Problem-Based Learning to Enhance Mathematical Communication Skills and Learning Outcomes in Graade V

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Abstract

The implementation of the Problem-Based Learning model can improve the learning outcomes in mathematics regarding the volume of rectangular prisms and cubes among fifth-grade students at Elementary School. This study employs the Classroom Action Research method in an elementary school in the Yogyakarta region.. This is evidenced by the increased learning outcomes of the students in mathematics during Cycle I, which was 83.3%, and Cycle II, which was 86.3%. In Cycle I, the average score of the students in the first meeting was 73, and in the second meeting, it was 72. In Cycle II, the score in the first meeting was 80, and in the second meeting, it increased to 91. Problem-based learning significantly enhances the learning outcomes in mathematics and mathematical communication skills of the fifth-grade students a Elementary School. The implementation of the Problem-Based Learning model is carried out through five steps. The application of the Problem-Based Learning model can improve the learning outcomes and mathematical communication skills. This is evidenced by the observed improvement in the students' mathematical communication skills in each cycle. The average observation results in Cycle I were 75.84%, and in Cycle II, it increased to 86%.

Keywords: *Problem Based Learning, learning outcomes in mathematics, mathematics communication skills*

Abstrak

Penerapan model Problem Based Learning dapat meningkatkan hasil belajar matematika tentang volume prisma segi empat dan kubus pada siswa kelas V Sekolah Dasar. Penelitian ini menggunakan metode Penelitian Tindakan Kelas di sebuah sekolah dasar di wilayah Yogyakarta. Hal ini dibuktikan dengan peningkatan hasil belajar matematika siswa pada Siklus I sebesar 83,3% dan Siklus II sebesar 86,3%. Pada Siklus I rata-rata nilai siswa pada pertemuan pertama sebesar 73 dan pada pertemuan kedua sebesar 72. Pada Siklus II nilai rata-rata siswa pada pertemuan pertama sebesar 80 dan pada pertemuan kedua meningkat menjadi 91 Pembelajaran berbasis masalah secara signifikan meningkatkan hasil belajar matematika dan kemampuan komunikasi matematis siswa kelas V Sekolah Dasar. Penerapan model Pembelajaran Berbasis Masalah dilakukan melalui lima langkah. Penerapan model Problem Based Learning dapat meningkatkan hasil belajar dan kemampuan komunikasi matematis. Hal ini dibuktikan dengan terlihat adanya peningkatan kemampuan komunikasi matematis siswa pada setiap siklusnya. Rata-rata hasil observasi pada Siklus I sebesar 75,84% dan pada Siklus II meningkat menjadi 86%.

Kata kunci: *Pembelajaran Berbasis Masalah, hasil belajar matematika, kemampuan komunikasi matematika*

INTRODUCTION

Problem-based learning is an instructional approach that allows students to learn through experiences in solving problems relevant to their daily lives (Abarang & Delviany, 2021). Through problem-based learning, students are presented with real-world problems that require critical and creative thinking, collaboration with classmates, and the communication of their solutions. Problem-based learning enables students to develop their mathematical communication skills because they need to be able to explain their thoughts clearly and use appropriate mathematical language in solving the problems (Zainal, 2022). Furthermore, problem-based learning can also enhance students' learning outcomes as they actively engage in the learning process.

The topic of geometric shapes is chosen because it requires a good understanding of geometry concepts and the ability to visualize three-dimensional objects (Zulhelmi & Anwar, 2021). By using problem-based learning in teaching geometric shapes, students will be able to deepen their understanding of these concepts and improve their abilities to visualize and communicate solutions to problems related to geometric shapes. In this context, the implementation of problem-based learning can be an effective alternative in enhancing students' mathematical communication skills and learning outcomes in the topic of geometric shapes (Rohid et al., 2019).

Based on initial observations and interviews with the fifth-grade homeroom teacher, it is known that students' learning outcomes in mathematics, particularly in the topic of geometric shapes, are still inadequate. Here are the initial data obtained:

Subject	Mid-term grade average	Final grade average
Religion education	86	86
Civic education	83	83
Bahasa	80	80
Math	71	73
Science	80	80
Social education	80	80
Arts	80	81
Physical education	83	84
Local content	76	77

The implementation of Problem-Based Learning in mathematics education offers several advantages (Rindengan & Wenas, 2020). Firstly, this method allows students to actively learn and engage in solving problems that are relevant to their everyday lives. In this way, students can see that mathematics is not merely theoretical but also closely connected to real-life situations. Secondly, Problem-Based Learning enables students to develop their mathematical communication skills effectively. While solving problems, students must be able to explain and defend their solutions clearly using appropriate mathematical language. This helps them enhance their mathematical communication abilities and improve their speaking and writing skills in the language of mathematics. Thirdly, Problem-Based Learning can enhance students' learning outcomes. Since students are actively involved in the learning process, they tend to understand mathematical concepts better and gain a deeper understanding compared to passive learning of theories. In PBL, students can also develop critical and creative thinking skills and learn to collaborate with their classmates (Kiswanto Kenedi et al., 2019).

Research conducted by (Eismawati et al., 2019) states that problem-based learning models can improve mathematics learning outcomes, especially in the area of plane geometry. This model has successfully increased the number of students achieving scores above the Minimum Mastery Criteria (KKM). Furthermore, there are differences in mathematical communication skills between students using problem-based learning and those using direct learning methods, as noted by (Kiftiah, 2022).

The implementation of Problem-Based Learning in teaching spatial figures also provides additional benefits. This topic requires the ability to visualize three-dimensional objects and understand geometric concepts effectively. Through Problem-Based Learning, students can develop these skills effectively in a fun and interactive manner (Tambunan, 2019). In Problem-Based Learning, students are given problems that involve geometric concepts in contexts relevant to their daily lives. For example, they may be asked to design a building with specific shapes and sizes or solve problems related to measurement and calculation of the volume and surface area of an object. In tackling these problems, students learn to visualize three-dimensional objects and apply geometric concepts practically. Therefore, Problem-Based Learning is an effective teaching method to enhance mathematical communication skills and improve students' learning outcomes on the topic of spatial figures (Siagian et al., 2019). It allows students to learn actively and engage in the learning process while developing critical and creative thinking skills essential in solving mathematical problems. Through the use of Problem-Based Learning, students will be able to develop these skills effectively in a fun and interactive manner. In Problem-Based Learning, students can be presented with problems involving geometric concepts in contexts that are relevant to their everyday lives.

METHOD

This research employs a collaborative classroom action research approach. Collaborative Classroom Action Research (CCAR) can be identified as an educational research approach involving cooperation between teachers and researchers, as well as active participation from students in the research process (Syahdan et al., 2022). This research aims to describe the improvement of mathematical communication skills and mathematics learning outcomes in the topic of three-dimensional shapes through the Problem-Based Learning model in mathematics instruction for fifth-grade students at a public elementary school. The conducted research consists of four stages: (1) planning, (2) implementation, (3) observation, and (4) reflection. These four components are then referred to as one cycle. The success indicators for this Collaborative Classroom Action Research (CCAR) are as follows:

a. Increased mathematical communication skills of students, as observed from the presentation of mathematical communication skills, reaching 85%.
b. Improved mathematical communication skills during the learning process. Students can comprehend and convey mathematical information, process it into mathematical language, and effectively communicate it both orally and in writing.
c. Improved mathematics learning outcomes, particularly in the topics of cubes and rectangular prisms, in each cycle exceeding the predetermined school criteria of 65% proficiency.

RESULTS AND DISCUSSION

Result

1) Description of the Initial Study Phase

This classroom action research was conducted in the fifth grade of Kembangsari Public Elementary School, Piyungan District, Bantul Regency, Academic Year 2022/2023. The research was carried out in two cycles to determine how to improve students' learning outcomes in mathematics on the topic of the volume of cubic and rectangular prisms, as well as their mathematical communication skills, through the Problem Based Learning method in mathematics learning for the fifth-grade students Piyungan, Bantul.

2) **Pre-Action Data**

Data obtained from observations with the class teacher on April 14, 2023, revealed that there were still several students who had not achieved the Minimum Criteria for Mastery (KKM) standard for mathematics set at 65 at Kembangsari Elementary School. Additionally, the mathematical communication abilities of the students were low during the learning process. To determine the extent of students' low mathematical communication abilities, the researcher observed the thematic learning process in the fifth grade of Kembangsari Public Elementary School, which was the object of the study.

3) **Cycle I Action Results**

Observations were conducted by the researcher and two colleagues using observation sheets to assess the implementation of the Problem Based Learning model by the teacher and students. The results of the observation are presented in the following table:

Table 1. Results of Observations on the Implementation of the Problem Based Learning Model for Teachers and Students in Cycle I.

| Steps	Cycle I			Cycle II		
	Meeting 1 (%)	Meeting (%)	Average (%)	Meeting 1 (%)	Meeting 2 (%)	Average (%)
Problem orientation	62,5	75	68,75	87,5	87,5	87,5
Learning organization process	62,5	75	68,75	75	87,5	81,25
Student guidance	75	75	75	87,5	87,5	87,5
Presentation of work	75	75	75	75	87,5	81,25
Analysis and evaluation of problem-solving process	75	75	75	87,5	87,5	87,5
Average	70	75	72,5	82,5	87,5	85

Explanation:
A = Excellent (85-100%)
B = Good (75-84%)
C = Satisfactory (65-74%)
D = Poor (55-64%)
E = Fail (≤54%)

Here is the graph of the mathematics learning outcomes from pre-cycle to cycle I.
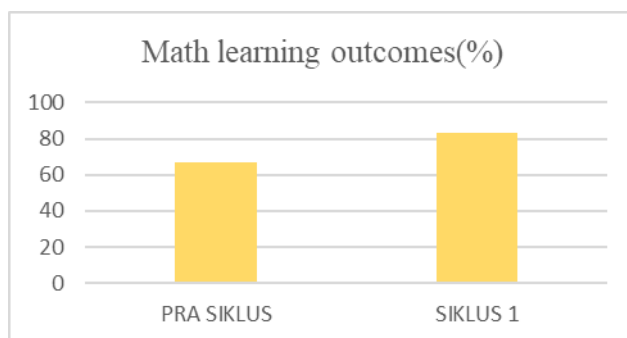
Below is the Table 2 of observations on students' mathematical communication skills in cycle I.

Observation indicators	Percentage (%)	
	Meeting 1	Meeting 2
The mathematical statements are presented clearly and systematically	76,42	77,14
Using accurate and proper mathematical terms	75,71	76,42
Using mathematical symbols or notations correctly.	77,14	77,14
Communicating mathematical understanding with appropriate sentences.	72,85	74,28
Using visual representations, such as diagrams or graphs, to explain problem-solving	75	75
Ability to actively listen when someone explains mathematical concepts	74,28	75
Ability to respond and provide feedback to questions or explanations of mathematical concepts from others	77,85	77,85
Having the courage to explain the solution to mathematical problems.	75,71	75,71
Total	604,96	608,54
Average	75,62	76,06
Composite average	75,84	

4) Cycle II Action Results

The observation was conducted by the researcher and two peers by filling out observation sheets on the implementation of the Problem Based Learning model for teachers and students. The observation results can be seen in the following table:

Table 3. Results of Observations on the Implementation of the Problem Based Learning Model for Teachers and Students in Cycle II.

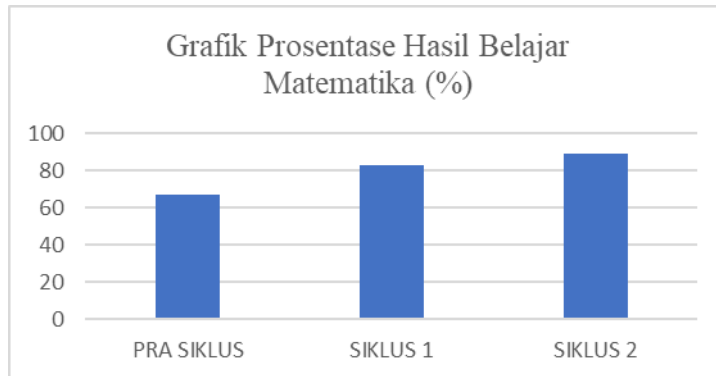| Steps	Cycle I			Cycle II		
	Meeting 1 (%)	Meeting (%)	Meeting 1 (%)	Meeting (%)	Meeting 1 (%)	Meeting (%)
Problem orientation	62,5	75	68,75	87,5	87,5	87,5
Learning organization process	62,5	75	68,75	75	87,5	81,25
Student guidance	75	75	75	87,5	87,5	87,5
Presentation of work	75	75	75	75	87,5	81,25
Analysis and evaluation of problem-solving process	75	75	75	87,5	87,5	87,5
Average	70	75	72,5	82,5	87,5	85

Explanation:
A = Excellent (85-100%)
B = Good (75-84%)
C = Satisfactory (65-74%)
D = Poor (55-64%)
E = Fail (≤54%)

Here is the graph of the mathematics learning outcomes

Here is the table 4 of observation results on the mathematical communication skills of students in cycle II:

Observation indicators	Precentage (%)	
	Meeting 1	Meeting 2
The mathematical statements are presented clearly and systematically	87,14	87,14
Using accurate and proper mathematical terms	86,42	86,42
Using mathematical symbols or notations correctly.	85,71	86,42
Communicating mathematical understanding with appropriate sentences.	85	86,42
Using visual representations, such as diagrams or graphs, to explain problem-solving	86,42	86,42
Ability to actively listen when someone explains mathematical concepts	85	85,71
Ability to respond and provide feedback to questions or explanations of mathematical concepts from others	87,14	87,14
Having the courage to explain the solution to mathematical problems.	85,71	86,42
Total	688,54	692,09
Mean	86,06	86,51
Composite average	86,28	

5) Comparison of Inter-Action Results

a) Math learning outcomes

The mathematical learning outcomes of students regarding the volume of rectangular prisms and cubes were obtained from evaluation questions completed by the students at the end of each learning session in Cycle I and Cycle II. The table analyzing the comparison of the students' learning outcomes in Cycle I and Cycle II can be seen below :

Table 5. Comparison of Learning Outcomes in Cycle I and Cycle II

Score	Cycle I		Cycle II	
	Meeting 1 (%)	Meeting 2 (%)	Meeting 1 (%)	Meeting 2 (%)
95-100	-	-	2,77	2,77
85-94	2,77	2,77	30,55	30,55
75-84	63,88	61,11	33,33	36,11
65-74	16,66	19,44	30,55	27,77
55-64	2,77	-	-	-
45-54	11,1	13,88	-	-
<45	2,77	2,77	2,77	2,77
Max	88	88	96	96
Min	0	0	0	0
Mean	73	72	80	91
Above the KKM	83,33	83,33	83,33	86,11
Under the KKM	16,67	16,67	16,67	13,88

b) Mathematical Communication Skills

The data on the observation of students' process skills were obtained from observations conducted during the learning process in Cycle I and Cycle II. The analysis of the comparison of students' process skill observations in Cycle I and Cycle II can be seen in the following table:

Tabel 6. Comparison of Mathematical Communication Skills between Cycles

INDICATORS	Cycle I		Cycle II	
	Meeting 1 (%)	Meeting 2 (%)	Meeting 1 (%)	Meeting 2 (%)
1	71,52	76,42	87,14	87,86
2	72,22	75,71	86,42	86,42
3	72,91	77,14	86,42	87,14
4	71,52	72,85	86,42	88,58
5	72,91	75	86,42	86,42
6	72,22	74,28	85,71	85,71
7	72,91	77,85	87,14	88,58
8	72,22	75,71	86,42	86,42
Mean	72,30	75,62	86,51	87,14

Based on the table above, it can be observed that the observation results of students' process skills have improved from Cycle I to Cycle II. The average percentage of students' process skills in Cycle I, Meeting 1, was 72.30%, and in Cycle I, Meeting 2, it increased to 75.62%. In Cycle II, Meeting 1, the average percentage obtained was 86.51%, and in Meeting 2, it further increased to 87.14%. The percentage achieved has reached the targeted percentage, which was planned to be 85%.

a. **Discussion**

1) **Implementation of Problem-Based Learning:**

Based on the observations conducted by the observer during the implementation of Problem-Based Learning by the teacher in Cycle I and Cycle II, there was a continuous improvement demonstrated by both the teacher and the students. The improvement occurred because there were consistent refinements made in each cycle to overcome challenges that arose, enabling the achievement of the expected research performance indicators (Wahyuningtyas & Kristin, 2021). The improvement in the implementation of Problem-Based Learning in teaching mathematics on the topic of the volume of rectangular prisms and cubes is relevant to a study conducted by Putu Agus and Wilibladus (Agus et al., 2018) titled "The Effect of Problem-Based Learning Model on Mathematics Learning Outcomes of Elementary School Students." The study mentioned a significant difference in mathematics learning outcomes between the group of students who were taught using Problem-Based Learning and the group who received conventional teaching methods. Therefore, it can be concluded that Problem-Based Learning has an impact on students' mathematics learning outcomes.

2) Improvement in Mathematics Learning Outcomes on the Topic of Volume of Rectangular Prisms and Cubes:

The pretest results from the pre-cycle showed that the percentage of students' learning outcomes mastery was still very low, with only 65%. The researcher attempted to improve these results by implementing Problem-Based Learning during the teaching of the volume of rectangular prisms and cubes. The posttest results at the end of each cycle showed an increase in the percentage of students' learning outcomes mastery, reaching 83% in Cycle I and 86% in Cycle II.

The above research findings support previous studies conducted by Eismawati and colleagues (Eismawati et al., 2019)which stated that teaching with Problem-Based Learning model can improve learning outcomes in mathematics for elementary school students.

3) Improvement in Mathematical Communication Skills in Mathematics Teaching

The observation results of process skills during the pre-cycle showed that the average percentage obtained had not yet reached the minimum target of 70.17%. The researcher attempted to improve the teaching process by implementing Problem-Based Learning during the teaching of the volume of rectangular prisms and cubes, resulting in an increase in the average percentage of process skill indicators to 75.84% in Cycle I and 86% in Cycle II.

These findings are relevant to a study conducted by Mirna and colleagues (Mirna et al., 2023) titled "Analysis of Improved Mathematical Communication Skills of Students through the Implementation of Problem-Based Learning Model," which demonstrated that the implementation of Problem-Based Learning model has a positive and significant impact on students' mathematical communication skills.

CONCLUSION

The implementation of the Problem-Based Learning model has shown an improvement in mathematics learning outcomes regarding the volume of rectangular prisms and cubes among the fifth-grade studentsin. This improvement is evident from the increased mathematics learning outcomes of the students in Cycle I (83.3%) and Cycle II (86.3%). In Cycle I, Meeting 1, the average score of the students was 73, and in Meeting 2, it was 72. In Cycle II, Meeting 1, the average score was 80, and in Meeting 2, it was 91. The Problem-Based Learning model has significantly contributed to enhancing mathematics learning outcomes and mathematical communication skills among the fifth-grade students.

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