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Problem-Based Learning Model as A Means of Improving Students' Mathematical Communication Abilities

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A B S T R A C T

The purpose of this study is to: (1) figure out how to improve students' performance. mathematical communication Skills taught using the problem-based learning model are better than those taught through ordinary learning methods. This helps in determining the effectiveness of the learning approach. whether there is an interaction between the learning model with the students' ability of early mathematic towards improving the students' mathematical communication, (3) Find out the process of students' solving mathematical communication taught with problem based learning model and ordinary learning. This study is a quasi-experimental research. The population in this study consists VIII SMP, By taking two classes as samples, each consisting of 60 students, using Teksin cluster random sampling. The analysis data was analyzed using ANOVA two-way. The results showed that (1) improving on students'. mathematical communication Skills taught using the problem-based learning model are better than regular learning. There is a connection between the learning model and students' early math abilities, which helps improve their math communication. The process of students' learning involves these factors. solving mathematical communication Teaching using a problem-based learning model works better than teaching with regular methods.

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INTRODUCTION

The world of education is experiencing a crisis. Rapid changes outside of education pose challenges that must be addressed. If teaching and educational practices in Indonesia remain unchanged, the nation will be left behind by other countries. In the 21st century, learning practices in schools need to be renewed. The role of education in preparing students for optimal social life requires the discovery and continuous implementation of effective learning processes and models. A nation's progress is determined by the development of education for its children. Progress over a long period of time can predict the quality of the nation in decades to come. The ultimate outcome of planned education is a society with a high level of education. Therefore, education plays a crucial role in human survival and the development of a nation. Similarly, the rapid development of science and technology (IPTEK) today allows us to access information about events occurring anywhere in the world immediately; time and national borders are no longer barriers. This has resulted in the birth of an era of globalization. Along with the development of science and technology, problem solving, critical thinking, creativity and communication skills are thought to be able to be developed through mathematics learning.

The National Council of Teachers of Mathematics (NCTM), as stated in NCTM (2000), says that mathematical communication skills are the ability to: (1) help students organize and put together their math thoughts through talking or writing; (2) share their math ideas clearly and in a way that makes sense to others like classmates or teachers; (3) look at and think about different ways people solve math problems and decide which ones work best; (4) use the right math words to explain math ideas correctly.Laurence (in Cangara, 2008: 20) states that "the definition of communication is a process in which two or more people form or exchange information with each other, which in turn will arrive at a deep mutual understanding". So it can be concluded that communication is a process of conveying information (messages, ideas, thoughts) from one party to another so that there is mutual influence between the two. If seen from its variety, communication consists of oral and written communication. Oral communication is communication carried out using sound as a medium. Then written communication is a communication activity that uses written media in conveying information, the medium used in written communication is oral communication (reading). The advantage of written communication is that there is in-depth preparation of the writing that will be presented, it can be corrected repeatedly before being presented.

The communication What is expected to be learned is the ability to communicate well, which helps both teaching and learning. However, from the current phenomenon of mathematics learning, students do not develop their thinking skills, students do not dare to express their own understanding in solving problems. Students tend to memorize concepts given by teachers without thinking about understanding the concepts, resulting in a lack of students' ability to connect and communicate concepts with the problems they are facing. This affects students' ability to think when solving a problem and students' understanding of mathematical language and symbols is still lacking due to

monotonous learning. Recognizing the importance of mathematical communication skills, teachers must strive to learn by implementing learning models that can provide opportunities and encourage students to practice mathematical communication skills. Misuse of models can hinder the achievement of desired educational goals and can even affect students' mathematical communication skills in particular. Of several learning models, there is a learning model that can trigger an increase in students' mathematical communication skills in solving math problems so that the solution process made by students becomes more systematic, namely the Problem-Based Learning Model (PBM).

Problem-Based Learning is adopted from the term Problem Based Instruction (PBI). This model has been known since the time of John Dewey, and continues to be developed today, including in Indonesia. According to Wena (2011: 91), "a problem-based learning strategy is a learning strategy that confronts students with practical problems as a basis for learning, or in other words, students learn through problems." Problem-based learning provides opportunities for students to engage their multiple intelligences (Gardner in Wena, 2011: 96).

According to constructivist theory, thinking and problem-solving skills can be developed if students independently discover and transfer the complexity of existing knowledge. This learning model can also enhance the growth and development of student learning activities both individually and in groups. In problem-based learning, there are five main steps: orienting students to the problem, organizing students for learning, guiding individual and group investigations, developing and presenting work results, and analyzing and evaluating the problem-solving process.

Several things that still need to be further revealed related to mathematics learning are initial mathematical abilities. Based on initial mathematical abilities, students are divided into high, medium, and low groups regarding the improvement of students' mathematical communication abilities. Gagne (in Sudjana, 2009: 158) assumes that "initial abilities are lower than new abilities in learning, initial abilities are prerequisites that students must have before entering the learning of the next, higher subject matter.

For students with high ability, after receiving instruction, their results tend to be positive. This occurs because high-ability students grasp the lesson more quickly. For students with average or low ability, if the teacher's learning model is engaging and engaging, and appropriate to their cognitive level, it's possible to achieve high results and ultimately improve their mathematical communication skills.

The main questions this study is asking are: (1) Do students who learn using the problem-based learning method show a greater improvement in their math communication skills compared to those who learn using the regular method? (2) Is there a connection between the learning method and students' starting math abilities when it comes to improving their math communication skills? (3) How do students who use the problem-based learning method approach and solve math communication problems?

Based on the descriptions above, what needs to be revealed in depth regarding mathematics learning is mathematical communication skills with problem-based learning models.

LITERATURE REVIEW

Problems in everyday life are not always problems. According to Hayet and Mayer (in Daulay 2011:20), we face problems when There's a difference between our current situation and our desired goal, but we aren't sure how to close that gap. Hayes (in Atun 2006:33) also supports this opinion by saying that a problem is a gap between the current situation and the desired goal, while we don't know what to do to achieve that goal. Thus, a problem can be interpreted as a question that must be answered at that time, while we don't have a clear solution plan. Meanwhile, Posamentier and Stepelmen (in Suhenri, 2006) have the same opinion, saying that a problem is a situation where there is something we aim for or want, but we don't know how to get it or achieve it in order to reach that goal or desire.

From this opinion, it is clear that problems arise because of a gap between what is expected and what is actually happening, between what is available and what is needed, and between what is known about a particular problem and what is desired. Therefore, this gap must be addressed immediately. The process of addressing this gap is known as problem-solving.

According to Dahar (1989:138), problem-solving is something people do using ideas and rules they have learned before. It's not just a general skill. This means that when someone can solve a problem, they are gaining a new ability. This ability helps them deal with similar problems. The more problems a person can solve, the more abilities they develop, which can help them in their everyday life. Therefore, a person's problem-solving ability needs to be continuously trained so that they can navigate a life full of complex problems.

According to (Kantowski, 1981; Sujono, 1988). In other words, a situation may be a problem for someone at one time, but not necessarily a problem for him at another time. A problem usually includes a situation that makes someone want to find a solution, but they don't know exactly what steps to take (Kantowski, 1981). If a child is given a problem and can immediately figure out the right answer, then it's not really a problem anymore.From the opinions of these experts, the author concludes that there is a fundamental difference between doing practice questions and solving problems in learning mathematics. In doing practice questions, students are only required to immediately obtain the answer, for example calculating such as addition and multiplication operations, calculating the value of trigonometric functions, and so on. Meanwhile, what is said to be A problem in math happens when a student can't figure out the answer right away. They have to think carefully, make an educated guess or prediction, discover a basic formula, and then show that it works. The characteristics that something is said to be a problem are that it requires thinking/reasoning power, challenges students to be able to guess/predict the solution, and the way to get the solution is not single, and it must be proven that the solution obtained is correct/precise.

Problem solving must be an integral part of the teaching process. According to Wahyudin (2003), there are 10 problem-solving strategies that can form the basis of a teaching approach, namely:

a. Working backward
b. Finding a pattern
c. Taking a different perspective
d. Solving a problem that is analogous to the current one but simpler
e. Considering extreme cases
f. Creating a picture (visual representation)
g. Making assumptions and testing based on reason
h. Considering all possibilities (a comprehensive list/listing)
i. Organizing data
j. Logical reasoning

METHODOLOGY

This research is an experimental research with a quasi-experimental type of research, because the class used had been formed previously. The research will be conducted in class VIII of junior high school. The research activities were carried out in the first semester with the population of all class VIII students. The research sample was selected randomly (cluster random sampling) to be determined as the experimental class. The random selection stage was because the abilities of students in each class were evenly heterogeneous. The researcher could not take students randomly to form new classes, so the researcher took the smallest sampling unit, namely class VIII-A as the experimental class and class VIII-B as the control class. In the experimental group, students were taught using problem-based learning, and in the control group, students were taught using regular learning.

The research to be conducted includes three stages, namely: (1) The stage of developing learning tools in the form of a Learning Implementation Plan (RPP), Student Activity Sheets (LAS) and research instruments in the form of critical thinking ability test sheets and mathematical communication ability test sheets; (2) The trial stage of learning tools; (3) The stage of implementing experiments with activity steps. Both groups were given an initial mathematics ability test which aimed to determine students' abilities in learning mathematics, then a pretest was given with the aim of determining the extent to which students were ready to receive lessons on the subject of Two Variable Linear Equation Systems. Then to determine any differences in the increase in students' critical thinking and mathematical communication abilities between the two groups, a posttest was conducted. Each stage was designed in such a way that valid data was obtained in accordance with the characteristics of the variables that were appropriate to the research.

Based on the data collection techniques used, two types of data were obtained: quantitative and qualitative. Quantitative data were obtained through initial mathematics ability tests, critical thinking ability tests, and mathematical communication ability tests, which were analyzed using inferential statistics with a two-way ANOVA test. In addition, qualitative data analysis of each question

item, namely by analyzing students' problem-solving processes in answering questions related to critical thinking and mathematical communication skills, was analyzed using descriptive statistics.

RESEARCH RESULT

1. Student Initial Ability Test Results (KAM)

The grouping of students' mathematical abilities (high, medium, and low) is formed based on the students' KAM test scores.

Table 1. Distribution of Research Samples

Research Sample Class	Student Abilities		
	High	Medium	Low
Experimental Class	6	19	5
Control Class	6	19	5
Amount	12	38	10

2. Students' Mathematical Communication Skills

a. Improving Students' Mathematical Communication Skills

Based on the results of the pretest given before learning and the posttest given after learning to both classes, namely the class taught with problem-based learning and the class taught with regular learning, the N-Gain calculation, the average and standard deviation of the results of the students' mathematical communication ability test were then carried out. The normalized N-Gain calculation of mathematical communication ability was obtained from the difference between the posttest and pretest scores divided by the maximum score (Ideal) with the pretest score. Where the average N-Gain value is a description of the increase in students' mathematical communication abilities based on the KAM of students taught with problem-based learning and regular learning.

Table 2. Description of N-Gain Data for Mathematical Communication Skills of the Two Learning Groups for the KAM Category

Category KAM	Statistical Data	Learning	
		Problem Based Learning	Regular Learning
High	N	6	6
	$\bar{x}$	0,637	0,446
	SD	0,036	0,047
Medium	N	19	19
	$\bar{x}$	0,520	0,407
	SD	0,081	0,098
Low	N	5	5
	$\bar{x}$	0,357	0,382
	SD	0,056	0,093

Descriptively, there are several conclusions related to table 2, namely: for high KAM, problem-based learning classes (0.637) have a higher increase than

regular learning classes (0.446). For medium KAM, problem-based learning classes (0.520) have a higher increase than regular learning classes (0.407). For low KAM, problem-based learning classes (0.357) have a lower increase than regular learning classes (0.382). This provides an initial argument that students' Initial Mathematical Ability (KAM) plays a significant role in influencing student learning outcomes.

Classically, it shows that students taught with problem-based learning experience a higher increase in mathematical communication skills than students taught with conventional learning. To test whether the mean difference is significant, a two-way ANOVA test was conducted, as shown in Table 3 below:

Table 3. Two-Way ANOVA Test Results

Source of Variance	JK	db	RJK	F_0	F_{tabel} $\alpha = 0,05$
Learning model	0,167	1	0,167	25,511	4,020
KAM	0,162	2	0,081	12,362	3,168
KAM Learning Model Interaction	0,065	2	0,033	5,001	3,168
Dalam	0,353	54	0,007		
Total	0,747	59			

Based on table 5, the calculated F value of 25.511 is greater than Ftable 4.020, meaning H0¬ is rejected, so it can be concluded that the increase in mathematical communication skills of students taught with problem-based learning is higher than students taught with ordinary learning.

b. Interaction of Learning Models and KAM on Improving Students' Mathematical Communication Skills

The interaction test between learning factors and KAM factors was carried out using two-way ANOVA (summarized in Table 3).

Based on table 5, it is obtained that the calculated F value for the KAM category is 12.362 with Ftable 3.168, which means H0 is rejected. So the KAM category has an effect on students' mathematical communication abilities. From Table 5, it can also be seen that for the learning and KAM factors, the F value obtained for the interaction of the learning model and students' initial mathematical abilities is 5.001 and Ftable 3.168. Because F0 > Ftable, it can be concluded that H0 is rejected and Ha is accepted, which means there is an interaction between the learning model and KAM on students' mathematical communication abilities. This can also be interpreted as having a joint influence given by the learning model and KAM on students' mathematical communication abilities. More clearly, the interaction between the learning model and students' initial abilities on improving students' mathematical communication abilities graphically can be seen in Figure 1 below:

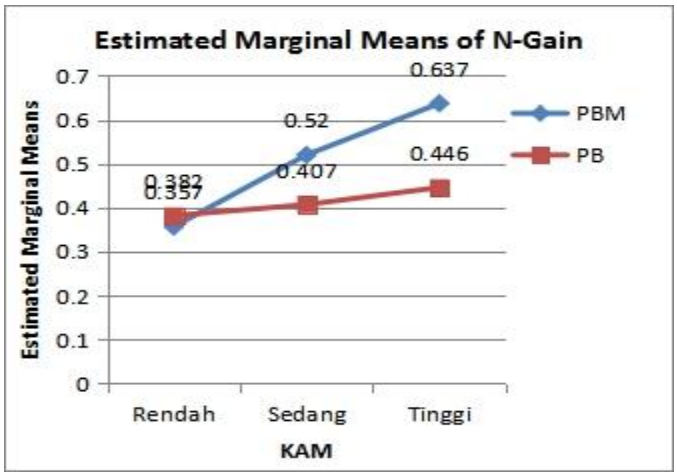

Figure 1. Interaction Between Learning and KAM on Improving Students' Mathematical Communication Skills

3. Analysis of the Problem Solving Process

Analysis of the Problem Solving Process of Mathematical Communication Ability. Based on the students' answer sheets regarding the students' mathematical communication ability test, the post-test results obtained a general picture of the variation in answers in solving problems of students taught with the Problem-Based Learning model and the Regular learning model. This question measures students' mathematical communication abilities through 3 indicators, namely: drawing, mathematical expression, and writing (written text). The results show that the problem-solving process of students' critical thinking abilities taught with problem-based learning is more varied and better than students taught with regular learning.

CONCLUSIONS AND RECOMMENDATIONS

The improvement of mathematical communication skills of students taught with problem-based learning is higher than that of students taught with conventional learning. There is an interaction between learning and students' initial mathematical abilities towards the improvement of students' mathematical communication skills. The process of solving students' mathematical communication problems through problem-based learning is better and more varied than that of conventional learning. This can be seen from the answer sheets of students in classes taught with problem-based learning, overall students can solve problems correctly and completely compared to students in classes taught with conventional learning who can solve problems correctly but incompletely, even many who answer incorrectly in solving mathematical communication problems.

ADVANCED RESEARCH

Based on these findings, future research can explore the long-term impact of problem-based learning (PBL) on students' mathematical communication skills across different grade levels and mathematical topics. It would also be beneficial to investigate how specific elements of PBL—such as collaborative group work, real-world problem contexts, and teacher facilitation strategies—contribute to students' ability to express mathematical ideas clearly and accurately. Additionally, future studies could examine the role of students' metacognitive awareness and self-regulation during problem-solving, and how these factors interact with initial mathematical ability to influence learning outcomes. Employing a mixed-methods approach may offer deeper insights into both the cognitive and affective dimensions of students' learning processes, thus supporting the development of more effective instructional strategies for enhancing mathematical communication in diverse classroom settings.

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