JURNAL ABSIS
Jurnal Pendidikan Matematika dan Matematika
Vol. 7 No. 2, December 2024

IMPLEMENTATION OF THE PROBLEM-BASED LEARNING MODEL TO IMPROVE STUDENTS' MATHEMATICAL PROBLEM-SOLVING SKILLS

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ABSTRACT This study aims to improve the learning process and students' mathematical problem-solving skills through the implementation of the Problem-Based Learning (PBL) model. The research employed a classroom action research design, conducted over two cycles in collaboration with a mathematics teacher. The subjects were students of class IX B at UPT SMP Negeri 2 Bangkinang Kota during the first semester of the 2023/2024 academic year. Research instruments included mathematical learning tools (syllabus, lesson plans, and student worksheets) and data collection tools (observation sheets and mathematical problem-solving tests). Data analysis combined qualitative descriptive analysis and quantitative descriptive statistical analysis. The results indicate that the implementation of PBL improved both the learning process and students' mathematical problem-solving skills. The average N-gain score increased from 0.42 (medium classification) in cycle I to 0.72 (high classification) in cycle II. Furthermore, the students' average score improved from 63.44 in cycle I to 84.56 in cycle II. These findings conclude that the Problem-Based Learning model effectively enhances the learning process and mathematical problem-solving skills of class IX B students at UPT SMP Negeri 2 Bangkinang Kota.

Keywords: problem-based learning, mathematical problem-solving, classroom action research, learning process improvement

ABSTRAK Penelitian ini bertujuan untuk meningkatkan proses pembelajaran dan kemampuan pemecahan masalah matematis siswa melalui penerapan model Problem-Based Learning (PBL). Penelitian ini menggunakan desain penelitian tindakan kelas yang dilaksanakan dalam dua siklus, bekerja sama dengan seorang guru matematika. Subjek penelitian adalah siswa kelas IX B di UPT SMP Negeri 2 Bangkinang Kota pada semester pertama tahun ajaran 2023/2024. Instrumen penelitian mencakup perangkat pembelajaran matematika (silabus, rencana pelaksanaan pembelajaran, dan lembar kerja siswa) serta alat pengumpulan data (lembar observasi dan tes pemecahan masalah matematis). Analisis data dilakukan dengan kombinasi analisis deskriptif kualitatif dan analisis statistik deskriptif

kuantitatif. Hasil penelitian menunjukkan bahwa penerapan model PBL meningkatkan proses pembelajaran dan kemampuan pemecahan masalah matematis siswa. Skor rata-rata N-gain meningkat dari 0,42 (klasifikasi sedang) pada siklus I menjadi 0,72 (klasifikasi tinggi) pada siklus II. Selain itu, rata-rata skor siswa meningkat dari 63,44 pada siklus I menjadi 84,56 pada siklus II. Temuan ini menyimpulkan bahwa model Problem-Based Learning secara efektif meningkatkan proses pembelajaran dan kemampuan pemecahan masalah matematis siswa kelas IX B di UPT SMP Negeri 2 Bangkinang Kota.

Keywords: problem-based learning, pemecahan masalah matematis, peningkatan proses pembelajaran, PTK.

INTRODUCTION

Mathematics is a fundamental skill that is crucial in everyday life and serves as the foundation for the development of modern technology. One of the primary goals of mathematics education is to equip students with mathematical problem-solving skills, which involve critical, logical, creative, and analytical thinking (Polya, 1973). However, the mathematical abilities of Indonesian students remain relatively low. According to the 2022 Programme for International Student Assessment (PISA) report, the average mathematics score of Indonesian students was 366 points, significantly below the OECD average, which ranges from 465 to 475 points (OECD, 2022). This score also reflects a decline compared to previous assessments in 2015 and 2018. With Indonesian students categorized at level 1a, they are only capable of solving simple problems using basic procedures and are unable to formulate solutions for more complex problems (OECD, 2022). This situation underscores the urgent need for more effective interventions to enhance students' mathematical abilities, particularly in the context of problem-solving skills.

The Ministry of Education and Culture Regulation No. 58 of 2014 states that one of the primary competencies students must acquire through mathematics learning is mathematical problem-solving skills. The National Council of Teachers of Mathematics (NCTM) also emphasizes that problem-solving is not only the ultimate goal of mathematics learning but also a key tool for understanding and applying mathematical concepts (Samosir et al., 2020). Hendriana and Soemarmo (2014) assert that problem-solving is at the core of mathematics learning, as the steps involved in the process reflect the essence of mathematics itself. Moreover, this ability has practical relevance because it can be applied in various contexts to solve problems or make decisions requiring critical, systematic, logical, and creative thinking.

Mathematical problem-solving is also considered one of the essential 21st-century skills, as it helps students develop higher-order thinking skills needed in the workplace and everyday life. However, the level of mathematical problem-solving skills in Indonesia remains a significant challenge, as evidenced by the PISA survey results. Therefore, assessing students' problem-solving abilities becomes a crucial first step in designing more effective learning strategies.

https://doi.org/10.30606/absis.v7i2.2622

To understand the level of mathematical problem-solving skills among the students of Class IX B at UPT SMP Negeri 2 Bangkinang Kota, the researchers conducted an initial test on the topic of plane geometry. The selection of this school was based on its representativeness of the general condition of students' mathematical abilities in Indonesia. The test was designed with careful attention to the stages of the mathematical problem-solving process, including problem identification, planning a solution strategy, implementing the strategy, and evaluating the solution. The results of the assessment of students' mathematical problem-solving abilities using a relevant scoring rubric can be seen in Table 1. This data will serve as the foundation for designing interventions based on more innovative and effective learning models.

Table 1. Percentage of Students Achieving Maximum Scores in Each Aspect

No	Aspect of Problem-Solving Skills Measured	Question 1		Question 2	
		Students meeting the aspect	Percentage	Students meeting the aspect	Percentage
1	Understanding the problem	10	33.33%	6	20%
2	Planning the problem-solving	8	26.67%	5	16.67%
3	Implementing the problem-solving plan	8	26.67%	3	10%
4	Interpreting the results obtained	5	16.67%	2	6.67%

The data presented in Table 1 reveals that many students were unable to complete the problems effectively across all aspects. At the local level, the results of the initial test indicate that the mathematical problem-solving abilities of the ninth-grade students of UPT SMP Negeri 2 Bangkinang Kota are still low. Based on the assessment, only 33.33% of students were able to understand the problem, 26.67% could plan a solution, and just 10% were able to execute the problem-solving plan. Most students struggled to interpret the results they obtained, with only 6.67% succeeding in this aspect. This low level of mathematical problem-solving ability can largely be attributed to teacher-centered instructional approaches, which limit students' active participation in the learning process. Interviews with teachers and students further revealed that many students find it challenging to comprehend problem-solving questions requiring creativity and logical thinking.

Mathematical problem-solving ability is critically important, as it not only serves as the core of mathematics learning (Hendriana & Soemarmo, 2014) but is also highly relevant in everyday life and decision-making (Effendi, in Septiani & Nurhayati, 2019). Furthermore, problem-solving is considered a primary goal of mathematics education according to the National Council of Teachers of Mathematics (NCTM)

(Samosir et al., 2020). However, the low level of students' mathematical problem-solving skills highlights an urgent need to improve the quality of mathematics instruction.

One of the approaches that has proven effective in enhancing mathematical problem-solving abilities is the Problem-Based Learning (PBL) model. According to Yarmayani (2016), PBL fosters students' ability to find creative and logical solutions through problem-based learning. This model employs real-world problems as the starting point for acquiring new knowledge and encourages students to engage in discussions and collaborative work, ultimately developing critical and analytical thinking skills. Previous studies have demonstrated the effectiveness of PBL in improving both the learning process and students' mathematical problem-solving skills. Gunantara et al. (2014) reported that PBL is effective in enhancing conceptual understanding and problem-solving abilities. Similarly, Handayani et al. (2017) found that PBL improves mathematical learning outcomes for middle school students.

In this study, it was observed that mathematics instruction in class IX B of UPT SMP Negeri 2 Bangkinang Kota remained teacher-centered, with minimal active participation from students. The initial mathematical problem-solving test results indicated that the percentage of students achieving maximum scores across all aspects of problem-solving abilities was still low. Moreover, interviews with teachers and students revealed that many students struggled to comprehend and solve problem-solving tasks, underscoring the need for a more student-centered and engaging instructional approach.

The implementation of the Problem-Based Learning (PBL) model at UPT SMP Negeri 2 Bangkinang Kota offers a potential solution to address the challenges faced, such as the lack of active participation among students in the learning process. By actively engaging students in solving real-world problems, PBL is expected to motivate students to develop greater enthusiasm for learning mathematics. This model also provides opportunities for students to independently construct their understanding and enhance their critical thinking skills through group discussions. To improve students' mathematical problem-solving abilities, it is essential to effectively manage the learning process. PBL, which utilizes problems as a starting point for acquiring new knowledge and involves students in the problem-solving process, holds promise for developing students' critical and analytical thinking abilities. Previous studies have confirmed that the implementation of the PBL model can enhance both the learning process and students' mathematical problem-solving skills (Handayani et al., 2017; Gunantara et al., 2014).

Thus, this study aims to implement the Problem-Based Learning model in mathematics instruction to improve the mathematical problem-solving abilities of class IX B students at UPT SMP Negeri 2 Bangkinang Kota on the topic of Similarity and Congruence. Through the PBL approach, it is expected that students will

https://doi.org/10.30606/absis.v7i2.2622

become more active and motivated in learning, thereby improving their mathematical problem-solving skills.

METHODS

The research employed a collaborative Classroom Action Research (CAR) approach, following the stages of CAR and comprising two cycles. According to Arikunto (2021), each cycle in CAR consists of four stages: planning, action, observation, and reflection.

The actions implemented during the learning process in this research involved the application of the Problem-Based Learning (PBL) model. The subjects of this study were 30 students of class IX B at UPT SMPN 2 Bangkinang Kota, comprising 11 male students and 19 female students with heterogeneous ability levels. The instruments used in this research included learning tools and data collection instruments. The learning tools consisted of a syllabus, Lesson Plans (RPP), and Student Worksheets (LKPD). The data collection instruments included mathematical problem-solving ability tests and observation sheets. Data were collected through test techniques and observation techniques.

The data analysis of teacher and student activities was based on observation sheets completed during the learning process. These observation sheets allowed the researcher to identify weaknesses and deficiencies in the actions taken. Any identified weaknesses and deficiencies were addressed in subsequent meetings.

The analysis of students' mathematical problem-solving ability test results was conducted quantitatively. The achievement of mathematical problem-solving aspects was analyzed by comparing the results after cycle I with those after cycle II. The analysis of students' problem-solving abilities before and after the intervention involved the pre-test and post-test results in both cycles, using relevant benchmarks. In the classical analysis of mathematical problem-solving abilities, the researcher examined the improvement in the average mathematical problem-solving scores before and after the intervention.

The criteria for the success of the intervention were marked by improvements in the learning process and enhancements in students' mathematical problem-solving abilities.

FINDING AND DISCUSSION

The research findings indicate significant improvements in both the learning process and student engagement following the implementation of the Problem-Based Learning (PBL) model. This approach, designed to enhance students' mathematical problem-solving abilities, aligns well with the specific needs and challenges of class IX B at UPT SMP Negeri 2 Bangkinang Kota. These students, many of whom come from backgrounds with limited access to additional learning resources,

demonstrated notable growth in their learning attitudes and skills throughout the research cycles.

The analysis revealed that the application of PBL proceeded in accordance with the lesson plan and effectively enhanced the quality of the learning process. Initially, it was observed that a large portion of the students relied heavily on direct instructions from the teacher to solve problems. For example, preliminary interviews indicated that 70% of students struggled to comprehend problem statements that required critical and analytical thinking. Additionally, the students' limited experience with collaborative work hindered the effectiveness of group discussions in the first cycle. Teachers reported that the learning patterns of the students tended to be individualistic, with only a few students actively contributing during discussions.

However, by the second cycle, significant progress was observed in student participation. Students became more engaged during the learning process, actively responding to initial questions (apperception), confidently expressing their opinions, and demonstrating higher involvement in group discussions. This improvement indicates that PBL successfully encouraged students to become more independent learners and actively participate in problem-solving processes.

The improvement in students' mathematical problem-solving abilities is evident through a comparison of test results from cycle I and cycle II. Table 2 displays the percentage of students who achieved maximum scores in each aspect of mathematical problem-solving during cycle I. The results indicate that while some students performed well in understanding and planning solutions, difficulties were still present in executing plans and interpreting results. This highlights areas that required further improvement in the subsequent cycle.

Table 2. Percentage of Students Achieving Maximum Scores in Mathematical Problem-Solving Aspects (Cycle I)

Aspect of Problem-Solving Skills Measured	Question Number	Number of Students Achieving Max Score	Percentage (%)
Understanding the problem	1	28	93,3
	2	25	83,3
	3	14	46,7
Planning the problem-solving	1	20	66,7
	2	11	36,7
	3	4	13,3
Implementing the problem-solving plan	1	17	56,7
	2	6	20
	3	3	10
Interpreting the results obtained	1	17	56,7
	2	3	10
	3	0	0

https://doi.org/10.30606/absis.v7i2.2622

In Cycle I, although there was a significant improvement compared to the initial condition, the aspects of "Planning Solutions" and "Executing Plans" remained challenging for most students. The percentage of students achieving the maximum score in these aspects was relatively low, with 36.7% and 20% for "Planning Solutions," and 56.7% and 10% for "Executing Plans." This data indicates that students still require more intensive guidance, particularly in understanding and applying systematic steps to solve mathematical problems.

Further improvements were observed in Cycle II, with higher percentages of students achieving maximum scores in all aspects of mathematical problem-solving. The detailed data for Cycle II will be presented in the following table.

Table 3. Percentage of Students Achieving Maximum Scores in Mathematical Problem-Solving Aspects (Cycle 2)

Aspect of Problem-Solving Skills Measured	Question Number	Number of Students Achieving Max Score	Percentage (%)
Understanding the problem	1	28	93,3
	2	29	86,7
	3	26	86,7
Planning the problem-solving	1	25	83,3
	2	27	90
	3	10	33,3
Implementing the problem-solving plan	1	15	50
	2	17	56,7
	3	9	30
Interpreting the results obtained	1	14	46,7
	2	17	56,7
	3	8	26,7

In cycle 2, there was a significant improvement across all aspects of mathematical problem-solving skills. Specifically, the aspect of "Planning Solutions" showed a remarkable improvement compared to cycle 1, with the percentage of students achieving the maximum score increasing to 90% on several questions. This improvement indicates that the Problem-Based Learning approach has been increasingly effective in helping students understand and apply systematic steps in solving mathematical problems.

To provide a clearer picture, an analysis of the improvement in students' mathematical problem-solving skills before and after the implementation of the Problem-Based Learning model on the topic of similarity and congruence is presented in Table 4 below.

Table 4. Improvement in Students' Mathematical Problem-Solving Skills

Cycle	Pre-Test	Post-Test	N-gain	N-gain Classification
Cycle 1	38.78	63.44	0.42	Medium
Cycle 2	45.33	84.56	0.72	High

The increase in the average scores demonstrates a significant progression in students' problem-solving abilities. The average pre-test score of 38.78 increased to 63.44 in cycle 1 and further rose to 84.56 in cycle 2. This indicates that the implementation of the Problem-Based Learning (PBL) model not only succeeded in enhancing learning outcomes but also provided a more meaningful learning experience for the students.

The discussion is based on the observation of teacher and student activities during mathematics learning, as well as the analysis of students' mathematical problem-solving skills from the final test results in each cycle. Initial observations and interviews with teachers revealed that students' mathematical problem-solving skills were relatively low, with an initial average score of only 41.5. Many students struggled to understand and solve problem-solving tasks due to a teacher-centered learning approach, which limited active student participation. To address this issue, the researcher implemented the Problem-Based Learning (PBL) model, designed to enhance students' problem-solving skills through real-world problem-based learning experiences. PBL encourages students to investigate problems, think critically, and independently find solutions. This approach has proven effective in creating more meaningful learning and increasing student engagement, as evidenced by previous research (Hesti, 2019).

In cycle 1, the application of PBL demonstrated positive outcomes, although challenges remained. These challenges included ineffective time allocation, where many groups were unable to complete tasks on time. Furthermore, students' active participation in group discussions was still limited, with some preferring to work individually. Another challenge was that the questions in the Student Worksheets (LKPD) were considered too abstract, making it difficult for students to comprehend the problems. To address these issues, several improvements were made in cycle 2, such as implementing more flexible discussion time management with clear time limits for each phase, enhancing guidance during group discussions, and modifying the LKPD to be simpler and more relevant to everyday contexts.

Results from cycle 2 showed significant improvements in the quality of learning and students' problem-solving skills. The average N-gain for students' problem-solving skills increased from 0.42 in cycle 1 (medium classification) to 0.72 in cycle 2 (high classification). Additionally, the average score improved from 41.5 in the initial test to 63.44 in cycle 1 and ultimately reached 84.56 in cycle 2. This improvement was attributed to the opportunities for students to better understand the material

https://doi.org/10.30606/absis.v7i2.2622

through group discussions, active participation in learning, and meaningful learning experiences using real-world problems as context. In cycle 2, almost all aspects of problem-solving skills experienced significant improvements, including understanding problems (93.3%), planning solutions (90%), executing plans (56.7%), and interpreting results (56.7%).

The application of the PBL model had a positive impact, not only improving students' cognitive abilities but also encouraging them to think critically, logically, and analytically. Moreover, students became more independent and actively involved in the learning process. These findings support previous research by Subekti et al. (2024), which demonstrated that PBL significantly improves mathematics learning outcomes.

The implementation of PBL requires careful planning, particularly in terms of time management and the design of relevant LKPD. Teachers also need to provide intensive guidance during group discussions to ensure active participation from all students. It is recommended that teachers consistently use PBL in mathematics learning by utilizing real-world problems as the context. Furthermore, future research should explore the implementation of PBL on other topics to expand its benefits. With well-planned approaches and continuous improvements, PBL can be an effective solution for enhancing students' mathematical problem-solving skills.

Based on the analysis of teacher and student activities and the analysis of students' mathematical problem-solving skills, it can be concluded that the proposed action hypothesis is validated. Thus, the implementation of the Problem-Based Learning model can improve the learning process and enhance the mathematical problem-solving skills of class IX B students at UPT SMP Negeri 2 Bangkinang Kota on the topic of Similarity and Congruence in the 2023/2024 academic year.

CONCLUSIONS AND RECOMMENDATIONS

The results of this study demonstrate that the implementation of the Problem-Based Learning model effectively improved the learning process and the mathematical problem-solving abilities of ninth-grade students at UPT SMP Negeri 2 Bangkinang Kota during the first semester of the 2023/2024 academic year. Quantitative data revealed a significant increase in students' average scores, from 41.5 in the pre-test to 63.44 in cycle 1, and finally reaching 84.56 in cycle 2. Additionally, the average N-gain of students' mathematical problem-solving abilities increased from 0.42 in cycle 1 (moderate classification) to 0.72 in cycle 2 (high classification). These improvements reflect the success of the Problem-Based Learning model in creating meaningful learning experiences, where students actively engaged in solving real-world problems. This approach also provided opportunities for students to develop critical, analytical, and logical thinking skills, while applying mathematical concepts to everyday life.

Based on these findings, several practical recommendations can be offered to teachers for optimizing the application of the Problem-Based Learning model. Teachers are encouraged to allocate classroom time systematically, ensuring sufficient time for group discussions and presentations. Active monitoring is also essential, such as tracking group progress through observation sheets and providing direct feedback. Moreover, teachers should reinforce problem-solving steps by incorporating contextual practice problems relevant to students' daily experiences. However, this study has limitations regarding its scope, as it involved only one class, indicating a need for further research with a broader population.

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