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The Problem-Based Learning Model in Mathematics Subjects by Controlling the Critical Thinking Ability of Elementary School Students

Ni Nyoman Ayu Purnama Dewi[1]*, Gusti Ngurah Sastra Agustika[2]

[1,2] Program Studi Pendidikan Guru Sekolah Dasar, Universitas Pendidikan Ganesha, Singaraja, Indonesia

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ABSTRAK

Rendahnya kompetensi pengetahuan pada mata pelajaran matematika disebabkan karena kurangnya peggunaan model pembelajaran yang sesuai dan lebih banyak mengacu pada teori yang terdapat pada materi pembelajaran daripada mengaitkan dengan kehidupan nyata atau kehidupan sehari-hari siswa. Tujuan dari penelitian ini adalah untuk menganalisis pengaruh model Problem Based Learning terhadap kompetensi pengetahuan matematika dengan mengontrol kemampuan berpikir kritis siswa kelas V sekolah dasar. Penelitian ini menggunakan desain eksperimen semu dengan rancangan desain penelitian Nonequivalent Control Group Design dan rancangan desain analisis data Single Factor Independent Group Design With Use Of Covariate. Populasi dalam penelitian ini sebanyak 194 orang siswa dari 3 sekolah negeri yang berbeda. Sampel ditentukan dengan teknik cluster random sampling yang sebelumnya populasi telah disetarakan menggunakan Uji Anava. Metode pengumpulan data menggunakan tes berbentuk uraian, data hasil penelitian dianalisis dengan teknik analisis statistik deskriptif dan teknik analisis statistik inferensial menggunakan Uji Anakova. Hasil analisis hipotesis diperoleh model Problem Based Learning berpengaruh terhadap Kompetensi Pengetahuan Matematika Siswa meskipun telah dikontrol Kemampuan Berpikir Kritis Siswa Kelas V di sekolah dasar. Disimpulkan bahwa model Problem Based Learning dapat meningkatkan Kompetensi Pengetahuan Matematika Siswa.

ABSTRACT

The low competence of knowledge in mathematics subjects is due to the need for appropriate learning models. It refers more to the theories in learning materials rather than relating them to real life or students' daily lives. This study aimed to analyze the effect of the Problem-Based Learning model on the competence of mathematical knowledge by controlling the critical thinking skills of fifth-grade elementary school students. This study used a quasi-experimental design with the Nonequivalent Control Group Design and the Single Factor Independent Group Design With the Use Of Covariate data analysis design. The population in this study was 194 students from 3 different public schools. The sample was determined using the cluster random sampling technique. Previously the population was equalized using the Anava test. Methods of data collection using tests in the form of descriptions and research data were analyzed using descriptive statistical analysis techniques and inferential statistical analysis techniques using Anakova Test. The results of the hypothesis analysis obtained that the Problem-Based Learning model affected Students' Mathematical Knowledge Competence even though it had been controlled for the Critical Thinking Ability of Grade V Students in elementary schools. It was concluded that the Problem-Based Learning model could improve Students' Mathematical Knowledge Competence.

1. INTRODUCTION

Mathematics is one of the subjects whose implementation has a variety of functions in everyday life. With the importance of mathematics in everyday life, mathematics subjects are obtained when individuals step on the most basic level of education up to university (Dwiana et al., 2021; Lestari et al., 2018). In human life, mathematics plays an important role in advancing human thinking. In this case, the

*Corresponding author
E-mail addresses: dewi24@gmail.com (Ni Nyoman Ayu Purnama Dewi)

learning of mathematics, especially at the elementary school education level, has a big role in applying the concept of mathematics which will be useful for higher levels of education and has the aim of developing students' thinking skills (Aledya, 2019; Lestari, 2021; Syahrir et al., 2020). Based on this, mathematics plays an important role in education, especially in understanding theory in mathematics. Education has achievements or knowledge benchmarks called knowledge competence (Hari, 2020; Suprianingsih & Wulandari, 2020). Knowledge competence is one of the competencies that students must achieve as a result of the learning process of the students themselves (Arianti et al., 2019; Handayani & Abadi, 2020). Knowledge competence contains three cognitive, affective, and psychomotor competencies (Juniarti et al., 2020; Prabaningrum & Putra, 2019). One of the competencies that tend to be considered in seeing the success of student learning is knowledge competence, or cognitive competence (Suprianingsih & Wulandari, 2020).

Cognitive competence is a competency that measures a combination of student understanding, skills, and basic values in mastering subject matter or student achievement in understanding what has been learned. One component that can be measured in cognitive competence in learning mathematics is the ability to think critically. Critical thinking is analyzing situations based on facts and evidence to conclude (Agnafia, 2019; Umam, 2018). In addition, critical thinking is also defined as the ability to develop and explain the results of thinking, which are then structured into a complex decision or idea. In the learning process, critical thinking skills are developed to direct students' thinking processes so that they can think in a structured and intelligent way in organizing various concepts and facts in the field (Fauzi & Abidin, 2019; Manalu & Siregar, 2019). Someone can think critically if he relies on his mind properly to find a solution that aims to solve the problems he faces (Effendi et al., 2021; Juhdi & Adila, 2018; Saputra, 2020). Students who have good critical thinking skills will tend to have appropriate problem-solving skills and be able to understand the problems given (Sitompul, 2021; Sukmawati, 2020). A person's way of thinking or mindset will certainly be different from one another. It is due to several factors such as environmental factors, association, how parents educate, and even the level of intelligence students possess from birth or what is called Intelligence Quotient (IQ) (Juhdi & Adila, 2018; Phasa, 2020).

The reality shows that students' critical thinking skills in mathematics are still relatively low. It aligns with the observations and interviews conducted at SD Negeri Gugus Ki Hajar Dewantara. The results of observations and interviews show that the average value of students' mathematics lessons is still relatively low. It is because, in the process of learning mathematics in the classroom, the teacher explains more material using the lecture method so that the class atmosphere becomes less active. Besides, learning is still centered on the teacher and has not linked learning with students' real world. Furthermore, the observation results show that the teacher still dominates the learning process, so students must properly develop their thinking skills. If left unchecked continuously, this problem will impact decreasing student learning outcomes and not achieving the goals of learning mathematics properly.

One of the efforts that can be made to overcome these problems is by applying a learning model that can improve students' mathematical abilities. One of the learning models that can be used is the Problem-Based Learning learning model. Problem-Based learning is a learning model that challenges students by providing real-life problems that encourage students to solve these problems individually or in groups (Heryanto et al., 2022; Yusri, 2018). Learning carried out by applying the Problem-Based Learning model will improve students' ability to understand the concept of learning material. The Problem-Based Problem-Based allows students to play an active role in developing their thinking skills and analyzing a problem presented (Dwianjani & Candiasa, 2018; Elita et al., 2019; Puspita et al., 2018; Yuhani et al., 2018). In this case, the Problem-Based Learning learning model can stimulate students to solve questions or problems in learning mathematics within everyday problems that students can imagine (Prasetyo & Kristin, 2020; Simanjuntak et al., 2021).

Previous studies have revealed that the problem-based learning model can improve students' critical thinking processes in mathematics (Phasa, 2020). The results of other studies reveal that Problem-Based Learning effectively improves students' critical thinking skills in mathematics (Sukmawati, 2020). Further research revealed that using the Problem-Based Learning model and students' critical thinking skills could improve mathematics learning outcomes in flat shape material in fourth-grade elementary school students (Utami, 2019). Based on the results of this study, applying the problem-based learning model can significantly improve critical thinking skills and students' mathematics learning outcomes. In previous studies, no studies specifically discussed problem-based learning models in mathematics by controlling elementary school students critical thinking skills. This research is focused on this study to know whether or not there is an influence on the Problem-Based Learning model when applied to high-

grade elementary school students if one of the students' internal abilities, namely students' critical thinking skills, is controlled using the Anakova test statistical technique.

2. METHOD

This research belongs to the type of quantitative research with a quasi-experimental design. The quasi-experimental design is a research design with a control group that cannot fully function to control external variables that affect the implementation of the experiment. The quasi-experimental design used in this study is the Nonequivalent Control Group Design. The data analysis design used in this study is the Single Factor Independent group design using covariate. The population of this study was all fifth-grade students at SD Negeri Gugus Ki Hajar Dewantara for the academic year 2022/2023, which consisted of 7 classes in three elementary schools. The total population of this study was 194 students. The large number of population members at SD Negeri Gugus Ki Hajar Dewantara for the 2022/2023 academic year made it impossible for researchers to examine all existing objects. Therefore, samples were taken from the population to determine the experimental and control classes. The research sample is part of a population to be studied, which is selected in certain ways. The conditions that the sample must meet are that the sample must be representative (representative) of the population.

The sampling technique in this study was the Cluster Random Sampling technique. Prior to the sampling technique using Cluster Random Sampling, the population must be equalized first, starting with giving a pre-test to all fifth-grade students in the population. Then, a prerequisite test will be carried out from the pre-test results, namely the data normality test with the Kolmogorof-Smirnof test and the homogeneity test with the Bartlett test. After all sample groups are declared normal and homogeneous, it can be continued with the equivalence test for all sample groups using the Anava test. The equivalence criterion with Anava is that if Fcount <Ftable, then the population is declared equal. After the entire population is declared equal, it is followed by a random draw of the experimental and control groups. The VA class at SD Negeri 9 Pedungan was obtained as the experimental group, and the VA class at SD Negeri 14 Pedungan as the control group. The experimental group was given the Problem-Based Learning model treatment, and the control group was taught conventionally.

Data collection in the study was carried out using the test method, with the research instrument in the form of a test in the form of a description. The test method is a data collection method that provides a question in the form of items used to measure the knowledge or competence of the research subject. The data to be collected in this study are data on the competence of mathematical knowledge and data on students' critical thinking skills. The tests used in this study are adjusted to the instrument grid that has been prepared according to the indicators of learning achievement that are adjusted to basic competencies and are arranged based on the levels of the cognitive domain starting from the cognitive level C4 (analyzing), C5 (evaluating), and C6 (create). Then the instruments used were tested by experts in their fields related to the competence of mathematical knowledge. The tests used were tried out on students to ensure the accuracy of the instruments used. The results of trials conducted on students were analyzed by testing their validity and reliability. The lattice of mathematical knowledge competency instruments and critical thinking ability instruments can be seen in Tables 1 and Tables 2.

The data obtained in the study were then analyzed using descriptive statistical analysis techniques and inferential statistics. Descriptive statistics are used to analyze data by describing the data that has been collected, which includes the average value, variance, and standard deviation. Inferential statistics are used to analyze data obtained from research or experimental results. In this study, the inferential statistics used to test the hypothesis were the Anakova test. Before the Anakova test, the analysis prerequisite test was carried out by testing the normality of data distribution, homogeneity of variance test, and linearity test.

Table 1. Mathematical Knowledge Competence Instruments

Core Competency (KI)	Basic competencies (KD)	Indicator
KI. 3 Understanding factual and conceptual knowledge by observing and asking questions based on curiosity about himself, God's creatures and their activities, and the objects he encounters at home, school, and playground.	**3.3** Describes the comparison of two different quantities (velocity as a ratio of distance to time, discharge as a comparison of volume and time).	3.3.1 Students can analyze units of time. 3.3.2 Students can change the conversion of speed units into meters/second. 3.3.4 Students can analyze discharge in different units.

Table 2. Critical Thinking Instruments

Indicators of critical thinking skills	Indicators of achievement of learning outcomes
1. Can write down what is asked clearly and precisely. 2. Write down the relationship of the concepts used to solve the problem.	Able to solve mathematical problems related to mixed integer arithmetic operations.
3. Can write down the solution to the problem. 4. Can conclude from what is asked logically. 5. Can give reasons for solving the questions made.	Able to solve everyday math problems related to the value of fractions of money.

3. RESULT AND DISCUSSION

Result

Based on research that has been done using experimental research methods, it is known that there is a difference in the average competency knowledge of the group of students who are taught with the Problem-Based Learning model and the group of students who are not taught with the Problem-Based Learning model after controlling students' critical thinking skills. From the results of observations when applying the Problem-Based Learning learning model, students in the experimental class were presented with problems in everyday life related to learning materials, in which students were seen to be actively involved in ongoing learning activities and enthusiastic when following the course of learning activities in class then increasing students' curiosity about the mathematics learning material studied through several problems raised by the teacher. Through the application of the Problem-Based Learning model, students are stimulated to imagine these problems and find answers to problems given by searching, asking questions, discussing, or looking for them in books, so that in this case, it is known that this model provides a stimulus for students to think about finding answers or connections of the problems given. In its application, the Problem-Based Learning learning model can increase student activity when learning which in the application of the Problem-Based Learning learning model is interspersed with practicum activities that require students to look for answers to problems given directly through practicum activities carried out by students, then added also learning media and simple practicum media that are adapted to the sub-learning material delivered to attract the focus and attention of students in the learning process. The learning material delivered by the teacher is more than just rote for students. With this Problem-Based Learning model, the teacher can embed the concept of learning material to be understood by students properly. The results of the recapitulation of the post-test scores of students' mathematical knowledge competence and the scores of critical thinking skills of the two sample groups can be seen in table 3.

Table 3. Recapitulation of the Average Post-Test Scores and Critical Thinking Abilities of the Two Sample Groups

No	Sample	*Post Test*	Critical Thinking Ability
1.	Experiment Group	80.81	58.69
2.	Control Group	72.20	60.00

The inferential statistic used in this study is the Anakova Test. Before carrying out the Anakova Test, the data to be tested must meet the prerequisite tests, including the normality test of data distribution, homogeneity of variance test, and the linearity test described as follows. First, the data tested in the inferential statistical test, namely post-test data of mathematical knowledge competency and thinking ability data critical for both sample groups. The normality test for the distribution of mathematical knowledge competency data in the experimental group used the Kolmogorov-Smirnov technique at a significance level of 5%, namely by deciding if the maximum value |Ft-Fs| < K-S table, it can be concluded that the data follows a normal distribution, and vice versa. Based on the results of normality calculations using the Kolmogorov-Smirnov technique, the mathematical knowledge competency data of the experimental group students obtained the maximum value |Ft-Fs| namely 0.141. At a significant level for n = 32, the value of the Kolmogorov-Smirnov table is 0.240. So it is known that the maximum value of |Ft-Fs| < K-S table, namely 0.141 < 0.240. It can be concluded that the mathematical knowledge

competency data of the experimental group students follow a normal distribution. Then the results of normality test calculations using the Kolmogorov-Smirnov technique for data on the mathematical knowledge competence of control group students obtained the maximum value |Ft-Fs| namely 0.160 at a significant level for n = 30, the value of the Kolmogorov-Smirnov table is 0.242. So it is known that the maximum value of |Ft-Fs| < K-S table, namely 0.160 < 0.242. It can be concluded that the mathematical knowledge competency data of the experimental group students follow a normal distribution.

Second, data on students' critical thinking abilities for both samples were tested for normality using the Kolmogorov-Smirnov technique and data on students' mathematical knowledge competence. The results of the calculation of the normality test using the Kolmogorov-Smirnov technique for the data on the critical thinking skills of the experimental group students obtained the maximum value |Ft-Fs| namely 0.215 then at a significant level for n = 32 the value of the Kolmogorov-Smirnov table is 0.240. So it is known that the maximum value of |Ft-Fs| < K-S table, namely 0.215 < 0.240. The experimental group's data on students' critical thinking skills follow a normal distribution. Then the results of normality test calculations with the Kolmogorov-Smirnov technique data on the critical thinking abilities of control group students obtained the maximum value |Ft-Fs| namely 0.173 at a significant level for n = 30, the value of the Kolmogorov-Smirnov table is 0.242. So it is known that the maximum value of |Ft-Fs| < K-S table, namely 0.173 < 0.242. The data on the critical thinking abilities of the control group students follow a normal distribution. The recapitulation of the data normality test results can be seen in Table 4.

Table 4. Recapitulation of Normality Test Results

No.	Data	Sample Group	Maximum Score |Ft-Fs|	Table score *K-S*	Conclusion
1.	Mathematics Knowledge Competency	Experiment	0.141	0.240	The data follow a normal distribution.
		Control	0.160	0.242	
2.	Critical Thinking Ability	Experiment	0.215	0.240	The data follow a normal distribution.
		Control	0.173	0.242	

After the data is declared normal, it is continued with the variance homogeneity test. The variance homogeneity test was carried out to determine the level of diversity of research data. The homogeneity test of the data used in this study uses the F (Fisher) test. The results of calculating the homogeneity test of the competence of mathematical knowledge for the two sample groups obtained an F-count of 1.30. F-table at α = 5% with df numerator = 1 and df denominator = 60 obtained F-table value = 4.00. So that the ratio of F-count < F-table is 1.30 < 4.00. Based on the results of these calculations, it can be concluded that the data on the mathematics knowledge competency of the sample group students are homogeneous. Then a similar homogeneity test was carried out on the students' critical thinking skills data with the calculation results, which obtained an F-count value of 1.02. F-table at α = 5% with df numerator = 1 and df denominator = 60 obtained F-table value = 4.00. So that the ratio of F-count <F-table is 1.02 < 4.00. Based on the results of these calculations, the data on students' critical thinking skills in the sample group is declared homogeneous. Data recapitulation of homogeneity test results can be seen in Table 5.

Table 5. Recapitulation of Homogeneity Test Results

No	Data	Group	Variance	F-Count	F-Table	Conclusion
1.	Mathematics Knowledge Competency	Experiment	67,90	1.30	4.00	Homogeneous
		Control	88,79			
2.	Critical Thinking Ability	Experiment	122,22	1.02	4.00	Homogeneous
		Control	124,69			

After the data is declared normal and homogeneous, it is continued with the data linearity test. The linearity test is one of the prerequisite tests used to see whether there is a linear relationship between the dependent variable studied and the covariables. This test uses the Matched Tuna Test. The data tested in this linearity test are data on students' mathematical knowledge competence with data on students' critical thinking abilities in the experimental and control groups. The following is a linearity test for the experimental group students' critical thinking skills with mathematical knowledge competence: the F-count value (Suitable Tuna) = 0.28. Then for the F-table at α = 5%, for the numerator dk = 6 and the denominator dk = 24, 2.51 is obtained. So it can be seen that the ratio of F-count (Suitable Tuna) < F-table is 0.28 < 2.51. Based on the test results, it can be concluded that the experimental group's critical thinking

ability data and the mathematical knowledge competence data have a linear relationship. Then the calculation results of the control group's linearity test obtained the value of F-count (Suitable Tuna) = 0.51. Then for the F-table at α = 5%, for the numerator dk = 5 and the denominator dk = 23, 2.63 is obtained. So it can be seen that the ratio of F-count (Suitable Tuna) < F-table is 0.51 < 2.63. The test results show a linear relationship between the critical thinking ability data and the control group's mathematical knowledge competency data. The data from the linearity test results are presented in Table 6.

Table 6. Recapitulation of Linearity Test Results

No	Sample	Dk	F-Count	F-Table	Conclusion
1.	Experiment	6 dan 24	0.28	2.51	Linier
2.	Control	5 dan 23	0.51	2.63	Linier

The data that has been tested fulfills the prerequisite test, which includes data following a normal, homogeneous, and linear distribution. After fulfilling the prerequisite test, it can be continued with hypothesis testing using an inferential statistical test, namely the Anakova Test. Based on the Anakova Test calculation results, the F-count is 14.92, and the F-table is 4.00, with α = 5%, dk quantifier = 1, and dk denominator = 59. Thus F-count > F-table is 14.92 > 4.00, so H0 is rejected. H0 in this study is that there is no difference in the Mathematical Knowledge Competence of the group of students who are taught using the Problem-Based Learning model and the group of students who are not taught using the Problem-Based Learning model after controlling for the Critical Thinking Ability of Fifth Grade Students at SD Negeri Gugus Ki Hajar Dewantara Academic Year 2022/2023. The recapitulation of the calculation results with the analysis of the Anava test for the sample group is presented in the following table. The results of the anaquavadi test can be seen in Table 7.

Table 7. Calculation Results of the Anakova Test

Source of Variance	Number of Quadrants	Dk	Mean Quadrant	F*	F table	Conclusion
Between	1171.981	1	1171.981	14.92	4.00	H0 is rejected
In	4633.911	59	78.540			
Amount	5805.892	60	-			

Based on the results of the Anakova Test calculations, it can be seen that the hypothesis states that there are differences in the competence of the mathematical knowledge of the group of students who are taught using the Problem-Based Learning model and the group of students who are not taught using the Problem-Based Learning model after controlling the critical thinking skills of fifth-grade students at SD Negeri Gugus Ki Hajar Dewantara accepted.

Discussion

Based on the results of the data analysis that has been done, the PBL model can improve students' mathematics learning outcomes. These results indicate that the PBL model can trigger the student learning process to know the concept of the material being studied, and the concept of the problem used is contextual (Nofziarni et al., 2019; Prasetyo & Kristin, 2020). The results of the research analysis also showed differences in the average competency knowledge of the group of students who were taught the Problem-Based Learning model and those who were not taught the Problem-Based Learning model after controlling for critical thinking skills. These results were obtained because the Problem-Based Learning model linked students with real life based on the problems presented during the learning activities (Heryanto et al., 2022; Yusri, 2018). The application of the PBL model in the learning process can help students to imagine what is being learned, where the problems presented are then related to the daily lives of students so that the learning material delivered by the teacher is not just rote for students but can also embed material concepts learning to be understood by students properly (Dwianjani & Candiasa, 2018; Elita et al., 2019; Puspita et al., 2018; Yuhani et al., 2018). Learning models related to problems in everyday life can stimulate the development of students' thinking skills in problem-solving, which can be one of the provisions in welcoming the 21st century with the skills needed (Herutomo et al., 2020; Kumullah et al., 2018).

In applying the Problem-Based Learning model by controlling the factors of students' critical thinking skills, they influence the competence of students' mathematical knowledge without any other

influencing factors such as students' internal factors, namely students' critical thinking skills. The ability of students to think is certainly different from one another, so controlling students' critical thinking skills. The Problem-Based Learning model can influence elementary school students' mathematical knowledge competence. The problem-based learning model can encourage students to think critically in finding answers and solutions to problem-solving so that students' understanding of the material being studied can be remembered longer by emphasizing questions in the form of inducements that help students to think and analyze (Eviani et al., 2019; Iskandar et al., 2021; Seibert, 2021). Learning by applying the Problem-Based Learning model in mathematics learning content provides opportunities for students to develop their thinking skills so that the knowledge received by students tends to be understood through the concepts of the problems studied (Maret & Syarifuddin, 2021; Simanjuntak et al., 2021; Widayanti & Dwi Nur'aini, 2020).

The results obtained in this study align with previous research results, which also revealed that the problem-based learning model could improve students' critical thinking processes in mathematics (Phasa, 2020). The results of other studies reveal that Problem-Based Learning effectively improves students' critical thinking skills in mathematics (Sukmawati, 2020). Further research revealed that using the Problem-Based Learning model and students' critical thinking skills could improve mathematics learning outcomes in flat shape material in fourth-grade elementary school students (Utami, 2019). Based on the results of the research analysis, which is supported by the results of previous research, applying the problem-based learning model can significantly improve critical thinking skills and students' mathematics learning outcomes

4. CONCLUSION

Based on the research and discussion results, the Problem-Based Learning model influences the mathematical knowledge competence of fifth-grade elementary school students after controlling for students' critical thinking skills.

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