



Problem Based Learning Using Open Ended Questions Improves Students' Mathematical Critical Thinking Ability in Elementary Schools

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ABSTRAK

Kemampuan berpikir kritis siswa sekolah dasar pada mata pelajaran matematika masih sangat rendah. Hal ini disebabkan oleh guru yang hanya memberikan pembelajaran dengan konsep hafalan tanpa ada kegiatan pemecahan masalah. Berdasarkan masalah tersebut diperlukan model pembelajaran yang dapat membantu siswa dalam mempelajari konsep pemecahan masalah dalam matematika. Sehingga dilakukan penelitian yang bertujuan untuk membuktikan pengaruh model Problem Based Learning menggunakan Open-Ended Question terhadap kemampuan berpikir kritis pada pembelajaran matematika siswa kelas III. Penelitian ini menggunakan desain penelitian non-equivalent control group desain. Populasi penelitian ini adalah siswa sebanyak 324 siswa. Sampel penelitian sebanyak 31 siswa sebagai kelompok eksperimen dan sebanyak 29 siswa sebagai kelompok kontrol. Metode pengambilan dan instrumen data diperoleh dengan memberikan tes esai. Analisis data menggunakan teknik statistika deskriptif dan analisis statistik inferensial dengan Uji-t polled varians. Hasil uji hipotesis menunjukkan model pembelajaran Problem Based Learning menggunakan Open-Ended Question berpengaruh terhadap kemampuan berpikir kritis pada pembelajaran matematika siswa kelas III sekolah dasar. Hasil penelitian yang dilakukan memberikan kontribusi yang baik pada pembelajaran matematika di sekolah dasar. Diharapkan hasil penelitian ini dapat digunakan untuk mengembangkan pemikiran penelitian yang akan datang.

ABSTRACT

Primary school students' critical thinking abilities in mathematics are still very low. This is caused by teachers who only provide learning with rote concepts without any problem solving activities. Based on this problem, a learning model is needed that can help students learn the concept of problem solving in mathematics. So research was conducted which aimed to prove the effect of the Problem Based Learning model using Open-Ended Questions on critical thinking skills in class III students' mathematics learning. This research uses a non-equivalent control group research design. The population of this research was 324 students. The research sample was 31 students as the experimental group and 29 students as the control group. Data collection methods and instruments were obtained by giving essay tests. Data analysis uses descriptive statistical techniques and inferential statistical analysis with polled variance t-test. The results of the hypothesis test show that the Problem Based Learning learning model using Open-Ended Questions has an effect on critical thinking skills in mathematics learning for third grade elementary school students. The results of the research carried out provide a good contribution to mathematics learning in elementary schools. It is hoped that the results of this research can be used to develop future research ideas.

1. INTRODUCTION

Mathematics learning in elementary schools often does not match the desired goals. Many problems arise during the process of learning mathematics at the elementary school level, causing this subject to be less popular with students (Fauzy & Nurfauziah, 2021; Permatasari, 2021). Most students think that mathematics is difficult and always involves numbers, formulas, and calculations (Sari et al.,

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2023; Aprilia & Fitriana, 2021). In addition, many concepts in mathematics are abstract, so students have difficulty understanding the material being taught (Khotimah & Risan, 2019; Pranata, 2016). Lack of understanding of a concept certainly has an impact on low student abilities, such as most have not reached the set completion standards. As a result, they need to repeat learning to achieve these standards.

Problems in the Mathematics learning process also occur in several Elementary Schools in the Letda Made Putra Cluster. Interviews and documentation recording have been carried out with several homeroom teachers of grade III of SD Gugus Letda Made Putra. The results of the interviews and document recording show that the average Mathematics score in the final semester assessment of the 2022/2023 academic year has not yet reached the sufficient category based on the Benchmark Assessment (PAP). According to the PAP category, students' mastery of knowledge is said to be good if they are able to achieve a percentage of 80-89. However, in reality, only 35.23% of the entire population of grade III students in the Letda Made Putra Cluster were able to achieve the good category, and 64.77% were still unable to achieve the expected category.

This is also supported by the results of interviews with each homeroom teacher of grade III of SD Gugus Letda Made Putra. The results of the interviews showed that Mathematics is difficult to deal with, especially on the material about probability. Generally in mathematics learning students are only asked to answer questions with one answer. However, students find it difficult to answer open-ended questions. This is because students are not used to looking for alternative answers, in addition to the lack of students' ability to analyze questions in the form of problems. This makes students often make mistakes when calculating and are less careful in working on the possibility questions.

The interview results were reinforced by the results of observations in of grade III of SD Gugus Letda Made Putra. Information was obtained that teachers were less precise in choosing learning resources, models, or learning methods. Teachers used more conventional learning that was still centered on the teacher and used monotonous methods. Teachers also did not direct students' thinking towards problem solving because the questions given were still in the realm of remembering, understanding, and applying. This means that the answers to the questions presented were always in the student's book, resulting in students' critical thinking skills not developing. In addition, the low critical thinking skills of students were marked by students being less active, only a few students were willing to ask and answer questions, students' lack of ability to develop an idea, and difficulty in analyzing a problem and making conclusions.

Based on these problems, it is known that students' critical thinking skills in mathematics are quite low. In addition, there was a gap between real conditions and expected conditions, namely that the mathematics learning process in schools does not encourage students to think critically. Learning activities only focus on memorization, do not provide enough problem-solving activities, so that student participation in developing ideas and critical thinking in learning activities is very minimal. If not addressed immediately, it is feared that it will have a negative impact on students in their daily lives. This is because the critical thinking skills of elementary school students are very important to enable students to get used to facing challenges and solving problems by analyzing their own thoughts.

Critical thinking skills are essential for students (Mahmudah, 2020; Pujiani et al., 2019). This is in line with the 2013 curriculum and the development of the 21st century paradigm, one of the demands of which is that students have critical thinking skills to solve problems (Saraswati & Ducha, 2021; Zubaidah, 2019). Critical thinking is a systematic process that a person has to be able to evaluate and formulate their own opinions and beliefs to make a decision (Ardiansyah, 2020; Hendriana, et al., 2018). Students with high critical thinking skills will be able to review the information received based on the knowledge they already have and can choose the information appropriately (Solikhin & Fauziah, 2021; Nugraha et al., 2017).

In response to these problems, efforts are needed to improve students' critical thinking skills, one of which is by using the right learning model and in accordance with the learning objectives. One of the learning models that can be used to improve and stimulate students' critical thinking skills is by using the problem-based learning model. Problem-based learning is a form of alternative learning that pays attention to students' thinking processes, including their critical thinking skills (Ratnaningsih et al., 2022; Hadiryanto & Thaib, 2017). Thus, problem based learning is a learning model that emphasizes active participation from students, requires critical thinking skills, and problem solving skills.

In addition to the learning model, the thing that teachers need to pay attention to is giving questions that can stimulate students' critical thinking skills. One way that can be done to measure and stimulate students' critical thinking skills is by giving open-ended problems (Juwanto, 2022; Hajar et al., 2019; Mursidik et al., 2015). Open ended questions are learning that can lead students to answer and solve problems in many ways and there may also be many correct answers (Lestari et al., 2019; Nissa et al., 2019). This certainly provides an opportunity for students to analyze and develop their ideas in solving the problems given, so that they can improve their critical thinking skills.

This is also supported by the results of several studies that have been conducted. The critical thinking skills of students who follow learning with the problem based learning (PBL) model are proven to be higher than using conventional models (Noer & Gunowibowo, 2018; Sianturi et al., 2018). Providing math problems in an open-ended format has an important role in improving students' critical thinking skills (Juwanto, 2022; Nissa et al., 2019). Based on several research results, it is believed that the novelty of the combination of problem-based learning models with the provision of open-ended questions is very useful in the learning process to foster students' critical thinking skills.

Based on this explanation, this study aims to improve the influence of the problem based learning model using open-ended questions on critical thinking skills in mathematics learning for grade III students. The results of this study are expected to be used to develop future research ideas and be able to provide an overview of research related to learning models. In addition, in the future it can also provide a good opportunity to conduct further studies with different research subjects.

2. METHOD

This study uses a quantitative research type with a quasi-experimental design. This study uses a non-equivalent control group design. The non-equivalent control group design by following this pattern can be shown in Figure 1.

E : O ₁	X	O ₂
K : O ₃	-	O ₄

Figure 1. The Quasi-Experimental Research Design using "Non-equivalent Control Group Design"

In this study, the experimental class and control class were first tested using a pre-test to measure the initial abilities of the samples used in the study. Then, the experimental group was given treatment using a problem-based learning model using open-ended questions. Meanwhile, the control group was not given treatment and only learned with the usual learning or often applied by teachers in class. Furthermore, a post-test was conducted after treatment was given to obtain data on the critical thinking skills of the experimental class and control class and then compare the results.

The implementation of this research consists of three stages, namely, the preparation stage, the implementation stage, and the final stage of the experiment. The population in this study were all students of grade III of SD Gugus Letda Made Putra which consists of 11 classes with a total of 324 students. After finding the population, the next step is to determine the number of samples. The technique used in determining the sample in this study is cluster random sampling. Based on the results of the lottery that has been carried out, class IIIB at SD Negeri 18 Dangin Puri was obtained as the experimental group and class IIIB at SD Negeri 2 Dangin Puri as the control group.

The data collection method used in this study is the test method. The data analyzed is critical thinking ability data, so to obtain this data, this study uses a test instrument. The type of test used to measure students' critical thinking abilities is an essay test. The number of essay tests used is 5 questions with each question item given a score adjusted to the assessment rubric. The critical thinking ability instrument grid can be seen in Table 1.

Table 1. The Critical Thinking Ability Test Research Instrument Grid

Basic competencies (KD)	Indicator
3.3 State a number as the sum, difference, product or quotient of two whole numbers	3.3.1 Analyze the possibilities that state the sum, difference, product or quotient of two whole numbers.
	3.3.2 Proving a pair of numbers that represents the sum of two whole numbers
	3.3.3 Interpreting numbers that represent the sum, difference, product and division of two whole numbers
	3.3.4 Creating the number of possibilities that state the sum of the difference, product and quotient of two whole numbers.
	3.3.5 Providing arguments according to the problems given.

Source : Nuzulaeni & Susanto (2022) with modification

When the instrument has been collected, the instrument is then tested and will get a result which will then be tested for content validity and item validity. The validity test is carried out on the critical thinking ability test instrument using Gregory's validity based on expert assessment. The validity test of the test items used in this study is the "product moment correlation" formula. The reliability test in this study was only carried out on test items that had been tested for test item validity and had also been declared valid. The formula used for the reliability test of the critical thinking ability essay test is to use the alpha coefficient (Alpha Cronbach). After the data is collected, the next step is the research process, namely data analysis.

The data analysis used in this study is descriptive statistical analysis and inferential statistical analysis. Descriptive statistical analysis is used to describe data on the critical thinking skills of students who are given treatment with groups that are not given treatment. The data presented in descriptive statistics are the calculation of the mean/average, standard deviation, and variance. Meanwhile, inferential statistics are used to test hypotheses, results, conclusions, and apply these conclusions to the population. Hypothesis testing in this study uses a t-test with a pooled variance formula. However, before conducting a t-test, there are several requirements that must be carried out first to test the hypothesis, namely the data analysis prerequisite test including the normality test of data distribution and homogeneity of variance.

3. RESULT AND DISCUSSION

Result

The data collected in this study were data on critical thinking skills in mathematics learning for grade III students at SD Gugus Letda Made Putra in the 2023/2024 Academic Year. The data that had been collected were analyzed according to the previously determined analysis techniques. Data analysis was carried out to describe the critical thinking skills of the group of students who were taught with the problem based learning model using open-ended questions (control group) and the group of students who were not taught with problem based learning using open-ended questions (control group).

The experimental group in this study were 31 students of class III B at SD Negeri 18 Dangin Puri. The experimental group was given a pre-test to determine the initial critical thinking skills of students. Based on the data in the table, it can be seen that the highest pre-test score in the experimental group was 70 and the lowest score was 40. The pre-test data of the experimental group had an average of 51.94 with a large deviation of 8.73 and a diversity of 76.13. Furthermore, the average (mean) pre-test data of the critical thinking ability of students in the experimental group can be categorized by converting it to the PAP criteria on a five-point scale. Based on the calculation results, the percentage of the mean pre-test score of the critical thinking ability of students in the experimental group was 51.94 and was in the "low" category.

The control group in this study were 29 students of class III B at SD Negeri 2 Dangin Puri. The control group was given a pre-test to determine the initial critical thinking skills of students. Based on the data in the table, it can be seen that the highest pre-test score in the control group was 70 and the lowest score was 35. The pre-test data for the control group had an average of 50.17 with a deviation of 11.84 and a diversity of 140.15. Furthermore, the average (mean) pre-test data of critical thinking skills of students in the control group can be categorized by converting to the PAP criteria on a five-point scale. Based on the calculation, the percentage of the mean pre-test score of critical thinking skills of students in the control group was 51.17 and was in the "low" category.

The experimental group in this study were 31 students of class III B at SD Negeri 18 Dangin Puri. The experimental group was given a pre-test and continued with treatment with a problem-based learning model using open-ended questions six times. Then at the end of the study, students were given a post-test. The highest post-test score in the experimental group was 95 and the lowest score was 60. The post-test data for the experimental group had an average of 80.16 with a deviation of 8.99 and a diversity of values of 80.81. Furthermore, the average (mean) post-test data of the critical thinking ability of students in the experimental group can be categorized by converting it to the PAP criteria on a five-point scale. Based on the calculation results, the percentage of the mean post-test data of the critical thinking ability of students in the experimental group was 80.16 and was in the "High" category.

The control group in this study were 29 students of class III B at SD Negeri 2 Dangin Puri. The control group was given a pre-test followed by being taught using the usual learning model used by the teacher six times. Then at the end of the study, students were given a post-test. The highest post-test score in the control group was 85 and the lowest score was 50. The post-test data for the control group had an average of 66.90 with a deviation of 10.72 and a diversity of 115.02.

Furthermore, the average (mean) post-test data of critical thinking skills of students in the control group can be categorized by converting it to the PAP criteria of a five-scale. Based on the calculation, the percentage of the mean post-test data of critical thinking skills of students in the control group was 66.90

and was in the "moderate" category. Furthermore, the data analysis prerequisite test was carried out before conducting the hypothesis test. There are several data analysis requirements that must be met, namely the data distribution normality test and the variance homogeneity test. The recapitulation of the prerequisite test results can be presented in Table 2 and Table 3.

Table 2. The Recapitulation of Post-test Data Distribution Normality Test Results

No	Sample	Many Samples	Maximum Value A1-A2	KS Table Value	Conclusion
1.	Experimental Group	31	0.18	0.24	Normal
2.	Control Group	29	0.12	0.25	Normal

Table 3. The Recapitulation of Variance Homogeneity Test Results

Group Data	Variance	F _{count}	F _{table}	Conclusion
Experiment	80.81	1.42	1.51	Homogeneous
Control	115.02			

Based on the results of the prerequisite test, it can be seen that the data obtained by the experimental group and the control group are normally distributed and homogeneous. Therefore, the data obtained has met the prerequisite test. Furthermore, a hypothesis test can be carried out using the t-test with the pooled variance formula. Hypothesis testing is carried out at a significance level of 5% or 0.05 with the testing criteria, namely if the t_{count} value $>$ t_{table} then H_0 is rejected and H_1 is accepted. The recapitulation of the results of the t-test analysis can be presented in Table 4.

Table 4. The Summary of t-Test Analysis Results

Group	Many subjects (n)	Average score (\bar{X})	Variance (s ²)	Degrees of freedom (df)	count	table
Experiment	31	80.16	80.81	58	5.24	2.00
Control	29	66.90	115.02	58		

Based on the recapitulation, the t-test results obtained $t_{\text{count}} = 5.24$ and the t_{table} value with a significance level of 5% with $dk = 58$ ($n_1 + n_2 - 2$) is 2.00. Therefore, the t_{count} value is greater than the t_{table} value ($5.24 > 2.00$). So it can be stated that H_0 is rejected and H_1 which means there is a significant difference in critical thinking skills between the group that was taught the problem based learning model using open-ended questions and the group that was not taught the problem based learning model using open-ended questions in mathematics learning for grade III students at SD Gugus Letda Made Putra. It can be concluded that the problem based learning model using open-ended questions has an effect on the critical thinking skills of grade III students in mathematics learning at SD Gugus Letda Made Putra in the 2023/2024 Academic Year.

Discussion

Based on the results of the analysis of the critical thinking skills of the two sample groups, it can be seen that the two groups that initially had equal abilities, after being given different treatments, the acquisition of critical thinking skills experienced differences. The critical thinking skills of students in the experimental group were better when compared to the critical thinking skills of students in the control group. The differences that emerged between the experimental class and the control class were caused by the application of the problem based learning model using open-ended questions applied in learning in the experimental class.

When learning in the experimental group class, students do more learning activities independently and in groups. These activities help students participate more actively in learning. In addition, the problem-based learning model using open-ended questions also has several stages. In the first stage, students are oriented to a problem. At this stage, the teacher gives a trigger question in the form of an open-ended question to understand the problem by expressing what is known and asked.

In the second stage, the teacher divides students into several small groups. At this stage, the teacher invites students to watch a learning video related to the material of probability. Next, students discuss with their groups to analyze how to determine two numbers whose sum, difference, multiplication, and quotient are known. In the third stage, the teacher distributes a LKPD for students to work on together. With this activity, of course, students will help each other learn in groups in solving the problems given.

In contrast to the control group, which in its implementation was not given treatment with the problem-based learning model using open-ended questions. In the learning process, the control class was dominated by lecture methods, questions and answers, and assignments that were only centered on the teacher, so that during learning activities the teacher played a more active role and students tended to be passive. In addition, students were given to do assignments until finally the teacher felt that what had been taught could be understood by the students. This resulted in students tending to get bored, lack of interest, and low student motivation to be involved in learning.

Problem based learning is a problem-based learning model. Problem-based learning is an alternative form of learning that pays attention to the thinking process of students, including their critical thinking skills. In line with this opinion, previous research also stated that the problem-based learning model provides great opportunities for students to gain more meaningful learning experiences, because students are given full freedom in the learning process to develop their ideas in expressing their opinions (Mashudi, 2021; Triningsih & Maward, 2020).

Based on the results of the research that has been conducted, the use of the problem based learning model using open-ended questions can improve students' critical thinking skills. Critical thinking skills are one of the components of high-level thinking that is needed and is a focus in learning in the 21st century so that students are able to solve real problems that exist in their daily lives (Darwati & Purana, 2021; Indraswati et al., 2020) Critical thinking indicators can be created based on Bloom's Taxonomy levels (Cintamulya, 2019; Yunita & Rohiat, 2018).

Critical thinking has the same meaning as a higher level of thinking, especially in Bloom's Taxonomy, namely in C3 analysis. However, this taxonomy theory has been revised by Krathwohl and Anderson who are Bloom's own students. The results of the revision make critical thinking fall into the category of high-order thinking skills (HOTS) which consist of analyzing, evaluating and creating.

HOTS and critical thinking skills are interrelated (Susilowati & Sumaji, 2021; Rohim, 2019). This is because the HOTS instrument refers to the cognitive levels of Bloom's Taxonomy revised by Anderson, namely analysis, evaluation, and creation. Meanwhile, critical thinking skills according to John Butterworth include analysis, evaluation, and compiling further arguments. The results of this study are in line with previous studies which state that the results of critical thinking skills of students who follow learning with the problem based learning (PBL) model are higher than students who follow conventional learning (Noer & Gunowibowo, 2018; Sianturi et al., 2018).

The use of open-ended type Mathematics questions in this study has an effect on improving students' critical thinking skills. This is in line with previous research which states that giving mathematics questions in the form of open-ended has an important role in improving students' critical thinking skills (Juwanto, 2022; Nissa et al., 2019). This indicates that students' critical thinking skills can improve after being trained by answering math problems in the form of open-ended questions compared to using ordinary questions that limit the correct answers.

The novelty in the form of a combination of problem-based learning models using open-ended questions has actively involved students and improved students' critical thinking skills in Mathematics learning. The problem-based learning model using open-ended questions can be selected and used by teachers in learning activities, especially in understanding material concepts in mathematics learning. This study has implications for further studies of similar studies with different research subjects. The limitation of this study is the use of a non-equivalent control group research design, so it cannot fully control external variables that can affect students' critical thinking skills. Further research can use a more effective research design to control external variables that can affect students' critical thinking skills.

4. CONCLUSION

Based on the explanation that has been presented, it can be concluded that the model problem based learning use open ended questionhas a positive influence on critical thinking skills in mathematics learning for of grade III of SD Gugus Letda Made Putra in the 2023/2024 Academic Year. The results of this study are one of the proofs that the novelty in the form of a combination of models problem based learning use open ended question provide a good contribution when applied to Mathematics learning in elementary schools.

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