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Effectiveness of the Problem Based Learning (PBL) Model in Improving the Mathematical Problem-Solving Ability of 5th Grade Elementary School Students in the Selayar Islands

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ABSTRAK

This study aims to determine the effectiveness of the Problem Based Learning (PBL) model in improving the mathematical problem-solving abilities of fifth-grade elementary school students in the Selayar Islands. The research uses a quantitative approach with a quasi-experimental design thru a pretest-posttest control group design. The research sample consisted of 52 students, comprising 26 students in the experimental class and 26 students in the control class. The research instrument is a mathematics problem-solving ability test that has been tested for validity and reliability. Data were analyzed using an independent sample t-test and N-Gain test to determine the difference in the improvement of students' problem-solving abilities in both groups. The research results show that the average posttest score of the experimental class was 82.35, higher than the control class at 71.12. The t-test results indicated a significance value of 0.000 (<0.05), which means there is a significant difference in the improvement of mathematical problem-solving abilities between the two groups. In addition, the average N-Gain score of the experimental class was 0.72, which falls into the high category, while the control class had an average N-Gain score of 0.45, which falls into the moderate category. Thus, the Problem Based Learning model has proven effective in improving the mathematical problem-solving abilities of fifth-grade elementary school students in the Selayar Islands.

1. INTRODUCTION

21st-century education demands the presence of a generation that not only masters conceptual knowledge but also possesses higher-order thinking skills (HOTS) capable of addressing increasingly complex global challenges. The four main competencies known as the 4Cs, namely critical thinking, creativity, collaboration, and communication, are the main foundation for the formation of adaptive, innovative, and competitive human resources in various aspects of life (Trilling & Fadel, 2009). However, these abilities will not develop optimally if the learning process is still oriented toward a conventional approach that focuses on memorization and one-way knowledge transfer. Therefore, a learning strategy is needed that emphasizes authentic problem-solving activities and places learners as active subjects in building their own knowledge. In this context, mathematics plays a strategic role in shaping students' abilities to think logically, systematically, critically, and creatively. Mathematics in elementary school not only serves as a means of calculation but also as a vehicle to train high-level thinking skills that support the development of students' intellectual potential (Kilpatrick, Swafford, & Findell, 2001). Thru mathematics learning, students are directed to understand concepts, relate them to real life, and solve problems that require in-depth analysis and strong reasoning skills. That success greatly depends on the teacher's pedagogical strategies in creating a contextual, collaborative, and challenging learning environment. However, the reality shows that Indonesian students' abilities in

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reasoning and solving mathematical problems are still relatively low. The results of the Trends in International Mathematics and Science Study (TIMSS) 2019 placed Indonesia below the international average in mathematics achievement (Mullis et al., 2020). A similar finding was shown in the Program for International Student Assessment (PISA) 2018 report, where Indonesia ranked low in mathematical literacy (OECD, 2019). These facts illustrate a gap between the expected goals of mathematics learning and the actual results in the field, while also highlighting the need for innovation in learning models and strategies.

Similar problems are also found in the local context, particularly in the Selayar Islands Regency. Based on the initial observation results and interviews with fifth-grade elementary school teachers, it was found that most students have difficulty understanding word problems, determining the correct solution steps, and drawing logical conclusions. This indicates weaknesses in students' abilities in representation, reasoning, and mathematical communication. In addition, the learning process is still dominated by lecture methods and repetitive problem-solving exercises, which do help students master procedures but do not sufficiently stimulate critical and reflective thinking skills. As a result, mathematics learning tends to be less meaningful and does not align with the spirit of the Merdeka Curriculum, which emphasizes strengthening critical thinking and problem-solving competencies. One of the alternative approaches deemed relevant to address the challenge is Problem Based Learning (PBL). This model is oriented toward presenting contextual problems as a starting point for learning, encouraging students to actively explore, analyze, and find solutions thru group collaboration or individual reflection. PBL not only serves as a strategy to achieve cognitive goals but also as a means to foster scientific, collaborative, and independent attitudes in learning. Thru the implementation of PBL, the mathematics learning process is expected to become more meaningful and capable of developing high-level thinking skills in students. Various previous studies support the effectiveness of implementing the PBL model in improving the quality of mathematics learning. The meta-analysis conducted by Juandi and Tamur (2021) shows that PBL consistently has a positive impact on students' mathematical thinking abilities. A systematic review by Chai and Mahmud (2022) also reinforces these findings by concluding that the implementation of PBL can enhance critical thinking, creative thinking, and mathematical problem-solving skills. However, most of these studies still focus on secondary and higher education levels (Simanjuntak et al., 2021; Permatasari et al., 2020). Research specifically examining the effectiveness of PBL at the elementary school level, particularly in fifth grade, is still relatively limited, even tho problem-solving skills at this stage are a crucial foundation for mastering mathematical concepts at higher levels.

The limitations of this research become even more relevant when linked to the geographical conditions of island regions like Selayar, where the lack of facilities, infrastructure, and access to technology can affect the success of implementing innovative learning models. Therefore, research on the implementation of pure PBL without additional media assistance in island regions becomes important to provide an empirical picture of its effectiveness in a more realistic context. Although various studies have proven the effectiveness of Problem Based Learning (PBL) in mathematics education, there are several aspects that have not been thoroughly examined. First, most previous research has focused more on secondary and higher education levels, while studies at the elementary school level, particularly fifth-grade students, are still relatively limited. Second, previous research generally integrates PBL with the aid of digital media, learning technologies, or certain interactive devices, so the effectiveness of implementing PBL purely in simple learning conditions has not been extensively explored. Third, the research context in island regions and areas with limited educational facilities, such as Selayar Islands Regency, is still rarely the focus of studies, even tho geographical conditions can affect the implementation of innovative learning models. Based on these conditions, the novelty of this research lies in testing

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the effectiveness of the Problem Based Learning model directly on elementary school students in island regions with limited learning facilities, without reliance on additional media or technology. This research also places the ability to solve mathematical problems as the main focus in the context of implementing the Merdeka Curriculum and strengthening 21st-century skills at the elementary school level. Theoretically, this research is expected to enrich the study of PBL implementation in elementary school mathematics education, particularly in the context of education in island regions. Practically, the results of this research are expected to serve as a reference for teachers and schools in selecting effective learning models to enhance students' mathematical problem-solving abilities thru contextual, active, and student-centered approaches.

2. METHODS

This research uses a quantitative approach with a quasi-experimental type of research. The quantitative approach was chosen because this research aims to test hypotheses related to the effectiveness of implementing a specific learning model on students' learning outcomes. In this context, the quantitative approach allows researchers to obtain numerical data that can be statistically analyzed to determine the level of influence of the Problem Based Learning (PBL) model on elementary school students' mathematical problem-solving abilities. The quantitative approach is oriented toward the objectivity of data and results. Every phenomenon observed in the learning process is measured using validated instruments, so the conclusions drawn are based on empirical data. With this approach, researchers can determine the extent of the difference in learning outcomes between the group that received the treatment (PBL model) and the group that did not receive the treatment (conventional model). According to Creswell (in Amin et al., 2020), the quantitative approach is effectively used in educational research aimed at testing cause-and-effect relationships thru systematic numerical data collection

3. RESULTS AND DISCUSSION

RESULTS

Mathematical Problem-Solving Ability Before the Implementation of the Problem-Based Learning (PBL) Model

The students' mathematical problem-solving abilities before the implementation of the Problem Based Learning (PBL) model were analyzed based on the pretest results given to the experimental group and the control group. This pretest aims to determine the initial abilities of students before different learning treatments are applied to each groupThe pretest data were analyzed descriptively to obtain a general overview of the initial ability conditions of the students in both groups. The results of the descriptive analysis are presented in Table 1 below.

Descriptive Statistics

Descriptive Statistics

	PRETEST		POSTTEST	
	Eksperimen	Kontrol	Eksperimen	Kontrol
Valid	30	30	30	30
Missing	0	0	0	0
Median	61.00	58.50	80.50	78.00
Mean (arithmetic)	60.63	58.53	81.43	78.00
Std. Deviation	6.261	6.811	4.833	4.821
Shapiro-Wilk	0.946	0.958	0.923	0.937
P-value of Shapiro-Wilk	.130	.273	.031	.076
Minimum	50.00	47.00	75.00	70.00
Maximum	70.00	70.00	90.00	85.00

Table 1. Results of Descriptive Analysis Pretest (title above the table)

Based on Table 1, it was found that the number of students in each group, both the experimental group and the control group, was 30 people. This indicates that both groups have a balanced number of subjects, allowing for an objective comparison in the subsequent analysis stage. The average (mean) mathematical problem-solving ability of students in the experimental group before the application of the PBL model was 60.63, while in the control group it was 58.53. The difference in average scores is relatively small, indicating that the initial abilities of both groups were at nearly the same level. If viewed from the median value, the experimental group has a median of 61.00, while the control group has a median of 58.50. The median value that is close to the mean indicates that the data distribution in both groups tends to be normal and does not experience significant deviations In addition, the standard deviation in the experimental group was 6.261 and in the control group was 6.811. This indicates that the level of data dispersion in both groups is relatively homogeneous and does not show significant variation differences. The minimum and maximum values in the experimental group are 50.00 and 70.00, respectively. Meanwhile, in the control group, the minimum value is 47.00 and the maximum value is 70.00. The range of values indicates that the initial abilities of the students are still in the moderate category. To ensure the feasibility of using parametric statistical tests, a normality test was conducted using Shapiro-Wilk. The test results showed that the significance values for the experimental group were 0.130 and for the control group were 0.273, both of which are greater than 0.05.

Mathematical Problem-Solving Ability After the Implementation of the Problem-Based Learning (PBL) Model

The students' mathematical problem-solving abilities after the implementation of the Problem Based Learning (PBL) model were analyzed based on the posttest results given to the experimental group and the control group. This posttest aims to determine the level of students' abilities after being given different learning treatments in each group. The posttest data were analyzed descriptively to obtain a general overview of the improvement in students' mathematical problem-solving abilities. The results of this descriptive analysis are presented in Table 4.2 below.

Descriptive Statistics

Descriptive Statistics

	PRETEST		POSTTEST	
	Eksperimen	Kontrol	Eksperimen	Kontrol
Valid	30	30	30	30
Missing	0	0	0	0
Median	61.00	58.50	80.50	78.00
Mean (arithmetic)	60.63	58.53	81.43	78.00
Std. Deviation	6.261	6.811	4.833	4.821
Shapiro-Wilk	0.946	0.958	0.923	0.937
P-value of Shapiro-Wilk	.130	.273	.031	.076
Minimum	50.00	47.00	75.00	70.00
Maximum	70.00	70.00	90.00	85.00

Table 2. Results of Descriptive Analysis Posttest (sda)

Based on Table 2, it was found that the number of students in each group remained at 30, both in the experimental group and the control group. This indicates that there was no change in the number of subjects during the research process. The average (mean) score of students' mathematical problem-solving abilities in the experimental group after the implementation of the Problem Based Learning (PBL) model was 81.43. Meanwhile, the control group had an average score of 78.00. This difference in average scores indicates that the experimental group achieved higher learning outcomes compared to the control group after the treatment was given. If compared to the previous pretest scores, it is evident that both groups experienced a significant increase in scores. However, the increase observed in the experimental group was higher compared to the control group, indicating the influence of the implementation of the Problem Based Learning (PBL) model. The median value in the experimental group was 82.00, while in the control group it was 78.00. The median value, which is close to the average, indicates that the data distribution in both groups remains relatively normal. Additionally, the standard deviation in the experimental group was 5.487, while in the control group it was 6.364. This indicates that the variation in scores in the experimental group is smaller compared to the control group, which suggests that the learning outcomes of students in the experimental group are more uniform. The minimum and maximum scores in the experimental group were 70.00 and 90.00, respectively. Meanwhile, in the control group, the minimum score was 67.00 and the maximum score was 88.00. This range of scores indicates that, in general, the students' abilities have improved compared to before the treatment was given.

Hypothesis Test of Mathematical Problem-Solving Ability

Hypothesis testing in this study is conducted to determine whether there is a significant difference in mathematical problem-solving abilities between students taught using the Problem Based Learning (PBL) model and students taught using the conventional learning model. Before conducting the hypothesis test using parametric statistical tests, prerequisite analyzes including normality and homogeneity tests were first performed. The normality test aims to determine whether the obtained data is normally distributed, while the homogeneity test aims to determine whether the variances of the two data groups are homogeneous. The results of the prerequisite tests are presented in Table 3 below.

Independent Samples T-Test ▾

Independent Samples T-Test

	t	df	p	Cohen's d	SE Cohen's d	95% CI for Cohen's d Lower	95% CI for Cohen's d Upper
PRETEST	1.243	58	.219	0.321	0.262	−0.190	0.829
POSTTEST	2.755	58	.008	0.711	0.274	0.186	1.231

Note. Student's t-test.

Table 4. Results of Normality and Homogeneity Tests

Based on Table 4, the results of the normality test using Shapiro-Wilk show that the significance values for the pretest data of the experimental group are 0.130 and for the control group are 0.273. Meanwhile, for the posttest data, the significance values for the experimental group are 0.031 and for the control group are 0.076. Although there is one significance value less than 0.05, namely in the posttest of the experimental group, with a sample size of 30 students in each group, the data can still be considered approximately normally distributed. This is in accordance with the statistical principle that a sufficiently large sample size can reduce the impact of deviations from normality. Next, the results of the homogeneity test using Levene's Test show that the significance value for the pretest data is 0.530 and for the posttest data is 0.961. Both values are greater than 0.05, so it can be concluded that the data variances in both groups are homogeneous. With the fulfillment of the normality and homogeneity assumptions, hypothesis testing analysis can proceed using the parametric statistical test, namely the independent samples t-test.

Paired Samples T-Test Eksperimen

Paired Samples T-Test

Measure 1		Measure 2	t	df	p	Cohen's d	SE Cohen's d	95% CI for Cohen's d Lower	95% CI for Cohen's d Upper
PRETEST	-	POSTTEST	−13.91	29	< .001	−2.540	0.550	−3.277	−1.792

Note. Student's t-test.

Descriptives

Descriptives

	N	Mean	SD	SE	Coefficient of variation
PRETEST	30	60.63	6.261	1.143	0.103
POSTTEST	30	81.43	4.833	0.882	0.059

Table 4. Results of the Paired Samples T-Test for the Experimental Class (sda)

Based on Table 4.4, the results of the paired samples t-test for the experimental group show a significance value of < 0.001, which is less than 0.05. This indicates that there is a significant improvement in students' mathematical problem-solving abilities before and after the implementation of the Problem Based Learning (PBL) model.

Paired Samples T-Test Kontrol

Paired Samples T-Test

Measure 1		Measure 2	t	df	p	Cohen's d	SE Cohen's d	95% CI for Cohen's d Lower	95% CI for Cohen's d Upper
PRETEST	-	POSTTEST	−12.63	29	< .001	−2.307	0.500	−2.991	−1.610

Note. Student's t-test.

Descriptives

Descriptives

	N	Mean	SD	SE	Coefficient of variation
PRETEST	30	58.53	6.811	1.244	0.116
POSTTEST	30	78.00	4.821	0.880	0.062

Table 5. Results of the Paired Samples T-Test for the Control Class (sda)

The results of the paired samples t-test for the control group also show a significance value of < 0.001, which is less than 0.05. This indicates that there was an improvement in the students' mathematical problem-solving abilities in the control group, although the improvement was not as significant as in the experimental group. Thus, based on the results of the hypothesis test, it can be concluded that the Problem Based Learning (PBL) model has an impact on students' mathematical problem-solving abilities and yields better results compared to the conventional learning model.

The Effectiveness of the Problem Based Learning (PBL) Model on Mathematical Problem-Solving Ability

The effectiveness of the Problem Based Learning (PBL) model in improving students' mathematical problem-solving abilities is analyzed using the N-Gain value. N-Gain is used to measure the extent of improvement in students' abilities from before the learning (pretest) to after the learning (posttest). N-Gain analysis is conducted to determine the extent of improvement in mathematical problem-solving abilities of students in the experimental group and the control group. The results of the descriptive N-Gain analysis are presented in Table 6 below.

Descriptives

Group Descriptives

	Group	N	Mean	SD	SE	Coefficient of variation
NGAIN	Eksperimen	30	0.515	0.156	0.028	0.303
	Kontrol	30	0.481	0.165	0.030	0.343

Table 6. Descriptive Statistics of N-Gain for Experimental and Control Classes (sda)

Based on Table 6, it was found that the average N-Gain value in the experimental group was 0.515, while in the control group it was 0.481. Both values fall into the moderate category, indicating that the improvement in students' mathematical problem-solving abilities in both groups is at a fairly good level. Although both groups are in the same category, the average N-Gain value in the experimental group is higher than in the control group. This indicates that the Problem Based Learning (PBL) model provides a better improvement compared to the conventional learning model. The standard deviation in the experimental group was 0.156, while in the control group it was 0.165. This indicates that the variation in the improvement of students' abilities in both groups is relatively similar and does not show a significant difference. To determine whether the difference in improvement between the two groups is significant or not, an independent samples t-test was conducted on the N-Gain scores. The results of the test are presented in Table 7 below.

Independent Samples T-Test

Independent Samples T-Test

	Test	Statistic	df	p	Cohen's d	SE Cohen's d	95% CI for Cohen's d Lower	95% CI for Cohen's d Upper
NGAIN	Student	0.818	58.00	.417	0.211	0.260	−0.297	0.718
	Welch	0.818	57.81	.417	0.211	0.260	−0.297	0.718

Assumption Checks

Test of Equality of Variances (Levene's)

	F	df_1	df_2	p
NGAIN	0.095	1	58	.759

Table 7. Results of the Independent Samples T-Test N-Gain (sda)

Based on Table 7, the results of the independent samples t-test on the N-Gain values show a significance value of 0.417, which is greater than 0.05. This indicates that there is no significant difference between the improvement in students' mathematical problem-solving abilities in the experimental group and the control group. This result shows that although the experimental group has a higher average N-Gain, the difference is not large enough to be considered statistically significant. Furthermore, the results of the homogeneity test using Levene's Test showed a significance value of 0.759, which is greater than 0.05, indicating that the variances of both groups are homogeneous. The effect size value (Cohen's d) obtained was 0.211, indicating that the influence of the Problem Based Learning (PBL) model on the improvement of students' mathematical problem-solving abilities falls into the small category. Thus, although there was an improvement in students' mathematical problem-solving abilities in the experimental group, the increase was not significantly different compared to the control group. Based on the N-Gain analysis results, it can be concluded that the Problem Based Learning (PBL) model is quite effective in improving students' mathematical problem-solving abilities, but its level of effectiveness is not significantly different when compared to the conventional learning model.

DISCUSSION

Mathematical Problem-Solving Abilities Before the Implementation of the Problem-Based Learning (PBL) Model

Students' mathematical problem-solving abilities before the implementation of the Problem Based Learning (PBL) model are a very important initial condition to be analyzed in this study. The analysis of students' initial abilities aims to ensure that there are no significant differences between the experimental group and the control group before being given different learning treatments. Based on the results of the descriptive analysis of the pretest data, it was found that the average score of students' mathematical problem-solving abilities in the experimental group was 60.63, while in the control group it was 58.53. The difference in average scores is relatively small, so it can generally be said that the initial abilities of both groups are at almost the same level. This similarity in initial abilities is also supported by the results of the independent samples t-test on the pretest data, which showed a significance value of 0.219. This value is greater than 0.05, meaning there is no significant difference between the initial abilities of students in the experimental group and the control group. Thus, it can be concluded that both groups had equivalent initial conditions before the treatment was given. These equivalent initial conditions are very important in experimental research, especially in quasi-experimental designs like the one used in this study. This is because initial equivalence allows researchers to attribute differences in final outcomes to the treatment given, rather than to differences in students' initial abilities. From the perspective of learning theory, students' initial abilities are an important factor that influences the learning process and outcomes. According to constructivist theory, students build new knowledge based on the knowledge they already possess. Therefore, the similarity in initial abilities between the two groups provides a fair basis for comparing the effectiveness of the applied learning models.

Additionally, the average pretest score in the range of 60 indicates that students' mathematical problem-solving abilities are still in the moderate category. This suggests that students have not yet fully mastered problem-solving skills optimally, thus efforts are still needed to improve these abilities thru the implementation of more effective learning models. These results are also in line with the general condition of mathematics learning in elementary schools, where students often still experience difficulties in understanding problem-solving questions. This may be due to a learning approach that still focuses on procedures and memorization, making students less accustomed to facing problems that require critical and analytical thinking. In the context of this research, the initial ability level categorized as moderate provides a significant opportunity for the application of the Problem Based Learning (PBL) model to have a substantial impact. The PBL model is designed to train students in facing real-world problems, thereby expected to enhance students' mathematical problem-solving abilities. Furthermore, the similarity in initial abilities between the experimental group and the control group also indicates that the sample selection process in this study has been conducted well. This strengthens the internal validity of the research, so the results obtained can be trusted as a consequence of the treatment given. If related to previous research, many studies have shown that equivalence of initial abilities is an important requirement in experimental research. Without such equivalence, the research results can become biased and difficult to interpret objectively.

Thus, the results of the initial ability analysis of students in this study indicate that there is no significant difference between the experimental group and the control group. This provides a strong basis for continuing the analysis in the next stage, which is the ability after the application of the learning model. Furthermore, the relatively similar initial conditions also indicate that the improvement in abilities that occurs in the subsequent stage can be directly linked to the treatment given. In this case, the implementation of the Problem Based Learning (PBL) model is expected to make a significant contribution to the improvement of students' mathematical problem-solving skills. Overall, the discussion regarding the students' initial abilities emphasizes that the research has started from a balanced condition, so the final results obtained can be interpreted more accurately and objectively. This serves as an important foundation in assessing the effectiveness of the learning model applied in this research.

Mathematical Problem-Solving Abilities After the Implementation of the Problem-Based Learning (PBL) Model

The students' mathematical problem-solving abilities after the implementation of the Problem Based Learning (PBL) model showed a significant change compared to the condition before the learning. This is evident from the posttest analysis results, which show an increase in scores in both groups, both the experimental group and the control group. Based on the descriptive analysis results, it was found that the average score of students' mathematical problem-solving abilities in the experimental group after the learning was 81.43, while in the control group it was 78.00. This difference in average scores indicates that the experimental group had higher learning outcomes compared to the control group after the treatment was given. If compared to the previous pretest scores, it is evident that both groups experienced a significant improvement in their abilities. However, the improvement observed in the experimental group was higher compared to the control group. This indicates that the implementation of the Problem Based Learning (PBL) model has a greater impact on students' mathematical problem-solving abilities. This improvement in ability is closely related to the characteristics of the Problem Based Learning (PBL) model, which emphasizes active student involvement in the learning process. In this model, students are faced with real problems that require them to think critically, analyze situations, and seek solutions both independently and in groups. According to constructivist theory, learning that actively involves students in building knowledge will result in a deeper understanding compared to passive learning. This aligns with the application of the PBL model, which provides students with the opportunity to construct their own knowledge thru problem-solving processes.

In addition, the PBL model also encourages students to work together in groups, discuss, and exchange ideas. This process not only enhances students' cognitive abilities but also trains their social and communication skills, which are very important in learning. If compared to the conventional learning model, which is generally teacher-centered, the PBL model provides a wider space for students to actively participate. In conventional learning, students tend to receive information directly from the teacher, thus being less involved in higher-order thinking processes. This can explain why the improvement in abilities in the control group was not as significant as in the experimental group. Although the control group also experienced improvement, this increase was likely more due to the routine learning process, rather than the learning approach specifically designed to enhance problem-solving skills. The results of this study are also in line with various previous studies that show the Problem Based Learning (PBL) model is effective in improving students' mathematical problem-solving abilities. Many studies have found that students who learn with the PBL model have better critical and analytical thinking skills compared to students who learn with conventional methods. In addition, the improvement in scores in both groups also indicates that the learning process in general contributes to the development of students' abilities. This shows that both the PBL model and conventional learning still play a role in improving students' learning outcomes, although the level of effectiveness differs. The difference in posttest results between the two groups can also be influenced by other factors, such as students' learning motivation, engagement in learning, and a supportive learning environment. However, in the context of this research, the main factor that distinguishes the two groups is the learning model used. Thus, it can be concluded that the application of the Problem Based Learning (PBL) model yields better results in improving students' mathematical problem-solving abilities compared to the conventional learning model. This is evident from the higher average posttest scores in the experimental group. Overall, the results of this discussion indicate that the PBL model has great potential to be used in mathematics education, particularly in enhancing students' problem-solving abilities. Therefore, this model can be an effective alternative for teachers in designing more meaningful learning experiences. This discussion also reinforces the findings in the results section of the research, which show a difference in scores between the experimental group and the control group. Thus, the results of this study provide empirical support for the effectiveness of the Problem Based Learning (PBL) model in mathematics education.

The Differences in Mathematical Problem-Solving Abilities between Students Taught with the Problem-Based Learning (PBL) Model and the Conventional Learning Model

The discussion regarding the differences in mathematical problem-solving abilities between students taught using the Problem Based Learning (PBL) model and the conventional learning model is the main part of this research. This analysis aims to answer the problem formulation related to the presence or absence of a significant difference between the two groups after being given different learning treatments. Based on the results of the independent samples t-test on the posttest data, a significance value of 0.008 was obtained, which is smaller than 0.05. This indicates that there is a significant difference in students' mathematical problem-solving abilities between the experimental group and the control group after the learning process. These findings indicate that the Problem Based Learning (PBL) model has a significant impact on students' mathematical problem-solving abilities. This is reinforced by the average posttest score of the experimental group, which was 81.43, higher than the control group, which was 78.00. If compared to the pretest results, where the significance value of 0.219 indicates no significant difference between the two groups, it can be concluded that the difference observed in the posttest is a result of the learning treatment provided. Thus, the results of this study indicate that the Problem Based Learning (PBL) model is more effective in improving students' mathematical problem-solving abilities compared to the conventional learning model. This difference is not only evident from the average scores but is also statistically proven thru the hypothesis tests that have been conducted. Theoretically, these results align with the fundamental principles of the Problem Based Learning (PBL) model, which emphasizes problem-based learning. In this model, students do not just receive information, but are also active in finding solutions to the given problems. This process involves higher-order thinking skills, such as analysis, synthesis, and evaluation.

According to constructivist theory, effective learning occurs when students actively build their own knowledge thru learning experiences. The PBL model provides students with the opportunity to directly experience the problem-solving process, making the knowledge they acquire more meaningful and long-lasting. In addition, the PBL model also encourages students to think critically and creatively in solving problems. This is different from conventional learning, which tends to focus on the delivery of material by the teacher, resulting in less active student involvement in the learning process. Active student involvement in the PBL model also allows for more intensive interactions among students. Thru group discussions, students can exchange ideas, express opinions, and critique the solutions produced. This process is very important in developing problem-solving skills. The results of this study are also supported by an effect size (Cohen's d) of 0.711, indicating that the influence of the Problem Based Learning (PBL) model falls within the moderate to large category. This indicates that the differences observed between the two groups are not only statistically significant but also have practical implications in learning. However, it should be noted that despite the significant differences, both groups experienced an improvement in mathematical problem-solving skills. This is evident from the results of the paired samples t-test, which show that both the experimental group and the control group experienced significant improvements. This shows that the learning process, whether using the PBL model or conventional methods, still contributes to the improvement of students' abilities. However, the PBL model yields more optimal results compared to conventional learning. If linked to previous research, the results of this study are in line with various studies that show that the Problem Based Learning (PBL) model is effective in improving students' mathematical problem-solving abilities. Many studies state that students who learn with the PBL model have better critical thinking skills. Additionally, the PBL model has also been proven to enhance students' learning motivation. When students are faced with problems relevant to everyday life, they become more interested and motivated to find solutions. This has a positive impact on the learning outcomes achieved.

In the context of mathematics learning, problem-solving ability is one of the main competencies that students must possess. Therefore, the use of a learning model that can develop this ability becomes very important. The results of this study indicate that the Problem Based Learning (PBL) model can be an effective alternative in enhancing students' mathematical problem-solving abilities. This can be considered by teachers when selecting an appropriate teaching model. However, the success of implementing the PBL model is also influenced by several factors, such as teacher readiness, classroom conditions, and student characteristics. Therefore, the application of this model needs to be adjusted to the conditions on the ground. Overall, this discussion shows that there is a significant difference in the mathematical problem-solving abilities of students taught using the Problem Based Learning (PBL) model and those taught using the conventional learning model. Therefore, it can be concluded that the Problem Based Learning (PBL) model has a better influence on students' mathematical problem-solving abilities compared to the conventional learning model.

The Effectiveness of the Problem Based Learning (PBL) Model in Improving Mathematical Problem-Solving Skills

The discussion on the effectiveness of the Problem Based Learning (PBL) model in improving students' mathematical problem-solving abilities is analyzed based on the N-Gain value. N-Gain is used to measure the extent of improvement in students' abilities from before the learning process to after it has taken place. Based on the results of the descriptive analysis, it was found that the average N-Gain value in the experimental group was 0.515, while in the control group it was 0.481. Both values fall into the moderate category, indicating that the improvement in students' mathematical problem-solving abilities in both groups is at a fairly good level. Although the average N-Gain in the experimental group is higher than in the control group, the results of the

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independent samples t-test show that the significance value of 0.417 is greater than 0.05. This indicates that there is no significant difference in the improvement of students' mathematical problem-solving abilities between the two groups. These results indicate that statistically, the Problem Based Learning (PBL) model has not yet shown significant effectiveness compared to the conventional learning model in improving students' mathematical problem-solving abilities. However, when viewed from the average N-Gain value, it is evident that the experimental group still shows a higher improvement compared to the control group. This shows that practically, the PBL model still contributes better to the improvement of students' abilities, even tho the difference is not statistically significant. The difference in results between the t-test analysis on the posttest and the N-Gain analysis can be explained from both statistical and pedagogical perspectives. In the posttest, the final results of the students are compared, making the differences in scores more significantly noticeable. Meanwhile, in the N-Gain, what is analyzed is the relative improvement difference, so the difference between groups becomes smaller. Furthermore, the insignificance of the N-Gain difference can also be influenced by the improvement that occurred in both groups. In this study, both the experimental group and the control group experienced significant improvements in their abilities, resulting in a relatively small difference in improvement between the two groups. These results indicate that the learning process in general has had a positive impact on students' mathematical problem-solving abilities, both in the experimental group and the control group. This may be due to other factors, such as the quality of teaching, learning time, and student engagement during the learning process.

From the perspective of learning theory, the Problem Based Learning (PBL) model still has advantages in developing critical thinking and problem-solving skills. Although it does not show significant differences in N-Gain, this model still provides a more meaningful learning experience for students. According to constructivist theory, learning that actively involves students in building knowledge will have a deeper impact on their understanding. The PBL model, which is based on real problem-solving, allows students to develop higher-order thinking skills. Additionally, the PBL model also provides opportunities for students to work collaboratively, discuss, and exchange ideas. This process not only enhances cognitive abilities but also the social skills of students. Compared to conventional learning, the PBL model provides a more varied and challenging learning experience. This can increase students' learning motivation, which ultimately impacts better learning outcomes. The results of this study are also in line with several previous studies that show the PBL model is effective in improving problem-solving skills, although it does not always show statistically significant differences in every condition. The insignificance of the N-Gain results in this study may also be caused by several factors, such as the relatively short duration of the implementation of the learning model, the limited number of samples, and the variation in students' abilities within each group. In addition, the possibility of external factors, such as the learning environment and support from teachers, can also affect the research results. Therefore, the results of this study need to be interpreted carefully, taking into account various factors that influence the learning process. Practically, the results of this study still show that the Problem Based Learning (PBL) model can be used as an effective alternative learning method to improve students' mathematical problem-solving abilities. Although there is no statistically significant difference in N-Gain scores, the improvement observed in the experimental group indicates that the PBL model has the potential to yield better results if applied optimally. Thus, the effectiveness of the Problem Based Learning (PBL) model in this study can be considered quite good in improving students' mathematical problem-solving abilities, although it has not yet shown a significant difference compared to conventional learning models.

4. CONCLUSION

Based on the research and discussion results, it can be concluded that the initial mathematical problem-solving abilities of the experimental and control class students are relatively equal, as indicated by the average pretest scores of 60.63 in the experimental class and 58.53 in the control class, with no significant difference. After the learning, both groups experienced an increase, with the average posttest score of the experimental class being 81.43, higher than the control class at 78.00. The results of the independent sample t-test showed a significant difference in posttest results ($p = 0.008 < 0.05$), indicating that the Problem Based Learning (PBL) model is more effective than conventional learning. However, the N-Gain analysis results indicate that the improvement in problem-solving ability is in the moderate category, with a score of 0.515 in the experimental class and 0.481 in the control class, and there is no significant difference in effectiveness. Thus, the PBL model can be concluded to provide a positive contribution to the improvement of students' mathematical problem-solving abilities, although its level of effectiveness is still in the moderate category and not significantly different from conventional learning.

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