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MATHEMATICAL PROBLEM-SOLVING ABILITY OF STUDENTS USING THE PROBLEM-BASED LEARNING MODEL IN THE TWO-VARIABLE LINEAR EQUATION SYSTEM MATERIAL

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ABSTRACT

This research was motivated by the low mathematical problem-solving ability of eighth-grade students. The aim was to measure the achievement of this ability in students learning through the Problem Based Learning (PBL) model compared to traditional teaching methods, as well as to evaluate the implementation process of PBL in the classroom. This study employed an experimental method with a quasi-experimental design, involving two groups: an experimental group and a control group. Data were collected through mathematical problem-solving tests administered before and after the learning process. The results showed that the problem-solving ability of eighth-grade students who used the Problem Based Learning model was better than that of students taught through conventional methods.

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Penelitian ini didasari oleh rendahnya kemampuan pemecahan masalah matematis siswa kelas VIII. Tujuannya untuk mengukur pencapaian kemampuan tersebut pada siswa yang belajar menggunakan model Problem Based Learning (PBL) dibandingkan dengan pembelajaran biasa, serta mengevaluasi proses penerapan PBL di kelas. Penelitian ini menggunakan metode eksperimen dengan desain quasi-eksperimen yang melibatkan dua kelompok yaitu kelas eksperimen dan kelas kontrol. Data dikumpulkan melalui tes kemampuan pemecahan masalah matematis yang diberikan sebelum dan sesudah pembelajaran. Hasil penelitian menunjukkan bahwa Kemampuan pemecahan masalah siswa kelas VIII yang menggunakan Model Problem Based Learning lebih baik dari pada pembelajaran biasa.

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INTRODUCTION

According to Law No. 20 of 2003 concerning the National Education System, particularly in Article 3, education in Indonesia plays a crucial role in national development. Education does not only serve as a means of transferring knowledge, but also has broader and deeper objectives. One of the main functions of education is to shape a quality young generation, both in terms of knowledge and character. This young generation is expected to contribute significantly to the intellectual development of the nation. Education also plays a role in forming individuals with strong character, integrity, good morals, and a high sense of nationalism. The generation formed through education is expected not only to be globally competitive but also to make a real contribution to the advancement of the nation and the country.

Therefore, education becomes a solid foundation for the development of competitive, ethical, and socially responsible individuals, which will ultimately lead Indonesia toward a brighter and more prosperous future (Suwartini, 2017). To achieve these goals, various fields of knowledge must be provided to students, one of which is mathematics. The National Council of Teachers of Mathematics (NCTM), as cited in (Al Ilahiyah, 2024; Margareta, 2023; Nurazizah et al., 2023; Pratiwi & Munandar, 2019), states that five mathematical standards in schools need to be developed: problem-solving ability, reasoning and proof ability, communication ability, connection ability, and representation ability.

Therefore, one of the abilities that must be developed by students is problem-solving ability. However, students' mathematical problem-solving ability remains lacking. Based on preliminary observations conducted by the researcher, it was found through information from the mathematics teacher that students often find it difficult to solve word problems involving problem-solving tasks in mathematics learning. This is further emphasized by (Aminah & Ayu Kurniawati, 2018; Damayanti, 2022; Sonia et al., 2022; Utami & Maskar, 2020), who stated that many students experience difficulties in solving word problems due to several factors. First, they often struggle to understand the meaning contained in the word problems, both in terms of language and the context presented. Second, students are often unable to identify and comprehend the mathematical concepts relevant to the word problems, which causes confusion in determining the steps that need to be taken.

Furthermore, another difficulty arises when students are required to formulate the problem into a mathematical model. This process requires the ability to convert verbal information into accurate mathematical expressions, and many students perceive this as a significant challenge. In addition, they often encounter obstacles in selecting the most appropriate problem-solving method. These challenges result in students having low mathematical problem-solving ability. One of the topics related to word problems is the two-variable linear equation system (SPLDV). The SPLDV material studied in Class VIII serves as a foundation for learning more complex mathematical topics in senior high school, such as linear programming and three-variable linear equations. Therefore, mastery of SPLDV material is essential for Class VIII junior high school students.

Therefore, an appropriate learning model is needed in which students build experiences by facing real-life problems to improve their ability to solve problems, think critically, and create new knowledge. Arends, as cited in (Pauweni & Iskandar, 2021), stated that the Problem-Based Learning (PBL) model presents various real and meaningful problems to students. This model is designed to develop students' critical thinking skills and enhance their problem-solving abilities. Through this model, students are expected to actively participate in finding solutions to problems that are relevant to daily life. According to Sari, as cited in (Noer & Gunowibowo, 2018), the PBL model also helps students become more active in conducting investigations as part of their efforts to solve a problem.

METHOD

This research was an experimental study with a quantitative approach using a quasi-experimental design in the form of a non-equivalent control group, in which, according to

(Abraham & Supriyati, 2022), the groups used in the study were not selected randomly. In its implementation, this study used two groups: the experimental group (the group taught using the PBL model) and the control group (the group taught using conventional learning methods). The population in this study consisted of junior high school students located in Bandung Regency, totaling 50 students. From this population, two classes with relatively equal academic abilities were selected as samples, making them suitable for comparison: 14 students for the experimental group and 11 students for the control group.

The data used were quantitative data, as the data collected and analyzed were numerical, namely the students' pre-test and post-test scores. The data analyzed included students' scores on mathematical problem-solving ability based on four essay questions on the topic of the two-variable linear equation system, which were developed based on problem-solving ability indicators according to Polya (Maya, 2018), namely: 1. Understanding the problem, 2. Devising a plan for solving the problem, 3. Carrying out the plan, 4. Looking back to check the results. Before being used in the research, the instrument underwent a validation process as well as a limited trial on students outside the research sample to ensure its feasibility.

After the validity test, a reliability test was conducted to determine the extent to which the instrument produced consistent and accurate data. Subsequently, difficulty level and discrimination index analyses were performed for each item to determine whether the items were difficult, moderate, or easy for students, and to indicate how well the items could distinguish between students who truly understood the material and those who did not. The data were then processed using IBM SPSS Statistics 25 software. A normality test was carried out to determine whether the data were normally distributed, followed by a homogeneity test to assess whether the data variances between the two groups were equal, and a mean difference test to examine whether there was a significant difference between the post-test results of the experimental group and the control group.

RESULTS AND DISCUSSION

Result

After both groups received different treatments, data processing was carried out to analyze the improvement of students' mathematical problem-solving abilities in both groups. The data analyzed included pre-test scores, post-test scores, and normalized gain (n-gain) scores. This data processing involved the calculation of the mean and standard deviation of the test results administered. The pre-test scores were used to measure the students' initial abilities before the different treatments were applied, while the post-test scores were obtained after the students received the respective treatments. The n-gain scores were calculated to assess the level of improvement in students' abilities from pre-test to post-test, and these results were then compared between the experimental group and the control group. Based on the collected data, the following is a description of the pre-test, post-test, and n-gain results from both groups used in this study.

Table 2. Description of students' mathematical problem-solving ability

		Pre-test		Post-test	
Group	N	$\bar{x}$	S	$\bar{x}$	S
Experimental	14	25,21	10,07	81,5	11,47
Control	11	25,36	9,49	64,18	23,74

From Table 2, the average pre-test scores in both groups were nearly the same, approximately 25. However, the standard deviation shows that the scores in the experimental group (10.07) were slightly more spread out compared to those in the control group (9.49). This means that the scores of students in the experimental group had slightly greater variation than those in the control group. After the learning process, the average post-test score in the experimental group increased significantly to 81.5, while in the control group, it increased to 64.18. However, the standard deviation in the control group (23.74) was much higher than that in the experimental group (11.47). This indicates that although the average post-test score in the control group increased, the scores varied widely. Some students in the control group may have obtained very high or very low scores, whereas in the experimental group, students' scores were more consistent around the mean.

Table 3. Normality test results

		Pre-test	Post-test
		Shapiro-Wilk	
Class	N	Sig.	Sig.
Experimental	14	0,360	0,748
Control	11	0,347	0,131

In Table 3, the Sig. value for the experimental group's pre-test is 0.360, while the control group's pre-test is 0.347. For the post-test results, the Sig. value for the experimental group is 0.748, and for the control group is 0.131. Since all Sig. values for both groups are greater than α, the samples are considered to come from normally distributed populations. Next, a homogeneity test was conducted.

Table 4. Homogeneity test results

		Pre-test	Post-test
		Levene Statistic	
Kelas	N	Sig.	Sig.
Eksperimen	14	0,928	0,001
Kontrol	11		

In the table above, the analysis of the pre-test data yielded a Sig. value of 0.928. Since the Sig. value is greater than α, it indicates that the variances between the two groups are homogeneous. Given that the homogeneity condition is fulfilled, the next step was to perform a mean difference test. Meanwhile, in the analysis of the post-test data, the obtained Sig. value was 0.001. In this case, the Sig. value is smaller than α, indicating that the variances between the two groups are not homogeneous. Due to the violation of the homogeneity assumption, the mean difference test was conducted using the t' test. This t' test method is necessary to ensure the validity of the mean difference analysis, even when there is a variance difference between the two groups being analyzed.

Table 5. Mean difference test results

		Pre-test	Post-test	Pre-test	Post-test
		Equal variances assumed		Equal variances not assumed	
Kelas	N	Sig.	Sig.	Sig.	Sig.

Eksperimen	14	0,970	0,025	0,970	0,044
Kontrol	11				

In the table above, the Sig. (2-tailed) value for the pre-test data is 0.970. Since this value is greater than α, it indicates that H_o is accepted and H_a is rejected, meaning there is no significant difference in the average initial mathematical problem-solving abilities between the two groups. For the post-test data, the Sig. (1-tailed) value is 0.022, which is less than α, indicating that H_o is rejected and H_a is accepted. Therefore, students' mathematical problem-solving ability using the PBL model is better compared to conventional learning.

Discussion

This study aimed to examine the achievement of students' mathematical problem-solving abilities after undergoing a specially designed learning process. Throughout seven meetings, the study involved a series of activities starting with a pre-test, followed by five instructional sessions that used the Problem-Based Learning (PBL) model for the experimental group and conventional learning for the control group, and concluded with a post-test. This entire sequence was systematically designed to evaluate the extent to which the application of a problem-based learning model could affect students' ability to solve mathematical problems. The objective of this study was to determine whether a learning approach focused on problem-solving yields more effective outcomes compared to conventional learning models commonly implemented in classrooms.

The analysis of pre-test data from both groups was conducted to observe differences in students' mathematical problem-solving abilities before the treatment was administered. The analysis results indicated no significant difference in the initial abilities of students in the two groups. This finding suggests that, before the application of different treatments, both groups had an equivalent level of mathematical problem-solving ability, thereby ensuring that any differences observed in the outcomes could be more clearly attributed to the learning model implemented during the study.

Next, the post-test data from both groups were analyzed to measure the achievement of mathematical problem-solving abilities after the implementation of different treatments. The analysis results showed that the experimental group achieved significantly higher outcomes compared to the control group. This greater improvement in the PBL group indicates that the effectiveness of the Problem-Based Learning model is higher in enhancing students' mathematical problem-solving abilities. This finding is consistent with the study by (Sapoetra & Hardini, 2020), which demonstrated that students' problem-solving abilities improved more effectively when using the PBL model. According to (Muthia et al., 2024), students' mathematical problem-solving abilities were better when taught through the PBL model compared to conventional instruction in the topic of ratios and proportions. This is also supported by research conducted by (Anggiana, 2019), which found that the improvement in problem-solving ability was more significant in groups using the PBL model than in those that did not.

Learning using the PBL model begins with observing a problem presented by the teacher for students to solve. The problem is delivered in the form of a scenario or situation that requires a mathematical solution, which is displayed using a projector. Students are then divided into several groups to develop collaborative and communicative skills among them. Next, the teacher distributes a student worksheet (LKPD) related to the problem-solving task, assigns roles to search for references through textbooks to identify known and unknown concepts, identify the core problem, formulate a plan to solve the problem, and ensure that each group member contributes to the problem-solving process. Students are then guided by the teacher during the investigation phase to generate ideas and solutions to the problem with their group members. At this stage, students are not only looking for solutions to the given problem but also learning new ways to approach it, thereby maximizing the development of their abilities. After the group discussion process, each group presents the results of their discussion in front of the class. In these presentations, students explain in detail the information obtained from the problem, the steps they took, and how they arrived at their solution, making the learning process more interactive and enabling students to learn from one another through each group's presentation. Finally, the teacher and students analyze and evaluate the problem-solving strategies presented by each group. The entire class collaborates to summarize the outcomes of the various proposed solutions, ultimately determining the best solution. This process enhances problem-solving abilities, improves conceptual understanding, and fosters the development of critical thinking and collaborative skills among students.

Learning that uses the PBL model appears to be more active due to the group activities that direct students to solve problems presented in the worksheets. Based on field observations conducted by the researcher during the first meeting, students tended to be passive and were not yet accustomed to the learning model being implemented. In the subsequent meetings, the teacher played an active role in motivating students to become more confident and courageous in completing the assigned tasks. With high enthusiasm, the teacher not only encouraged students to become more engaged individually but also reinforced their confidence to express opinions, both during group discussions and when presenting in front of the class. These efforts yielded positive results. Although some students still felt shy, with continuous encouragement from the teacher, they gradually began to show improvement in their confidence and participation in expressing their ideas.

As time progresses, it was observed that student engagement continued to increase. They began to feel more comfortable with group learning and demonstrated improved ability in solving various problems presented. When faced with challenges, students were no longer hesitant to ask questions and interact with the teacher, indicating a significant improvement in their learning attitudes and skills. By the end of the study, students were better prepared to take the final test (post-test). This positive development is consistent with the findings of (Putri et al., 2019), which shows that the implementation of the PBL model can enhance student engagement and overall learning abilities.

CONCLUSION

Based on the analysis of students' mathematical problem-solving achievement, it is found that the mathematical problem-solving ability of students who participate in learning using the PBL model is better than that of students who receive conventional instruction. Overall, the results of this study indicate that the implementation of the PBL model is effective, as reflected in the higher levels of student engagement and enthusiasm during the learning process. In addition to the learning model, future research may consider the influence of external factors such as technological support or classroom environment on students' problem-solving achievement.

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