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Using Problem-Based Learning Approach with Scaffolding Technique to Enhance Students' Mathematical-logical Thinking Ability

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Abstract

The objective of this research was to analyze students' mathematical-logical thinking ability. This research used the quasi-experimental method with randomized control group post-test only design. The sample of research was 82 students of the seventh grade which were chosen by using cluster random sampling technique. The experimental class, taught using problem-based learning approach with scaffolding technique, consisted of 40 students while the control class, taught using conventional learning, consisted of 42 students. The research instrument was mathematical-logical thinking ability test. The findings showed that students in the experimental class had higher mathematical-logical thinking ability than those who were taught by using conventional learning. It can be concluded that problem-based learning approach with scaffolding technique had the significant effect on students' mathematical-logical thinking ability.

Keywords: Problem-based Learning Approach, Scaffolding Technique, Mathematical-logical Thinking Ability

1 INTRODUCTION

Mastering mathematics is important because it develops human thinking ability. In the process of learning mathematics itself, thinking is an essential activity. Johnson and Rising (1972) define mathematics as a paradigm, a scheme of logical proof organization, and a language which uses a careful, clear and accurate-defined term. Moreover, mathematics is an active, dynamic, and generative process. Mathematics contributes a lot to improving students' common sense, logical, systematic, critical, objective and open-minded thought in the process of problem-solving. To be able to think logically, students should be familiar in responding of what, why, and how-questions.

Based on TIMSS data, Indonesian students still have low logical thinking ability. The students can solve the simple problem of mathematics but not the more complex one. Students were not able to communicate problems logically, conclude and use a complex information to solve the problem. Based on the test result of PISA (Program for International Students Assessment), it was found that Indonesian learner cannot improve their thinking ability well and thus, they were not able to handle a complex situation (PISA, 2012). Therefore, there should be some efforts to improve students' critical and logical thinking ability.

The observation result which was conducted at the seventh grade of SMP Al-Hasra (Al-Hasra Junior High School) showed that students' logical thinking ability was dissatisfying. Based on the test which was administered by giving four questions related to quadrangle material, the students' average score of logical thinking activity was 49 out of 100. It was very low for logical thinking ability. Presumably, it happened as the influence of learning process.

Some factors which influence the learning process were teachers' roles in motivating students to learn optimally and the effectiveness of learning approach. Teacher-centered reduces students' thinking ability since students are treated as the passive object only. Therefore, here was proposed an innovative and appropriate technique namely problem-based learning (PBL) as an effort to enhance the quality of learning process.

Problem-based learning improves students' energetic in the process of learning. This approach requires students to be an active, logical and critical

thinker. At the beginning of the process, students were stimulated by attaining a problem, not only memorizing as usual. Moreover, students can deliver their conclusion related to their answer. However, based on previous related studies of problem-based learning, students would get difficulties if they are asked to complete any assignment without learning the material before. Scaffolding technique allows teachers to control and assist the students in the process of problem- solving.

Problem-based learning is started by giving the students some problems related to the available fact and data. Students are then asked to formulate and analyze the problem. Referring to their hypothesis, students, then obtain data to be tested. The final step is formulating the problem solving based on the data. Students will be familiar to solve problems by identifying the facts, reasoning, and concluding. They will be assisted until they achieve the higher thinking ability level.

Based on the discussion above, the problem formulation of this research was How was mathematical-logical thinking ability of students who were taught by using problem-based learning with scaffolding technique? How was mathematical-logical thinking ability of students who were taught by using conventional learning? Was mathematical-logical thinking ability of students who were taught by using problem-based learning with scaffolding technique higher than those who were taught by using conventional learning?

This research was aimed to analyze mathematical-logical thinking ability of students who were taught by using problem-based learning with scaffolding technique, to analyze mathematical-logical thinking ability of students who were taught by using conventional learning, and to analyze mathematical-logical thinking ability of students who were taught by using problem-based learning with scaffolding technique and those who were taught by using conventional learning.

2 LITERATURE REVIEW

2.1 Mathematical-logical Thinking Ability

Thinking is the activity of obtaining ideas and information and linking parts of the information to the problem. Poedjawijatna (as cited in Saragih, 2006) says that people who think logically will obey the logical rules. Thus, logical thinking follows a certain system. The logic term comes from Greek that is *logos* which means speech, words, and definition. To think accurately, it is required considerable rules or standards to gain rational truth (Saragih, 2006). Thinking is a general process of identifying an issue in mind, while logic is the way of thinking. Therefore, two people who think the same thing may have different conclusion since the first one think logically while the one does not. Logical thinking is a characteristic of a logical-rational person.

Logical thinking is a process of operating mind consistently to gain a conclusion. Logical thinking is involved in a condition or problem which needs structure, the relation between facts, argumentations and understandable, logical series. Therefore, think logically, and common sense cannot be separated.

Based on the discussion above, the instrument of this research was used to measure logical thinking ability with indicators such as:

1. Identifying the relationship between the facts in problem- solving.
2. Solving the problem by reasoning.
3. Making a conclusion based on similarities of two processes.

2.2 Problem-based Learning Approach Scaffolding Technique

Problem-based learning approach is started by serving a problem or issue which is relevant to the material to stimulate the students to understand the concepts, think critically, learn independently, work in the team, and solving a problem (Sumarmo, 2013).

Boud and Feletti (1997) state that problem-based learning is an educational significant innovation to improve reflective, critical, active and open-minded thought in long life education. Essential for PBL is that students learn by analysing and solving representative problems (Dochy, F at.all, 2003). The objective of problem-based learning is to develop students' critical thinking and logical systematic analysis by exploring the data empirically to develop scientific attitude (Wina Sanjaya, 2011).

However, since problem-based learning has some weaknesses, scaffolding technique was applied to cover the limitation. Scaffolding technique avoids wasting time that often happens when students are getting confused as they get problem before achieving material before. Scaffolding technique guided the students to recognize the problem and its' objectives to be able to solve the problem and improve their critical thinking ability.

Knowledge or concept is developed step by step continuously in the social context. In scaffolding, students are given the complex and realistic tasks to be solved with proper assistance (Ridwan, 2013). If a student cannot move from his/her low cognitive level,

she/he needs scaffolding from the teacher or classmate, but it would be not necessary anymore if he/she can improve his/her cognitive competencies (Warsono, 2012).

Referring to the literature review above, generally, problem-based learning with scaffolding technique would be implemented as follows.

1. Directing students to the problem.
2. Managing students to learn.
   Students define the problem step by step under teacher's guidance.
3. Guiding to individual and teamwork inquiry.
   a. Students were directed to gain facts and information by using a method and then manage them.
   b. Students make a hypothesis of the problems.
   c. Students study the information and data in teamwork under teacher's control.
4. Developing and serving the result.
   a. Students conclude the problem-solving alternatives collaboratively.
   b. Students test the result (solution) of problem-solving in their team.
5. Analyzing and evaluating the process of problem-solving.

3 METHOD

This research was conducted by using quasi-experimental method and Post Test Only Control Design (Sugiyono, 2010). The population was the seventh-grade students of SMP Al-Hasra. There were two classes which were chosen by using simple cluster random sampling technique. The first was the experimental class which was taught by using problem-based learning with scaffolding technique, and the second was the controlled class which was taught by using conventional learning. Both of classes were given the same test after achieving different treatment.

The data of this research was the students' scores of mathematical-logical thinking ability which was obtained by using mathematical-logical thinking ability test.

4 FINDING AND DISCUSSION

4.1 Finding

4.1.1 Students' Mathematical-logical Thinking Ability of the Experimental and Controlled Class

The lowest score of the experimental class was 43 while the highest score was 96. Meanwhile, the lowest score of the controlled class was 29, and the highest score was 82. The students' score of mathematical-logical thinking ability from both groups was presented in Table 1.

Table 1. Students' Mathematical-logical Thinking Ability of Experimental and Controlled Class

Descriptive Statistic	Class	
	Experimental	Controlled
Students' Number	40	42
Maximum Score (X maks)	96	82
Minimum Score (X min)	43	29
Mean ($\bar{x}$)	70,85	57

Table 1 above shows the difference of experimental and controlled class statistic. The mean of the experimental class was higher than the controlled class with deviation 14.06.

4.1.2 Students' Mathematical-logical Thinking Ability of Experimental and Controlled Class in Each Indicator

Students' mathematical-logical thinking ability was focused on three indicators; identifying the relation between the facts in problem-solving, solving the problem by reasoning, and concluding based on similarities of two processes. Students' mathematical-logical thinking ability scores of the experimental and the controlled class bassed on each indicator were presented in Table 2.

Table 2. Students' Mathematical-logical Thinking Ability in Each Indicator

No	Indicator	Ideal Score	Experiment class		Control class	
			$\bar{x}$	%	$\bar{x}$	%
1	*Identifying the relation between the facts in problem-solving*	12	7.5	62.5	6.31	52.58
2	*Solving the problem by giving reason and opinion*	8	6.68	83.44	5.31	66.37
3	*Making conclusion based on similarities of two process*	8	5.5	68.75	4.55	56.85

The difference of ideal score for each indicator depended on number of questions item related to the indicator. Each item has the maximum score of 4. Table 2 shows that in general students of the experiment class express higher percentage in all indicators. The highest percentage is shown by the students of the experiment class in the second indicator, that is, 83, 44%. This indicator also shows the most significant difference of the percentage between students of the experiment class and the control class, i.e., 17.07%. One reason that might be the cause of this result is different teaching approach applied in both classes. Whilst the experimental class was treated by using scaffolding technique which facilitated students to give reason and opinion to their answers, the control class is only treated with common problem-based teaching.

4.2 Discussion

This research was conducted on the material of triangle. One of the indicators of mathematical-logical thinking ability was identifying the relation between some facts in problem-solving to know students' ability in recognizing problem by studying the relationship. Based on the normality and homogeneity test, it was found that the data of both classes were normal and homogenous. After conducting a t-test, it was found that $t_{observed}$ (4.59) > t_{table} (1.99) in significant level $\alpha = 0.05$.

For the question which asks the way of gain EDF angle, students of the controlled class answered correctly but too briefly without any explanation. In contrast, the students of the experimental class systematically convey the explanation how to gain EDF angle. They got EDF angle by finding the 180°-vertical angle firstly, then finding the sum of three angles of the triangle. The controlled class students only answered without any clear explanation of vertical angle and the total three angles of the triangle.

Students of the experimental class can explain clearly because in the learning process they were trained to know where the answer comes from. Furthermore, the students were able to identify and recognize the relation between the problem and their prior knowledge. Therefore, the mathematical-logical thinking ability of the experimental class students was higher than the controlled class.

The second indicator measured the ability of reasoning. The controlled class students only stated "less than 90°" without any clear explanation of why the angle is lesser than 90°. There was no picture and the number of angles which were formed by the triangle. In contrast, the students of experimental class drew and from the triangle and the angles correctly. It showed that the experimental class students answered the question systematically and were able to give a specific reason to support their answer. It happened because the students of the experimental class were familiar with discussion technique, delivering opinion and analyzing the problem to find the solution. They were able to solve the problem more effective and efficiently than those from the controlled class.

The third indicator measured students' ability to conclude based on the similarities of two processes. The students of the experimental class were familiar with searching proper information which can be used in problem-solving, therefore they could make a conclusion based on the similarities of two processes. They gave examples of the requirement of drawable and un-drawable pictures. In contrast, the students of controlled class only gave a short reason without any conclusion. It can be concluded then that the students of experimental class could solve the problem by searching proper information before and delivering what they have known systematically because they have been trained in scaffolding technique to identify and then conclude the similarities of two processes.

In conclusion, problem-based learning with scaffolding technique affected students' mathematical-logical thinking ability, especially in the second and third indicators. Meanwhile, the first indicator also effected but was not as significant as the others. In other words, students who were taught using problem-based learning with scaffolding technique had higher mathematical-logical thinking ability than those who were taught using conventional approach.

5 CONCLUSION AND SUGGESTION

Based on the finding and discussion about the effect of problem-based learning with scaffolding technique on students' mathematical-logical thinking ability, it can be concluded that:

1. The mean of mathematical-logical thinking ability of the experimental class students who were taught using problem-based learning with scaffolding technique was 70.85. The percentage of students' ability to identify and recognize the relation between some facts in problem-solving was 62.5%, the ability to solve the problem and giving reason was 83, 44%, and the ability to make a conclusion based on similarities of two processes was 68.75%.
2. The mean of mathematical-logical thinking ability of controlled class students who were

taught using conventional approach was 57. The percentage of students' ability to identify and recognizing the relation between some facts in problem-solving was 52.58%, the ability to solve the problem and giving reason was 66.37%, and the ability to make a conclusion based on similarities of two processes was 56.85%.

3. Based on the analysis of post-test score using a t-test, it was found that students who were taught using problem-based learning with scaffolding technique had higher mathematical-logical thinking ability than those who were taught using conventional approach.

Finally, based on the findings, the researcher delivered some suggestion as follows.

1. In designing classroom activities by using problem-based learning with scaffolding technique, teachers should prepare everything properly such as the allocation of time, the material, classroom management, and so on to improve learning quality.
2. Students must be active in delivering ideas, identifying, reasoning, and concluding to develop their mathematical-logical thinking ability.
3. The institution has to support the learning process by improving school sources and facilities to help teachers to implement some various teaching strategies and methods, especially problem-based learning with scaffolding technique to improve students' mathematical-logical thinking ability.
4. This research was limited to the material of triangle. Therefore, it is required further research to study the other mathematical-logical thinking ability which can be improved in a different level and material.

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