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THE EFFECT OF PROBLEM BASED LEARNING ON STUDENTS' MATHEMATICAL PROBLEM SOLVING SKILLS

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ABSTRACT

This study was motivated by the low mathematical problem-solving skills of students at SMP Negeri 2 Suwawa, which is believed to be caused by the use of the Direct Instruction model that has not effectively supported the development of such skills. This study aimed to examine the effect of implementing the Problem-Based Learning (PBL) model on students' mathematical problem-solving abilities, particularly on the topic of Systems of Linear Equations in Two Variables (SPLDV). The research employed a quasi-experimental method with a pretest-posttest design with a nonequivalent group. The participants were students of classes VIII-3 and VIII-4 at SMP Negeri 2 Suwawa, selected through cluster random sampling. The instrument used was a test measuring mathematical problem-solving skills based on SPLDV material. The hypothesis was tested using the t-test, which yielded a result of $t_h = 3.767 > t_t = 2.024$, indicating that students taught using the PBL model had significantly higher average problem-solving abilities than those taught using the Direct Instruction model. Additionally, the effect size calculated with Cohen's d was 1.191, categorized as a high effect. These results suggest that the implementation of Problem-Based Learning significantly enhances students' mathematical problem-solving skills and can serve as an effective alternative to traditional instructional models in mathematics learning.

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INTRODUCTION

Mathematics is one of the essential subjects that students need to learn at school. Therefore, it becomes one of the subjects with the highest proportion of instructional hours compared to other subjects (Usman et al., 2022). According to (Kue et al., 2022) mathematics is a branch of science taught from elementary school to university level. Essentially, mathematics holds the position as the queen of sciences and, as a discipline, serves both as a foundation and a supporting tool for other branches of knowledge (Irfah & Rahmah, 2017). Thus, mathematics is a fundamental science that should be taught to everyone.

In addition, mathematics is also a field of knowledge that studies concepts which enable students to actively engage in mathematical problem-solving (Pauweni et al., 2022). This aligns with the opinion of (Irhamna et al., 2020), who stated that an essential goal in mathematics learning is the development of problem-solving abilities. Therefore, mathematical problem-solving skills can be considered one of the primary objectives in mathematics education.

Problem-solving ability is a learning process that encourages students to actively participate in the learning process (Dwita Imannia et al., 2022). The goal of developing problem-solving skills is to enable students to overcome problems and respond to questions effectively. To support the development of these skills, it is important to first identify the indicators of problem-solving. According to Polya, as cited in (Irfah & Rahmah, 2017), there are four indicators of problem-solving,: 1) understanding the problem; 2) devising a plan; 3) carrying out the plan; and 4) reviewing the solution.

Based on an interview conducted at SMP Negeri 2 Suwawa, one of the mathematics teachers stated that the learning model used in the classroom is Direct Instruction (DI) a teacher-centered model in which the teacher delivers the material in a structured and sequential manner using simple steps. As a result, students have not yet developed strong mathematical problem-solving skills. This can be seen from the results of the mid-semester examination, as shown in Figure 1 below

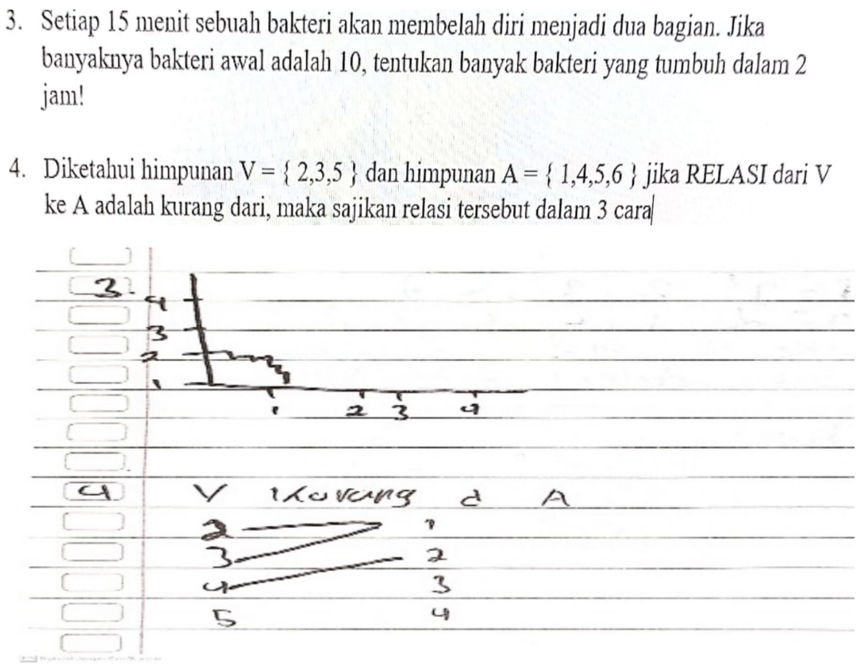

Figure 1. Mid-Semester Test Results of Students

Based on Figure 1, it can be seen that students only wrote down the answers without including the steps in solving the problem. To address this issue, one approach that can be taken is to use a learning model that can enhance students' mathematical problem-solving skills during lessons. Problem-Based Learning (PBL) is an alternative learning model that can be used to overcome the issue mentioned above. According to (Hermuttaqien et al., 2023).

, Problem-Based Learning (PBL) aims to encourage students' progress in solving problems during the learning process. In line with the opinion of (Sholikah et al., 2023), the Problem-Based Learning (PBL) model is a learning model that helps students solve problems with the goal of improving their own knowledge, enhancing their thinking skills, and fostering independence and self-confidence. Moreover, the Problem-Based Learning (PBL) model is designed in the form of learning that begins with real-world problem structures related to the mathematical concepts being taught. Students are not merely passive recipients of information from the teacher; instead, the teacher must motivate and guide students to actively participate in the entire learning process (Usman et al., 2022)

METHOD

The approach used in this study is a quantitative approach with a quasi-experimental method, as the subjects in this study can be strictly arranged and controlled. The research design used is the pretest-posttest design with nonequivalent groups. To conduct this research, one experimental group and one control group were used to observe students' mathematical problem-solving abilities. The PBL learning model was applied to the experimental group, while the control group used the DI (Direct Instruction) learning model, serving as a comparison group that did not receive any special treatment. The following is the research design used

Table 1. Research Design

Class	*Pretest*	Treatment	*Posttest*
Experimental (PBL)	O_1	X_1	O_2
Control (DI)	O_1	X_2	O_2

Explanation:
X_1 = Learning using the Problem-Based Learning model
X_2 = Learning using the Direct Instruction model
O_1 = Pretest for the experimental class and the control class
O_2 = Posttest for the experimental class and the control class

The population of this study consists of all eighth-grade students at SMP Negeri 2 Suwawa, which comprises four classes with a total of 93 students. The sample used in this study was class VIII3 as the experimental group with 20 students and class VIII4 as the control group. The sampling technique employed was cluster random sampling (Kurniawati, 2017)

The instrument used was a test sheet in the form of 8 essay-type questions. The data collection technique involved the use of a pretest and posttest. The data analysis techniques included prerequisite tests (normality and homogeneity tests) and hypothesis testing using the t-test, which was used to determine the significance of the difference in mean scores. After the t-test results, the analysis continued with Cohen's effect size test to determine the magnitude of the effect, using the following criteria

Table 2. Criteria for Cohen's Effect Size Test

Effect Size	Explanation
0,00-0,20	Has a weak effect
0,21-0,50	Has a low effect
0,51-1,00	Has a moderate effect
>1,00	Has a strong effect

Source: (Cohen, 2019).

RESULTS AND DISCUSSION

Results

The data in this study were obtained from the results of students' mathematical problem-solving ability tests in the form of essay-type questions, conducted after the learning process in the experimental class (class VIII.3 with 20 students) and the control class (class VIII.4 with 20 students). The subject matter used in this research was the System of Linear Equations in Two Variables (SPLDV), where the experimental class applied the Problem-Based Learning (PBL) model, while the control class used the Direct Instruction (DI) model. In this case, the tests consisted of 5 valid pretest questions and 5 valid posttest questions.

Next, the prerequisite tests for analysis included normality and homogeneity tests. The normality test is used to determine whether the data collected by the researcher is normally distributed or not (Nasrum, 2018). In this study, the Liliefors test was used for the normality test, with the following results:

Table 3. Results of the Pretest Normality Test

Class	N	L_calculated	L_table	Explanation
Experimental	20	0,12	0,19	Normal
Control	20	0,09	0,19	Normal

Based on the results of the normality test for the pretest, it was found that Lcount < Ltable at a significance level of 0.05. Therefore, H_0 is accepted, indicating that the data is normally distributed. It can thus be concluded that the samples from class VIII3 and VIII4 have a uniform distribution and can accurately represent the population.

Table 4. Results of the Posttest Normality Test

Class	N	L_calculated	L_table	Explanation
Experimental	20	0,15	0,19	Normal
Control	20	0,12	0,19	Normal

The results of the posttest normality test show that L_calculated) < L_table at a significance level of 0.05, therefore H_0 is accepted. It can be concluded that the data are normally distributed, indicating that the samples from classes $VIII_3$ and $VIII_4$ have an even distribution and truly represent the population.

After the data sets were found to be normally distributed, a homogeneity of variance test was conducted. The purpose of this test is to determine whether the characteristics and abilities of the two classes are homogeneous or not. The following are the results of the homogeneity test:

Table 5. Results of the Pretest Homogeneity Test

Class	Variance	F_calculated	F_table	Explanation
Experimental	21,46	1,53	2,16	Homogen
Control	13,95			

By comparing the calculated F value with the table F value, it was found that F calculated < F table, namely 1.53 < 2.16 at a significance level of 0.05. Based on the results, it can be concluded that both the experimental class and the control class come from homogeneous populations.

Table 6. Results of the Posttest Homogeneity Test

Class	Variance	F_calculated	F_table	Explanation
Experimental	16,83	1,83	2,16	Homogen
Control	9,18			

By comparing the calculated F value with the table F value, it was found that F calculated < F table, namely 1.83 < 2.16 at a significance level of 0.05. Based on the results, it can be concluded that both the experimental class and the control class come from homogeneous populations.

After conducting the prerequisite tests, where the results showed that the data are normally distributed and homogeneous, the next step is to perform a t-test. The following are the results of the t-test on mathematical problem-solving ability

Table 7. Results of the t-Test

Statistical Values	Class	
	Experimental	**Control**
Mean	28,1	25,85
Standard Deviation	4,102	3,030
Variance	16,83	9,18
Sample Size	20	20
t_Calculated	3,767	
t_Table	2,024	

Based on the results of the analysis using the t-test, the calculated t value was 3.767, while the critical t value at the significance level of $\alpha = 0.05$ was 2.024. Since t calculated > t table (3.767 > 2.024), the null hypothesis (H_0) is rejected and the alternative hypothesis (H_1) is accepted. Therefore, there is a significant difference in the application of the Problem-Based Learning model on students' mathematical problem-solving ability.

After conducting the t-test, the results showed a significant difference in the data. The next step is to perform an effect size test to determine the magnitude of the effect. The test used is Cohen's d. The following are the results of the effect size analysis.

Table 8. Results of the Cohen's d Effect Size Test

Statistical Values	Class	
	Experimental	**Control**
Mean	28,1	25,85
Standard Deviation	4,102	3,030
Sample Size	20	20
SD_{pooled}	1,888	
Effect Size (ES)	1,191	

Based on the results of the Cohen's d calculation, the effect size obtained was 1.191. Referring to Cohen's criteria table, if the effect size is greater than 1.00, it falls into the high effect category.

The presentation and analysis of the data show a significant difference between the value of t calculated and ttable. Based on the t-test analysis, it was found that t calculated = 3.767, while the t table value at a significance level of $\alpha = 0.05$ is 2.024. From these values, it can be seen that t calculated > t table (3.767 > 2.024), therefore H_0 is rejected and H_1 is accepted. This hypothesis finding leads to the conclusion that: "The average mathematical problem-solving ability of students after the implementation of the Problem-Based Learning (PBL) model is higher than the average mathematical problem-solving ability of students after the implementation of the Direct Instruction (DI) model". After identifying a significant difference in the average scores, an effect size test was conducted. According to (Cohen, 2019), the effect size test is used to determine how strong the influence of the Problem-Based Learning (PBL) model is on students' mathematical problem-solving abilities. The result of the effect size test using Cohen's d showed a value of 1.191 > 1, indicating that "The implementation of the Problem-Based Learning model has a high effect on students' mathematical problem-solving abilities."

Discussions

The Problem-Based Learning model has been proven to influence students' mathematical problem-solving abilities, as evidenced by the improvement in their scores. Students who were taught using the Problem-Based Learning model achieved better results in meeting the indicators of mathematical problem-solving ability compared to those who were taught using the Direct Instruction model. This can be seen from the average score obtained by the experimental class (VIII.3), which was 28.1, while the average score of the control class (VIII.4) was 25.85. From these average scores, it can be concluded that the students in the experimental class performed better than those in the control class.

The study conducted by (Masturoh, 2023) stated that the Problem-Based Learning model is more effective in improving problem-solving abilities compared to the Direct Instruction model. This is evidenced by the average score of the Problem-Based Learning class, which was 51.5, while the Direct Instruction model had an average score of 35.5.

Similarly, research by (Oktaviana & Haryadi, 2020) also found that the Problem-Based Learning model is more effective than direct instruction in enhancing students' problem-solving skills. This can be seen from the average scores, where the Problem-Based Learning class achieved an average score of 84.3, while the direct instruction class had an average score of 71.1.

The study conducted by (Permatasari & Marlina, 2023) found that the average score of the Problem-Based Learning class was 77.86, while the traditional learning model class had an average score of 51.44. Therefore, it can be concluded that the Problem-Based Learning model is more effective than the traditional model in improving students' mathematical problem-solving abilities.

Research by (Sholikah et al., 2023) also stated that students' mathematical problem-solving abilities were better when taught using the Problem-Based Learning model compared to those taught using a conventional learning model. This is supported by the comparison of average scores, where the Problem-Based Learning model achieved an average of 92, while the conventional learning model obtained an average score of 85.

The study conducted by (Hakim et al., 2016) stated that the Problem-Based Learning model can improve students' mathematical problem-solving abilities.

Problem-Based Learning is an instructional model based on the principle of using problems as the core of new knowledge (La`ia, 2019). Therefore, the Problem-Based Learning model creates learning activities that stimulate students' curiosity by presenting problems related to their daily lives, encouraging group work, creating projects or reports, and presenting them (Ardianti et al., 2021). These activities make Problem-Based Learning a preferred model among students, as it increases their motivation to engage in the learning process.

This contrasts with the Direct Instruction model. According to (Tatia et al., 2023), Direct Instruction is a teacher-centered learning model in which the teacher dominates the learning process, causing students to spend more time listening, observing, and memorizing rather than discovering concepts on their own. As a result, students find it difficult to understand the material being taught and are only active in listening to the teacher's explanation and writing down notes.

CONCLUSION

A study conducted at SMP Negeri 2 Suwawa found a significant difference in the average scores regarding the implementation of the Problem-Based Learning model on mathematical problem-solving ability. This is evident from the t-test results on the posttest data, where the calculated t-value was greater than the table t-value (3.767 > 2.024). The Problem-Based Learning model is more effective than the Direct Instruction model in improving students' mathematical problem-solving abilities. This conclusion is based on the average posttest scores of both classes: the experimental class achieved an average score of 28.1, while the control class achieved an average score of 25.85. Thus, the average score of the experimental class was higher than that of the control class. Furthermore, based on the results of Cohen's effect size test, an effect size value of 1.191 was obtained. Since the effect size is greater than 1, it can be concluded that the implementation of the Problem-Based Learning model has a strong effect on students' mathematical problem-solving abilities.

It is recommended that teachers use the Problem-Based Learning model to improve students' mathematical problem-solving skills. Future researchers are encouraged to explore different subject matter using this approach.

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