The effect of problem-based learning model on mathematical communication ability of junior high school students on the material of flat-sided space building

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ABSTRACT

This study was influenced by the low mathematical communication of students due to the learning system that still uses the traditional system. The application of the problem-based learning (PBL) model is very important. This research is based on a quantitative approach using a quasi-experimental type with a planning framework of a non-equivalent control group design and a post-test only. The population of this study was VIII-grade students at SMPIT AT-Taufiq in the 2022–2023 school year. The sample consisted of 26 students who received treatment (experimental class) and 25 students who did not receive treatment (control class). The information storage strategy is carried out using a written mathematical communication ability test tool of 7 questions with 3 indicators. The Mann-Whitney U test was used for hypothesis testing, and data analysis strategy was used to determine the effect of the problem-based learning (PBL) model on communication skills using effect size. This study resulted in a significance value of 0.000 <0.05, with 87% in the high category. Students who received the problem-based learning (PBL) treatment had a mean score of 88 compared to 75 for students who did not receive the treatment. In this study, we found that problem-based learning (PBL) for materials has an impact on the competence of the problem-based learning (PBL) model on students' mathematical communication skills.

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INTRODUCTION

(Menteri Pendidikan dan Kebudayaan Republik Indonesia, 2018)Permendikbud No. 58 of 2014 stated that mathematics is included in the category that really needs to be contemplated at all levels of education so that students have abilities such as basic, consequent, inventive, and orderly and consider explanations in solving everyday problems (Wedekaningsih, Koeswati, & Giarti, 2019). Mathematics can be an essential science that underlies the improvement of science, innovation, and other sciences. Thus, students must be able to master mathematics so that it is easier for them to master other fields of science. The Council of Teachers of

Mathematics (National Council of Teachers of Mathematics, 2000) indicates that students must have the following basic skills: 1) problem-solving skills; 2) the ability to think rationally; 3) effective communication skills; 4) the ability to make connections; and 5) the capacity to present.

Among these scientific capacities, mathematical communication is needed by every student to face challenges in the current era of globalization and data (Lomibao, Luna, & Namoco, 2016). La'ia & Harefa (2021) appreciated that mathematical communication ability is the ability to express certain thoughts, describe, and talk about mathematical concepts coherently and clearly. The ability to communicate thoughts using mathematical concepts in the form of instructions, equations, graphs, diagrams, or tables is made possible through the science of mathematics. Thus, students must have mathematical communication skills to achieve long-term goals. Based on this picture, it can be said that mathematics makes a difference in creating this ability. Dialogues conducted by analysts with several junior high school teachers revealed that students are still lacking in mathematical communication, both verbal and written (Dilla, Adriati, & Novtiar, 2018; R. A. Nurhasanah, Waluya, & Kharisudin, 2019). The emergence of perceptions in several students revealed that students still find it difficult to work on problems in the framework of story problems in the form of images or mathematical symbols. According to Rismen, Mardiyah, & Puspita (2020) and Sulastri, Marwan, & Duskri (2017), in learning mathematics, students must have the most important role in communication because it allows them to share ideas with fellow students as well as with teachers and the environment. Students can express and describe mathematical concepts not only orally and in writing through mathematical communication but also through the use of illustrations, tables, diagrams, formulas, and demonstrations (Prayitno, Suwarsono, & Siswono, 2013). Then, students must also master mathematical communication skills (Ismayanti & Sofyan, 2021). Mathematical communication skills include the ability to improve one's mathematical thinking, communicate mathematical ideas to others in an assertive and logical manner, evaluate and analyze one's mathematical thinking and the approaches taken by others, and use mathematical language to express ideas appropriately (Asnawati, 2017). Oral communication skills are seen when students communicate their mathematical ideas to teachers or friends at the discussion stage. When students use models, tables, diagrams, or other mathematical symbols to solve problems, they demonstrate written communication skills. Mathematical communication ability then also creates skills to explain and test ideas, among others. Mathematical communication is a communication ability that uses notation, terminology, and mathematical structures to describe situations in mathematical problems (Rahmalia, Hajidin, & Ansari, 2020). One of the factors that contributes to effective communication is the achievement of learning objectives (Oktasari, Jumadi, Warsono, Hariadi, & Syari, 2019).

The determination of learning strategies is urgent. The concern in choosing a strategy lies in its ability to create student competencies so that they are able to think basic, consistent, and imaginative (Assingkily & Hardiyati, 2019; Hanum, 2020). Mathematical communication between students can be improved if the presentation of learning is adapted to the situation and learning environment of the students. Based on these problems, it is necessary to improve students' mathematical communication skills. One of the models used as the model

of choice in this study is the problem-based learning model (Hafely, Bey, Jazuli, & Sumarna, 2019; Ningrum, 2016). Direct and instructive methods that can help students communicate mathematical thoughts better with problem-based learning (PBL). PBL, also known as problem-based learning, involves exposing students to real-world, pressing issues that prompt them to ask questions. Problem-based learning can be a learning approach where students work on critical issues by reflecting on their own information, making demands, and developing higher-order reasoning capacities, creating opportunities and confidence. So, this learning can be utilized to develop mathematical communication skills for understanding important issues and student commitment. Problem-based learning (PBL) makes it easier for students to investigate and ask questions by asking them real and relevant questions. Using real-world problems as content, the problem-oriented learning approach is a teaching strategy that teaches students critical thinking and problem-solving skills (Fathurrohman, 2015; Rahayu & Fahmi, 2018). A learning model called problem-based learning forces students to learn and work in groups (Sumandya, 2019). This is in line with Gorghiu, Drăghicescu, Cristea, Petrescu, & Gorghiu (2015), who stated that inquiry-based learning, also known as problem-free learning, is a good way for students to work together to build basic skills in various learning domains. Pansa, Caswita, & Suharsono (2017) determined that worksheets to create a problem-based learning model meet the requirements of being direct and efficient to improve mathematical communication skills. Their findings also show how problem-based instruction can help students' communication skills. On the other hand, the problem is that there are still many math students who use descriptive methods. Under these circumstances,

Nurhasanah & Luritawaty (2021) provide opportunities for students to search for and edit information. This happens to students who do not understand the problem and whose learning preparation does not fully meet the requirements of their 2013 curriculum.

Teachers must understand the concept of mathematical communication ability, choose learning models, indicators, or facets of mathematical communication, and arrange the most proficient way to carry out mathematics learning in order to realize the goal of creating mathematical communication ability. Students are required to be able to construct mathematical concepts and materials that they must learn in mathematics. Because students need mathematical communication skills, they are unable to ask questions, voice their conclusions, provide an outline of what they have learned, or illustrate their work (Khairunisa & Basuki, 2021; Nuraeni & Afriansyah, 2021).

Because of these problems, they lack mathematical communication skills. This finding highlights that students' communication skills in mathematics are rather passive. Usually, learning becomes less interesting when learning mathematics still uses traditional learning concepts and students are less active in learning, even less enthusiastic and creative in learning. Based on these problems, this study aims to determine the effect of problem-based learning models on junior high school students.

METHOD

By using a quasi-experimental-type strategy and a non-equivalent control group design framework, where the experimental class and control class are randomly selected, this type of research is more precisely quantitative. This study was conducted to compare two groups of students: the treated group (the experimental class) and the untreated

group (the control class). Only the post-test was used as a strategy. The sample taken was from class VIII SMPIT AT-Taufiq in the 2022–2023 school year. Probability sampling with cluster random sampling was used for the sampling process. The selected samples were classes VIII A and VIII B. Class VIII A was selected to be the experimental class, receiving treatment from as many as 26 students, and class VIII B was selected to be the control class, not receiving treatment from as many as 25 students. In the implementation of learning, the group of students who received treatment (experimental class) applied a problem-based learning system (PBL). In contrast, the conventional learning system was applied to the group of students who did not receive treatment (the control class).
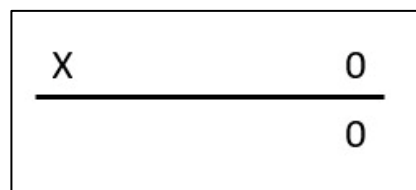
X	0
	0

Figure 1. Research Design

Description:
X : Group treated with problem-based learning
0 : Mathematical communication ability post test

This instrument test is a description test. This post-test question was used to measure students' mathematical communication skills. The test device is arranged as a question grid with questions, answer keys, and scoring guidelines based on students' communication ability scores. a tool to evaluate mathematical communication ability in a detailed and reliable manner. Indicators of mathematical communication skills can be seen in Table 1.

Table 1. Mathematical Communication Ability Indicator (Hendriana, Rohaeti, & Sumarmo, 2017)

Mathematical Communication Ability Indicator	Description
Written text	Providing answers using self-communication, modeling situations or problems by speaking or writing concretely, realistically, and logarithmically, clarifying and making mathematical arguments that have been learned, reviewing and writing about mathematics, making conjectures, defining arguments, and generalizing.
Drawing	Reflect real objects, images, and graphs into mathematical thinking.
Mathematical expressions	Communicate mathematical concepts by expressing ordinary events in mathematical language or pictures.

In addition, the data analysis method in this study uses a normality test, analyzed by the Shapiro-Wilk test using SPSS 22, and a significance value of 5% or 0.05. Information is considered normal if the value (Sig.) > 0.05. Otherwise, if the value (Sig.) < 0.05, the data is not sent periodically. Research hypothesis testing is carried out using parametric data if the data is normally distributed. However, if the data were not normally distributed, a nonparametric measure, the Mann-Whitney U test, was used.

RESULTS AND DISCUSSION

This perspective sees mathematical communication as the dependent variable (Y) and problem-based learning (PBL) as the independent variable (X) The mathematical communication test posttest results provide data from these findings. Students using the problem-

based learning (PBL) model and the conventional learning method with the material of "flat-sided spaces" had to ask straightforward questions that included seven inquiries and three indicators of their mathematical communication ability. The distribution of experimental class posttest scores is shown in Table 2.

Table 2. Frequency Distribution of Experimental Class Posttest Results

intervals	Frequency	Relative Frequency (%)
53-60	3	11.54
61-68	1	3.85
69-76	0	0
77-84	2	7.69
85-92	7	26.92
93-100	13	50
Total	26	100

Based on Table 2, the frequency distribution above shows that students with the highest scores are in the range of 93–100. Students with the lowest scores increased in the interval 53–60.

Table 3. Frequency Distribution of Control Class Posttest Results

Interval	Frequency	Relative Frequency (%)
37-44	1	4
45-52	3	12
53-60	1	4
61-68	1	4
69-76	2	8
77-84	13	52
85-92	4	16
Total	25	100

It can be seen in Table 3, frequency distribution, that the percentage of students who get the highest score is in the interval value 77–84, while the percentage of students who get the lowest score is in the interval value 37–44. It can be proven in the comparison of statistical tests in Table 4.

Table 4. Comparison of Posttest of Experimental Class and Control Class

Statistics	Experiment Class	Control Class
Minimum	54	39
Maximum	100	91
Mean	88	75
Median	92	80
Modus	100	84
Deviation	14.43	14.97
Variance	208.2	224.2

Based on Table 4, comparing the factual information after the material test, it can be seen that problem-based learning (PBL) taught by students is better compared to conventional learning. Measured by a maximum score of 100 and a minimum score of 54 in the treatment group of students (experimental class) and a maximum score of 91 and a minimum score of 39 in the control group of students (control class). We found that the treated group of students (the experimental class) had a greater number than the untreated group of students who received conventional learning treatment (the control class).

After obtaining information about students' mathematical communication ability after testing, to ascertain whether the data set is regularly distributed on this characteristic, a normality test was conducted. Therefore, the post-test data from the experimental class and control class were used in the Shapiro-Wilk test using the SPSS 22 program.

Table 5. Normality Test Results

	Shapiro-Wilk		
	Statistic	Df	Sig
Experimental Class (PBL)	.774	26	.000
Control Class (Conventional)	.819	25	.000

Regarding the calculated mathematical communication ability, as shown in Table 5, the treated student group (experimental class) had an Asymp. Sig. (2-tailed) value of 0.000 < 0.05, and

the untreated student group (control class) had an Asymp. Sig. (2-tailed) value of 0.000 < 0.05. It can be concluded that the data is not normally distributed because the value of the mathematical communication ability test in both classes is less than 0.05. In the next step, the analyst conducted hypothesis testing, specifically the Mann-Whitney U test, to determine the effect on students' mathematical communication skills. The Mann-Whitney U test results are shown in Table 6.

Table 6. Mann Whitney U test results

	Value
Mann-Whitney U	123.000
Z	-3.824
Asymp. Sig. (2-tailed)	.000

It can be seen in Table 6 that the significant value is at the 5% level with an Asymp. Sig. (2-tailed) of 0.000. So that H_0 is rejected because there is no difference between the two classes and H_a is accepted because there is a difference between the two classes. Thus, the results of the discussion on the mathematical communication skills of junior high school students indicate that there is an effect of problem-based learning (PBL). Research by Dimas, Iskandar, Ermiana, Nur, & Rosyidah (2021) and Kurniati, Sumadji, & Suwanti (2019) supports this. In addition, the effect size is used to calculate the size of the influence, which results in a moderate effect of 87%.

According to the above quote, students who followed PBL were described as having higher pretensions than students who followed conventional PBL.

Table 7. Posttest Averages by Indicator

Indicator of Mathematical Communication Ability	Experimental		Control	
	$\bar{x}$	%	$\bar{x}$	%
Providing answers using own communication, modeling circumstances or problems by speaking or writing concretely, realistically, and logarithmically, clarifying and making mathematical arguments that have been learned, examining and writing about mathematics, making guesses, defining arguments, and making generalizations.	20.88	87.02	17.12	71.33
Reflect real objects, images, and graphs into mathematical thinking.	6.77	84.62	6,6	82.25
Communicate mathematical concepts by expressing ordinary events in mathematical language or pictures.	21.69	90.38	18.08	75.33

Based on the three markers, Table 6 compares students' mathematical communication abilities between the treated and untreated groups. It can be seen that the mathematical communication ability of the treated group of students (the experimental class) is more dominant in each indicator than the mathematical communication ability of students (the control class).

This may happen because in PBL (problem-based learning), students often discuss their daily activities related to the assigned work, making them more biased when discussing specific topics related to flat-sided space building. The comparison of the level of mathematical communication ability between the experimental and control classes can be seen visually in the following graph, Figure 2.
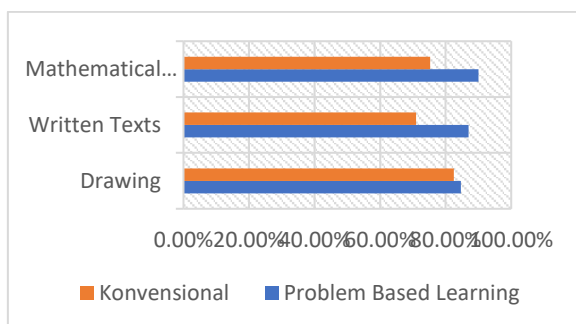
Figure 2. Percentage of Achievement of Student Mathematical Communication Ability Indicators

Based on Figure 2, it can be seen that the achievement of mathematical communication competency indicators is higher in problem-based learning (PBL) than in students who follow conventional learning. Consistent with research by Layliyyah, Wisudaningsih, & Rahayu (2022), students tend to be more proactive in exploratory teaching because they display images of existing information, describe situations, and are used to clarify understanding of the problem in problem-based learning. The main test in both learning classes is drawing, learning the importance of reflecting on objects, pictures, and original drawings in mathematical thinking. Problem-based learning (PBL) is superior to conventional learning in terms of content structure and formulas. This means that most people can explain mathematical concepts by representing common events in mathematical language and images.

A study on the effect of mathematical communication on each other found that the group of students with treatment (experimental class) had a higher ratio than the group of students without treatment (control class). This shows that there is a difference in learning outcomes between the two classes. We know that the average value of the experimental class is 88 with a maximum value of 100 and a minimum value of 54, while the average value of the control class is 75 with a maximum value of 91 and a minimum

value of 39. This shows that overall, experimental class students have a higher average than control class students who do not get treatment. In addition, it is known from the results of hypothesis testing that students who follow problem-based learning (PBL) have better problem-solving skills than students who follow conventional learning. Researchers often agree with this (Madhavia, Murni, & Saragih, 2020; Sinaga & Manik, 2019).

The Mathematical Communication Test will ask 7 questions with a maximum score of 3 about "written", "drawing", and "mathematical expression", which are indicators of mathematical communication. Each question has several indicators, drawing indicators on numbers 1 and 2. Written indicators on numbers 1, 2, 3, 5, 6, and 7. Mathematical expression indicators: 2, 3, 4, 5, 6, 7. So divided into 3 categories, the categories taken are high, medium, and low. The categories of mathematical communication ability can be seen in Table 8.

Table 8. Category of Mathematical Communication Ability

Class	Frequency Category		
	High	**Medium**	**Low**
Experimental	-	22	4
Control	1	19	5

As shown in Table 7, in the category of Mathematical Communication Ability of the treated student group (experimental class), it turns out that there are no students in the high category, while 22 students are in the medium category, and the low category contains 4 students. It can be seen that in the group of students who did not receive treatment (the control class), there was 1 student in the high category, 19 students in the medium category, and 5 students in the low category. One of the post-test results for moderate category students in the experimental class is shown in Figure 3.
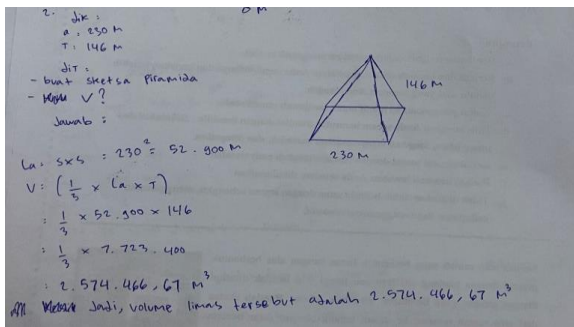
Figure 3. Posttest Results of Medium
Category Students (Experimental Class)

Figure 3 shows that students' final scores cover three indicators. In the written indicator, a score of 4 is obtained by choosing the appropriate mathematical approach, performing calculations, or obtaining placements that are summed and adjusted. This means that students can be said to culminate, starting with compiling data, making mathematical explanations, and being able to clarify important thoughts using mathematical sentences. Drawing indicator score 4 is obtained by making the addition and adjusting the image, graph, or table correctly and clearly. In describing it, students provide information that shows the approximate side base and height of the pyramid. The score obtained for the mathematical expression indicator is 4 with a mathematical explanation that is reasonable, clear, and arranged systematically. This means that students can already know the right mathematical concepts by expressing events in mathematical language or images accurately, such as finding the volume of a pyramid with a square base side. As for one of the posttest results of students in the low category in the group of students who were given treatment (experimental class), it is shown in Figure 4.
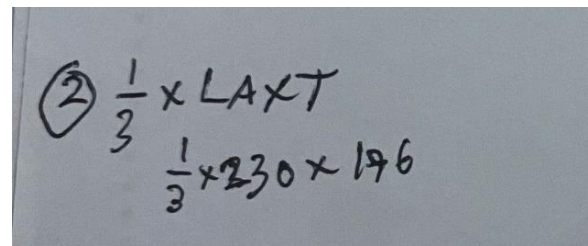

Figure 4. Posttest Results of Low
Category Students (Experimental Class)

It can be seen in Figure 4 that the written indicator obtained a score of 0, and there is no explanation systematically and regularly. This means that students cannot identify the question in the articulation of the question and do not write the question asked in the question. The drawing indicator score obtained is 0, so students cannot reflect the image. In this case, students do not sketch the pyramid into the shape of the space. The mathematical expression indicator score is 2, modeling the problem in a mathematical approach correctly but incorrectly finding a solution. This means that students can basically show numerical thinking, but they are not precise in their solution steps in finding the volume, they cannot make the final result of the solution, and they cannot type the final conclusion. One of the student posttest results in the high category in the control class is shown in Figure 5.
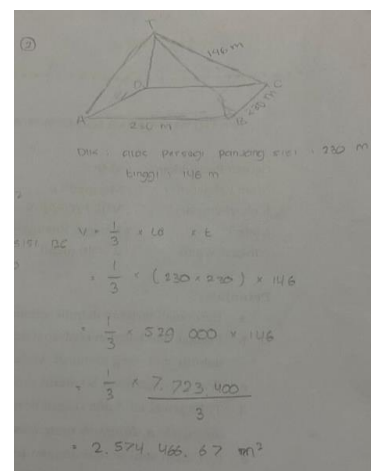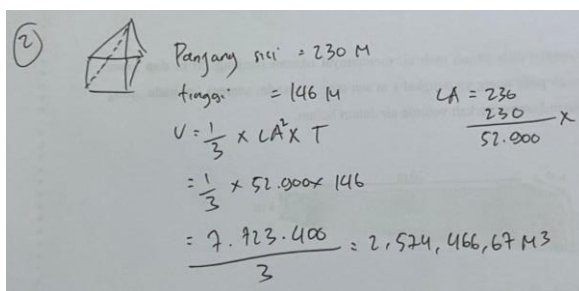

Figure 5. Posttest Results of High
Category Students (Control Class)

It can be seen in Figure 5 that the written indicator obtained a score of 3 with an explanation systematically, neatly arranged, or with few errors, then performed calculations in a logical and precise order. This means that students can be said to be able to achieve the written indicator of writing known information and can clarify thoughts using mathematical sentences, but they do not write what is asked in the problem of finding the volume of the pyramid. The drawing indicator obtained a score of 4 by making a complete picture, chart, or table so that it is easy to get, and in describing it, students provide data that shows the size of the side base and side height of the pyramid. The mathematical expression indicator obtained is 3, which can show the problem in a mathematical approach correctly and perform calculations or get arrangements, but there are slight errors in calculations that occur in the base area, and high school students should not be divided by 3 again. Indeed, even though the final result is improvement and other things have been learned, students cannot compile the final conclusion. As for one of the results of the work of students in the medium category in communicating efficiently in the group of students who were not given treatment (control class), as shown in Figure 6.
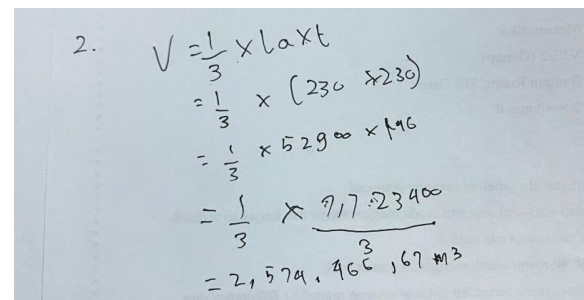
Figure 6. Posttest Results of High Category Students (Control Class)

In Figure 6 in the written indicator, the score is 3. The explanation is mathematical, not consistently organized or there are few errors, this implies that students cannot recognize the data asked in the problem statement. The drawing indicator gets a score of 2 by making the drawing inadequate and needs to be corrected. In this case students do not provide data that shows the size of the base of the sides and the height of the pyramid. The score obtained for the mathematical expression indicator is 3, modeling the problem in a mathematical approach correctly, and performing calculations or composing but there are some wrong answers. Students are basically able to show mathematical thinking, but students cannot compile the final conclusion. As for one of the results of the category of lacking in communicating efficiently students in the group of students who were not given treatment (control class) as Figure 7.

Figure 7. Posttest Results of Low Category Students (Control Class)

In the written indicator, the score is 0, and there is no organized explanation. This means that students cannot identify the known data in the problem statement and do not identify the things that are asked in the problem explanation. The drawing indicator score is obtained, but students may not reflect the image. In this case, students did not sketch the pyramid into a pyramidal space shape. The mathematical expression indicator with a score of 3 can show the problem in a mathematical approach correctly and perform calculations or get arrangements, but there are slight errors in writing in making the base area and height not have to be divided by 3 again even though the final result is correct, and other things

prevent students from compiling the final conclusion.

Based on the results of students' answers, students' mathematical communication skills are included in the high category, and students are also able to construct information in their own language and translate known information into a documentation framework. Good mathematical descriptions and solutions will allow students to assess their own answers. Learning how to use images accurately will ultimately allow students to express problems consistently and appropriately in any situation.

Students with mathematical communication skills are in the medium category. Students can write information in their own language. Students are able to translate the information they know into mathematical notation or symbols and understand it correctly. Students have not been able to make judgments to double-check their answers. Although the students seemed to be able to determine the point, they could not complete the big picture completely or accurately, and they were able to elaborate on the problem in a coherent but less than ideal way.

Students with mathematical communication skills fall into the category, students are unable to convey the information from the problem in their own language, but they quickly write it down in mathematical notation and drawings and placement. or cannot understand the answers received from students and cannot solve the problem.

This study provides insight into students' preferences and concerns, and the shortcomings of this study can be used as a reference to improve the quality of learning exercises and develop learning strategies to achieve achievable learning goals. For students, this question is a reference and inspiration to create mathematical communication to understand the problem.

This is in accordance with research findings by (Ana, Negara, & Wati, 2019)that students with high mathematical communication skills are usually able to explain problems accurately using dialect-based response strategies, images, and mathematical imagery. Students with direct mathematical communication are good at solving problems using their own level of dialect and diagrams, but students who are unable to understand the problem well use their own level of mathematical diagrams. There are also Students who are able to communicate mathematically, use dialect to solve problems easily, and argue with images. This is because students still often make mistakes with rows of mathematical images.

It can be found that the content delivered by problem-based learning (PBL) is higher than that delivered by regular learning. Perceptions emerging from research on problem-based learning (PBL) state that PBL learning is linked to exploratory teaching and makes students more dynamic by giving them opportunities to engage with goals. Students who are able to organize and dynamically source information as they learn to develop their skills, which lead to more information and progress, make problem-based learning (PBL) programs attractive. Because when students develop their knowledge, they can demonstrate their ability to understand math problems to other students. Students who are able to answer questions from the teacher and other students feel happy and excited, while students who are not used to answering questions feel challenged, encouraging more dynamic learning and ultimately progress. Students' ability to understand the problem.

From the description, the use of PBL is able to improve students' mathematical communication skills, such that the final score of students in the experimental test class is higher than the mathematical

problem-solving ability in the control class. This clearly shows what can be done. From this, it can be concluded that there is an effect of Problem Based Learning Demonstration (PBL) on the mathematical communication skills of SMPIT At-Taufiq students in the 2022–2023 school year.

CONCLUSIONS AND SUGGESTIONS

Judging from the results of inquiry and dialogue, it was found that the learning system of counting by utilizing problem-based learning (PBL) shown by students of classes VIII A and VIII B at SMPIT At-Taufiq was classified as very good. The benefits of learning through the process are considered good for students' movement in learning. Students who completed problem-based learning (PBL) improved their mathematical communication skills significantly more than students who completed conventional learning. Problem-based learning (PBL) has a significant effect on students' mathematical communication skills on flat-sided space building material, showing an effect of 87% in the high category. Mathematical communication skills in the experimental class were in the medium category by 84% and low by 16%. Mathematical communication skills in the control class were in the high category by 4%, moderate by 76%, and low by 20%.

The researcher argues that further research at a comparable junior high school level could lead to more complex directions. Since student learning success cannot only be measured through written exams, more in-depth research needs to be conducted on junior high school students who improve their mathematical communication skills by using a problem-based learning model.

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