



Mathematical Communication Skills in Middle School: A Study of Eighth-Grade Students in West Timor, Indonesia

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ABSTRACT

This study aims to analyze the mathematical communication skills of grade VIII students of the First Secondary School on the material of Relations and Functions. The method used was qualitative descriptive research with the subjects of 21 students in class VIII-B for the 2024/2025 school year. Data was collected through a description test that included indicators of mathematical communication skills and interviews to deepen the results of the analysis. The results of the study show that students' written mathematical communication skills still vary with a tendency to be in the medium to low category. The indicator expressing mathematical ideas in written and visual form obtained the highest achievement of 76.38%, while the indicator interpreted and evaluated ideas only reached 52.86% and the use of mathematical notation reached 47.62%. High-skill students are able to write mathematical models correctly even though the use of formal terms is not consistent, moderate-skill students tend to provide limited explanations, while low-skill students copy more problems without constructing a proper mathematical model. These findings indicate the need for a learning strategy that emphasizes written mathematical communication exercises in a more orderly manner, both in the form of sentences, tables, graphs, and symbols to improve the quality of students' understanding of concepts.

Keywords: Mathematical Communication Skills, Middle school, Relationships and functions.

1. Introduction

Mathematics is one of the disciplines that occupies an important position in the world of education because it functions as a means of logical, critical, systematic, and creative thinking. The National Council of Mathematics Teachers (NCTM, 2000) emphasizes that mathematics learning is not only oriented to the results of calculations, but also to the process of how students build and communicate their mathematical ideas. Mathematical communication skills are one of the main goals of mathematics learning, because through communication students can organize their thoughts, connect ideas, explain strategies, and evaluate solutions (Usolin, Son, Maifa & García-García, 2023).

Mathematical communication is not just about mathematics, but the skills of students to express ideas in various representations: oral, written, symbolic, table, graphic, and diagram. With good communication, students are able to convey what they understand, interpret the meaning of concepts,



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and relate them to everyday problems (Lomibao, Luna & Namoco, 2016). Hendriana, Rohaeti, & Sumarmo (2017) emphasized that mathematical communication is a means to strengthen understanding of concepts and bridge ideas between teachers and students as well as between students. Therefore, low mathematical communication skills will have a direct impact on students' difficulty understanding more complex concepts (Siregar, 2025).

One of the materials that is very closely related to mathematical communication is Relations and Functions. This material is studied in grade VIII of secondary school and becomes the foundation for other materials such as equations, linear function graphs, and trigonometry at the next level. The concept of relationships and functions requires students to be able to connect two sets, express relationships in various forms of representation (arrow diagrams, tables, sequential pairs, Cartesian diagrams), and write mathematical models in the form of function notation. This skill obviously requires not only understanding concepts, but also the skills to convey ideas in writing and visually.

However, facts in the field show that the achievement of mathematical communication skills of junior high school students, especially in relation and function materials, is still relatively low. Research by Zaditani & Ruli (2022) revealed that students often have difficulty writing down mathematical ideas in a coherent and formal manner. Similarly, Andini & Marlina (2021) research shows that the majority of students are only able to copy information from questions without developing a proper mathematical model. Similar findings were also obtained by Ats-Tsauri et al. (2021) who stated that although some students understand the concepts of relationships and functions, they are still weak in communicating ideas both in writing and visually.

This condition is in line with the researchers' initial observation in high school, where students tend to be passive, lack confidence, and have difficulty explaining mathematical ideas with symbols, tables, or graphs. The diversity of students' skills is also one of the influential factors. Not all students are in the same category (Nguyen, Nguyen, Nguyen, Truong & Thai, 2025). There are students who are able to master mathematical notation well, some who simply understand ideas without being able to evaluate them, and there are also those who have difficulty expressing even simple ideas (Rohid & Rusmawati, 2019). For this reason, it is important to conduct a more in-depth analysis based on the category of students' skills. In this study, students' mathematical communication skills were analyzed in three categories, namely students' high skill, with an emphasis on indicators of the use of mathematical notation. Medium skills, with a focus on indicators interpreting and evaluating ideas. Low skills, with attention to indicators expressing mathematical ideas in written and visual form. Based on the description above, the purpose of this study is to analyze the mathematical communication skills of grade VIII high school students on Relations and Function materials.

2. Method

The research method used in this study is qualitative descriptive. According to Sugiyono (2022), the qualitative descriptive research method is research used to research the condition of natural objects where the researcher is a key instrument. This research approach was taken because the researcher wanted to analyze and describe the mathematical communication skills in the relationship and function materials of junior high school students.

This research was carried out at Nunbai State Junior High School located in East Letmafo Village, Central Insana District, North Central Timor Regency, which took Mathematics subjects in class VIII-B on the material of relations and functions for the 2024/2025 school year.

The data collection techniques used in this study are by means of tests, interviews, questionnaires, observations, documentation and triangulation. The data analysis techniques used in this study are, data reduction, data presentation, and conclusion drawn.

The research method used in this study is qualitative descriptive. According to Sugiyono (2022), the qualitative descriptive research method is research used to research the condition of natural objects where the researcher is a key instrument. This research approach was taken because the researcher wanted to analyze and describe the mathematical communication skills in the relationship and function materials of junior high school students. The subjects in this study are students at a junior high school in West Timor.

Data collection techniques are techniques or ways of collecting relevant information data and are needed in research (Sugiyono, 2022). The data collected in the study will be used to answer questions on the formulation of the problem. Data collection techniques according to Sugiyono (2022) can be carried out by means of tests, interviews, questionnaires, observations, documentation and triangulation.

Data analysis is the process of systematically compiling data obtained from interviews, observations, documentation, and other relevant materials so that it is easy to understand and the findings can be informed to the general public (Sugiyono, 2022). In this study, data analysis techniques are used, namely, data reduction is carried out on data that is not needed in the research, data presentation is the process of systematically compiling information to draw conclusions from the data, conclusion drawing is the drawing of conclusions obtained from the results of data that has been collected and presented.

3. Results and Discussion

At this stage, the researcher conducted a test using 3 description questions given to 21 students in class VIII-B. The purpose of this test is to determine students' mathematical communication skills in writing on the relationship and function material. The test begins by distributing questions and answer sheets to students, then telling students to write biodata and immediately work on the questions. The implementation of the test went quietly and smoothly. After completing the questions, the researcher collects all the results of the student's work to be examined.

Based on the results of the test examined, the researcher selected 6 students, namely 2 students with high mathematical communication skills, 2 students with moderate mathematical communication skills and 2 students with low mathematical communication skills.

Based on the analysis of test results for 21 students in grades VIII-B SMP Negeri Nunbai on the relationship and function material, it showed that the indicator stated an idea or idea by 76.38%, the indicator used symbol notation and mathematical language by 52.86% and the indicator presented mathematical ideas in visual form by 47.62%.

a). Description of test results and interviews of the first highly qualified student (HS1)

To describe the mathematical communication skills of the first high- skills student, the following test results are presented in question number 1:

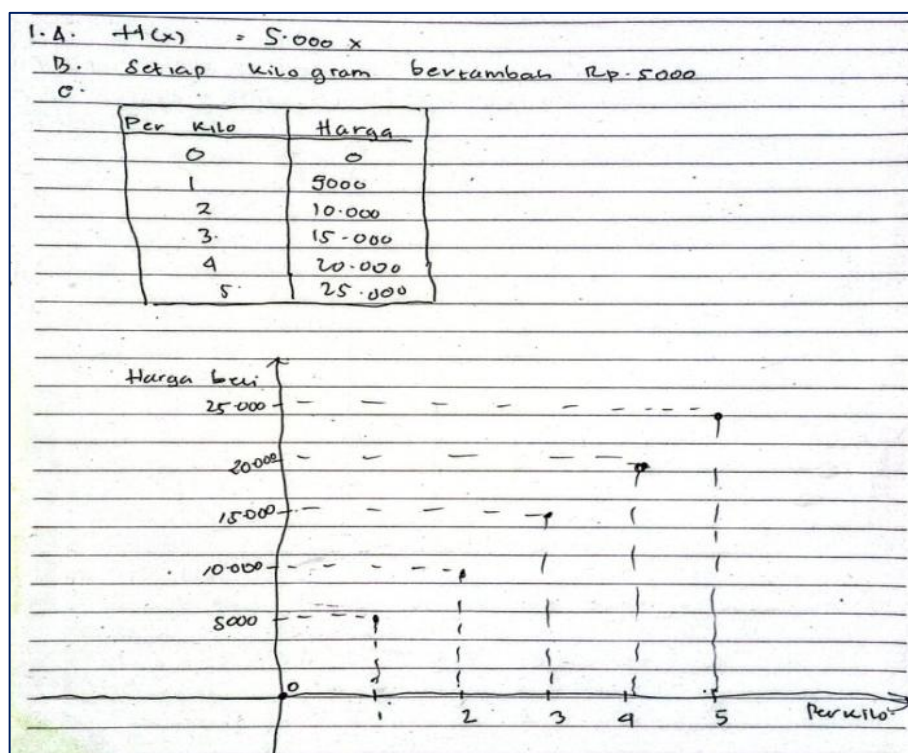


Figure 1 Students HS1 answers to question 1.

Based on figure 1, students write down mathematical models in the form of functions as expressions of symbolic ideas. In addition, students write a simple explanation " $H(x) = 5000x$ every kilogram adds Rp.5000" to show an understanding of the concept of price increase. In the visual aspect, students describe the relationship between kilograms and prices in a Cartesian diagram, so that they are able to express mathematical ideas through written forms of tables and visuals, students also understand that prices increase proportionally as kilograms increase, this can be seen from the students' answers in the form of a table that shows the relationship between the number of kilograms and the price. The representations made are still simple, but reflect the students' understanding of the relationships between variables and use function notation to express mathematical relationships, as well as write numbers (5000, 10,000, 15,000 etc.) in the form of a table. Students also use the horizontal axis (kilograms) and the vertical axis (price) in the graph. Although the graph is still simple, the use of notation, symbols, and table structure already shows that there is a skill to present ideas.

To describe the mathematical communication skills of the first high-skilled student (HS1), the following test results are presented in question number 2:

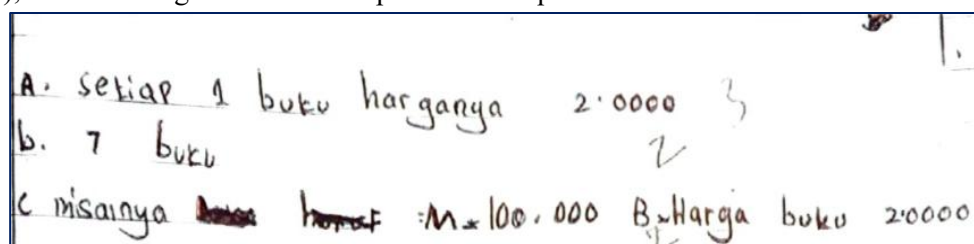


Figure 2 Students HS1 answers to question 2.

Based on figure 2, students write down basic information with the simple sentence HS1 "1 book costs 20,000", this shows that students are able to show that they are able to

express mathematical ideas in written form. The representation given is only in the form of simple sentences and calculations, thus students can already communicate ideas, but still in simple form, students also show understanding by writing down the number of books and prices, but the explanation sentences written are still short and not completely clear so that the mathematical meaning is limited, this shows that the skills of students to interpret the relationship between variables already exists, but not accompanied by in-depth evaluation, for example through the preparation of tables or graphs, students also try to use the symbols M and B to declare the number of books and prices. However, the use of these symbols is still inappropriate because it is not formally written in the form of a function, this shows that students' skills to use terms and notation already exists but is still limited.

To describe the mathematical communication skills of the first high- skills student, the following test results are presented in question number 3:

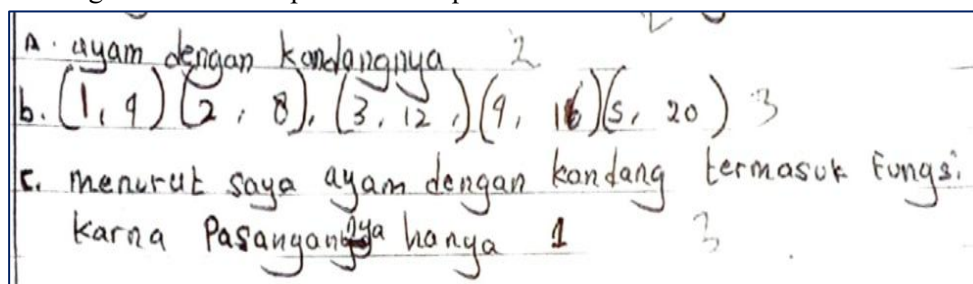


Figure 3 Students HS1 answers to question 3.

Based on figure 3, students write down the relationship between the chicken and the cage, to express the relationship, students also write sequential pairs (1,4), (2,8), (3,12), (4,16), (5,20) as this mathematical representation shows the skill of students to write mathematical ideas with symbols, students also use simple language to explain the problem "in my opinion chickens with their cages include functions because the pair is only 1" It shows that in the indicator expressing mathematical ideas through writing even though the language is still simple, students are able to explain in their own words, and students also write sequential pairs (1,4), (2,8), (3,12), (4,16), (5,20) as this mathematical representation shows the skill of students to write mathematical ideas with symbols. The following is an excerpt of the results of the interview conducted by researcher (R) with the students HS1.

R : Do you understand the problems that exist in these questions?

HS1 : Yes, understands.

R : What do you understand about the problem?

HS1 : For question number 1 about the price of oranges per kilogram, question number 2 about books and their prices, and question number 3 about chickens and cages.

R : Do you understand what is known and asked about the question?

HS1 : Yes, I understand.

R : Which problem is the easiest for you to understand?

HS1 : The easiest one for me to understand is number 1.

R : How do you solve the problem?

HS1 : I read the question and then I immediately finished it.

R : Do you have problems solving problems with these problems?

HS1 : Yes, miss having problems

R : How do you know the truth of the answer?

- HS1 : From the solution that the mother has.
 R : Can the solution be found in other ways?
 HS1 : Yes miss, but all I understand is that.
 R : After working on the question whether you are sure the answer is correct or wrong
 HS1 : I'm sure mom, except for numbers 2 and 3 I'm not sure.
 R : Well, in question number 2b why don't you write down how it works but immediately answer the result is 7 books.
 HS1 : I immediately added 20,000 and didn't make it work miss.
 R : Then on question 2c, why don't you continue more clearly with the explanation that you have written?
 HS1 : I understand that's it, miss.

From the results of the interview, it is known that the students *HS1* Already able to expressing his mathematical ideas in writing. Next on Indicators of students' skills to understand, interpret and evaluate mathematical ideas can also be completed in its own way and on indicators skills to use terms, notation and mathematical structures also the students did well.

The high skills category represents Indicators: using mathematical terms, notations, and structures to present ideas. Highly capable students are able to write mathematical models in the form of functions, such as $H(x) = 5000x$, as well as use sequential pairs and tables to illustrate the relationships between variables. In addition, students can create simple graphs on Cartesian diagrams with precise horizontal and vertical axes. Although the presentation of the graph is still simple, the use of notation, symbols, and mathematical structures is quite consistent. This shows that students are able to present mathematical ideas by using terms and notation formally even in a simple form.

b) Description of test and interview results the first moderately capable student (*MS1*)

To describe the mathematical communication skills of students with first moderate skill, the following test results are presented in question number 1.

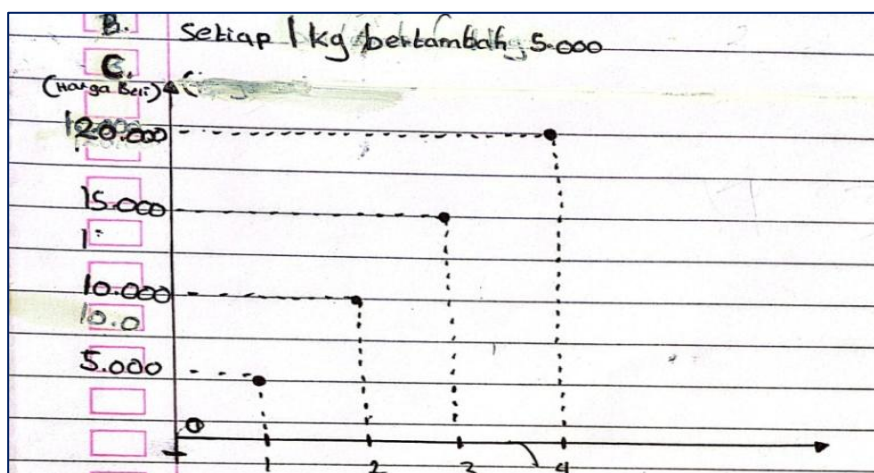


Figure 4 Students *MS1* answers to question 1.

Based on figure 4 students have written a mathematical model in the form of a function $H(x) = 5000x$, namely, this shows that students are able to express mathematics in symbolic

form, students also write an explanation with simple words "every 1 kg adds 5000" this sentence shows the concept of price increase which describes understanding in written form, besides that students also understand the relationship between kilograms and prices, As well as depicting it in the form of a Cartesian diagram, this shows the skills to express mathematical ideas in visual form, students also understand that the price of oranges will increase proportionally according to the number of kilograms, the graph drawn also shows the interpretation of the linear relationship between kilograms and prices, although the representation is not clear but it can be understood and students also use the notation function of number notation (5000,10,000, etc.) and the structure of the table to show the relationship between variables, in the graph students use the horizontal axis (per kilo) and the vertical axis (price) although it is still simple and unclear, but it already reflects the use of appropriate mathematical representations.

Furthermore, to describe the mathematical communication skills of students with first moderate skills (MS1), the following test results are presented in question number 2.

A.	Setiap jumlah buku yang dibeli bertambah 1 maka harganya 20.000
B.	Jadi buku yang diperoleh Maria adalah 2 buku
C.	misalnya harga M 100.000 B. Harga buku 20.000

Figure 5 Students MS1 answers to question 2.

Based on figure 5, students are able to write basic information by writing "each book bought increases 20,000", meaning that students understand what is on the graph and can write down written ideas but still limited and simple in their own understanding, students also write explanations in their own words to show the number of books directly without completing what is known and what is asked in the question, and students try to use the symbols M and B to state the price and number of books but it is not clear and appropriate overall.

And to describe the mathematical communication skills of students with moderate skills first (MS1), the following test results are presented in question number 3.

A	= Hubungan 1 kandang ada 4
B	= (1,4), (2,8), (3,12), (4,16), (5,20)
C	= menurut saya ayam dengan kandang let masuk Fungsi karena pasangannya hanya 1

Figure 6 Students MS1 answers to question 3.

Based on figure 6, the student writes down the relationship between the chicken and the cage with his own understanding by saying "the relationship of 1 cage there are 4", this shows that the student is able to understand but is not yet able to articulate his understanding well, the student also uses simple language to show that it is a function by saying "I think the chicken with the cage is a function because the pair is only one" Although the language is still simple, students are able to explain that the relationship is a function, while students also write

sequential pairs (1,4), (2,8), (3,12), (4,16), (5,20) as mathematical representations, this shows the skill of students to write mathematical ideas with symbols.

The following is an excerpt of the results of the interview conducted to the students MS1.

- R : *Do you understand the problems that exist in these questions?*
 MS1 : *Yes miss, I understand.*
 R : *What do you understand about the problem?*
 MS1 : *For question number 1 about the price of oranges per kilogram, question number 2 about books and their prices, and question number 3 about chickens and cages.*
 R : *Do you understand what is known and asked about the question?*
 MS1 : *Yes, I understand.*
 R : *Which problem is the easiest for you to understand?*
 MS1 : *The easiest thing for me to understand is only the number 1 miss.*
 R : *How do you solve the problem?*
 MS1 : *I read the question and then I immediately did it miss.*
 R : *Do you have problems solving problems with these problems?*
 MS1 : *Yes, had a problem miss.*
 R : *How do you know the truth of the answer?*
 MS1 : *From the solution miss.*
 R : *Can the solution be found in other ways?*
 MS1 : *"I don't know, miss.*
 R : *After working on the question, are you sure the answer is right or wrong?*
 MS1 : *I'm sure mom, except for numbers 2 and 3 I'm not sure.*
 R : *Well, on question number 2c why didn't you solve it?*
 MS1 : *I don't understand anymore, mother.*
 R : *Then on question number 3, why is the answer number 3a not quite right but number 3c is the right answer?*
 MS1 : *Because all I know is that the function of the partner is only miss.*

From the results of the interview, it is known that the students SS₁ Already able to expressing his mathematical ideas in writing. Next on Indicators of the skill to understand, interpret and evaluate mathematical ideas Students can also solve existing problems but not as a whole and on the skills to use terms, notation and mathematical structures also, students also understand and can solve it.

The medium skill category represents Indicators: Understand, interpret, and evaluate mathematical ideas. Students with medium skill are able to understand the questions and write explanations in their own language, for example "each book purchased adds Rp.20,000". Although the completion is not complete, students can demonstrate an understanding of the relationships between variables through simple calculations, symbols, or simple graphs. However, the interpretation and evaluation of mathematical ideas have not been carried out thoroughly. This can be seen from the skills of students to continue the completion steps in several parts of the problem. Thus, students in the medium category already understand basic ideas and are able to interpret them, but evaluation is still limited.

c). Description of test results and interviews of the first low- skills student (LS1).

To describe the mathematical communication skills of the first low- skills student (LS1), the following test results are presented in question number 1.

Nama:	
	JOSEP. ARACHA Sio
Kelas:	VIII B
a) tulislah bentuk Fungsi dari total harga nya	
H(x) jika x adalah banyaknya jeruk dalam kg.	
jabarlah.	
Setiap kg bertambah 5000 kg kalau dua 10000 kg	
kalau tiga 15000	

Figure 7 Student LS1 answers to question 1.

Based on figure 7, students do not write down the function asked but only rewrite the problem, this shows that students are not yet able to express mathematics in symbolic form. Students also write an explanation with simple words "each kilogram of baerplus 5000 if two 10,000, if three 15,000" this sentence wants to show that there is an increase in prices that describes understanding in written form, but students have not been able to express their understanding correctly, in the following indicators there is no answer from the students.

Furthermore, to describe the mathematical communication skills of the first low- skills student (LS1)

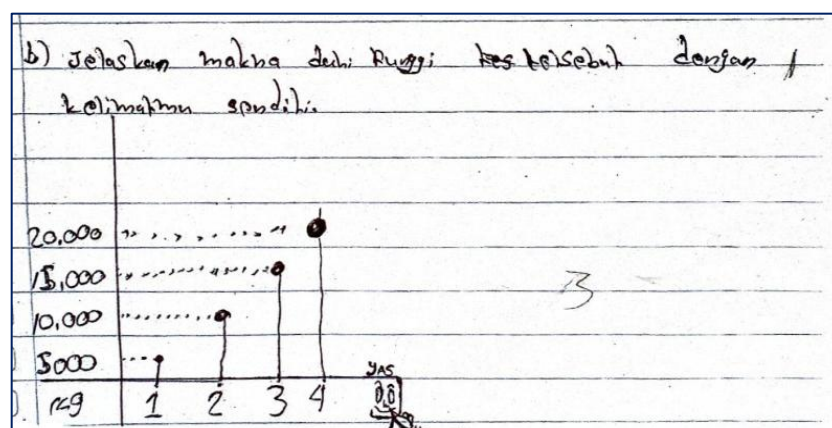


Figure 8 Student LS1 answers to question 2.

Based on figure 8, students do not write down the function asked but only rewrite the problem, this shows that students are not yet able to express mathematics in symbolic form, in the next indicator it can also be seen that students only rewrite the problem. In the next indicator, there was no answer from the students.

And to describe the mathematical communication skills of the first low- skills student (LS_1), the following test results are presented in question number 3.

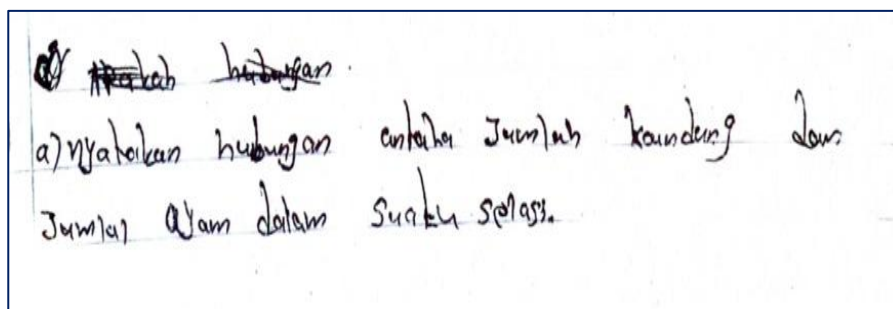


Figure 9 Student LS1 answers to question 3.

Based on figure 9, students do not write down the function asked but only rewrite the problem, this shows that students are not yet able to express mathematics in symbolic form, next it can also be seen that students only rewrite the problem.

The following is an excerpt of the results of the interview conducted with the students LS1 :

- R : Do you understand the problems that exist in these questions?
 LS1 : Yes, I understand, but not all of it.
 R : What do you understand about the problem?
 LS1 : For question number 1 about the price of oranges per kilogram, question number 2 about books and their prices, and question number 3 about chickens and cages.
 R : Do you understand what is known and asked about the question?
 LS1 : Don't understand number 2 with 3.
 R : Which problem is the easiest for you to understand?
 LS1 : The easiest thing for me to understand is only the number 1 miss.
 R : How do you solve the problem?
 LS1 : I read the question and then I immediately did it.
 R : Do you have problems solving problems in These questions?
 LS1 : Yes, I having problems miss.
 R : How do you know the truth of the answer?
 LS1 : From the solution miss.
 R : Can the solution be found in other ways?
 LS1 : I don't know mom
 R : After working on the question whether you are sure the answer is correct or wrong
 LS1 : Unsure miss.
 R : Why don't you solve the existing problems?
 LS1 : I don't understand you anymore
 R : Then on question number 2, why is number 3 also why is it written back on the question?
 LS1 : Because I don't know.

From the results of the interview, it is known that the students LS1 not yet able expressing their mathematical ideas in writing students only read the problem and then immediately work without writing down the steps to solve it in a sequence. Next on Indicators of the skills to understand, interpret and evaluate mathematical ideas Students only understand some and do not understand others and have not been able to understand

the results of their work and on the skills to use terms, notation and mathematical structures. Also, students have not been able to use symbols or mathematical representations correctly because the answer is more in the form of a final result without an explanation process.

The low skill category represents Indicators: Expressing mathematical ideas orally, in writing, demonstrating them, as well as visually depicting them. Low- skill students are not yet able to write mathematical models or use symbolic representations correctly. The answer is more in the form of a repetition of a question or a simple statement, such as "every kilogram increases by 5000". In interviews, students admitted to understanding only a small part of the question and were unsure of the answers. Visualizations in the form of graphs or tables are hardly written, and some questions are simply answered by copying the questions again. This shows that students' skills to express mathematical ideas both in writing, verbally, and visually is still very limited.

The results of the study showed that the indicator expressing mathematical ideas obtained the highest percentage (76.38%), students tended to be able to write down mathematical ideas, either through simple sentences, tables, or graphs. This is especially noticeable in students with high skills who can present functions through price tables and charts. This finding is in line with Hadi, Wahyudin, & Usdiyana (2024) who stated that it is easier for students to write ideas descriptively compared to writing formal mathematical notation. Similarly, Tajrumi, Murni & Roza (2025) stated that mathematical communication is more prominent in verbal explanations than symbolic and visual representations. This result is in line with the opinion of Novitasari, Usodo & Fitriana (2021) who states that it is easier for students to convey ideas descriptively compared to purely symbolic representations. Thus, it can be concluded that Nunbai State Junior High School students have a stronger tendency to communicate ideas through visual representation than verbal explanations. However, there are still some students who have difficulty in providing written explanations in mathematical situations. They tend to explain in a concise and limited way, while lacking in showing the relationship between concepts. This shows that students' mathematical communication skills are in the medium to high category, but still need to be improved (Halawati & Laelasari, 2022).

Skill to understand, interpret and evaluate mathematical ideas. In this indicator, student achievement is 52.86%. Highly capable students can interpret relationship patterns, but many still cannot evaluate ideas properly. Students with medium learning can only answer part of the question without a detailed explanation, while students with low skills tend to repeat the question sentence without showing in-depth analysis. This is in accordance with the findings of Asoraya & Ruli (2022) who stated that the mathematical communication skills of junior high school students in relation and function materials are relatively low, especially in explaining situations and interpreting mathematical meanings. Research by Yanti, Melati & Zanty (2019) also showed that the average mathematical communication skills of students only reached 32.22%, especially low in the aspect of interpreting and evaluating ideas.

Skill to understand, use notation terms and mathematical structures to presenting ideas. This indicator has the lowest percentage of 47.62%. Most students are not used to using terms, function notation, or pairs in order correctly. High- skill students are able to write function symbols simply, but moderately and low-skilled students often misuse symbols or simply copy problems without mathematical representations. This finding is strengthened by research by Ats-Tsauri (2021) who found that students had difficulty writing relationships and functions in the form of formal symbols.

This is consistent with previous research that states that the written mathematical communication skills of junior high school students are still dominant in verbal or descriptive explanations, but weak in symbolic and evaluative aspects (Asoraya & Ruli, 2022; Yanti, Melati, &

Zanty, 2019; Ats-Tsauri, 2021). Thus, it can be emphasized that students' written mathematical communication still needs to be improved, especially in the use of symbols, notation, and the skills to interpret and evaluate mathematical ideas.

4. Conclusion

Based on the results of the research and discussion, it can be concluded that the written mathematical communication skills of grade VIII students of a Junior High School in relation and function materials still vary, with a tendency to be in the medium to low category.

In general, indicators expressing mathematical ideas in written and visual form have the highest achievement of 76.38%. This shows that most students are able to pour out metamatic ideas in the form of simple sentences, tables or graphs, but in the indicators of interpreting and absorbing ideas only reached 52.86% and the use of mathematical notation was only 47.62%. Highly capable students are able to write mathematical models, tables and graphs correctly, although the use of formal mathematical terms is not yet completely consistent. Students with moderate skills are able to express ideas in written form, but explanations are still limited and incomplete. The use of mathematical notation and symbols is also still inappropriate.

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