The Effect of Problem-Based Learning (PBL) Model to Improve Students' Critical Thinking Skills: A Quasi-Experimental Study

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Abstract: Students need critical thinking skills to develop their ideas in mathematics learning situations at school, and they can apply mathematical concepts in solving contextual problems. Junior high school students have unique characteristics and are highly curious about new knowledge. Therefore, it is crucial to apply the learning models that support the development of critical thinking skills. Problem-based learning is a student-centered learning model that familiarizes students with finding solutions to a problem. This study aims to see how applying the Problem-Based Learning model affects students' critical thinking skills. This type of research is a quasi-experimental conducted at one of the junior high schools in Yogyakarta in odd semesters of the 2022/2023 academic year using 2 subjects: a control class and an experimental class. The pretest and post-test were analyzed using the SPSS-assisted. The result shows that the N-gain score of students in the experimental class is 0,703 which is categorized as the high level, and the N-gain score of students in the control class is 0,417 which is in the medium level. This means that the Problem-Based Learning (PBL) model influences students' critical thinking skills more effectively than the conventional learning method.

Keywords: Critical Thinking, Problem-Based Learning, Quasi-Experiment

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Introduction

Educational problems are endless issues to be discussed on various occasions. According to Law Number 20 of 2003, chapter II Article 3 “education has the function of educating the life of the nation by developing capabilities and forming dignified national character and civilization, to develop the potential of students”. The potential in question is faith and piety to God Almighty, having noble character, being healthy, knowledgeable, capable, creative, independent, and being a democratic and responsible citizen. However, achieving this goal is very complex and not easy to achieve. There needs to be an effort to improve the various components involved in education.

Broadly speaking, the problems of education in Indonesia are divided into two, namely macro problems and micro problems. Macro problems are problems in education as a system and its relation to other broader systems. Meanwhile, micro problems include problems in the education component itself (Adrianto, 2019). According to (Kurniawati & Auliah, 2022), micro problems in education include inadequate facilities and infrastructure, monotonous learning methods and models, and low student achievement. The problem of curriculum complexity which is increasingly confusing, education is not evenly distributed, and problems with the quality and misplacement of teaching staff are part of the micro problems in national education.

Technical issues in the educational component such as the use of methods, models, approaches, and strategies are some of the most influential things because they involve students directly. This is in line with the opinion of (Gomes et al., 2023), who voiced the importance of considering the characteristics, behavior, and psychological conditions of students in determining the teaching style of an educator. There are many learning models and approaches currently developing, but their effectiveness is of course influenced by students, educators, and subjects in the learning itself. In other words, a learning model may be effective for certain class groups but not necessarily as effective for other classes. Even different subjects may affect the effectiveness of a learning model.

One of the most widely applied learning models today, especially in mathematics learning, is the problem-based learning model, better known as Problem Based-Learning (PBL). PBL is a model that focuses the learning process on students who are stimulated by clinical, social, and scientific problems and focuses on solving them (Barrows, 1986; Davis & Harden, 1999). The selection of the learning model greatly determines the achievement of the objectives of the learning itself.

Problem-Based Learning is a model that refers to the four pillars of universal education, namely learning to understand (learning to know), learning to do, learning to be oneself (learning to be), and learning to work together or live in togetherness. According to Isrok'atun & Rosmala (2018) Learning to understand is when students learn a lesson concept not using memorization techniques, but understanding the contents of the concept instead. In understanding this concept, students learn by directly carrying out learning activities in the classroom so that they can develop an attitude of cooperation and understanding together. According to Sukirwan et al., (2018), PBL is a teaching model characterized by real problems as contexts for students to learn critical thinking and problem-solving skills and acquire knowledge.

Isrok'atun & Rosmala (2018) in problem-based learning, "students are given the opportunities to solve the problem in a collaborative setting, create mental models for learning, and form self-directed learning habits through practice and reflection". In this case, students are seen to be active in learning activities by practicing collaboratively in solving the problems they face. Learning like this can accustom students to learning independently and not relying on the teacher's explanation. Students have their way of solving problems. This is because students have initial knowledge that they get from their daily environment regarding the problems presented, not least regarding mathematical problems. Through the initial knowledge that students have, it can make it easier for them to solve mathematical problems. Problem-based learning has several stages, starting with a problem and ending with a solution to the problem. The stages of problem-based learning according to Suradika et al., (2023) are as follows.

Table 1. Problem-based learning syntax

Phases	Teachers Activities	Students Activities
Phase 1 Student orientation on the problem	• explain the learning objectives, explain the logistics needed • Motivate students to be actively involved in solving selected problems	Students record and prepare the needs needed in the learning process and are in predetermined groups.
Phase 2 Organizing students	Help students define and organize learning tasks related to these problems.	Students limit the problems to be studied.
Phase 3 Guide individual or group investigations	Encourage students to collect appropriate information, carry out experiments to get explanations and problem-solving	Students find out, investigate, and ask questions to get answers to the problems they face.
Phase 4 Develop and present the work	Assist students in planning and preparing appropriate work such as reports, models, and sharing assignments with friends	Students compile reports in groups present them in front of the class and discuss them in class.
Phase 5 Analyze and evaluate the problem-solving process	Evaluate learning outcomes about the material that has been studied or ask the group to present the work	Evaluate learning outcomes about the material that has been studied or ask the group to present the work.

Learning objectives as stated in Law Number 20 of 2003 cover many things, including skills, in terms of learning mathematics, of course, what is meant is mathematical skills. Mathematical skills include 1) conceptual understanding; 2) procedural fluency; 3) strategic competence; 4) adaptive reasoning; and 5) productive disposition (Kilpatrick & Swafford, 2001). To achieve these mathematical skills, there are process standards that must be met such as problem-solving abilities, mathematical communication, mathematical connections, critical thinking skills, and so on.

Critical thinking ability is a series of thinking processes consisting of interpretation, analysis, evaluation, and inference, as well as exposure to concepts, evidence, methodology, criteria, and contextual considerations which then become the basis for decision-making or concluding (Facione, 1991). According to (Setiana & Purwoko, 2020), a person's critical thinking ability is greatly influenced by his learning style because each learning style has different characteristics so it also influences the way of thinking. On this occasion, the author wants to see the effect of the learning model on students' critical thinking skills. Critical thinking is needed by everyone to address problems in the unavoidable reality of life. By thinking critically, a person can organize, adjust, change, or improve his thoughts, so that he can make decisions to act more appropriately.

Mathematical critical thinking ability is a mathematical ability and disposition to include prior knowledge, mathematical reasoning, and cognitive strategies to generalize, prove, or evaluate unfamiliar mathematical situations reflectively. According to Glazer, an unfamiliar situation is a situation where individuals cannot directly understand mathematical concepts or know how to determine solutions to problems. Meanwhile, reflective thinking involves communicating solutions with full consideration, making meaning of answers or arguments that make sense, determining alternatives to explain concepts or solve problems, and or generating extensions for further studies.

Mathematical critical thinking is an intellectual ability possessed by a person to understand mathematical problems. They can analyze these problems and decide on appropriate solutions to these problems (Oktaviani et al., 2018). In line with that, mathematical critical thinking can also be defined as the ability to think logically and reflectively which focuses on how to make decisions that can be trusted (Isrok'atun & Rosmala, 2018; Oktaviani et al., 2018). Therefore, someone who can think critically and mathematically has the intellectual ability to think logically and reflectively in understanding mathematical problems, analyzing problems, and deciding on the right solutions.

According to Kowiyah in studying mathematics, you will learn how to formulate problems, plan solutions, study steps for completion, and make assumptions if the data presented is incomplete, so a skill called critical thinking is needed. This thinking activity is in line with the steps of Problem-Based Learning which can stimulate students' critical thinking skills. The indicators of critical thinking skills in the Problem-Based Learning model are as follows.

Table 2. Critical thinking ability indicator in PBL

Problem-Based Learning Model	Critical Thinking Ability Indicator
1. Orientation of students to problems	• elementary clarification (give a simple explanation)
2. Organizing students to study	• Basic Support (building skills) • Inference (conclude)
3. Guiding individual and group	• Basic Support (building skills)

investigations	
4. Develop and present the work	• inference (conclude) • Advance clarification (providing a further explanation)
5. Analyze and evaluate the problem-solving process	• inference (conclude) • Strategy and tactics (set strategy and tactics)

Method

This research is a type of quasi-experimental research that was conducted to test the hypothesis about whether there is an effect of an action. This research was conducted to determine students' critical thinking skills between the experimental class that applied the Problem-Based Learning (PBL) learning model and the control class that applied conventional learning methods.

The population of this study was all classes at one of the schools in Yogyakarta consisting of 3 classes, where each class consisted of 32 students. The sample for this study was class VIII B and class VIII C, respectively, the experimental class and the control class. The independent and dependent variables in this study are the Problem-Based Learning model and without the Problem-Based Learning model and students' critical thinking skills. The research design is in Table 3.

Table 3. Research design

Class	Learning Method		
Experimental	Pretest	Problem-Based Learning	Post-test
Control		Conventional Learning	

This study uses quantitative analysis, which is an analytical technique in which the process is carried out by calculating the results of critical thinking skills tests given to students. The instrument used in this research is a test that measures students' critical thinking abilities in the form of an essay test, which has been adapted to indicators of critical thinking abilities. The test consists of four math questions related to circles. The pre-test and post-test questions are different but have the same level of difficulty to avoid bias in research. Both the pretest and posttest have gone through a validation process by experts and have been tested with the results that the instruments are valid and reliable. The analysis was carried out by comparing the test results of the experimental class and the control class.

Before the statistical test is carried out, a prerequisite test is first carried out, namely the normality test and homogeneity test. The normality test is carried out on a series of data to find out whether the data population is normally distributed or not, if the data is known to be normally distributed then parametric statistics will be tested whereas if the data is not normally distributed then non-parametric statistical tests will be carried out. Testing the normality of the data in this study used SPSS software with the *Shapiro-Wilk* test. Homogeneity testing aims to find out whether the object under study has the same variant. The homogeneity test used in this study uses the SPSS software with the Levene test.

The hypothesis test was carried out after the prerequisite test to see the comparison of the average variable of the two samples. Hypothesis testing was carried out on pretest and posttest data. The hypothesis test on the pretest is to see whether students from both classes have the same level of initial critical thinking skills using the Compared Means Independent Sample T Test. The hypothesis test on the post-test data is used to see whether there is an effect of the Problem-Based Learning model and conventional learning method on students' critical thinking skills or not, which was tested using the Paired Sample T Test. In the next stage, the hypothesis was tested with the N-Gain Test which aims to see which model is the most influential on students' critical thinking skills. The criteria for the N-Gain Score test are shown in Table 4.

Table 4. N-Gain score criteria

N-Gain Score	Category
$g > 0,7$	High
$0,3 \leq g \leq 0,7$	Medium
$g < 0,3$	Low

Results

The first thing that needs to be conveyed in the results of this research is a report on learning implementation. The research took place over eight meetings, the first meeting was the pre-test while the last meeting was the post-test. The second to seventh meetings were a learning process using the PBL model for the experimental class and conventional learning for the control class. The learning process using the PBL model was carried out well with an implementation percentage of 85% following the PBL phases listed in Table 1. Meanwhile, the conventional learning given in the control class was teacher-centered. In this process, the teacher explains the material and the students listen, then the students are allowed to ask and answer the teacher's questions regarding the learning material. This learning was carried out well with an implementation percentage reaching 90%.

The second thing is data description, to show the initial abilities and learning outcomes of the two classes descriptively. The result of descriptive statistics is shown in Table 5.

Table 5. Descriprive statistic result

Descriptive Analysis	PBL Model	Conventional Method

	Pretest	Post-test	Pretest	Post-test
Number of samples	36	36	36	36
Average	61	87	64	79
Median	67	85	66	73
Maximum score	73	95	75	88
Minimum score	51	72	51	68
Standard deviation	5,79	6,48	5,28	6,73

Table 5 above shows that the initial abilities of students from both classes tend to be the same, but the learning outcomes after treatment are quite different, which indicates the influence of the learning model applied in both classes. Then to see this influence in more detail, we carry out inferential analysis, but first it must be ensured that the data is normally distributed and homogeneous. The results of the normality test and homogeneity test are presented in Tables 6 and 7 below.

Table 6. Normality test results

	Experimental Class		Control Class	
	Pretest	Post-test	Pretest	Post-test
p-value	0,43	0,47	0,27	0,31

Based on Table 6, it can be seen that the normality test of the pretest and post-test from both classes obtained more p-value of 0,05. Thus, it can be interpreted that data are normally distributed and it can be used for the next stage.

Table 7. Homogeneity test results

	Experimental Class		Control Class	
	Pretest	Post-test	Pretest	Post-test
p-value	0,89	0,77	0,73	0,81

Table 7 shows that the statistical p-value of the data is higher than 0,05. So it can be concluded that the variance of students from the experimental class and the control class are the same. Thus, the data has met the prerequisite tests so that analysis can be continued at the next stage. The next step is to look at the average initial critical thinking ability of students in the two classes. If there is no difference in the average initial ability then the t-test can be continued.

Statistical hypothesis testing is as follows:

$H_0: \mu_1 = \mu_2$: There is no significant difference in the average critical thinking ability between students in the experimental class and the control class

$H_1: \mu_1 \neq \mu_2$: There is a significant difference in the average critical thinking ability between students in the experimental class and the sample class

The test criterion is that H_0 is accepted if sig. α > 0,05. Test results can be seen in Table 7.

Table 8. Average initial ability test result

Compared Means Independent Sample T Test	
sig.	0,913

Table 8 shows that H_0 is approved due to the signature (two-tailed) value being greater than 0,05 which means there is no significant difference in critical thinking ability between the students of the two classes. Furthermore, to find out the treatment applied in each class, whether the Problem-Based Learning learning model and conventional learning method have an effect or not on students' critical thinking skills, a hypothesis test is carried out. Hypothesis testing was carried out on pretest and post-test data using the Paired Sample T Test. The hypothesis formulation is written below.

H_0 : The Problem-Based Learning model does not affect students' critical thinking abilities
H_1 : The Problem-Based Learning model affects students' critical thinking abilities

The same hypothesis formulation also applies to the conventional learning method. The criterion of the test, H_0 is rejected if the sig. (two-tailed) < 0,05. The results of the Paired Sample T Test are shown in Table 9.

Table 9. PBL model and conventional learning method affect the test result

Paired Sample T Test	
Class	sig.
PBL model	0,000
Conventional learning method	0,002

The table above shows that both the PBL model and conventional learning method may affect students' critical thinking ability. This is indicated by the sig value both classes are smaller than 0,05, which means that H_0 is rejected. Next, to see which effect is greater between the two learning methods, an N-gain test is carried out. The result is summarized in Table 10.

Table 10. N-Gain score results

Class	N-Gain Score	Category
Experimental Class (PBL Model)	0,703	High
Control Class (Conventional Learning)	0,417	Medium

Based on the results, there is a difference in scores between both classes. The N-Gain score of the class applying the Problem-Based Learning model shown in the table above (see Table 10) reaches 0,703 and is in the high category. This shows that the application of PBL in circle material has a big influence on helping students improve their critical thinking skills. While the conventional learning method shows an N-gain score of 0.417 which is in the medium category. This means that the conventional learning method also influences students' critical thinking abilities in learning mathematics, especially circle material, but the influence is not significant.

Overall, the Project-Based Learning model applied in the experimental class and the conventional learning method applied in the control class in learning about circles were proven to influence increasing students' critical thinking abilities. However, when compared to the Project-Based Learning model provides a more effective influence so the application of this model is highly recommended in the learning process.

Discussion

The results of this study indicate that there is a positive relationship between the application of the problem-based learning model and students' critical thinking skills which are very important abilities for students, especially in learning mathematics. However, this research is still limited to a small population and only considers learning in circle material, research with other materials and linking it to certain approaches might strengthen references in improving students' critical thinking skills. In general, problem-based learning can improve students' thinking skills because this learning model is more real and acceptable to students, rather than providing theory which tends to be abstract and less acceptable to students. Other learning models may have a positive influence on students' critical thinking skills in different ways.

Conclusion

To conclude, the mathematical critical thinking ability of students who take part in Problem-Based Learning (PBL) is higher than that of students who take conventional learning. This shows that the Problem-Based model influences students' mathematical critical thinking skills.

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