The Effect of Problem Based Learning on Mathematical Critical Thinking Skills of Junior High School Students

Fitriana Yolanda
Program Studi Pendidikan Matematika Universitas Islam Riau. Jalan Kaharuddin Nasution No.113, Marpoyan, Pekanbaru, Riau, Indonesia.
fitriayan@edu.uir.ac.id

Abstract. This research aims to know the effect of problem based learning on mathematical critical thinking skills of junior high school students. This research is a quasi-experimental study with a non-equivalent control group design. This research was carried out in class VIII in one of the junior high school in Bandung, West Java Province, academic year 2014/2015 on relations and functions. Determination of the sample was conducted with purposive sampling and two classes were selected as the research sample, namely class VIII.C as the experimental class that received problem based learning and class VIII.F as the control class that received learning with the scientific approach. The results showed that the average post-test for problem based learning was 42.16 and the average posttest of the learning class with a scientific approach was 35.27. Then after being analyzed using the t-test obtained a significance value of 0.024 < 0.05. It can be concluded that there is an effect of problem based learning on mathematical critical thinking skills of junior high school students.

1. Background
Critical thinking is one of the high-level thinking skills that needs to be developed in mathematics learning from elementary to high school. Critical thinking is a directed and clear process used in mental activities such as solving problems, making decisions, persuading, analyzing assumptions, and conducting scientific research [1]. A person who has critical thinking skills is able to think of ways to solve problems with certain steps. People who have critical thinking skills will always be active in understanding and analyzing the information obtained so that critical thinking skills include intellectual processes related to the process of understanding, analyzing, synthesizing and evaluating and applying information based on experience and observation. Therefore a systematic process related to critical thinking encourages students to formulate and evaluate students' self-beliefs and opinions.

Critical thinking is the basis of students' ability to focus and clarify, analyze, understand and estimate a solution to problems with self-regulatory and regular assumptions [2]. In addition, based on the results of Asiedu [3] research states that students with low mathematical skills are a result of the inability of students to think critically and analyze mathematical concepts systematically. In line with this opinion, according to Juano and Pardjono [4] states that critical thinking guides students in determining which information is acceptable and which information is not acceptable, so students who think critically are able to distinguish which ones are trustworthy. According to Ruseffendi [5], it cannot be denied that the presumption that is currently developing in most students is mathematics is a difficult and unpopular field of study, only a few are able to explore and understand mathematics as a
science that can improve critical thinking skills. Karim [6] in his research revealed that the average critical thinking ability of junior high school students is in poor qualification. From this fact it can be generalized that critical thinking skills in students both at the elementary and secondary levels are still has some problem.

If you look further at mathematics learning that occurs in classes, generally it has not yet presented learning that fosters the ability to think critically. Learning in the classroom is still focused on the teacher as the only source of knowledge with the lecture method is still the main choice of learning methods. The learning process that occurs in one direction which only emphasizes the cognitive aspects of students only while the affective and psychomotor aspects of students are not being prioritized. Students only "know" and do not "experience" what they are learning. Such learning does not develop students' high-level thinking skills. The impact of students’ attitudes toward lessons, especially mathematics, tends to be negative, which ultimately can lead to low student learning outcomes.

Based on preliminary studies conducted on SMP Negeri 15 Bandung towards 37 students, students' ability to generalize from function problems is still on a sufficient scale. The following questions are given: Consider the table below:

| X    | 2 | 3 | 4 | ... |
|------|---|---|---|-----|
| Y    | 10| 14| 18| ... |

Based on the table above, create a rule that states the relationship between x and y, if it is known that the function is a linear function! Determine the value of y for x = 15!

Based on the research, it was found that students were not able to generalize the function problems correctly. As a result the solution given to answer the problem is not right. In addition according to observation in classes also showed that some of the students who faced with the problem of thinking critically not eager to solve it and tend to give up without trying first. Based on the results of these studies it can be concluded that students' critical thinking skills are still low.

Based on the above studies, it can be said that students' critical thinking skills in Indonesia still have not achieved satisfactory results. Therefore we need a learning that can develop students' mathematical critical thinking skills, namely problem based learning. According to Rusman [7] Problem Based Learning is learning that uses real (authentic) unstructured problems and is open as a context for students to develop problem solving and critical thinking skills while building new knowledge.

Problem based learning starts with presenting the problem whose solution requires student collaboration [8]. Problem Based Learning or PBL is used to support high-level thinking (HOT or higher order thinking) in problem oriented situations, including learning "how to learn" [9]. In line with the above opinion, Fathurrohman [10] states that Problem Based Learning is a learning model that involves students to solve a problem through the stages of the scientific method so that students can learn knowledge related to the problem and at the same time have the skills to solve problems. The advantages of the problem-based learning model according to Hamdayama [11] are that students are involved in learning activities so that their knowledge is properly absorbed, students are trained to cooperate with other students, and students can obtain knowledge from various sources.

Sianturi el al [12] in his research revealed that several critical thinking indicators used were: (1) Elementary clarification, (2) Basic support, (3) Inference and (4) Strategies and tactics. Furthermore, the formulation of the problem used is the mathematical critical thinking ability of students who take learning Problem Based Learning (PBL) models higher than students who take conventional learning. Furthermore, research conducted by Fakhriyah [13] revealed that some weaknesses in problem-based learning are the independent learning activities of each student is highly demanded at the implementation stage of the learning process, some stages of learning cannot be done in a relatively short time and in the learning process some students are still some rely on friends in their respective groups.

The difference in research conducted by the author with other research that is in this study the authors use five indicators of mathematical critical thinking ability consisting of (1) looking for
similarities and differences, (2) making generalizations, (3) making and considering decisions and applying principles, (4) ability to give reasons, and (5) identify problems. While the formulation of the problem in this study is whether there is an effect of problem-based learning on the mathematical critical thinking ability of junior high school students. During the learning process, student activities are quite conducive and effective. Students also look active and enthusiastic in solving problems, discussing, asking questions, asking friends for an explanation when discussing, giving different opinions, or refuting a friend’s answer by giving reasons. This is what adds to the more conducive and enthusiastic learning atmosphere, although there are some students who are often silent, ashamed to give ideas, just write without commenting or giving opinions.

According to Ibrahim and Nur [14], problem based learning is not designed to help provide as much information as possible to students and aims: (a) Helping students development: (1) ability or thinking skills; (2) problem solving skills; (3) intellectual skills; (b) make students learn various roles of adults (learning to be) with their involvement in real experiences or simulations; (c) make students as autonomous and independent learners. Based on the description above, the authors hope that problem-based learning influences students’ critical thinking skills mathematically. So the title of this research is "The Effect of Problem Based Learning on Mathematical Critical Thinking Skills of Junior High School Students"

2. Research Methods

This research was conducted in class VIII in one of Junior High Schools (SMP) in Bandung, West Java Province in the 2014/2015 academic year. Determination of the sample is done by purposive sampling, namely sampling techniques based on certain considerations [15], namely classes that have equivalent academic characteristics and abilities, so that two classes are selected as research samples namely class VIII.C as the experimental class and class VIII .F as a control class. In the experimental class, problem based learning was carried out. In the control class learning was carried out with a scientific approach. This research is a Quasi Experimental study consisting of two research groups. The research design used in this study is the design of non-equivalent control groups [5]. The instruments in this study were obtained through tests of students' mathematical critical thinking skills (pretest and posttest) arranged in the form of descriptions. In this study, before the instrument was used, the instrument was first tested on students who had obtained material related to what they were going to study. The test results of students' mathematical critical thinking ability tests were then analyzed to determine the validity of the items, the reliability of the test, the distinguishing power of the test items, and the level of difficulty of the test items. This trial was conducted to obtain a measuring instrument that was as expected. Then the results of tests of students' mathematical critical thinking skills (pretest and posttest) were analyzed using the normality test, the variance homogeneity test and the t-test. This research uses SPSS software program version 21 for windows for processing data.

3. Result and Discussion

Result

3.1. Mathematical Critical Thinking Ability

| Value | Problem Based Learning | Learning with Scientific Approach |
|-------|------------------------|-----------------------------------|
|       | N | X_{min} | X_{max} | \bar{x} | Sd | N | X_{min} | X_{max} | \bar{x} | Sd |
| Pretest | 37 | 0 | 25 | 7.43 | 6.934 | 37 | 0 | 25 | 6.76 | 5.678 |
| Posttest | 37 | 15 | 70 | 42.16 | 13.720 | 37 | 10 | 60 | 35.27 | 11.899 |

Ideal maximum score = 100
The table above illustrates that the average pretest of students’ critical thinking skills in the problem-based learning class and learning class with the scientific approach is not much different. Where the average pretest of mathematical critical thinking skills of students in the problem-based learning class is 7.43 while the average pretest of mathematical critical thinking skills of students in the learning class with the scientific approach is 6.76. So that the average pretest of mathematical critical thinking skills of the students of the two classes is relatively same. However, the posttest average in the problem-based learning class is greater than the posttest average in the class with scientific approach.

3.2. Analysis of Students’ Mathematical Critical Thinking Ability Pretest Score

Analysis of the pretest score was done to determine the students’ critical thinking skills before being given treatment both to students in the class who received problem-based learning as well as to students who received learning with the scientific approach. To determine the right statistical test, the normality test and homogeneity test are first carried out. If the data meets the requirements for normality and homogeneity, the average similarity test uses the t-test, whereas for data that does not meet the normality requirements, it uses a non-parametric test.

| Table 2 Mann-Whitney Test Results Pretest Score Mathematical Critical Thinking Ability |
|---------------------------------|
| Overall pretest                 |
| Mann-Whitney U                  | 667,500 |
| Wilcoxon W                      | 1370,500|
| Z                               | -1.190  |
| Asymp. Sig. (2-tailed)          | .849    |

Based on the table above it can be seen that the value of Sig. (2-tailed) Mathematical Mann-Whitney test of pretest critical thinking ability data is equal to 0.849 which is greater than 0.05, then H0 is accepted. This means that there are no differences in the students’ mathematical critical thinking skills pretest between both classes

3.3. Analysis of Students’ Mathematical Critical Thinking Ability Posttest Scores

The average posttest difference test was conducted to test whether the sample in the problem-based learning class and the class with the scientific approach had different final abilities. The posttest difference test uses 2 Independent Sample test at a significant level $\alpha = 0.05$. The criteria used are if the sig.2-tailed value $> \alpha$ then $H_0$ is accepted and the opposite statement $H_0$ is rejected. The following are the test results for the average post-test score difference:

| Table 3. Posttest Score Test Results Problem Based Learning Class and Learning Class with Scientific Approach |
|--------------------------------------------------|
| Levene's Test for Equality of Variances          | t-test for Equality of Means |
| F       | Sig. | T    | Df  | Sig. (2-tailed) | Mean Difference | Std. Error |
|---------|------|------|-----|----------------|-----------------|------------|
| Overall Posttest Equal variances assumed        | 657  | .420 | 2,308 | 72  | .024 | 6,892 | 2,986 |
| Equal variances not assumed                      | 2,308 | 70,587 | .024 | 6,892 | 2,986 |
Based on the table above, the value of Sig. (2-tailed) t-test posttest mathematical thinking ability is 0.024 < α, so it can be concluded that there is the effect of problem based learning on mathematical critical thinking skills of junior high school students.

Discussion

This research was conducted in one of the junior high school in Bandung in the 2014/2015 academic year, precisely in class VIII (eight). The learning process is conducted in the experimental class using problem-based learning and the control class with the scientific approach. Arend [16] says that there are five stages of problem-based learning, including: (1) Student orientation to the problem; (2) Organizing students to learn; (3) Guiding individual and group investigations; (4) Develop and present the work; (5) Analyze and evaluate the problem solving process.

The learning process in both classes runs in accordance with the lesson plans that have been prepared before learning is conducted. Different treatment gives a significant impact on learning outcomes in both classes. In problem-based learning students are grouped in group learning consisting of 4-5 students, aiming that student can play an active role in the thought process and in teaching and learning activities. According to Trianto [8] states that learning by involving groups will make it easier to find and understand concepts if they discuss with each other. At this stage, the teacher is not just grouping students and let students work together, but the teacher must continue to encourage each student to fully participate in group activities and take responsibility for their work. The teacher ensures that each student is responsible for their respective group work and encourages students to be able to express ideas and opinions and think critically in solving the given problem. Research related to group-based learning was conducted by Somakim [17] who suggested that students' critical thinking skills improved significantly compared to the usual approach.

Ibrahim [14] added that problem-based learning was not designed to help provide as much information to students as possible and aimed at: (1) Helping students’ development: (a) Ability or thinking skills; (b) Problem solving skills; (c) Intellectual skills; (2) Making students learn various adult roles (learning to be) by engaging in real or simulated experiences; (3) Making students autonomous and independent learners. From the beginning students who obtain problem-based learning have been directed to be able to think critically and be able to obtain and use learning resources appropriately so they can find concepts, procedures or mathematical principles both individually and in groups. So it is very possible that students who get problem-based learning have a better mathematical critical thinking skills compare to students who get learning with a scientific approach. This can be seen based on the results of the students' mathematical posttest data, where the posttest average of students who receive problem-based learning is higher than the posttest average of students who receive learning with the scientific approach.

Unlike the experimental class that received problem-based learning, students in the control class applied learning with a scientific approach. The lesson plans that are designed and adopted based on the book are then outlined in the form of worksheets. Learning with a scientific approach used group and individual settings. Learning with scientific approach describes the learning steps into five, namely: observing, asking, trying, associating and communicating [18]. In problem based learning students have the freedom to explore their abilities. Here students are given the freedom to determine ways and solutions to problem solving so that what is obtained and what is used is based on their abilities, whereas in the scientific approach there is a tendency in the process of systematic discovery so that students are not given the freedom to express their ideas.

The mathematical critical thinking abilities measured by the indicators include: (1) Finding similarities and differences; (2) Make generalizations; (3) Making and considering decisions and applying principles; (4) Ability to give reasons; (5) Identifying problems. Based on preliminary data the results of the acquisition of pretest scores, students in both classes had the same mathematical
critical thinking skills. After being given problem-based learning in the experimental class and learning with a scientific approach in the control class, there was a critical thinking skills improvement in the problem-based learning class compared to the class with a scientific. This shows that problem-based learning can influence students' critical thinking skills mathematically. From the results of the pretest of the two classes it was found that the average problem-based learning class pretest was 7.43 with the highest score of 25 and the lowest score of 0 with a standard deviation of 6.934. While the average acquisition pretest score of the class with a scientific approach of 6.76 with a standard deviation of 5.678 and a maximum value of 25 and a minimum value of 0.

Although descriptively there are differences, but based on statistical tests it can be concluded that there is no difference between the average initial ability of students' mathematical critical thinking in both classes, because the values obtained significance of 0.849 greater than $\alpha = 0.05$. This means that the initial mathematical thinking ability of the two classes is not significantly different. Based on descriptive statistics, it was found that the average posttest of problem-based learning class of 42.16 was greater than the average posttest of the learning class with a scientific approach of 35.27. The results of the above data are also needed by testing the difference in the average of the two classes. The average difference test results showed that the average of mathematical critical thinking skills posttest score of students who received problem-based learning was higher than the posttest average of students who received learning with a scientific approach with a significance value of 0.024 smaller than $\alpha = 0.05$. Thus it can be concluded that there is the effect of problem based learning on mathematical critical thinking skills of junior high school students. This achievement is strengthened by research conducted by [4] which states problem posing learning affect students' critical thinking skills.

4. Conclusion
Based on the results of the analysis, findings and discussion described in the previous chapter, it was found that the average post-test for problem-based learning class was 42.16 greater than the average posttest of the class with a scientific approach with 35.27. Furthermore, after using posttest data analysis using the t-test, a significance value of 0.024 was smaller than $\alpha = 0.05$. The conclusions from this research show that there is the effect of problem based learning on mathematical critical thinking skills of junior high school students. Based on the conclusions obtained, it is advisable for teachers to pay attention to time management in order to be as efficient as possible, because problem-based learning requires considerable time. Furthermore, students should think more critically to improve their ability to solve mathematical problems during the learning process in class. The subject that was developed was only at the junior high school level, namely relations and functions, so there is still an opportunity to conduct further research at the level and other material.

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