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Analysis of Mathematical Communication Ability in Terms of Students' Numerical Ability

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Abstract- This research is motivated by the low mathematical communication ability of students. Students have difficulty in expressing problems into mathematical notation and performing arithmetic operations and re-expressing mathematical descriptions. This is related to the students' numerical ability. Therefore, this study aims to describe students' mathematical communication ability in terms of high, moderate and low numerical abilities. The type of research used is descriptive qualitative research. The subjects in this study were students of class X IPA-1 SMA N 1 Kec. Lareh Sago Halaban which consists of 6 students with 2 students each with high, moderate and low numerical abilities. The instruments used in collecting data in this study include the researcher as the main instrument, and supporting instruments in the form of numerical ability tests, mathematical communication ability and interview guidelines, with data collection techniques carried out by tests and interviews. The data analysis technique used is the Miles and Huberman concept, namely data reduction, data presentation and conclusion drawing. Checking the validity of the data used is triangulation technique. The results showed that subjects with high numerical abilities were easier to interpret and communicate mathematical ideas. Subjects with moderate numerical ability tend to be less capable and have little difficulty in interpreting and communicating mathematical ideas. Subjects with low numerical ability tend to be unable to interpret and communicate mathematical ideas.

1. Introduction

Mathematics is one of the branches of science that is taught at all levels of education, it can be seen by the fact that mathematics is one of the compulsory subject in schools with the aim that student can think logically,

systematically, and structured. Therefore, the government and teacher always try so that students get the best mathematics learning outcomes. Kemendikbud (2022) stated the purpose of mathematics learning is to equip students to be able to: (1) Understand mathematics learning materials in the form of facts, concepts, principles, operations and mathematical relations and apply them in a flexible, accurate, efficient, and precise manner in solving mathematical problems (mathematical understanding and procedural skills), (2) using reasoning on patterns and properties, performing mathematical manipulations in making generalizations, compiling evidence, or explaining mathematical ideas and statements (mathematical reasoning and proof), (3) solving problems that includes the ability to understand problems, design mathematical models, complete models or interpret solutions obtained (mathematical problem solving), (4) communicate ideas with symbols, tables, diagrams, or other media to clarify situations or problems, and present a situation in symbols or mathematical models (mathematical communication and representation), (5) linking Mathematics learning materials in the form of facts, concepts, principles, operations, and mathematical relations in a field of study, across fields of study, across fields of science, and with life (mathematical connections) (6) have an attitude of appreciating the usefulness of mathematics in life, namely having a sense of curiosity, attention, and interest in learning mathematics, as well as creative, patient, independent, diligent, open, tough, tenacious, and confident attitude in problem solving (mathematical disposition). From the objectives of learning mathematics above, it can be seen that one of the factors for the success of students in learning mathematics is seen in the fourth goal of being able to communicate mathematical ideas.

Mathematical communication is a learning process in order to express and implement mathematical ideas that students have, which is in accordance with the notion of mathematical communication which is the process of expressing and implementing mathematical ideas and understanding orally, visually and in writing using numbers, symbols, graphs, diagrams and words. Mathematical communication skills are very important, because with mathematical communication students can organize and apply their mathematical thinking patterns as well as support for student competencies. Baroody, et al (in Umar, et al, 2012) mentioned that students need mathematical communication for several important reasons, namely: (1) *mathematics as language*, meaning that mathematics is not only a tool for thinking, a tool for finding patterns, solving problems or drawing conclusions, but also a valuable tool for communicating ideas clearly, accurately and carefully, (2) *mathematics learning as social activity*, meaning that it is a social activity in learning mathematics, mathematics is also a carrier of interaction between students and a carrier of communication between teachers and students. Which is the most important part of accelerating students' understanding of mathematics. Based on the above two reasons mathematical communication ability is a very important skill important in mathematics, in the form of ability for by consistent disclose and execute ideas and idea mathematical to others good in language oral nor writing. Mathematical communication ability is a mathematical skill that includes the ability to represent, listen, read, discuss and write, and consistently expressing mathematical ideas to friends, teachers and others, solving problems or doing reasoning and expressing mathematical ideas both in writing and orally (Heryan, 2018: 98)

Mathematical communication ability can be seen from several aspects including Maulyda (2020: 65): (1) The ability to express mathematical ideas orally, in writing and can describe visually, (2) The ability to interpret and evaluate mathematical ideas both orally and in writing, (3) Ability in use terms, symbols math, structure and model something problem math. These aspects of mathematical communication ability are then translated into several indicators of written mathematical communication ability as shown in table 1.

Table 1. Mathematical Communication Ability Indicator

Variable	Indicator
Mathematical communication ability	Ability to write down what is known and asked in a problem. Capable make modeling mathematics or write operation appropriate count _ with what is meant question. Capable interpret solution or write reason in answer question. Able to use symbols, terms, pictures, tables, graphs, models and others properly and clearly. Able to state conclusions.

Some literature says that students' mathematical communication ability is still relatively low (Wijayanto, 2018, and Merdian, 2018). Students' mathematical communication ability are still relatively low, where students have difficulty in expressing problems into mathematical notation and in solving problems with indicators compiling arguments, formulate definitions, generalizations and re-express mathematical descriptions in their own language. The low mathematical communication ability of students can also be seen in SMA N 1 Kec. Lareh Sago Halaban, where there are still many students who are unable to communicate ideas into mathematical language both orally and in writing. The results of observations on learning exponential function graph material, it appears that most students have not been able to describe graphs and write down mathematical ideas completely. In addition, most students immediately make graphic images, when in fact there are steps in completing and communicating answers. One of them is in the indicators of mathematical communication ability in the form of being able to write arithmetic operations that are in accordance with the intended problem and being able to interpret solutions. As in the problem given in the form of "Draw a graph of the exponential function of the function $f(x) = (\frac{1}{4})^x$

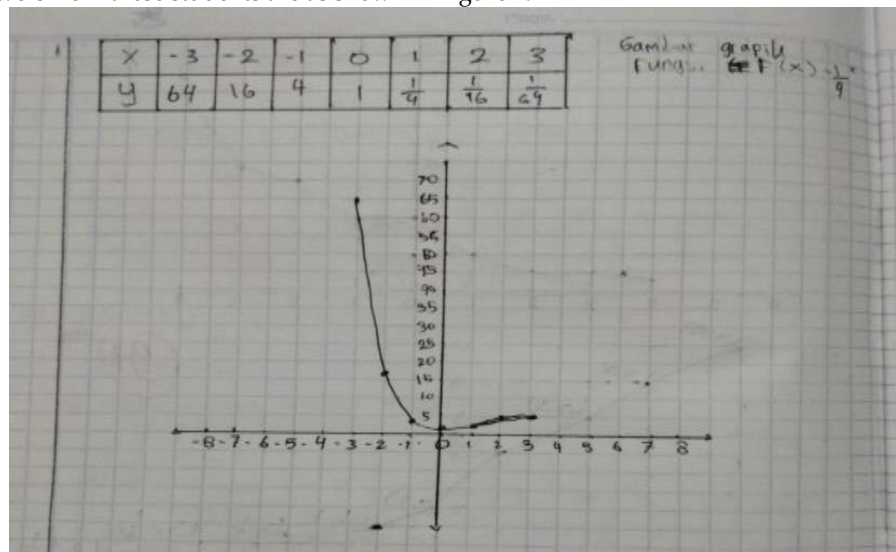The answers from these students are as shown in Figure 1:

Figure 1. Student's Answer Sheet

Based on Figure 1 where students directly make answers, without making mathematical modeling or arithmetic operations in accordance with the question, such as arithmetic operations to determine the value of y. The answers given by students are also not correct on the graph even though the values in the table are correct. It can be seen that students are less able to relate mathematical ideas to pictures and graphs, whereas expressing mathematical ideas to pictures is an indicator of mathematical communication ability in the form of being able to use symbols, pictures and graphs to convey mathematical ideas.

In relation to the students' mathematical communication ability, there are many things that greatly affect these abilities, including internal factors and students' external factors. Internal factors such as interests, talents, cognitive abilities as well as physical and psychological conditions of students, while external factors such as curriculum, infrastructure and environmental conditions around students (Gunur, 2019: 225). The internal factor in this study is in the form of students' cognitive abilities, which are more specific, namely numerical abilities. Numerical ability is a person's ability to use numbers, and perform calculations (Kencanawaty, 2016: 113). Further Bedilius (2018) said that numerical ability is a person's intellectual ability to perform calculations and is also the basis for learning mathematics. Numerical ability is one of the five dimensions that make up intellectual abilities, in the form of the ability to perform calculations quickly and precisely and is one of the requirements for students to be able to develop mathematical abilities (Utomo, 2017: 238). There are four indicators of numerical ability as shown in table 2 (Nurmaningsih, 2019: 342)

Table 2. Numerical ability indicator

Variable	Indicator
Numerical Ability	Mathematical calculations, is the ability to perform basic calculations such as ordinary calculations, algebra, etc.
	The ability to think logically, which is all that is related to the ability to explain cause and effect logically and systematically.
	Ability to solve problems and formulate into mathematics.
	Ability in differentiate patterns numeric as well as relationship.

Numerical ability is very closely related to ability in mathematics, one of research show that there is a significant relationship between numerical ability and students' mathematical communication ability where the contribution is large (20.9%) (Gunur, 2019). This result indicates that the better the students' numerical ability, the better the students' mathematical communication ability. From the observations and interview with students, it can also be seen that there is an influence and relationship between numerical ability and mathematical communication ability, where students who have good numerical abilities will find it easier to communicate their mathematical ideas, and vice versa. Most students still have difficulty in performing mathematical calculations, such as in performing basic calculations.

Numerical abilities vary from person to person, some have high numerical abilities and some have low numerical abilities. For students who have high numerical abilities they will be better at counting and for students who have low numerical abilities will have difficulty in counting Sitriani (2019 :162) and (Nurmaningsih, 2019). Several studies have shown that someone who has high numerical ability will be able to develop new concepts and integrate various basic concepts and also be able to convey mathematical ideas properly and correctly. Numerical ability has a contribution to the success of students' mathematics learning in this case to students' mathematical communication ability (Gunur, 2019).

Analysis of mathematical communication ability in terms of students' numerical abilities is important to know, especially for teachers, because then teachers can find out students' numerical abilities, whether students have high, moderate or low numerical abilities, so that they can be a reference and benchmark for teachers as input for choose strategies and methods that can optimize students' numerical abilities. Based on the description above, the aim of this research is knowing mathematical communication ability seen from students' numerical abilities.

2. Methods

The type of research used in this research is descriptive qualitative research which has the aim of describing, and interpreting a thing. The research was conducted at SMA N 1Kec. Lareh Sago Halaban which is located in the district. Lareh Sago Halaban, Fifty Cities District, West Sumatra. The subjects in this study were students of class X IPA-1 SMA N 1 Kec. Lareh Sago Halaban.

Data collection in this study includes tests and interviews. The research instrument used is the researcher as the main instrument. Numerical ability test, mathematical communication ability test and interview guide as supporting instruments. The data analysis technique was carried out using the Miles and Huberman model using data reduction, data presentation and drawing conclusions. To ensure the correctness of the data collected, technical triangulation was carried out.

To determine students' numerical abilities, numerical ability test is given so that students' numerical abilities can be grouped into three categories, namely high, moderate and low numerical abilities. The following table grouping students based on numerical ability:

Table 3. Numerical Ability Classification

Numerical Ability Category	Score
High	$X \geq 80$
Moderate	$60 \leq X < 80$
Low	$x < 60$

Where for the percentage of students' numerical ability the formula is used:
$$X = \frac{SS}{ST} \times 100$$

Information:
X   = Percentage of students' numerical ability
SS = student score
ST = total score (Halyadin, 2019, p. 94)

3.   Results and Discussion

The data obtained in this study are the results of numerical ability tests and mathematical communication ability conducted on 31 students of class X IPA-1. Then the researcher categorizes the students based on high, moderate and low numerical abilities. The results of students' mathematical communication ability levels are presented in table 4.

Table 4. Level of Numerical Ability of Students

No	Numerical Ability Level	Many Student	Mathematical Communication Ability			
			Average ($\bar{x}$)	Standard Deviation	The Highest Score	Lowest Value
1	High	9	60.18	8.48	70	48.33
2	Moderate	17	42.35	9.74	61.67	26.67
3	Low	5	33.67	13.66	46.67	13.33
Total Students		31				

Based on table 1, it can be seen that there are 9 students with high numerical ability, 17 students with moderate numerical ability and 5 students with low numerical ability. It can be concluded that more than half of the students of class X IPA-1 are in the category of moderate numerical ability. After the numerical ability test was carried out, the same student was also tested for mathematical communication ability.
After the students were grouped based on the results of the mathematical communication ability test, the researchers then conducted interviews with the students. Interviews were conducted directly based on the results of the mathematical communication ability test, only six students in class X IPA-1 were divided into three groups, namely 2 students with high numerical abilities, 2 students with moderate numerical abilities and 2 students with low numerical abilities.

(a)   Description and analysis of mathematical communication ability of students who have high numerical abilities

Students with high numerical abilities are able to write and state some of the information in the problem, and explain their answer precisely and clearly. It indicates that they can think logically and have good problem-solving skill. They also can write arithmetic operations according to the question, although there are still some shortcomings. Based on answer of subject 1, she is able to solve the problem, the subject can estimate the answer with a picture, and immediately makes an answer to find a vector by using a formula based on a sketch image. The subject is able to present symbols, as well as images in every problem solving even though there are a few shortcomings such as the lagging behind in writing vector symbols. the subject can state conclusions even though the subject does not write on the answer sheet. Some of the shortcomings in the indicator can perform arithmetic operations according to the question and interpret the solution can be seen in the figure 2.
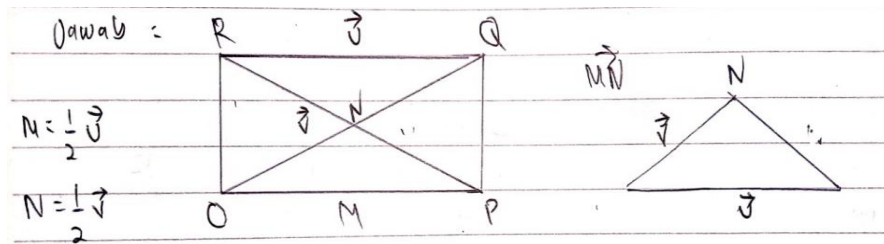
Figure 2. Answer of 1st subject

This is reinforced by the following excerpts from the interview with subject 1:

R   : *how do you determine the value of the MN vector?*

S1   : *by looking at the picture and I estimate with vector m equal to half of vector u and vector n equal to half vector v*

Students with high mathematical communication ability are less able to interpret solutions that must be used in solving problems, because to determine the MN vector, the subject immediately states that the value of m is equal to half the vector u and the value of N is half of the vector V when students should be able to do the steps to determine the solution.

Based on the description above, it can be seen that subjects with high numerical abilities able to understand what information is in the questions, the objectives to be achieved by the questions, able to make modeling and arithmetic operations requested by the questions even though they are not perfect and there are few shortcomings, able to state solutions or interpreting solutions to problems, able to present symbols, terms and pictures as asked for questions properly and clearly, and able to state conclusions. Although most of them are not written on the answer sheet. So it can be seen that the high numerical ability subject is considered capable of mastering all indicators of numerical ability. The results of this study are in line with previous research conducted by Gunur (2019). From the results of his research, it was found that someone with high numerical ability showed a tendency to like doing arithmetic activities and had high speed in solving math problems or problems. Good numerical ability makes it easier for someone to manage numbers and logic with the main activities of logical thinking, performing mathematical calculations, solving problems, and compiling numerical patterns and their relationships. With this ability, it will be easier for someone to interpret various mathematical ideas in the form of symbols. Furthermore, it is also stated that someone who has high numerical ability will perform the calculation process more easily and will work quickly (Nurmaningsih, 2019).

(b)   Description and Analysis of Mathematical Communication Ability of Students Who Have Moderate Numerical Abilities

Students with moderate numerical ability able to write and state some of the information in the problem, and explain their answer precisely and clearly. Based on answer of subject 3, the subject is less able to write arithmetic operations according to the question referred to, cannot complete the arithmetic operations requested by the question. The subject only estimates the MN vector by removing a triangle image from the rectangle, then the subject immediately mentions that the vectors m and m are half of the vectors u and v by looking at the image. So it can be concluded that the subject is less able to interpret the solution, because the subject should be able to determine the MN vector based on the image.

The subject is able to present symbols, as well as images in every problem solving even though it is not perfect because there are symbols left behind such as the use of vector symbols. For the use of pictures, the subject also had difficulty in the placement of the points even though in the end some of the subject's answers were correct. One of them is reinforced by the following answers in figure 3 and excerpts of the interview results:
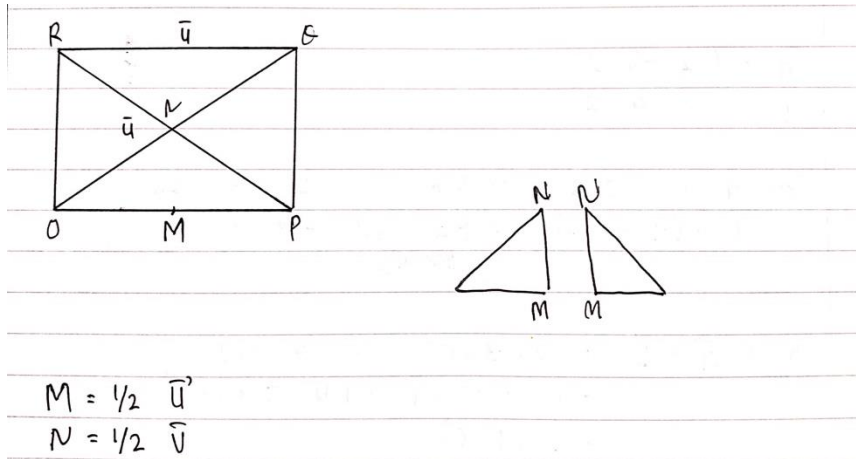
Figure 3. Answer of 3rd subject

R   : when working on the problem how do you determine the value of the MN vector?
S3   : by removing a right triangle from the rectangle and I can see that the vectors are half.

In accordance with the answers of subject 3 above, subject 4 also experienced the same thing where subject 4 was also less able to meet the indicators of mathematical communication ability, especially for indicators of performing arithmetic operations and interpreting solutions, as in the figure 4.
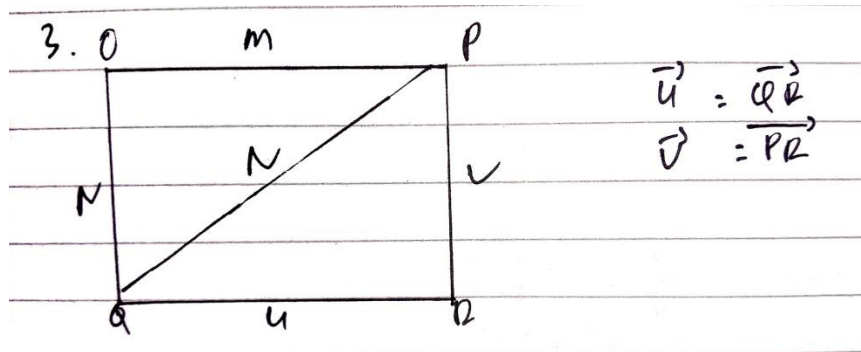

Figure 4. Answer of 4th subject

R   : based on what is known and asked what do you think? Or what steps do you take next?
S4   : draw a rectangle at number 3
R   : what steps will you take next
S4   : I don't know what else to do, so I just got there I answered

Based on the description above, it can be seen that subjects with moderate numerical ability tend to be able to understand what information is in the problem, the objectives to be achieved by the question, are less able to make modeling and arithmetic operations requested by the question because there are several shortcomings so that there are some objectives of the questions that are not achieved. The subject also less able to state solutions or interpret solutions to problems, less able to present symbols, terms and pictures as asked for questions properly and less able to state conclusions even though most of them are not written on the answer sheet. So it can be seen that students with moderate numerical abilities in this case are less able to master indicators of mathematical communication ability, especially for indicators of performing arithmetic operations according to the question, and interpreting solutions for each problem so that the subject has difficulty in interpreting mathematical ideas. This is in line with research conducted by Utomo (2017) those who say that students will have difficulty in learning mathematics if they do not have sufficient numerical abilities.

(c) Description and Analysis of Students' Mathematical Communication Ability Who Have Low Numerical Abilities

Students with low numerical abilities are less able to state some of the information contained in the problem, and explain what will be solved, so that what is stated by the subject is less precise. Based on students' answer, the subject is not able to write the arithmetic operation as intended by the question, the subject's answer only makes a rectangular image and the points made are wrong. the subject also cannot complete the answer during the interview. The subject is considered less able to use and describe it, because the image made by the subject on the answer sheet is not correct. The subject is unable to present the required symbol and for the placement of points, she also made mistakes. The subject cannot state conclusions because the subject's answers are incomplete, so she cannot solve the questions given. This is reinforced by the results of student answers in figure 4 and excerpts of interviews with subjects 5:
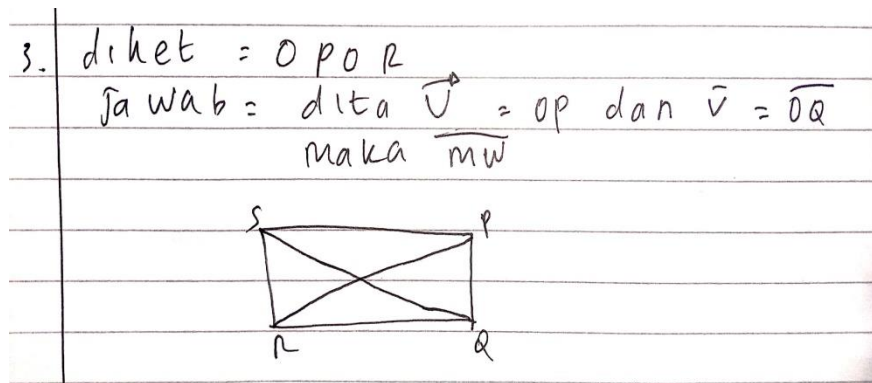
Figure 5. Answer of 5th subject

R   : based on what is known and asked what do you think? Or what steps do you take next?
S5   : I have trouble sketching a rectangular image so I don't make a point. After that I don't know anymore
Furthermore, subject 6 also experienced the same thing where subject 6 was also unable to show the indicators of mathematical communication ability. It can be seen in the student's answers in figure 6.
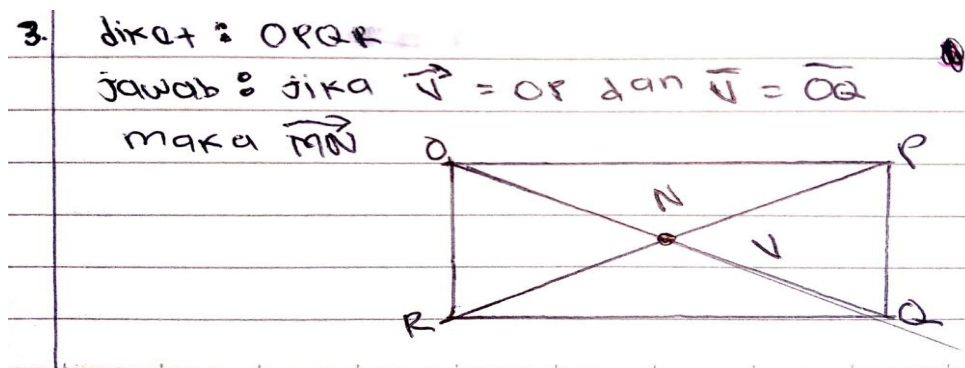

Figure 6. Answer of 6th subject

Based on the description above, students with low numerical abilities have difficulties in interpreting and communicating mathematical ideas. They are not able to understand what information is in the questions, the objectives to be achieved by the questions, unable to make modeling and arithmetic operations that asked questions so that the purpose of the questions was not achieved, unable to state solutions or interpret solutions to problems, less able to present symbols, terms and pictures as asked for questions and unable to state conclusions because the purpose of the questions could not be solved so the subject could not state conclusions. Students will have difficulty in learning mathematics if they do not have adequate numerical abilities (Utomo, 2017). This is in accordance with the research which showed that subjects with low numerical abilities had difficulty in interpreting and communicating mathematical ideas.

4. Conclusion

Mathematical communication ability of students with high numerical abilities are considered to be able to understand what information is in the problem, the goals to be achieved by the question, able to make modeling and arithmetic operations requested by the question even though it is not perfect and there are few shortcomings, able to state solutions or interpret solutions to problems , able to present symbols, terms and pictures as asked for questions properly and clearly, and able to state conclusions. Students are easier to interpret and communicate mathematical ideas and ideas in the form of conveying answers to the given math problems.

The mathematical communication ability of students with moderate numeric abilities is considered less able to meet the indicators of mathematical communication ability, because students tend to be able to understand what information is in the questions, the objectives to be achieved by the questions, are less able to make modeling and arithmetic operations requested by the questions because there are several shortcomings. so there are some goals of the question that are not achieved, less able to state solutions or interpret solutions to problems, less able to present symbols, terms and images as asked for questions properly and less able to state conclusions. Students with numerical abilities are having little difficulty in interpreting and communicating mathematical ideas.

The mathematical communication ability of students with low numerical abilities is considered unable to meet the indicators of mathematical communication ability, because students are less able to understand what information is in the questions, the goals to be achieved by the questions, are unable to make the modeling and arithmetic operations requested by the questions so that the purpose of the questions not achieved, unable to state solutions or interpret solutions to problems, less able to present symbols, terms and images as requested for questions and unable to state conclusions because the purpose of the problem cannot be solved so that the subject cannot state conclusions. Students with low numerical ability have difficulty in interpreting and communicating mathematical ideas.

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