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Analysis of Students' Mathematical Communication Ability in Completing Mathematical Modeling

M Khusnudin[1], Haninda Bharata[2]

[1, 2] Lampung University, Indonesia
Correspondence: ✉ khusnudin22@gmail.com

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Abstract

Mathematical communication skills are essential skills that students must have in learning mathematics. The communication process can help students build their understanding of concepts in mathematics and are easy to understand. Mathematical communication is a tool for transmitting mathematical knowledge in building mathematical knowledge in learning activities. Indicators of students' ability to communicate mathematically in learning mathematics are (1) expressing mathematical ideas by speaking, writing, demonstrating, and describing them in visual form, (2) understanding, interpreting, and assessing mathematical ideas presented in written, oral or visual form, (3) use language, notation and mathematical structure to express ideas, draw relationships and build models. This study aims to: (1) describe the mathematical communication skills of grade 7 students in completing mathematical modeling on the One Variable Linear Equation (PLSV) material and (2) identify the components of students' mathematical communication skills on each achievement indicator. This research is a qualitative descriptive study. A qualitative approach is used to understand the context of the subject. Based on the three indicators of students' mathematical communication skills, an average of 17.86% of students' skills can be classified as very low. It shows that most students cannot model solving real problems or everyday life related to mathematical communication.

INTRODUCTION

Mathematical communication ability is an essential ability that students in learning mathematics must possess. The communication process can help students build their understanding of the concepts in mathematics and make them easy to understand [1]. Communication in mathematical concepts is a language conveyed orally or in writing so that other people can find out the information conveyed [2]. Oral and written communication can bring students to a deep understanding of mathematics. Graphs, charts, diagrams, symbols, symbols, and equations are ways of communication that are often used in mathematics. Tables, charts, and graphs lead students to make new conclusions, predictions and questions. Through tracing patterns and similarities, students learn to communicate an understanding of sequence and repetition, symbolized using pictures or symbols [3].

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Mathematical communication is a tool for transmitting mathematical knowledge in building mathematical knowledge in learning activities. [4] In mathematical communication, several aspects must be met, namely the ability to present, the ability to listen, the ability to read or understand, the ability to discuss, and the ability to write mathematical ideas into mathematical language [5]. According to Ansari, indicators of students' ability to communicate mathematically in learning mathematics are (1) expressing mathematical ideas by speaking, writing, demonstrating, and depicting them in visual form, (2) understanding, interpreting, and assessing mathematical ideas presented in writing, orally or in other forms. Visual, (3) using language, notation, and mathematical structures to express ideas, draw relationships and create models [6]. Indicators of mathematical communication ability in mathematics learning, according to NCTM, can be seen from: (1) The ability to express mathematical ideas through oral, written, and demonstrating and visually describing them; (2) The ability to understand, interpret, and evaluate Mathematical ideas both orally and in other visual forms; (3) Ability to use mathematical terms, notations and structures to present ideas, describe relationships and model situations [7].

The importance of communication in learning mathematics is also stated in the Regulation of the Minister of National Education no. 22 of 2006 concerning Content Standards. The regulation states that one of the goals of learning mathematics is for students to have the ability to communicate ideas with symbols, tables, diagrams, or other media to clarify situations or problems. The importance of mathematical communication is also listed in the standard document on the mathematics education process in the United States, which includes problem-solving, reasoning and proof, communication, connection, and representation [8].

Based on the results of interviews with teachers conducted at SMP Negeri 2 Rawajitu Selatan, Tulang Bawang Regency, information was obtained that most students had low mathematical communication skills in mathematics. This is seen in student behavior as follows: (1) students do not understand ongoing mathematics learning because the prerequisite material related to this material has not been fully mastered (2) there are still many students who are unable to express mathematical ideas by speaking, writing, demonstrating and describe it in visual form (3) most students are unable to model mathematics to solve mathematical problems related to the real world or problems that exist around students.

Several studies have discussed students' mathematical communication skills that are still low at the junior high school level. Junior high school students often make a mistake in solving PLSV word problems that students cannot translate the questions into open sentences. Besides that, students also make many mistakes in calculating PLSV story questions [9]. Findings in previous research illustrate that students still lack understanding of questions and concepts in story type. [10]. Students' difficulty in solving word problems is modeling mathematics in their completion. Therefore, this study aims to: (1) describe the mathematical communication abilities of grade 7 students in completing mathematical modeling in the material of One Variable Linear Equations (PLSV), (2) identify the components of students' mathematical communication skills in each achievement indicator.

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METHOD

This research is a qualitative descriptive study. A qualitative approach is used to understand the context of the subject [11]. Mathematical Communication Skills Students of 28 students in grade 7 were tested, observed, and explained. The research subjects were 7th-grade students of SMP Negeri 2 Rawajitu Selatan with a well-accredited junior high school. There were 28 students consisting of 17 boys and 11 girls.

Two types of test instruments are used in this study, namely primary and secondary. The primary instruments are planners, data collectors, analysts, interpreters, and reporters. The secondary instrument tests students' mathematical communication skills in completing mathematical modeling on One Variable Linear Equations (PLSV) material, assessment rubrics, and interview guidelines. The test of mathematical communication skills consists of two questions to measure students' abilities in Drawing, Mathematical expressions, and Written text [12].

Table 1. Indicators of Student's Mathematical Communication Ability

Mathematical Indicators	Communication Ability
1. Drawing	The ability to express mathematical ideas orally, in writing, and to demonstrate and describe them visually
2. Mathematical Expressions	Ability to understand, interpret, and evaluate Mathematical ideas both orally and in other visual forms
3. Written text	Ability to use mathematical terms, notations, and structures to present ideas, describe relationships, and model situations

(Adapted from NCTM)

In analyzing student answers, a scoring technique was used on the communication skills test questions based on the holistic scoring rubrics from Cai, Lane, and Jakabcsin [13] as follows:

Table 2. Guidelines for Scoring Mathematical Communication Skills

Score	Description
4	Can answer all aspects of questions about mathematical communication and be answered correctly and clearly or completely
3	Can answer almost all aspects of questions about communication and are answered correctly.
2	Can answer only some aspects of questions about communication and are answered correctly.
1	Inappropriate answers to aspects of the question about communication or drawing the wrong conclusion
0	No answer

Twenty-eight students of 7th-grade junior high school were involved in this study. Research subjects were asked to complete a math test to assess mathematical communication skills. The test time was 60 minutes. Next, the collected worksheets were codified (numbers 1 to 28). Answers are scored according to the Mathematical Communication Skills Scoring Guidelines. In addition to the written test, interviews were conducted with a time of 5-10 minutes for each research subject.

Data analysis was carried out in three stages. First, the data obtained from the tests and interviews were reduced by selecting the significant ones and eliminating the insignificant data.

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Second, the data on the written test results were analyzed by calculating the percentage. In addition, several points from the tests and interviews were described descriptively and presented in three parts, namely: (a) students' mathematical communication skills in Written text, (b) students' mathematical communication skills in Drawing, and (c) students' mathematical communication skills in Mathematical expressions.

Furthermore, the results of the percentage scores of students' mathematical communication skills were categorized into very high, high, medium, low, and shallow categories. This category is converted using score conversion according to Nurkancana and Sunarta [14]

Table 3. Classification of mathematical communication skills

Percentage	Category
$90{,}00 \leq P \leq 100$	Very High
$80{,}00 \leq P < 90{,}00$	High
$65{,}00 \leq P < 80{,}00$	Middle
$55{,}00 \leq P < 65{,}00$	Low
$P < 55{,}00$	Very Low

RESULTS AND DISCUSSION

Based on the results of data analysis in the form of tests and interviews, students' mathematical communication skills in each indicator were obtained.

Drawing Ability

Based on data analysis, only six students (21.43%) could reflect natural objects, pictures, and diagrams into mathematical ideas, while 22 students (78.57%) could not reflect correctly. The results of student tests and interviews showing low students' mathematical communication abilities on the drawing indicator are shown in the student's answers to subject 12, which are explained below.

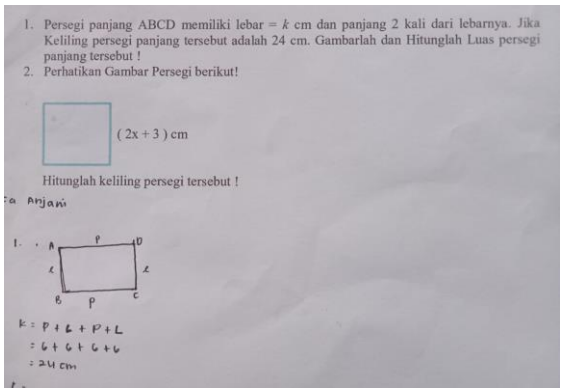

Figure 1. Answers subject S12

Interview with S12 :

G : Are you sure about your answer?
S12 : yes, but not sure
G : Why are you not sure?
S12 : Confused, sir, how to write a long and wide description

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G : Look at your answer!
S12 : (See the answer)
G : Have you drawn according to the provisions in the question?
S12 : Yes, sir, but the explanation is confused about the length and width of the rectangle. Only the length is two times the width,
G : Confused where? Take a look at your rectangular drawing! Is the length twice the width?
S12 : Not yet, sir, I just drew it right away
G : Well, when you drew a rectangle, the length was two times the width. For example, the width is approximately four units, so the length is eight units because 2 x 4 = 8
S12 : I didn't understand that far, sir.
G : Okay, that is okay, now you understand?
S12 : Yes, sir
G : Look at the description of the length and width in your answer. Why is the length written as p and the width written as l?
S12 : Usually, sir, the abbreviation
G : Let us look at the description again. It is written that the width is symbolized as k, while the length is two times the width is two times what?
S12 : 2k sir, yes sir?
G : That is right, it should be written on the picture, length 2k and width k

The result sheet of tests and interviews on subject 12 above shows that students cannot draw rectangles because they cannot reflect images into mathematical ideas. Although subject 12 understands that the length of the rectangle must be two times the width because the value of the width is not known, the subject is confused about determining the size of the image

Mathematical expressions Ability

Based on the results of data analysis, only five students (17.86%) got the medium category on the students' abilities on the Mathematical expressions indicator, while 13 students (46.43%) got a low category and the remaining ten students (35.71%) including the deficient category. The results of student tests and interviews showing low students' mathematical communication abilities on the Mathematical expressions indicator are shown in the students' answers to subject nine, which are explained below.

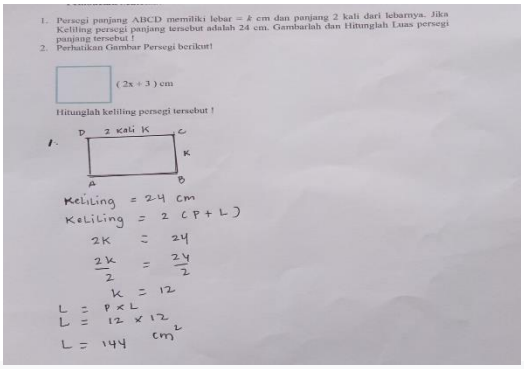

Figure 2. Answers subject S9

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Interview with S9 :

G : Are you sure about your answer ?
S9 : Not sure, sir
G : What makes you less sure about your answer ?
S9 : I am confused how to find the value of the length and width, sir
G : Ok, If the problem is given the perimeter of a rectangle and the length and width values are still in the form of variables, what should you do?
S9 : I do not know, sir
G : So, when we know the perimeter of a flat shape and find the area of the data shape, then we can use the known circumference to find the area of the flat shape.
S9 : I have written the formula for the perimeter of the rectangle sir
G : What is the formula for the perimeter of a rectangle?
S9 : $k = 2\ (p + l)$ sir
G : How much length and width do you know in the problem?
S9 : unknown sir,
G : Try to reread it because
S9 : (While reading), sir, the width is k, and the length is two times the length
G : So, l = k and p = 2. k = 2k, after we know the value of this length and width, we can enter it into the perimeter formula, can we?
S9 : Confused sir
G : What is the formula for the perimeter of a rectangle? Later p will be replaced by $2k$, and l will be replaced with k
S9 : $K = 2\ (p + l)$ sir,
G : Try changing p to $2k$ and l to k
S9 : $K = 2\ (2k + k)$
G : So yes, how much is the circumference known in the problem? Change the value
S9 : The circumference is 24 cm, sir, so what?
G : Well, replace K = 24
S9 : $24 = 2\ (2k + k)$. Is that so, sir?
G : Well, we will have to find the value of k using Algebra. Next, when the value of k is obtained, find the length and width of the rectangle to calculate its area.
S9 : Oh yes, sir

The results of tests and interviews on subject nine above show that students cannot express mathematical concepts by stating everyday events in mathematical language or symbols. The low ability of Mathematical expressions in subject nine can be seen from the students only knowing the basic formulas of flat shapes. Although subject 9 knows the formula for the perimeter of a rectangle, the subject line cannot convert the problem in the problem into mathematical symbols or model mathematical equations to express the problem in the problem so that the problem cannot be solved.

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Ability Written Text

Based on the results of data analysis, students' ability on the Written text indicator, there were only four students (14.28%) who got the medium category, while five students (17.86%) got a low category, and the remaining 18 students (67.86%)) is included in the deficient category. The results of student tests and interviews showing low students' mathematical communication skills on the Written text indicator are shown in student answers to subject 23, which are explained below.

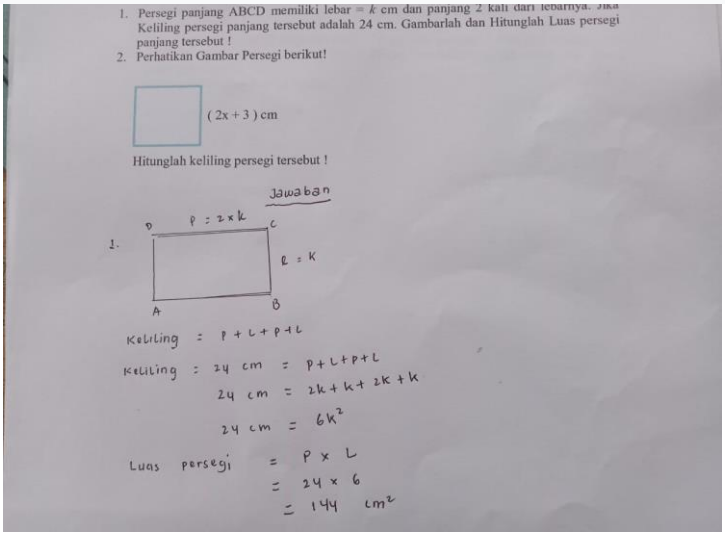

Figure 3. Answers subject S23

Interview with S23

G : Are you sure about your answer ?
S23 : No, sir.
G : Why are you not sure about your answer? Is your answer wrong?
S23 : It seems wrong sir,
G : Where is the fault? How do you know if the answer is wrong?
S23 : Not sure, sir, I can only write the formula for the perimeter of a rectangle, but I don't know the algebra of the area.
G : Which algebra?
S23 : looking for the value of k sir, I have entered it in the circumference but can't find it
G : Try it now, what is the equation or formula for the perimeter of a rectangle?
S23 : Length + Width + Length + Width pack
G : So, what are the length and width of the rectangle?
S23 : (While thinking for a long time), the width is k, sir, the length is 2 times the width, which is 2k, sir
G : So, if you already know the length is 2k and the width is k, then we need to put it into the circumference equation, so how do we do it?
S23 : already, sir, K = $2k + k + 2k + k$, but then I do not understand.

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G : Oh, how come you do not understand? You add up while the value of the circumference is 24 cm. so 24 = $2k + k + 2k + k$
S23 : yes sir, I have been like that but confused about adding $2k+k$
G : if $x + 2x$ is equal to how much?
S23 : $3x$ sir,
G : well, k is the same as x, which is a variable. It can be added up if it is the same or the same. So $2k + k + 2k + k$ equals how much?
S23 : $6k$, sir?
G : That is right. Continue later after getting the value of k, and look for the length and width. I just determined the area of the rectangle
S23 : yes, sir

The test results and interview sheets on subject 23 above show that students have not provided answers using their language and using algebraic assistance. Although 23 drawing skills and mathematical expressions are sufficient, it turns out that the concept of algebra is still constrained. After further interviews, subject 23 understands the concept of algebraic addition, but the variable used is limited to x, so it is necessary to understand the concept related to algebraic operations again.

Table 4. Recapitulation of mathematical communication skills

The ability of Mathematical Communication	Percentage	Category
1. Drawing	21.43 %	Very Low
2. Mathematical expressions	17,86 %	Very Low
3. Written text	14,28 %	Very Low
Average	17,86 %	Very Low

Based on the three indicators of students' mathematical communication skills shown in Table 4, students' skills can be classified as very low. It shows that most students cannot model solving real problems or everyday life related to mathematical communication.

Based on the results of the data analysis, it can be stated that the mathematical communication skills of class VII students of SMP Negeri 2 Rawajitu Selatan are included in the deficient category. This is indicated by the average recapitulation of the three indicators on students' mathematical communication skills: drawing, mathematical expressions, and written text, which are categorized as very low. Students are not accustomed to mathematical modeling problems with mathematical language or symbols. In addition, learning activities that involve students' mathematical communication skills in class are also not used to being carried out. Another obstacle that causes students to have difficulty solving mathematical modeling problems is the lack of understanding of the prerequisite material that has been studied previously. This can be improved by designing lessons that improve the ability to understand concepts in the prerequisite material, namely algebra, and designing lessons that improve students' mathematical communication skills in PLSV material.

Good ability in mathematical expressions indicators, namely being able to model mathematical problems to help students find solutions to mathematical problems. However, the

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thing that needs to be considered is that when students solve math problems on the written text indicator, the ability to remember and repeat material that has been previously studied must also be mastered by students. This happened to subject 23 when adding algebraic forms in the form of 2k + k + 2k + k, who experienced confusion because when studying algebraic material, they did not understand the concept of adding algebraic forms properly. This is supported by Usman and Kristiawati (2022) research, which states that the higher the students' mastery of the prerequisite material, the more likely it is to answer the questions properly and correctly. This is because someone who has mastered the prerequisite material must know a lot about mathematical concepts. Especially on the basic concepts [17]. Furthermore, to solve the problem correctly, students are expected to be able to build and connect mathematical models that are by the situation model in the word problem [18]

Based on the explanation above, it can be said that students' low mathematical communication skills are related to errors in describing problem conditions in the form of images that help students to model the problem. This is supported by Abdullah and Sharadgah's research which states that the error of the mathematics learning method prioritizes memorization rather than understanding. Some of the difficulties experienced by students, namely absorbing information correctly, lack of experience in working on math problems, understanding the material provided comprehensively, and the prerequisite skills required weak [19]

Student mathematical modeling is a process that can explain logically and clearly the solution to a problem posed. Student knowledge will be constructed where information or elements he often encounters in the real world will be translated into mathematical elements to obtain a solution. Mathematical modeling ability is essential for students and teachers to learn and apply because its application will be used in and outside the school environment. This is the opinion of Zbiek, R. M., & Conner, which states that through mathematical modeling, students can develop their skills in using mathematics in everyday life, giving them the skills to reflect on what they have learned [20] so that the importance of a teacher to develop the ability to model mathematics in students to improve students' mathematical communication skills in learning mathematics by honing in on non-routine word problems.

CONCLUSION

Based on the study's results, it was found that the mathematical communication skills of class VII students were included in the deficient category. This is indicated by the average recapitulation of the three indicators on students' mathematical communication skills: drawing, mathematical expressions, and written text, which are categorized as very low. The average score of mathematical communication skills from the three indicators only reached 17.86 %. These findings are expected to provide an overview for teachers to improve learning in the classroom so that mathematical communication skills reach an excellent category. It is recommended that teachers develop mathematical modeling skills in students learning mathematics by honing in on non-routine story problems.

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