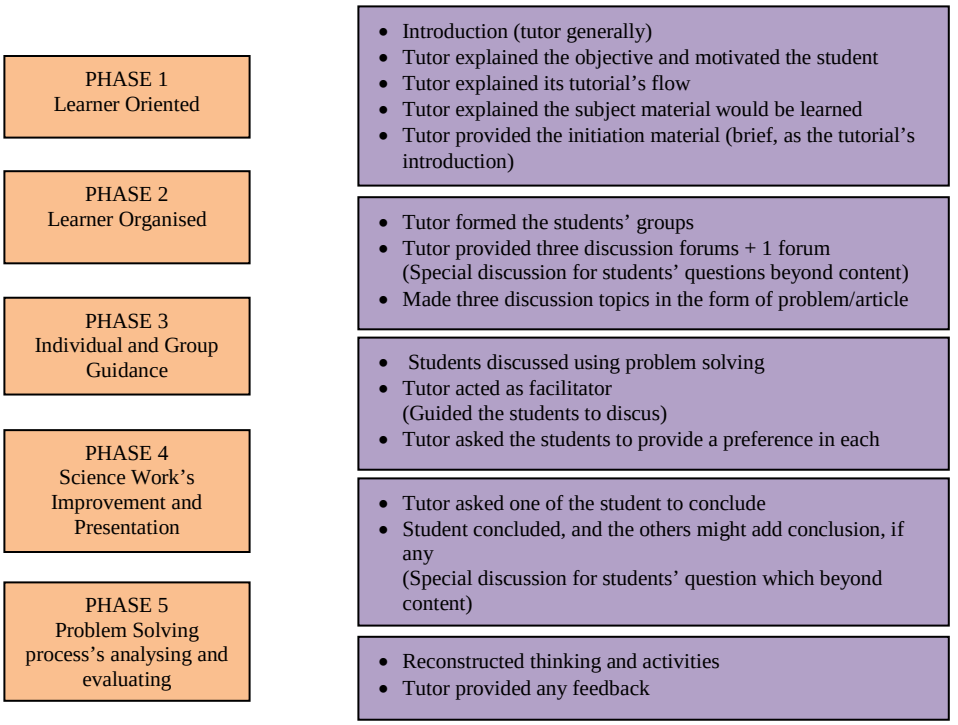

Figure 1 Five phases for implementing a PBL-based online tutorial

During the phase of orienting the learners toward the problem, the tutor explained and motivated the student, explained the tutorial flow and explained the learned material. In addition to that, the tutor also submitted the initiation material. All activities of this stage were conducted on the first day. The researcher also conducted the phase of organising the learners on the first day. In this phase, the tutor formed three groups of students and three problems for discussion by each group on the discussion forum. Furthermore, the third phase, guided inquiry, was conducted on the first day up to the sixth day. In this stage, students began to discuss the prepared discussion topic. In this activity, the tutor only acted as facilitator.

The next phase was to develop and to present student work. The tutor asked the students to conclude their discussion so that other students might add comments when the conclusion was completed. This activity was

conducted on the sixth day. Analysing and evaluating the problem solving process were the last phase of this model. During the phase, the tutor asked the students to reconstruct their thinking and activities that had been conducted during their learning process. Feedback was conducted in this phase on the seventh day.

All phases were conducted in one week. Because the online tutorial period was conducted over eight weeks, PBL's phases were conducted eight times online. In this tutorial, the tutor was required to access the tutorial every day, while students were required to access the tutorial once a week minimum. In each week, students were required to participate in a discussion. The following were eight discussion topics that developed during the tutorial.

Table 1 Topic of discussion

Week	Topic
1	Curriculum development problems (teacher, school management, education bureaucracy elements)
2	Curriculum implementation problems of Education Level Unit [*Kurikulum Tingkat Satuan Pendidikan (KSTP)*] at school (teacher, school management, education bureaucracy elements)
3	Curriculum implementation problems 2013 (teacher, school management, education bureaucracy elements)
4	Math teaching problems (Geometric, Algebra, Statistic)
5	Analysis of lesson plan
6	Analysis of the case study
7	Analysis of the learning article
8	General discussion

Methodology

The research subjects were students in a postgraduate mathematics education program at Open University, totalling 40 students. Each student was a mathematics teacher at different schools. The research was conducted during online tutorial period 2013.1. During this period, the researcher applied the PBL-based online tutorial and analysed the students' thinking skills. The data were collected by participant observation. In this case, the researcher performed any observation of

students while the discussion occurred. The evaluation of the students' critical thinking skills was adapted from Johnson's theory (2002) in his writing *Using Thinking Skills to Enhance Learning* as follows:

1. ***Inferring:*** Go beyond the available information to identify what may reasonably be true.

   Thinking Frame
   (a) Identify what is known.
   (b) Identify similar situations or important knowledge.
   (c) Make a reasonable guess based on 1 and 2.

2. ***Compare and Contrast:*** Find similarities and differences between/ among two or more items.

   Thinking Frame
   (a) Look at all items.
   (b) Find the similarities.
   (c) Find the differences.
   (d) Conclude and describe.

3. ***Analyse:*** Break an item or event down into its component parts.

   Thinking Frame
   (a) Look at the item or event.
   (b) Identify important parts.
   (c) Describe each part.
   (d) Describe the whole in terms each part

4. ***Supporting a Statement:*** Used appropriate reasons, detail, or examples to support a statement, idea, or conclusion.

   Thinking Frame
   (a) Make a statement or claim.
   (b) Gather information/data to support the statement.
   (c) Organize the information.
   (d) Describe the original statement in terms of the new information.

5. ***Decision Making:*** Examine the options and alternatives in order to decide on a course of action.

   Thinking Frame
   (a) Identify the problem or decision.
   (b) Generate decision options.
   (c) Evaluate costs and rewards of options.
   (d) Make a choice based on the above.

6. ***Ordering:*** Arrange events, concepts, or items in sequential order based on a criterion.

   Thinking Frame
   (a) Look at or define a criterion.
   (b) Look at the whole.
   (c) Arrange items within the whole according to the criterion.
   (d) Describe the whole in terms of the new order.

7. ***Evaluation/Critique:*** Make a formal critique based on a set of criteria.

   Thinking Frame
   (a) Look at or define a criterion.
   (b) Look at the subject.
   (c) Compare the subject to the criterion.
   (d) Describe the subject relative to the criterion.

8. ***Creating Groups:*** Impose order on a field by identifying and grouping common themes or patterns.

   Thinking Frame
   (a) Look at the whole.
   (b) Identify reoccurring items, themes, or patterns.
   (c) Arrange into groups.
   (d) Describe the whole in terms of groups.

The data were analysed using a qualitative descriptive method. The analysis steps were as follows:

1. Measuring the students' critical thinking skills was done by making a rubric of the critical thinking skill theory according to Johnson (2002) with the following criteria: *high proficiency*, *proficiency*, *some proficiency* and *no/ limited proficiency.*
2. The test results were scored according to a rubric.
3. All students on each aspect were summed and their percentages were calculated. For example, the percentage of each aspect was *P*.

   $Y \times 100\%$
   X = score total amount per aspect of each point
   Y = minimum score of each aspect

Then, it was categorised according to the category of the following percentage results:

$90.00\% \leq P$	Very high
$80.00\% \leq P < 90.00\%$	High
$65.00\% \leq P < 80.00\%$	Medium
$55.00\% \leq P < 65.00\%$	Low
$P < 55.00\%$	Very Low

Adapted from a score conversion of Nurkancana (1986)

Result and Discussion

Overall, the results for the students' critical thinking skills were good. The best accomplishment of students was primarily in the category of Compare and Contrast at 91.25% and the lowest accomplishment was 70.625% for the category of Creating group.

Table 2 Result of critical thinking skills

Aspect	Percentage	Category
Inferring	88.75%	High
Compare	89.00%	High
Compare and Contrast	91.25%	Very High
Analyse	86.25%	High
Supporting a Statement	86.25%	High
Decision Making	89.75%	High
Ordering	81.875%	High
Evaluation/Critique	86.25%	High
Creating Group	70.625%	Medium
Investigation	88.125%	Low

During the first and second session, the researcher provided curriculum problems that related to the daily activities of the students as schoolteachers. In the first session, students dealt with curriculum development problems. In the second session, students discussed the curriculum implementation problems of Education Level Unit (*KTSP*) in the school. Both problems were reviewed in consideration of three different elements, namely teacher, school management and education bureaucracy. It appeared in the discussion forum that students were very excited to participate in the discussion because the topics related to their daily experiences. This observation coincides with Muslimin's statement (2000) that thinking skills are one of the resources students need in facing present knowledge and technology development. Skills for success are determined by thinking skills, particularly in solving life problems.

Other questions that triggered the students' critical thinking were in the third session regarding the curriculum 2013. The curriculum 2013 was the prevailing curriculum in Indonesia started in 2013. The next question was "Curriculum 2013, which presently prevails, emphasises the moral value and manner sides of learning. However, the government required students to pass the National Examination, so many students and teachers ignored the moral topics. What is your response?"

Based on the answers, students' responses varied. One of them stated, "Curriculum 2013 was a curriculum designed to prepare learners for

dealing with a future challenge. Curriculum implementation 2013 in this school had an aptitude value that was useful to form Indonesian humans in whole because this curriculum contained some human aptitudes. They were spiritual, social, and skill, so that these matters would form Indonesian human character in whole. I agreed with the national examination, as long as it wasn't intended for determining graduation, but only as a quality mapping tool for the government. If the curriculum 2013 was applied, but the evaluation used the national examination, that meant inconsistency. One of its solutions was to restore the national examination to the school and the government only conducted the quality control at the school. Actually, it was in line with the education decentralization spirit and National Education System Law, so that the moral value of student and teacher could be monitored."

It could be seen from the answers that students could have conducted an analysis on the curriculum policy; they could prevail and provide a solution to solve the problem. This conclusion is in line with Nasution (2008) who stated that thinking skills also served as a means to accomplish the education objective so the student could solve a high-level problem.

As presented on Table 2, the category of Compare and Contrast obtained the highest results. The biggest accomplishment of students for this category was in the fourth session. In this session, the given question was about mathematics learning. The given problem was about the differentiation of learning methods for congruence and geometry for students in elementary school, middle school, and high school. Some students had connected the problem solving with math learning theory.

The best result showed that critical thinking skills are one of the basic intellectual resources that are crucial for everyone. In addition, according to Penner (Muslimin, 2000), this ability is a fundamental part of human maturity. Critical thinking is reasonable and reflective thinking that suppresses the decision making about what must be trusted and performed (Hassoubah, 2002). The results of group creating had the lowest value, which was 70,625%. Students had trouble imposing order on a field by identifying and grouping common themes or patterns through online discussion.

In the fifth session, students were required to make learning plans for teaching material related to the presented case. In the sixth discussion, students dealt with mathematics learning problems in the class with case form. In the first case, the teacher explained, "Two round numbers added to 84. What is the largest number that could result from multiplying both round numbers?" In the second case, the teacher taught "the ball width." These cases could improve the student's critical thinking skills, particularly for the category of *Decision Making*. In the beginning, the students identified the teacher's advantage or disadvantage during the teaching activities, and then they made a decision on a suitable learning strategy for teaching material in that case.

Muslimin (2000) stated that critical thinking was a mental process that organised decision making for problem solving by analysing and interpreting the data in scientific inquiry activities. The conclusion of this research result was a decision made by students. A student's critical thinking skills were helpful in making decisions exactly, systematically, correctly, and logically by considering multiple viewpoints or aspects. This decision became a solution for the problem.

Conclusion

The application of problem-based learning for an online mathematics curriculum analysis tutorial could improve students' critical thinking skills. Overall, the students' critical thinking skills were good. The application had some constraints besides the time limit of the tutor, so it was very difficult to conduct any observation during the discussion. In addition, students who participated in the established tutorial were not heterogenic. Students who registered for the class were mathematics teachers from a similar area.

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