



Improving the Mathematics Learning Process and Students' Problem-Solving Skills through Problem-Based Learning

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ABSTRACT

This study aims to improve the learning process and improve students' mathematical problem-solving abilities by implementing the problem-based learning model. The subjects of this study were students of class VIII.1 of SMP YLPI P. Marpoyan in the first semester of the 2024/2025 academic year. This study consisted of two cycles, the first cycle containing two meetings with the material One Variable Linear Equations, and the second cycle containing two meetings with the material One Variable Linear Inequalities. Data analysis was carried out using a combination of qualitative descriptive analysis and quantitative descriptive statistical analysis. The data analysis technique used in this study consists of analyzing data on teacher and learner activities and analyzing data on students' mathematical problem-solving abilities. The results showed that the application of the problem-based learning model improved the learning process and improved students' mathematical problem-solving abilities. The average N-gain score increased from 0,58 with a medium classification in cycle I to 0,88 with a high classification in cycle II. In addition, the average student test increased from 54,38 in cycle I to 76,88 in cycle II. The results showed that the application of the problem-based learning model improved the learning process and improved the mathematical problem-solving abilities of class VIII.1 SMP YLPI P. Marpoyan.

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INTRODUCTION

Solving problems is directly tied to mathematics. In addition to calculating and solving problems, junior high school (SMP) pupils must develop the ability to solve problems in both real-world situations and those pertaining to mathematics. The goal of problem-solving abilities is to help students develop their ability to think mathematically and fluently while also gaining a solid grasp of the issue [1]. Students' satisfaction with their mathematics learning outcomes will also be impacted by their ability to solve mathematical problems [2].

The ability of students to comprehend a problem by recognizing known elements, questions, and the sufficiency of the necessary components, develop or assemble a solution strategy, and represent (using symbols, images, graphs, tables, diagrams, models, etc.), select or implement strategies to obtain solutions, and verify the accuracy of the solution to interpret it is known as problem solving ability [3]. Mathematical problem-solving ability, according to [4], is the capacity of pupils to apply mathematical activities to solve issues in mathematics, other sciences, and daily life. In contrast, [5] defines mathematical problem-solving skill as the capacity to use previously acquired

knowledge and then apply it as a solution to solve the problem. Therefore, mathematical problem-solving ability refers to the ability of students to solve mathematical problems that are relevant to their daily lives using a variety of strategies, including comprehending the problem, developing a mathematical model, solving problems using the prepared mathematical model, and interpreting the results.

Indicators of mathematical problem-solving ability, namely: (1) identify the elements known, asked, and the adequacy of the required elements; (2) formulate mathematical problems or mathematical models; (3) apply strategies to solve problems; (4) explain or interpret the results of problem solving [3]. According to [6], explain the indicators of mathematical problem-solving ability, namely: (1) understanding the problem, which includes the ability to identify known and questionable elements; (2) making a problem-solving plan; (3) implementing a problem-solving plan; (4) implementing a mathematical problem-solving plan and interpreting the results obtained. The indicators of mathematical problem-solving ability used in this study are: (1) understanding the problem; (2) creating a mathematical model; (3) solving the problem using the mathematical model that has been prepared; and (4) interpreting the results obtained.

Researchers conducted interviews with class VIII.1 math teacher at YLPI P. Marpoyan Junior High School. Based on the results of the interview, it was found that the students' learning outcomes were low in solving problems. To find out the extent of problem-solving skills of students in class VIII.1 SMP YLPI P. Marpoyan, researchers gave an initial test in the form of two Algebra material problems. They found that most students have not been able to solve math problems using the stages of the problem-solving process, so students' problem-solving skills are low. Based on observations, it was found that learning activities carried out in the classroom were still teacher-centered. In fact, according to [7], the principles for achieving an effective learning process include, among others, learning focused on students and interactive reciprocal relationships between teachers and students.

The students' lack of problem-solving skills is not only due to the abstract nature of mathematics, but also the learning process, filled with teachers who only explain the material, give examples of problems, and give problems, which can also cause the students' problem-solving skills not to be maximized [8]. For this reason, teachers can be taught by teachers to improve students' problem-solving skills by implementing the right learning model, and can optimize students' problem-solving skills. According to [9], teaching through problem solving allows students to develop mathematical skills and concepts in the context of an inquiry-oriented experience. Therefore, one of the learning models that is closely related to problem solving is the Problem-Based Learning model.

Through the problems presented, learners work together in groups, trying to solve the problems presented with the knowledge they have, while looking for relevant information for the solution. At the same time, the teacher serves as a facilitator who directs students in determining solutions [10]. According to [11], problem-based learning can develop students' skills in identifying problems, collecting alternative solutions that are most appropriate to the problems given through the process of information gathering and investigation. Put forward by [12], the objectives of problem-based learning in detailed, namely: (1) helping students develop thinking and problem-solving skills; (2) learning various adult roles through their involvement in real experiences; (3) becoming autonomous learners so that the problem-based learning model is suitable in improving students' mathematical problem-solving skills.

The problem-based learning model is a learning model in which, in the process, students are faced with a real-world problem, and it is carried out when learning begins as a stimulus, so that it

triggers students to learn and work hard in solving a problem [13]. As [10] revealed, problem-based learning is a systemic learning process in which problems are designed that require students to gain essential knowledge, make them proficient in solving problems, and have the skills to participate in groups. Similar to [12], suggests that the problem-based learning model is a learning model that uses real-world problems as a context for students to learn critical thinking and problem-solving skills and to gain knowledge of the essential concepts of the subject. So, it can be concluded that problem-based learning is a learning model that uses problems as a learning context by combining theory and practice and steps in the form of: orienting students to the problem, organizing students to learn, guiding individual and group investigations, developing & presenting work, and analyzing & evaluating.

The events that must appear in the implementation of problem-based learning suggested by [12] are: (1) engagement; (2) inquiry and investigation: exploration and distributing information; (3) performance: presenting findings; (4) debriefing: testing the accuracy of the solution; and (5) reflection on problem solving. According to [13], there are five stages in implementing problem-based learning, namely, students are oriented to the problem, students are organized to learn, individual and group investigations, create and present products or works, and analyze and evaluate the problem-solving process. Researchers adapted what had been described to develop problem-based learning steps. So, the steps of problem-based learning that will be used in this study are: (a) Orienting students to the problem, students are asked to observe a problem presented by the teacher. The problem presented is in accordance with the indicators of competency achievement to be achieved; (b) Organizing students to learn, students are asked to work together in their groups to identify the problems given; (c) Guiding individual and group investigations, students are asked to gather information and actively discuss in solving problems; (d) Developing and presenting work, students are asked to submit the results of their group discussions and provide conclusions from the problems given; (e) Analyzing and evaluating, including activities to analyze and evaluate the results of the discussion. The teacher is in charge of confirming, completing, and providing additional information that students have presented.

According to Polya, as cited [14], in the phases of comprehending the problem, formulating a strategy, carrying out the plan, and checking back can be used to solve mathematics tasks that gauge problem solving. Problem-based learning, or problem-based learning is crucial to helping students develop their problem-solving skills [15]. The findings of a study conducted by [16] further confirm this, showing that using the problem-based learning paradigm can enhance both the learning process and students' skills.

The steps of mathematical problem-solving ability are related to the five steps of applying the problem-based learning model, namely, at the stage of orienting students to the problem, followed by the stage of organizing students to learn. Researchers present problems that are in accordance with the indicators of competency achievement to be achieved. Researchers direct students to understand and identify problems. Students are required to understand these problems individually. From the two phases of problem-based learning, it is in line with the ability to solve mathematical problems, namely understanding the problem, which includes identifying the known elements and those asked from the problem.

At the stage of guiding individual and group investigations, researchers encourage students to collect data and carry out the problem-solving process. Through this stage, students can apply the problem-solving steps, namely making mathematical models and solving problems using the

mathematical models that have been prepared. At this stage, the researcher facilitates students during the problem-solving process. Researchers also assist if students in groups encounter difficulties in solving problems.

At the stage of developing and presenting work results, followed by the stage of analyzing and evaluating the problem-solving process in problem-based learning, students present the results of their group discussions in front of the class. Learners are required to be active in asking questions and answering during presentations by the presenting group. Then the researcher, together with students, makes conclusions from problem-solving and summarizes the learning process for that day. The fourth and fifth phases of the PBL model are in line with the last indicator of problem-solving ability, namely the ability to interpret the results obtained.

The purpose of this study is to improve the learning process so that it can improve the mathematical problem-solving ability of students in class VIII.1 SMP YLPI P. Marpoyan, odd semester of the 2024/2025 school year on the subject matter of One Variable Linear Equation System and One Variable Linear Inequality through the application of the Problem-Based Learning model.

METHODS

This research is a Classroom Action Research conducted in class VIII.1 SMP YLPI P. Marpoyan in the odd semester of the 2024/2025 school year, with the subject of this research being students of class VIII.1 SMP YLPI P. Marpoyan, totaling 16 students. The implementation of this study consisted of two cycles. Data collection techniques used observation techniques, and mathematical problem-solving ability test techniques. Researchers conducted a mathematical problem-solving ability pretest and posttest for cycle I and performed a mathematical problem-solving ability II pretest and posttest for cycle II. The score rubric used in this study is based on the researcher's modified rubric sourced from [6] and [17] in Table 1.

Table 1. Rubric for Mathematical Problem-Solving Ability Score

Indicators	Score	Description
Understanding the problem	0	Did not write what is known and what is asked
	1	Mentioning what is known without mentioning what is asked or vice versa
	2	Mentioned what is known and what is asked, but not quite right
	3	Mentioning what is known and what is asked correctly
Create a mathematical model	0	Did not create a mathematical model at all
	1	Create a mathematical model, but less precise.
	2	Create mathematical models appropriately.
Solve the problem using the mathematical model that has been prepared	0	There is no answer at all
	1	Solves the problem using the mathematical model that has been developed, but the answer is wrong, or a small part of the solution is correct.
	2	Solves the problem using the mathematical model that has been developed, and half or most of the answers are correct.
Interpret the results obtained	3	Solve problems using mathematical models that have been compiled completely and correctly.
	0	Did not write the conclusion
	1	Interprets the results obtained by making conclusions, but less precise or incomplete
	2	Interpret the results obtained by making precise and complete conclusions.

The data analysis technique used in this study consists of analyzing data on teacher and learner activities and analyzing data on students' mathematical problem-solving abilities. Data analysis on

teacher and learner activities through the stages of data reduction, data presentation, and conclusion drawing. As for data analysis of students' mathematical problem-solving ability, researchers classically analyzed the average score of students, analyzed the achievement of mathematical problem-solving ability indicators, and analyzed the qualifications of students' mathematical problem-solving ability before and after the action. In the analysis of classical mathematical problem-solving ability, researchers analyzed the increase in the average score of mathematical problem-solving ability before and after the research. In analyzing the achievement of mathematical problem-solving ability, the researcher used the mathematical problem-solving ability score rubric, then determined the percentage of students who got the maximum score on each indicator using the formula:

$$\text{Percentage} = \frac{\text{Number of students with maximum score}}{\text{Total number of students}} \times 100\% \quad (1)$$

In the analysis of the qualifications of students' mathematical problem-solving abilities before and after action, the pretest and posttest scores in cycle I and cycle II were analyzed quantitatively to determine the level of students' mathematical problem-solving abilities. Researchers use the normalized N-gain average formula with the following formula:

$$N - \text{gain} = \frac{(\text{posttest score}) - (\text{pretest score})}{(\text{maksimal ideal score}) - (\text{pretest score})} \quad (2)$$

The results of the calculation of the average N-gain KPMM are interpreted in the table as follows [18].

Table 2. Normalized N-gain Criteria

N-gain Score	Interpretation
$0,70 \leq g \leq 1,00$	High
$0,30 \leq g < 0,70$	Medium
$0,00 < g < 0,30$	Low
$g = 0,00$	No Improvement

RESULTS AND DISCUSSION

The discussion of the research results is carried out on the results of observations through observation sheets of teacher and student activities in learning mathematics, and analysis of the results of the Mathematical Problem Solving Ability test of students through test questions in each cycle. Analysis of teacher and learner activities showed that there was an improvement in the learning process from cycle I to cycle II based on the observation sheet of teacher and learner activities carried out. In cycle I, students were still passive in the learning process. In the apperception and motivation activities, only a few students responded to what the researcher said. Learners are also still less active in discussions. Researchers made improvements in cycle II, including building a better classroom atmosphere, paying attention to and controlling the class better during the learning process, and inviting students in the group to participate in active discussions. So that in cycle II, students began to be active during the learning process, most students responded to the motivation and apperception given, and actively discussed in groups.

Data analysis on teacher and learner activities showed that the quality of the implementation of the PBL model was increasingly in accordance with lesson planning, and the learning process was getting better. The interaction between teachers and students is getting better, and most students are more active in carrying out each step of problem-solving. The application of PBL has provided opportunities for students to be active in the learning process, including actively responding to the motivation and apperception given, playing an active role in group discussions, and getting trained in

solving problems. This is in line with the opinion [10], which states that through the problems presented, learners work together in groups trying to solve the problems presented with the knowledge they have, while looking for relevant information for the solution.

The analysis of the Mathematical problem-solving ability of students is calculated using the mathematical problem-solving ability rubric and analyzed for improvement using N-gain based on pretest and posttest scores in each cycle. Based on the analysis of the Mathematical Problem Solving Ability I Posttest results, the percentage of students who got the maximum score for each aspect of Mathematical Problem Solving Ability can be seen in Table 3.

Table 3. Percentage of Learners who Got the Maximum Score on the Mathematical Problem Solving Ability Indicator Cycle I

Indicators	Understanding the problem		Create a mathematical model		Solve the problem using the mathematical model that has been prepared		Interpret the results obtained	
	1	2	1	2	1	2	1	2
Question Number	1	2	1	2	1	2	1	2
Number of learners with the max score	7	7	1	4	2	6	2	3
Percentage	44%	44%	6%	25%	13%	38%	13%	19%

Based on Table 3, the percentage of students who achieve the maximum score on each KPMM indicator, students have solved problems using mathematical problem-solving ability indicators, even though some students skip problem-solving steps or are still inaccurate, so not all students achieve the maximum score on each indicator of mathematical problem-solving ability.

Based on the analysis of the Mathematical Problem Solving Ability II Posttest results, the percentage of students who got the maximum score for each aspect of Mathematical Problem Solving Ability can be seen in Table 4.

Table 4. Percentage of Learners who Got the Maximum Score on the Mathematical Problem Solving Ability Indicator Cycle II

Indicators	Understanding the problem		Create a mathematical model		Solve the problem using the mathematical model that has been prepared		Interpret the results obtained	
	1	2	1	2	1	2	1	2
Question Number	1	2	1	2	1	2	1	2
Number of learners with the max score	10	7	10	4	8	7	8	8
Percentage	63%	44%	63%	25%	50%	44%	50%	50%

Based on the data in Table 4, it is obtained that the value of each indicator of mathematical problem-solving ability is increasing from cycle I. Of the two problems given, in general, students make mistakes in problem number two, which is about solving problems related to linear inequality of one variable. Some learners are less precise in making mathematical models, but some learners can still solve problems correctly. Overall, learners' mathematical problem-solving skills are getting better compared to cycle I or before the study.

The data presented in Table 5 below shows the improvement of students' mathematical problem-solving skills from cycle I to cycle II.

Table 5. Improving Students' Mathematical Problem-Solving Ability

	Cycle I				Cycle II			
	Pretest	Posttest	N-gain	Criteria	Pretest	Posttest	N-gain	Criteria
Average Score	19,69	54,38	0,59	Medium	14,69	76,88	0,88	High

Based on the data obtained in cycle I and cycle II, after being given the research as a whole, the mathematical problem-solving ability of students has increased. The average N-gain of students'

mathematical problem-solving ability in cycle II increased to 0.88 with a high classification, compared to the average N-gain of students' mathematical problem-solving ability in cycle I of only 0.58, with a medium classification. The average test of students' mathematical problem-solving ability in cycle II increased to 76.88 compared to the test results in cycle I of only 54.38, and the results of the initial test of mathematical problem-solving ability were only 35.63. Despite some shortcomings, students became more active in learning activities, so that the learning process was not only dominated by researchers. Learners are also more motivated to be active in discussing and solving problems using problem-solving steps.

The increase in students' mathematical problem-solving ability is due to the application of the problem-based learning model. The problem-based learning model provides opportunities for students to be active during the learning process and build their own knowledge so that the learning experience is more meaningful. This is in line with research conducted by [19], which states that the problem-based learning model can improve students' mathematical problem-solving skills.

Based on the analysis of teacher and learner activities and the analysis of the results of students' mathematical problem-solving skills, it can be concluded that the proposed research hypothesis can be accepted. Thus, the application of the Problem-Based Learning model can improve the learning process and improve the Mathematical Problem Solving Ability of Class VIII.1 YLPI P. Marpoyan Junior High School Students.

CONCLUSIONS AND SUGGESTIONS

The results of this study indicate that the application of the Problem-Based Learning model can improve the learning process and enhance the mathematical problem-solving skills of students in class VIII.1 SMP YLPI P. Marpoyan, odd semester of the 2024/2025 school year. The application of PBL encourages students to actively participate in discussions during the learning process and learn to solve problems by applying their existing knowledge and newly acquired information. The average N-gain in cycle I was 0.59, which is medium, and increased by 0.29 in cycle II, bringing the average N-gain to 0.88, which is high. Based on the research that has been carried out, the researcher provides several recommendations related to the application of the Problem Based Learning model, namely: (1) The application of the problem-based learning model can be used as an alternative learning model that can be applied to improve the learning process to introduce students to problems in everyday life; (2) For teachers or researchers who want to apply the problem-based learning model, it is necessary to monitor and direct students properly during the learning process so as not to lack time; (3) Teachers or researchers must continue to train students to solve problems using problem solving steps. Teachers or researchers must also guide students competently so that they do not miss the steps of problem-solving. In addition, further studies are recommended to examine the implementation of the Problem-Based Learning model in different topics and grade levels to broaden the findings and ensure the consistency of the results.

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