Can Problem Based Learning Models Improve Students' Mathematical Problem-Solving Ability?

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Abstract. This research was motivated by the low problem-solving abilities of students, especially on the indicators of understanding the problem and checking back on the answers obtained. This research is classroom action research, which aims to improve students' mathematical problem-solving abilities through the Problem Based learning model. The subjects of this research were 35 students in class X 4 of SMAN 1 Sinjai, SMP Negeri 1 Patampanua class VII.5, totaling 26 people, and SMP Negeri 1 Mattirosompe class VIII.1, totaling 22 people. This research was carried out in two cycles. The research work procedure for each cycle takes place in four stages, namely: (1) planning, (2) implementing actions, (3) observing, and (4) reflecting. Data collection was carried out by giving problem solving tests to students. The data was analyzed using quantitative and qualitative analysis. Based on the results of the research and discussion, it can be concluded that the application of the Problem Based Learning learning model in two different phases in three schools can improve students' mathematical problem-solving abilities. After carrying out 2 learning cycles using Problem learning, it was found that the level of mathematical problem-solving ability for each indicator met the minimum criteria of 65%, and students' classical problem-solving completeness reached 100%.

Key words: problem based learning, mathematical problem-solving.

BACKGROUND

Education is a conscious effort to develop the potential that exists within humans through teaching activities [1]. Education plays a role in developing abilities, forming a dignified national character and civilization in order to make the nation's life more intelligent, and can increase knowledge, abilities, and creativity along with the development of science and technology. Learning in the 21st century must be able to prepare generations of Indonesian people to face advances in information and communication technology in social life.

Mathematics, as one of the fundamentals of knowledge is considered to play a very important role in forming quality and intelligent students [2]. Mathematics is a scientific field that is used to train problem solving in everyday life because almost all aspects of life require problem solving to solve the problem. Problem solving means looking for a way, method or approach to solving it through several activities, including observing, understanding, trying, guessing, and finding and reviewing [3]. These activities encourage students to think intensively and creatively about solving the problems they face (Elita, etc., 2019) [4].

The National Educational Technology Standards for Students (NETS-S) state that there are six important skills that students must have and be taught by teachers at school, one of which is problem solving [5]. Problem-solving abilities are very important in the learning process. This is in accordance with what was stated by the National Council of Teachers of Mathematics (NCTM), which determines five standards for basic mathematical abilities, namely: 1) mathematical problem solving; 2) mathematical reasoning and proof; 3) mathematical communication (mathematical communication); 4) mathematical connections (mathematical connections); and 5) mathematical representation (mathematical representation). Mathematical problem-solving ability is a cognitive aspect because, by solving problems, students can think critically. Students are required to use all the knowledge they have acquired to be able to solve a mathematical problem [6].

Mathematical problem-solving ability is a student's skill or ability to apply the knowledge they have to solve a problem or mathematical problem [7]. Mathematical problem-solving abilities can train students to identify known and questionable elements of a problem, develop mathematical models of existing problems, choose problem-solving strategies, then implement these strategies to solve problems and interpret the results according to the problem. This can encourage the development of students' understanding of mathematical principles, values, and processes. Apart from that, it can foster reasoning power and help you think logically, regularly, critically, and creatively. So, with mathematical problem-solving abilities, it is hoped that they can help students understand a problem better and be able to solve it [8]. Mathematical problem-solving abilities include the ability to understand problems, design mathematical models, complete models, and interpret the solutions obtained [9].

Researchers' observations at the junior and senior high school levels in several parts of South Sulawesi have yielded results that indicate students struggle with contextual problems that require problem solving. A few pupils expressed their inability to recognize the issue in order to derive the appropriate formula for resolving it. In addition, making the correct deductions from the given information presents a challenge for students while answering problems; typically, they work on problems just until a mathematical score is obtained, ignoring the questions' genuine questions and their intended answers.

Some students are able to grasp the questions, but they struggle to write in an organized manner when solving them. Typically, they just move on to the next phase of the solution until they get the answers, and they are also unable to articulate the questions' conclusions. Pupils lack the effort or commitment to solve problems using proper and logical techniques; instead, they just consider the problem's outcome in the end. These observations' findings indicate that teachers must work to help pupils become more adept at solving problems during the learning process. [10].

Due to the low effectiveness of the learning methodologies employed and the teacher-centered nature of most current learning, students' ability to solve mathematical problems is low. Aside from that, pupils lack motivation, make very little effort to comprehend the lesson content that is delivered by the teacher, and are not excited about engaging in the learning process. Therefore, in order to enhance students' mathematical problem-solving skills, more efficient learning methodologies are required. One method of learning that is thought to be able to enhance problem-solving skills and motivate students to learn mathematics is applying the Problem Based Learning learning model. [11].

A problem-based learning approach is one that allows students to solve a problem by following the steps of the scientific method. This allows students to gain knowledge about the subject and the problem-solving abilities at the same time [1]. Stated differently, it is clear that problem learning provides learning experiences related to problem solving, such as hypothesizing, designing experiments, conducting investigations, collecting data, interpreting data, making conclusions, presenting, discussing, and making reports [7]. Students are exposed to real-world challenges through the Problem-Based Learning (PBL) learning approach, and they subsequently get experience using their knowledge to comprehend and resolve these difficulties. One of the features of the problem-based learning (PBL) learning paradigm is that it presents real-world problems as learning objectives for students right from the start. [11].

According to the above description, the author conducted an action research study in the classroom using the problem-based learning model in an attempt to enhance students' capacity to solve mathematical problems. The objective of the study was to enhance students' mathematical problem-solving skills through the use of the problem-based learning model in the learning process.

METHOD

This type of research is classroom action research, which is designed to improve students' mathematical problem-solving abilities based on polya-solving steps through the application of the problem-based learning model. This research was carried out in three schools with two different phases, namely phase E at SMA Negeri 1 Sinjai and phase D at SMP Negeri 1 Patampanua and SMP Negeri 1 Mattirosompe. The research subjects at SMA Negeri 1 Sinjai were 35 students in class X.4, 26 students at Patampanua State Middle School in class VII.5, and 22 students at Mattirosompe State Middle School in class VIII.1. This research was carried out in the even semester of the 2022/2023 academic year. This research was carried out in 2 cycles, where each cycle consisted of several stages, namely: 1) action planning (planning); 2) carrying out actions (acting); 3) observation (observing); and 4) reflection (reflecting).

The instrument used in this research was a teacher observation sheet, which was filled in by the observer, namely the mathematics teacher in the class. Then the assessed student learning outcomes are obtained from the final test scores obtained by students in each cycle. The level of students' problem-solving abilities is calculated from the scores

obtained by students from each problem-solving indicator and the total score from all questions using descriptive statistics. Then, proceed with qualitative analysis by describing it in the form of descriptions.
The steps are as follows:

a. Calculate the Percentage of the Total Score for Each Problem Solving Ability Indicator [1]

$$PSI_k = \frac{SI_k}{SMI_k} \times 100\%$$

$PSIk$: Total score percentage of k indicator =1,2,3,4
SIk : Total score of k indicato =1,2,3,4
$SMIk$: Maximum score of k indicator =1,2,3,4

The score guidelines that need to be considered for assessing problem-solving abilities for each indicator use the assessment criteria from the Vermont Math Problem Solving Criteria by making several modifications according to research needs [12] as follows:

TABLE 1. Criteria for Assessment of Problem-Solving Indicators.

Problem Capability Indicator	Score	Criteria
Understand the problem	3	All known and disclosed information is accurately and fully written.
	2	Written information that has been requested and known about is either erroneous or lacking.
	1	Only one of the known and requested pieces of information is recorded.
	0	Not writing down known and asked information
Determining a Problem-solving Strategy Plan	3	Write the formula correctly
	2	Write a formula, but it is inaccurate or incomplete
	1	Write the formula, but it's not correct
	0	Didn't write down the formula
Completing Problem Solving Strategies	3	Complete and correct completion steps
	2	The solution steps are incomplete but correct
	1	The solution steps are incomplete and inaccurate
	0	Didn't write down the solution steps
Checking the Answers Obtained Again	3	Write the conclusion correctly
	2	Write a conclusion, but it is inaccurate or incomplete
	1	Write a conclusion, only in the form of a final answer to the solution
	0	Don't write a conclusion

b. Categorize students' problem-solving abilities based on the total score obtained. Criteria for the level of students' problem-solving abilities can be made as follows [13].

TABLE 2. Solving Ability Category.

Percentage	Criteria
90 % - 100%	Very high ability
80 % - 89%	High ability
65 % - 79%	Medium ability
55 % - 64%	Low ability
0 % - 54%	Very low capability

c. Determine the percentage of the class that has been able to solve the problem [1]

$$DSK = \frac{X}{N} \times 100\%$$

with:
DSK : Percentage of Classes that Complete Problem Solving
X : The number of students who have completed solving the problem
N : Banyak Siswa dalam Kelas
By criteria:
$0\% \leq DSK < 85\%$: Unfinished Class Solving Problems
$85\% \leq DSK \leq 100\%$: Complete Classes Solve Problems [14]

In this research, there are indicators of research success, namely:

a. The level of student problem solving ability for each indicator is at least in the medium category
b. Percentage of total score for each indicator (PSIk) from the problem-solving test ≥ 65%
c. The percentage of students who have completed solving the problem is at least 85% of the number of students in the class.

RESULTS AND DISCUSSION

Results of Problem-Solving abilities in Phase E

After the implementation of cycle I actions in phase E was completed, the results obtained based on observations were the learning steps that had not been implemented properly, namely the activities of guiding individual and group investigations. Based on the indicator problem solving test, which has reached a minimum limit of 65%, namely, the indicator of the student's ability to plan a solution is 93.3 in the very high category and the total score percentage is 93.3%, the indicator of the student's ability to carry out the solution plan is 97.1 in the very high category. and the total score percentage is 97.1%, as well as the indicator of rechecking the results with an average of 78.1 in the medium category with a total score percentage of 78.1%. In cycle I, there were still indicators that had not reached the minimum limit of 65%, namely the indicator of students' ability to understand problems with an average of 62.85, which was in the low category with a total score percentage of 62.85%. The number of students who had completed solving problems in cycle I was 32 out of 35 students in the sample. Classical completeness is 91.4%, so the class is considered to have completely solved the problem. From the data resulting from the implementation of actions in cycle I, it can be concluded that the research target has not been achieved. For this reason, it is necessary to carry out the next cycle by paying attention to the shortcomings in cycle I so that they can be further improved in the next cycle to achieve the target.

The implementation of cycle II is based on research targets that have not been achieved in cycle I. From the results of reflection in cycle I, there are several problems that need to be corrected, including:

1. Learning steps that still need to be improved are activities to guide individual and group investigations. Some students have not been actively involved in the learning process, some are just silent without providing ideas to solve the problems given.
2. During the learning that was distributed to each group, several groups experienced difficulties, including not knowing the meaning of what was asked in the questions and not being able to interpret the results of the mathematical answers obtained in the form of problem-solving results from the questions.
3. The ability to understand problems has not yet reached the minimum requirements for completeness. The total score percentage for understanding the problem is 62.85%, so it needs to be increased to reach the target of at least 65%.

The results obtained in cycle II showed that the learning management carried out by the teacher was good. Students appear more active in participating in learning because the problem-based learning steps can be carried out well. The results obtained in cycle II for each indicator of problem solving have reached a minimum limit of 65%, where the indicator of students' ability to understand problems is 90.74 with a very high indicator which has a total score percentage of 90.74%, the category of students' ability to plan solutions is 98.1 with a high indicator which has a total score percentage of 98.1%, an indicator of the student's ability to carry out the completion plan is 99 with a very high category which has a total score percentage of 99%, and checking the results again is 81.29 with a medium category which has a total score percentage of 99%. In cycle II, the average score for students' problem-solving abilities was 96.2 in the very high category and had reached the research target, namely at least medium with a classical completeness of 100%, so that in the class it was categorized as complete problem-solving because it had reached or even exceeded the target of 85%. Based on the information obtained from the data resulting from the implementation of the action, the target in this research has been achieved, so the research will not continue to the next cycle.

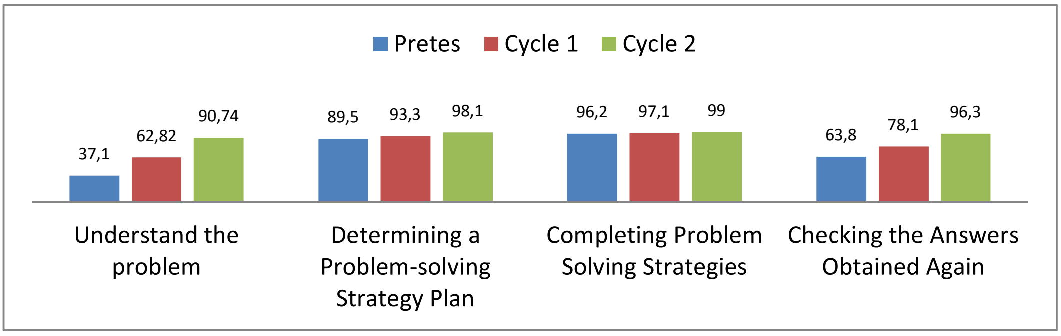

FIGURE 1. Diagram of Student Problem Solving Ability Levels for each Cycle in Phase E

Results of Problem-Solving abilities in Phase D

The results of the research in phase D of cycle I were based on the results of observations; the steps for guiding group and individual investigations were not optimal in their implementation. Based on the problem-solving test, the indicator that has reached the minimum limit is 65%, namely, the indicator of the student's ability to plan a solution is 91.83 in the very high category and the total score percentage is 91.83%, and the indicator of the student's ability to carry out the solution plan is 79.78 in the moderate category and the total score percentage is 79.78%. In cycle I, there were still indicators that had not reached the minimum limit of 65%, namely the indicator of students' ability to understand problems with an average of 64.62, which was in the low category with a total score percentage of 64.62%, and the indicator of checking the results again with an average of 63.16 in the medium category with a total score percentage of 63.16%. So, the number of students who had completed solving problems in cycle I was 39 out of 48 students in the sample. Classical completeness is 81.25%, so the class is considered to have completely solved the problem.

From the data resulting from the implementation of actions in cycle I, it can be concluded that the research target has not been achieved. For this reason, it is necessary to carry out the next cycle by paying attention to the shortcomings in cycle I so that they can be further improved in the next cycle to achieve the target.

The implementation of cycle II is based on research targets that have not been achieved in cycle I. From the results of reflection in cycle I, there are several problems that need to be corrected, including:

1. The learning management carried out by teachers (researchers) is not optimal. Learning steps that still need to be improved are activities to guide individual and group investigations. Some students have not been actively involved in the learning process; some are just silent without providing ideas to solve the problems given.
2. When learning was distributed to each group, several groups experienced difficulties, including not knowing the meaning of what was asked in the questions and not being able to interpret the results of the mathematical answers obtained in the form of problem-solving results from the questions.

3. The ability to understand problems has not yet reached the minimum requirements for completeness. The total score percentage for understanding the problem is 64.62%, and the indicator for checking the results again is 63.16%, so it needs to be improved to reach the minimum target of 65%.

The results obtained in cycle II, namely the results of problem solving based on polya solving steps, have reached the minimum limit of 65%, where the indicator of students' ability to understand the problem is 88.42 with a very high indicator, which has a total score percentage of 88.42%, the student ability category. Planning completion is 99.24 with a high indicator, which has a total score percentage of 99.24%; an indicator of the student's ability to carry out a completion plan is 87.53 with a high category, which has a total score percentage of 87.53%; and checking the results again is 81, with 29 in the medium category, which has a total score percentage of 81.29%. In cycle II, the average score for students' problem-solving abilities was 89.15 in the high category and had reached the research target, namely at least medium with a classical completeness of 100%, so that in the class it was categorized as complete problem-solving because it had reached or even exceeded the target of 85%.

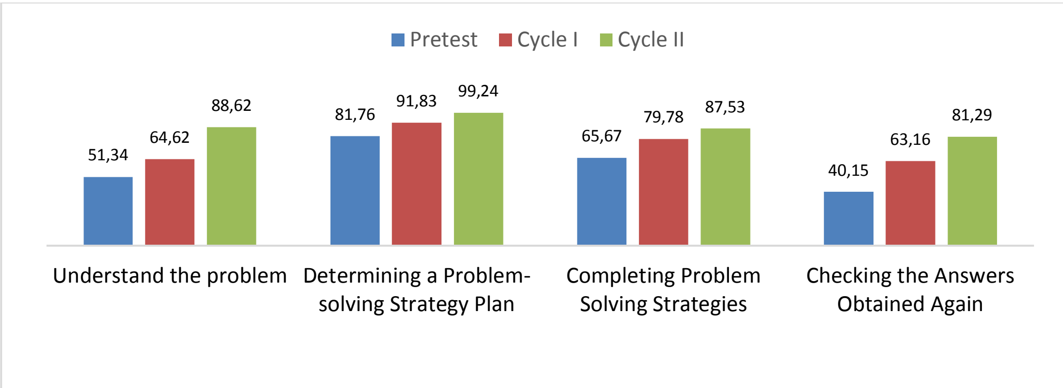

FIGURE 2. Diagram of Student Problem Solving Ability Levels for each Cycle in Phase E D

Discussion of Research Results

Based on the research conducted, it can be found that increasing students' mathematical problem solving by implementing problem-based learning shows significant results. In cycle 1, both phase D and phase E, students' mathematical problem-solving abilities for each indicator began to increase, although there were still indicators that had not reached the research success criteria. After implementing problem-based planning in cycle 2, with improvements to the learning process based on cycle 1, students' mathematical problem-solving abilities for each indicator have reached the research success criteria, namely that the total score for each indicator is above 65% and the number of students who are able to solve mathematical problems is above 85%.

Problem-based learning is a good technique for stimulating students to be more active and think critically because students are given the opportunity to find their own solutions to problems using group collaboration so that it is easier for them to understand the material. The increase in students' mathematical problem-solving abilities can be seen from the increase in average scores and the increase in students' mastery (mathematical problem-solving abilities) in the percentage of individual learning completeness and classical learning completeness. Thus, the problem-based learning model is one effort that can be made to improve students' mathematical problem-solving abilities.

There are several learning theories that support these results, namely constructivism learning theory. According to the constructivist view, learning is a process of forming knowledge. This formation must be carried out by students. This is in accordance with the characteristics of problem-based learning, namely that learning must be student-centered. This theory explains that the main role in learning activities is students' activities in constructing their own knowledge through materials, media, equipment, environment, and other facilities provided to assist this formation [14].

In research conducted by Budianto, it was found that the application of the PBL learning model was successful in increasing problem-solving abilities and motivation in class XI MIPA 1 SMA Negeri 1 Moga academic year

2019/2020 material. The average increase in problem-solving ability increased from 46.36 in the initial condition to 69.88 in cycle I and increased again in cycle II to 76.03 [11].

Panjaitan in his research, found that the application of the problem-based learning model could improve the mathematical problem-solving abilities of students in X MIPA 1, SMA Negeri 4 Medan. There was an increase in students' problem-solving abilities by 28.58% from 65.71% in the first cycle, increasing to 94.29 % in cycle II. Apart from that, in cycle I, the number of students who achieved increased problem-solving abilities was 23 students from 35 students in cycle I increased to 33 students in cycle II. The average class score was 70.79 in cycle I and increased to 84.36 in cycle II, resulting in an increase in the average score of students' problem-solving abilities of 13.57 [2].

The data obtained above shows that teaching and learning activities can be improved using the problem-based learning model. Thus, learning by applying the problem-based learning model has an important role in an effort to improve students' mathematical problem-solving abilities.

CONCLUSION

Based on the results of the research and discussion, it can be concluded that the application of the problem-based learning model in two different phases in three schools can significantly improve students' mathematical problem-solving abilities. After carrying out 2 learning cycles using problem-based learning, it was found that the level of mathematical problem-solving ability for each indicator met the minimum criteria of 65%, and students' classical problem-solving completeness reached 100%.

GRATITUDE NOTE

The author would like to thank the parties who have provided support to perfect this research. Apart from that, the author would also like to thank SMA Negeri 1 Sinjai, SMP Negeri 1 Patampanua, and SMP Negeri 1 Mattirosompe for allowing and providing support to the author to conduct research at their schools.

REFERENCE

1. Pandiangan, L. W. "Penerapan *problem based learning* untuk meningkatkan kemampuan pemecahan masalah matematis siswa kelas VIII SMP Swasta Santa Maria Medan" dalam *Jurnal Inspiratif*, 6(1), 1-13 (2020).
2. Panjaitan, M., & Rajagukguk, S. R. "Upaya Meningkatkan Kemampuan Pemecahan Masalah Matematika Siswa Dengan Menggunakan Model Pembelajaran Problem Based Learning di Kelas X SMA" dalam *Jurnal Inspiratif*, 1-17 (2017).
3. Hendriana.H. *Hard skill dan soft skill matematis siswa* (PT. Refika Aditama, Bandung, 2018).
4. Elita, G. S., Habibi, M., Putra, A., & Ulandari, N. "Pengaruh pembelajaran *problem based learning* dengan pendekatan metakognisi terhadap kemampuan pemecahan masalah matematis" dalam *Mosharafa: Jurnal Pendidikan Matematika*, 8(3), 447–458 (2019).
5. Syahputra, E. "Pembelajaran abad 21 dan penerapannya di Indonesia" dalam *Sinastekmapan*, 1, 1276–1283 (2018).
6. Reski, R., Hutapea, N., & Saragih, S. "Peranan model *Problem Based Learning* (PBL) terhadap kemampuan pemecahan masalah matematis dan kemandirian belajar siswa" dalam *Juring: Journal for Research in Mathematics Learning,* 049 – 057 (2019).
7. Al-haddad, I., Hamid, H., Tonra, W. S., & Siddik, R. "Penerapan *Problem Based Learning* (PBL) untuk meningkatkan kemampuan pemecahan masalah matematis pada sistem persamaan linear dua variabel (SPLDV)" dalam *Delta-Pi: Jurnal Matematika dan Pendidikan Matematika*, 9(2), 223–236 (2020).
8. Mahsuna, I., Setiawan, Y. E., & Ilmi, Y. I. "Penerapan model pembelajaran *Problem Based Learning* (PBL) untuk meningkatkan kemampuan pemecahan masalah matematis siswa pada materi segi empat kelas VII" dalam JP3, 1-10 (2023).
9. Setiawan, A & M.Khan. "*Self-determination in mathematics learning process by using generative multi–representation learning (GMRL) model*" dalam *Journal of Physics: Conference Series* (2018).
10. Monica, H., Kesumawati, N., & Septiati, E. "Pengaruh model *Problem Based Learning* terhadap kemampuan pemecahan masalah matematis dan keyakinan matematis siswa" dalam *MaPan*, 7(1), 155–166 (2019).

11.Budianto, U. T. “Penerapan model *Problem Based Learning* untuk meningkatkan kemampuan pemecahan masalah dan motivasi siswa” dalam *Jurnal Paedagogy: Jurnal Penelitian dan Pengembangan Pendidikan*, 8(3), 338-344 (2021).
12. Damayanti, N., & Kartini, K.. “Analisis kemampuan pemecahan masalah matematis siswa SMA pada materi barisan dan deret geometri” dalam *Mosharafa: Jurnal Pendidikan Matematika*, 11 (1), 107–118 (2022).
13. Surya, E., Simamora, R. E., & Rotua Sidabutar, D. “*Improving Learning Activity and Students' Problem Solving Skill through Problem Based Learning (PBL) in Junior High School*” dalam *Article in International Journal of Sciences: Basic and Applied Research*, 33(2), 321–331 (2017).
14. Suparlan. “Teori konstruktivisme dalam pembelajaran” dalam *Islamika: Jurnal Keislaman dan Ilmu Pendidikan*, 79-88 (2019).