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IMPROVING STUDENTS' MATHEMATICAL REPRESENTATION ABILITY THROUGH PROBLEM-BASED LEARNING MODEL

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ABSTRACT The basis of the problem in this research is the low level of mathematical representation ability among students in class IX B at SMP IT Al Fityah Pekanbaru. The initial test results showed that the percentage of students achieving the maximum score in the visual representation indicator was 32%, in the mathematical expression representation indicator was 43%, and in the word representation indicator was 36%. This study was conducted in two cycles using the problem-based learning model on the topic of geometric transformation. Each cycle included planning, action, observation, and reflection activities. The purpose of this study was to improve the learning process and enhance students' mathematical representation abilities. Data were collected using observation techniques and mathematical representation ability tests. The results showed improvements in both the learning process and students' abilities. The average percentage of students achieving the maximum score across the two cycles was 86% in visual representation, 82% in mathematical expression representation, and 52% in word representation. It can be concluded that the problem-based learning model is an effective teaching method for improving students' mathematical representation abilities.

Keywords: mathematical representation, problem-based learning, geometric transformation, learning improvement

ABSTRAK Dasar permasalahan dalam penelitian ini adalah rendahnya kemampuan representasi matematis siswa di kelas IX B SMP IT Al Fityah Pekanbaru. Hasil tes awal menunjukkan persentase siswa yang mencapai skor maksimum pada indikator representasi visual sebesar 32%, pada indikator representasi ekspresi matematis sebesar 43%, dan pada indikator representasi kata sebesar 36%. Penelitian ini dilakukan dalam dua siklus dengan menerapkan model pembelajaran berbasis masalah pada materi transformasi geometri. Setiap siklus terdiri dari kegiatan perencanaan, tindakan, observasi, dan refleksi. Tujuan penelitian ini adalah untuk meningkatkan proses pembelajaran dan kemampuan representasi matematis siswa. Data dikumpulkan menggunakan teknik observasi dan tes kemampuan representasi matematis. Hasil penelitian menunjukkan adanya peningkatan baik dalam proses pembelajaran maupun kemampuan siswa. Rata-rata persentase siswa yang mencapai skor maksimum dari kedua siklus adalah 86% pada representasi visual, 82% pada representasi ekspresi matematis, dan 52% pada representasi kata. Dengan demikian,

dapat disimpulkan bahwa model pembelajaran berbasis masalah merupakan metode pengajaran yang efektif untuk meningkatkan kemampuan representasi matematis siswa.

Keywords: representasi matematis, pembelajaran berbasis masalah, transformasi geometri, peningkatan hasil belajar

INTRODUCTION

Mathematics learning has specific objectives that must be achieved as indicators of learning success. According to As'ari et al. (2017) and Arcat & Subchan (2019), the 2013 curriculum emphasizes that one of the goals of mathematics learning is for students to understand mathematical concepts accurately, flexibly, efficiently, and effectively when solving problems. This includes the ability to present concepts in various forms of mathematical representation, such as mathematical models, sketches, tables, pictures, diagrams, and graphs. Widakdo (2017) further highlights that mathematical representation skills form the foundation for understanding mathematical ideas. These ideas or concepts can be expressed in multiple forms, including tables, graphs, diagrams, pictures, numbers, or mathematical notation in written form (Azizah et al., 2019).

Despite the importance of mathematical representation, teachers often do not view it as a critical component of mathematics learning (Huda et al., 2019). Teaching and learning activities remain teacher-centered, limiting students' opportunities to develop their own representations. As a result, students tend to follow the problem-solving algorithms provided by teachers without exploring alternative methods. Moreover, teachers predominantly rely on textbooks and conventional teaching methods, such as explaining material, providing example problems, and assigning exercises. This approach fails to develop students' mathematical representation skills, leaving these skills underutilized.

To examine the state of students' mathematical representation abilities, a mathematical representation test was administered using data presentation material. The problem-solving steps in the test were aligned with the indicators of mathematical representation. Table 1 presents the results of the assessment, which was conducted with 25 students in class IX B at SMP IT Al-Fityah Pekanbaru.

Table 1. Percentage of Class IX B Students Achieving Maximum Scores on Each Indicator

Qualification	Visual of Representation			Representation of Mathematical Expressions			Representation of Words		
	1	2	3	1	2	3	1	2	3
Number of Students with Maximum Score	0	8	16	2	11	19	1	5	21
Percentage (%)	0	32	64	8	44	76	4	20	84

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The results in Table 1 indicate that the mathematical representation abilities of class IX B students at SMP IT Al-Fityah Pekanbaru remain low. Students struggled to find correct solutions to the given problems. To explore the causes of this issue, interviews were conducted with two students possessing medium and high cognitive levels. The findings revealed several factors contributing to the low representation abilities, including (1) a lack of understanding of how to convert data into percentages, degrees, or vice versa; (2) difficulty in constructing tables and diagrams accurately; and (3) frequent calculation errors due to a lack of carefulness when solving problems.

These findings are corroborated by interviews with teachers and classroom observations conducted in class IX B at SMP IT Al-Fityah Pekanbaru during the odd semester of the 2023/2024 academic year. Observations revealed that the provision of problem-solving opportunities was not incorporated into the teaching process. Instead, students were provided with explanations of material, step-by-step instructions for using formulas, and practice exercises, without being encouraged to solve problems mathematically. This teaching approach hindered students' ability to use representations to deepen their understanding of mathematical concepts and explore relationships between these concepts.

From the results of interviews with class IX B mathematics teachers at SMP IT Al-Fityah Pekanbaru regarding teaching and learning activities in class, the following information was obtained: (1) students are not used to working on questions in the form of problems; (2) students usually answer questions according to the formulas and examples of questions given; (3) students cannot connect mathematical concepts using representations, so they have difficulty understanding more complex mathematical concepts and solving problems.

Based on the description of the results of observations and interviews, problems were found in class IX B of SMP IT Al-Fityah Pekanbaru in the odd semester of the 2023/2024 academic year. The problems include students not being able to properly identify a problem in real life mathematically, students only referring to the algorithm taught by the teacher, which results in students' creativity and ideas in solving problems not developing. Furthermore, students are not accustomed to solving problems with various representations and are unable to solve problems involving mathematical representations. These problems contribute to the low level of students' mathematical representation ability.

Efforts to improve the learning process and enhance the mathematical representation ability of class IX B students at SMP IT Al Fityah Pekanbaru in the odd semester of 2023/2024 involve utilizing an innovative learning model. According to Fitri et al. (2017) and Man et al. (2022), a learning model is needed to help students become accustomed to solving problems related to mathematical representation ability. Fauzan et al. (2019) suggest that the problem-based learning model has the potential to significantly improve mathematical representation ability, as it

emphasizes the process of solving problems scientifically. Through problem-based learning, students can engage in intensive group discussions, enabling them to ask, answer, critique, correct, and clarify concepts collaboratively (Ermida et al., 2024; Artiah & Untarti, 2017). The application of the problem-based learning model provides appropriate actions needed to train and familiarize students with mathematical representation ability. During the phase of guiding group and individual investigations, students have the opportunity to explore and solve problems. This process trains students to use visual representations, mathematical expressions, and words to address problems (Annajmi & Afri, 2019; Armadan et al., 2017).

Based on an interview with a mathematics teacher of class IX B at SMP IT Al-Fityah Pekanbaru regarding students' difficulties in learning geometric transformation material, it was found that students often struggle to understand abstract concepts such as the center of rotation and reflection lines. They also face challenges in applying geometric transformations to various problem contexts, understanding the connections between geometric transformation concepts, visualizing transformed objects, and making accurate notations and calculations. On the other hand, geometric transformations are closely related to real-world applications, such as in the fields of health, optics, programming, photography, architecture, and automotive industries (Winanto, 2022). What distinguishes this study from relevant research by Jenita et al. (2017) and Fitri et al. (2017) is the homogeneous composition of students (all female) and the selected material.

In this study, the application of the problem-based learning model was implemented to improve the learning process and enhance the mathematical representation ability of class IX B students at SMP IT Al-Fityah Pekanbaru in the odd semester of 2023/2024 on geometric transformation material. Through the implementation of the problem-based learning model, it is expected that students will have greater opportunities to think and develop ideas individually or in groups, thereby improving the mathematical representation ability of class IX B students at SMP IT Al-Fityah Pekanbaru.

METHODS

This research employed Classroom Action Research, which was conducted in class IX B of SMP IT Al Fityah Pekanbaru during the odd semester of the 2023/2024 academic year, focusing on the topic of geometric transformation. The implementation of the research took place from November 7, 2023, to December 5, 2023. According to Arikunto (in Surya, 2017), Classroom Action Research is carried out through four stages: (1) planning, (2) acting, (3) observing, and (4) reflecting.

This study was conducted over two cycles. The first cycle consisted of three meetings and one daily test (mathematical representation ability test I). The second cycle included two meetings and one daily test (mathematical representation ability test

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II). In the first cycle, the actions were based on the problem-based learning model. The actions in the second cycle also followed the problem-based learning model but incorporated improvements derived from the reflections on the first cycle.

FINDING AND DISCUSSION

This section presents the findings and discussion based on the implementation of the problem-based learning model in class IX B of SMP IT Al-Fityah Pekanbaru during the odd semester of the 2023/2024 academic year. The results focus on the analysis of student and teacher activities, the progression of students' mathematical representation ability through cycles I and II, and the overall impact of the learning intervention. These findings are supported by observations, test data, and relevant literature to provide a comprehensive evaluation of the learning process.

During the implementation of cycle I, as illustrated in Figure 1, students began to actively engage in solving problems provided in the student worksheets. This marked an improvement, as learning became more meaningful by training students to construct their understanding through the problem-based learning model. However, despite these advantages, several shortcomings were observed in the learning process. Activities such as motivation, apperception, and learning evaluation showed that students were not yet fully active in responding to the material presented. Only a few students took the initiative to provide responses without being directly prompted. To address these issues, efforts were made to encourage students to express their understanding through random selection and additional incentives, alongside fostering their confidence in providing responses by employing stimulus and positive reinforcement.

Figure 1. Students Conduct Group Investigations

In addition to these challenges, there were also shortcomings in classroom management during cycle I. Some students lacked focus and failed to collaborate effectively with their group members, which caused them to lag in understanding the learning material. Furthermore, the time allocation for each activity did not align

with the planned schedule. For instance, the time spent on apperception activities exceeded expectations, LKPD-2 was not presented by students, and formative tests were not administered during the first and second meetings. To address these issues, improvements were made by closely monitoring each student and paying special attention to those who were less active. These students were actively involved in learning through strategies such as asking them questions, selecting them to answer in front of the class, and providing additional guidance to help them comprehend the material. Additionally, efforts were made to improve time management by adhering more strictly to the planned schedule and familiarizing students with the problem-based learning model.

In cycle II, corrections were made based on the reflections from cycle I, resulting in significant improvements in the learning process. Discussions were conducted more effectively, both in groups and in class, as students followed teacher guidance to form groups in an organized manner. Collaboration among group members improved, as adjustments were made not only based on academic performance but also on compatibility between student characteristics. Students became more active in providing responses and asking questions, supported by additional motivation from the teacher, such as recording the names of those who actively participated in class. The consistent application of the problem-based learning model over five meetings (excluding the mathematical representation ability test) helped students become more familiar with and accustomed to problem-based learning activities. This increased participation in the problem-solving process led to more effective and optimal use of time compared to cycle I. Overall, the activities of both students and teachers improved significantly, as shown in Figure 2.

Figure 2. Students Actively Analyze and Evaluate

The analysis of student and teacher activities was conducted using observation sheets that documented various aspects of the lesson implementation plan. The aspects in the observation sheets were adjusted to align with the modification of problem-based learning as outlined in Permendikbud (2014). According to

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Fadhilaturrahmi (2017), qualitative data analysis involves several stages: data collection, data reduction, and data presentation. The data from the observation sheets, collected from the first to the final meeting, were analyzed to identify changes in the learning process.

The data on student and teacher activities were analyzed to evaluate improvements in the learning process after implementing the problem-based learning model in the lesson implementation plan. The alignment between the planning phase of the problem-based learning model and the actions during learning activities was reviewed through the observation sheets from each meeting. The analysis included preliminary, core, and closing activities. At each meeting, the activities of both students and teachers became increasingly aligned with the lesson plan. Discussions, teacher guidance, and the implementation of the problem-based learning model showed continuous improvement from cycle I to cycle II, with students becoming more accustomed to the approach. The shortcomings observed in the learning process during cycle I were addressed and reduced in cycle II. The positive aspects of learning activities from cycle I were maintained and further improved by both teachers and students in cycle II.

The analysis of learning steps in cycles I and II revealed a marked improvement in the learning process for class IX B of SMP IT Al Fityah Pekanbaru during the odd semester of the 2023/2024 academic year, specifically on the topic of geometric transformation.

The evaluation of students' mathematical representation ability was based on the results of the mathematical representation test conducted in cycle I. The qualification scores achieved by students for each indicator of mathematical representation are presented in Table 2.

Table 2. Student Performance by Indicator in Cycle 1

Qualification	Visual of Representation			Representation of Mathematical Expressions			Representation of Words		
	1	2	3	1	2	3	1	2	3
Number of Students with Maximum Score	21	9	19	20	8	13	7	5	8
Percentage (%)	84	36	76	80	32	52	28	20	32

Table 2 indicates that not all students achieved the maximum score across the different indicators of mathematical representation. The number of students who attained the maximum score in the visual representation and mathematical expression indicators showed an improvement compared to the initial test, while the verbal representation indicator did not show similar progress. The verbal representation indicator had the lowest number of students achieving the maximum score, primarily because many students failed to provide answers or made errors in

their explanations. These errors in the verbal representation indicator were closely linked to mistakes made in the visual representation and mathematical expression indicators, highlighting the interconnected challenges across these skills.

Following the completion of cycle 2, an analysis of the mathematical representation test results revealed updated qualification scores for each indicator. These results are summarized in Table 3.

Table 3. Student Performance by Indicator in Cycle 2

Qualification	Visual of Representation		Representation of Mathematical Expressions		Representation of Words	
	5	6	5	6	5	6
Number of Students with Maximum Score	22	17	20	21	17	18
Percentage (%)	88	68	80	84	68	72

Table 3 reveals that, although not all students achieved the maximum score for each mathematical representation indicator, there was a general improvement in students' mathematical representation scores in cycle II compared to cycle I. The lowest percentage in cycle 2 was observed in question number 5 under the verbal representation indicator and question number 6 under the visual representation indicator. For question number 5 in the verbal representation indicator, several students were still unable to provide complete explanations or conclusions. Similarly, errors persisted in the visual representation indicator and mathematical expressions, which hindered students from delivering proper and accurate explanations.

In question number 6 of the visual representation indicator, students struggled to create complete and accurate diagrams. Some students failed to fully depict the dilated object, with partial representations that lacked critical details. These issues highlight the ongoing challenges students faced in mastering these specific aspects of mathematical representation, even after improvements in cycle 2.

The qualifications of students' mathematical representation abilities before and after the intervention were further analyzed to evaluate the overall effectiveness of the implemented actions. These qualifications are summarized in Table 4.

Table 4. Students' Representation Ability Qualifications Before and After Action

Value Interval	Total Students			Qualification
	Initial Test	Cycle 1	Cycle 2	
$(86 \leq N \leq 100)$	1	6	16	Very High
$(71 \leq N < 86)$	2	2	6	High
$(56 \leq N < 71)$	4	9	3	Currently
$(0 \leq N < 56)$	18	8	0	Low

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Further analysis of the overall improvement in mathematical representation abilities is summarized in Table 5. This data reflects the classical improvement across the initial test, cycle I, and cycle II, measured by the average score of students.

Table 5. Improvement in Students' Representation Ability Scores

Information	Initial Test	Cycle 1	Cycle 2
Average Score	48.68	60.76	87.64
Improvement	-	12.08	26.88

The initial average score of 48.68 increased to 60.76 in cycle I, representing an improvement of 12.08 points. In cycle II, the average score rose further to 87.64, showing a more substantial increase of 26.88 points. This demonstrates the effectiveness of the Problem-Based Learning model in enhancing students' mathematical representation abilities.

The findings of this study demonstrate significant improvements in the learning process and the students' mathematical representation abilities. This aligns with the research by Jenita et al. (2017) and Fitri et al. (2017), which concluded that the Problem-Based Learning model effectively enhances students' abilities by encouraging active engagement and the development of ideas during problem-solving. Additionally, this study revealed a connection between the homogeneity of students (all female) and the seamlessness of the learning process in the classroom. This observation is consistent with the research by Aditya et al. (2019), which found that homogeneous classrooms foster greater concentration, reduce hesitation in expressing opinions, encourage freer socialization among peers, strengthen relationships due to shared biological similarities, and enhance learning motivation.

The findings from classroom actions in class IX B of SMP IT Al-Fityah Pekanbaru corroborate these earlier studies. Students who participated in the interventions exhibited a consistent pattern of improvement in the learning process, characterized by increased concentration, effective communication, and heightened motivation to learn. This underscores the effectiveness of the Problem-Based Learning model in creating an active and supportive learning environment conducive to improving students' mathematical representation abilities.

CONCLUSIONS AND RECOMMENDATIONS

Based on the results and discussions, it can be concluded that the implementation of the Problem-Based Learning (PBL) model effectively improves the mathematics learning process in class IX B of SMP IT Al Fityah Pekanbaru during the odd semester of the 2023/2024 academic year, specifically on the topic of geometric transformation. The improvements in the learning process achieved through the application of the PBL model significantly enhance the mathematical representation abilities of the students, as evidenced by the observed progress in their understanding and problem-solving skills.

As a recommendation, the student worksheets (LKPD) provided should allow greater opportunities for students to construct their own reasoning processes with minimal instructions from the teacher. The problems presented in the LKPD should be contextual and accompanied by more detailed illustrations to facilitate students' understanding and problem-solving. Such enhancements can further support the development of students' independent thinking and mathematical representation abilities.

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