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MATHEMATICAL COMMUNICATION ABILITY IN SOLVING SQUARE FUNCTION QUESTIONS VIEWED FROM STUDENTS' LEARNING INTERESTS

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Abstract

Mathematical communication skills are one of the basic skills that students at the secondary school level must have. This research aims to describe students' mathematical communication skills in solving quadratic function problems based on their learning interests. This research used a descriptive qualitative approach involving 29 class XI B2 students at SMAN Colomadu. Data was collected through questionnaires, tests and interviews and then analyzed using data reduction, presentation and conclusion-drawing techniques. The three subjects represent different levels of learning interest: low, medium, and high. The results show that students with a high interest in learning can fulfil all indicators of mathematical communication. Students with moderate interest can fulfil the second and fourth indicators: Expressing mathematical ideas appropriately using mathematical language and Examining and assessing other people's mathematical thinking and techniques. Students with low interest can only fulfil the fourth indicator: Examining and assessing other people's mathematical thinking and techniques.

Keywords: mathematical communication skills, quadratic function, interest in learning

Abstrak

Keterampilan komunikasi matematika merupakan salah satu keterampilan dasar yang harus dimiliki siswa di tingkat sekolah menengah. Penelitian ini bertujuan untuk mendeskripsikan kemampuan komunikasi matematis siswa dalam memecahkan masalah fungsi kuadrat berdasarkan minat belajarnya. Penelitian ini menggunakan pendekatan kualitatif deskriptif yang melibatkan 29 siswa kelas XI B2 di SMAN Colomadu. Data dikumpulkan melalui kuesioner, tes dan wawancara dan kemudian dianalisis menggunakan teknik reduksi data, presentasi dan penarikan kesimpulan. Ketiga mata pelajaran mewakili tingkat minat belajar yang berbeda: rendah, sedang, dan tinggi. Hasil penelitian menunjukkan bahwa siswa dengan minat belajar yang tinggi dapat memenuhi semua indikator komunikasi matematika. Siswa dengan minat sedang dapat memenuhi indikator kedua dan keempat: Mengekspresikan ide-ide matematika dengan tepat menggunakan bahasa matematika dan Memeriksa dan menilai pemikiran dan teknik matematika orang lain. Siswa dengan minat rendah hanya dapat memenuhi indikator keempat: Memeriksa dan menilai pemikiran dan teknik matematika orang lain

Kata kunci : Kemempuan Komunikasi Matematis, fungsi kuadrat, minat belajar

INTRODUCTION

The government has set new educational standards that align with modern thinking concepts, including 21st-century skills or what are known as 4C skills. These 4C skills include four important aspects that students must master: the ability to think critically, think creatively, communicate and collaborate (Nahdi, 2019). Apart from that, the National Council of Teachers of Mathematics (NCTM, 2000)emphasizes that there are five main competencies in mathematics learning that students need to master: problem-solving abilities, reasoning,

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connections, communication and mathematical representation. As stated in Minister of Education and Culture Regulation No. 21 of 2016, mathematics learning aims to develop student's abilities to communicate mathematical ideas clearly and effectively through various media such as symbols, tables and diagrams (Permendikbud, 2016).

Mathematical communication is a skill that can be developed in every mathematics learning topic (Yulianto & Suprihatiningsih, 2019). With mathematical communication, students can hone their ability to express ideas using language and symbols to solve mathematical problems (Ningrum et al., 2024). These skills are very important for students, both at the primary and secondary school levels. If students' mathematical communication skills are weak, this can negatively impact their mastery of other aspects of mathematics (Swastika, 2016). Baroody, as quoted in (Hendriana & Soemarmo, 2014), explains two reasons why mathematical communication is important for students: first, mathematics is a language, which means mathematics is not just a tool for thinking; and second, mathematics is a social activity in learning, which shows that social interaction in learning mathematics is key. Therefore, students with good mathematical communication skills will find it easier to interpret and solve various problems (Nurhasanah et al., 2019).

Students can demonstrate their mathematical communication skills when they prove that the mathematical communication abilities indicators have been met. However, students' mathematical communication skills in Indonesia still need to improve. Compared with other countries, Indonesian students' abilities in this regard need to catch up. For example, only around 5% of Indonesian students can correctly answer mathematical problems related to mathematical communication, far below countries such as Singapore, Korea and Taiwan, which reach more than 50% (OECD, 2019).

Learning mathematics with effective communication and strong interest can support the development of interaction and the ability to express ideas because students are involved in an active learning atmosphere (Anderson & Smith, 2015). According to Slameto (in Fauziah & Desniarti, 2021), interest is an interest in something that is liked, resulting in feelings of pleasure when doing activities of interest. Students with a high interest in mathematics tend to have better communication skills because they are more motivated to understand and

explain mathematical concepts and more confident in communicating their understanding (A. et al., 2022). In this context, mathematical communication is very important because it allows students to share information, exchange ideas and knowledge, and understand concepts in mathematics learning (Haniyah & Khusna, 2023).

One material that requires students to communicate their mathematical ideas is quadratic functions. For example, when graphing quadratic functions, students must present their ideas as mathematical symbols connected to graphs or pictures. Hence, they must communicate this in writing (Anderson & Smith, 2015). Every subject, including mathematics, should aim to develop students' communication skills (P. Johnson, 2018).

Based on the description above, research is needed regarding mathematical communication skills in solving quadratic function problems by considering students' learning interests. The formulation of the problem in this research is how mathematical communication skills in solving quadratic function problems are viewed from high, medium and low student interest in learning. This research aims to determine mathematical communication skills in solving quadratic function problems in terms of students' level of interest in learning, whether high, medium or low.

METHODS

This research uses qualitative research methods with a descriptive approach. According to Lestari and Yudhanergara (2019), qualitative research is based on postpositivism philosophy, which is used to research the conditions of natural objects, with the researcher as the key instrument of the research. The research sample consisted of 29 class XI B2 students at SMAN Colomadu, Karanganyar Regency.

The research instruments used were a learning interest questionnaire, mathematical communication test questions, and interview guide sheets. The learning interest questionnaire contains 20 statements consisting of positive and negative statements. Students are categorized based on their level of interest in learning, divided into low, medium and high. The following indicators of interest in learning are presented in Table 1 below.

Table 1. Indicators of Learning Interest

Learning Interest Indicator	Information
Feelings of joy	1. Students' Feelings During Mathematics Learning 2. Students' opinions regarding mathematics learning 3. Students' impressions of mathematics teachers
Interest in learning	1. Students' curiosity when participating in learning 2. Students' responses when given assignments/homework by the teacher
Pay attention while studying	1. Pay attention when learning 2. Students' attention when discussing lessons
Engagement in learning	1. Student activity while learning mathematics 2. Students' awareness when studying mathematics at home

Subjects can be categorized according to the criteria in Table 2 below based on the indicators of interest in learning above.

Table 2. Scoring Criteria for Learning Interest Questionnaire

Final Score	Categories
$x > \bar{x} + SD$	Tall
$\bar{x} - SD \leq x \leq \bar{x} + SD$	Currently
$x < \bar{x} - SD$	Low

Information: $x = score\ obtained$

$\bar{x} = mean(average\ value)$

$SD = Standard\ Deviation$

$$Final\ Score = \frac{the\ number\ of\ questionnaire\ scores\ obtained}{maximum\ questionnaire\ score} \times 100\%$$

The subjects selected in this research were three students, including one student with a high interest in learning, 1 student with a moderate interest in learning, and 1 student with a low interest in learning. Subject selection also considers good communication skills, as conveyed by information from the teacher, so that the data obtained aligns with expectations

(Hinton et al., 2016). After identifying students' learning interests, students are given a test to determine their mathematical communication skills. The instrument for testing students' mathematical communication skills is in the form of KKM test questions and interview guidelines. The KKM questions given contain two essay test questions with quadratic function material. The following indicators of mathematical communication skills are presented in Table 3 below.

Table 3. Indicators of Mathematical Communication Skills(NCTM, 2000)

Indicators of Mathematical Communication Skills	Information
1. Explain mathematical ideas to friends, teachers and others orally and in writing clearly and concisely;	Explain their mathematical thinking and processes verbally through group discussions, class presentations, and well-structured written answers.
2. Express mathematical ideas appropriately using mathematical language;	Use of appropriate mathematical symbols and notation to explain their mathematical ideas.
3. Organize and consolidate their mathematical thinking through communication;	Organize their thoughts well and strengthen their understanding by discussing ideas with others.
4. Examining and assessing the mathematical thinking and techniques of others.	Read and evaluate other people's mathematical explanations or arguments carefully.

After students complete the KKM test questions, the next stage is to conduct an interview. This interview aims to find out the steps students took to complete the test. The next step is to draw conclusions regarding students' mathematical communication skills based on the results of answer analysis and describe students' answers from the KKM question test instrument and interview results.

The questionnaire, test, and interview instruments were validated by two people: a mathematics education lecturer and a high school mathematics teacher. The qualitative data analysis techniques used are data reduction, data presentation, and drawing conclusions. The validity of the data used is triangulation techniques using interviews.

RESULTS AND DISCUSSION

This research collected data through questionnaires, written tests and interviews. Data was obtained from 29 class XI B2 students at SMAN Colomadu, and three students were taken based on certain considerations to determine the students' mathematical communication skills.

The results of the study interest questionnaire for class XI B2 students at SMAN Colomadu are presented in Table 4.

Table 4. Results of the Interest in Learning Questionnaire

Interest in Learning	Score Criteria	Number of Students
Tall	$x > 61{,}69\%$	6
Currently	$52{,}79\% \leq x \leq 61{,}69\%$	20
Low	$x < 52{,}79\%$	3

In this research, one subject will be selected for each learning interest, which is divided into high, medium, and low. *A purposeful sampling* technique was used to determine the research subjects.

The determined research subjects will be analyzed for their mathematical communication skills based on their learning interest from the test answers and questionnaires that have been given as follows:

1. **Mathematical Communication Ability Test Results for High-Interest Students (SMT)**

The following are the SMT test answers for KKM questions number 1 and number 2, shown in Figure 1 and Figure 2 below.

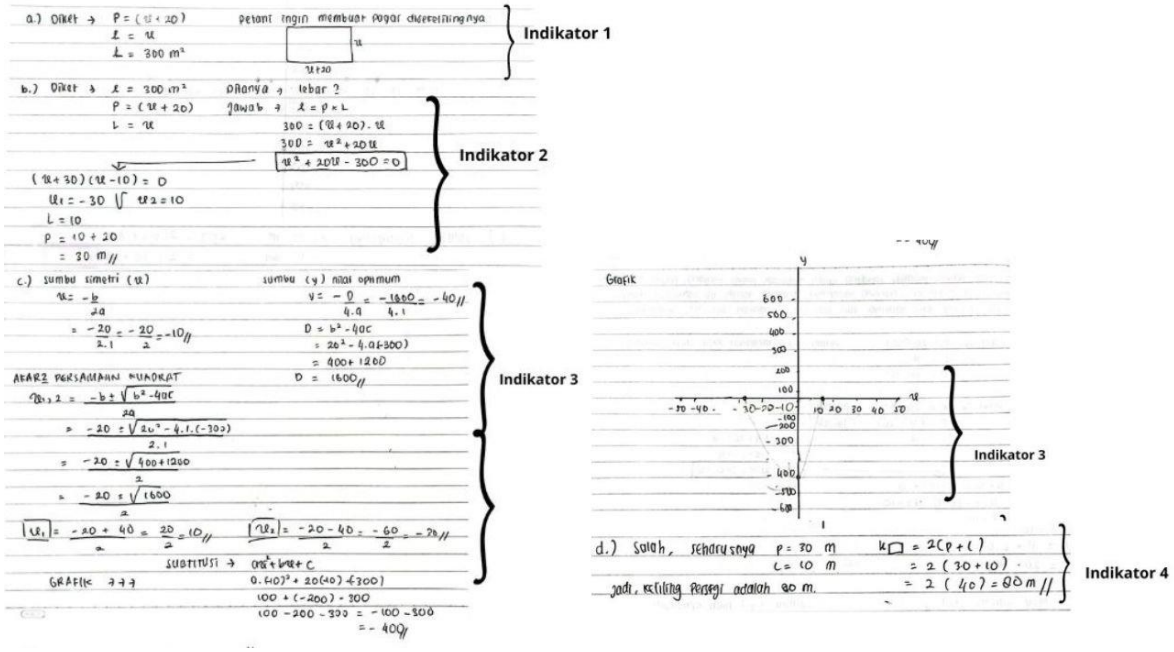

Figure 1. SMT question number 1

Below are presented the results of interview number 1 by the researcher coded "P" with the SMT subject:

P: What information can be obtained from the questions? So, do you need help illustrating this problem?

SMT: Problem number 1 is that the land area is 300 square meters, and the length of the land is 20 meters longer than the width, so I will assume x meters for the width. I did not find it difficult because the question clearly stated the information.

P: How do you determine the quadratic equation?

SMT: Because I already know the area of the rectangular land, I just plug what I know into the formula for the area of a rectangle to get the quadratic equation.

P: How do you determine the graph of a quadratic function? Are there any problems completing it?

SMT: First, I looked for the roots of the quadratic equation, then for the axis of symmetry and the optimum value, then substituted them into the equation to

get the peak point, and finally, I made a graph based on the existing points. I had no problems answering because I still remembered the material.

P: Did you solve it yourself or ask someone else?

SMT: Yes, I asked to confirm whether my answer was wrong.

P: In your opinion, is the answer to question number 1d correct?

SMT: Wrong because the length and width values should be positive. So the width = 10 m and the length is 30 m. So, the circumference is positive 80 meters.

Based on Figure 1 and reinforced by interview results, it can be analyzed in detail based on indicators of mathematical communication skills. In indicator 1, SMT can answer what information is obtained and illustrate the problem. In indicator 2, SMT can answer questions using appropriate mathematical symbols or notation based on mathematical rules. In indicator 3, SMT can solve problems by discussing them with others. In indicator 4, SMT is able to write that the statement in the question is wrong and accompanied by an argument.

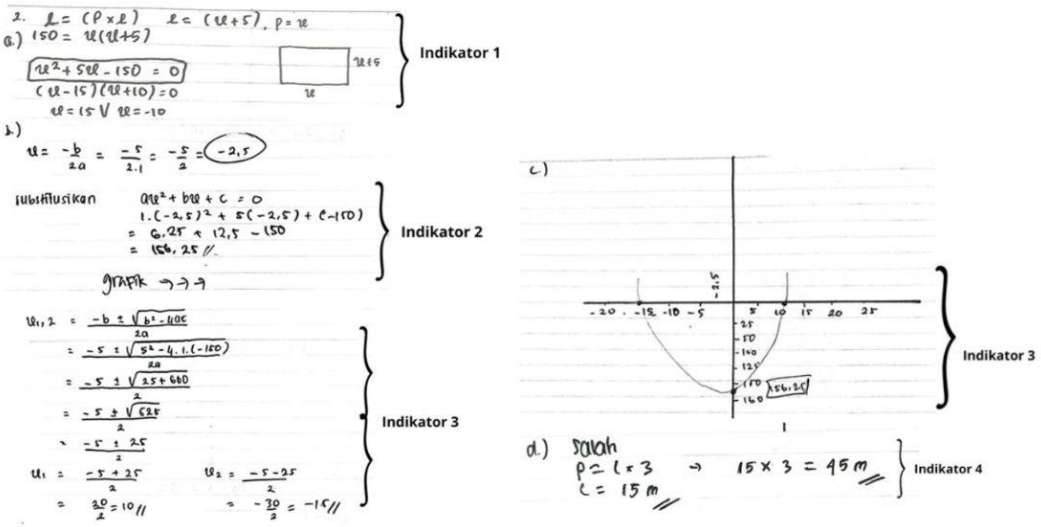

Figure 2. SMT question number 2

Below are presented the results of interview number 2 by the researcher coded "P" with the SMT subject:

P: What information can be obtained from the questions? So, do you need help illustrating this problem?

SMT: For question number 1, it is known that the shelf area is 150 square meters and the shelf width is 5 meters wider than the length, so I will assume x meters for

the length. I also did not find it difficult because the information was already in the question.

P: How do you determine the quadratic equation?

SMT: Like problem number 1, I input what is known into the formula for the area of a rectangle to get the quadratic equation.

P: Are there any problems when you determine the graph of a quadratic function?

SMT: I had no problems determining the graph because the question was similar to number 1, and I still remembered the material.

P: Do you find calculating the multiplication between negative and positive numbers difficult?

SMT: No, I do not find it difficult. For negative times negative, the result is positive; for positive times negative, the result is negative.

P: Did you solve it yourself or ask someone else?

SMT: I also asked whether my answer was correct or wrong.

P: In your opinion, is the answer to question number 2d correct?

SMT: Wrong, because what should be known is that the length = three times the width = 3l. For l, it is known that it is 15 meters, so the length is 45 meters.

Based on Figure 2 and interviews, it can be analyzed in detail based on indicators of mathematical communication skills. In indicator 1, SMT is the same as the analysis in Figure 1. In indicator 2, SMT is the same as in the analysis in Figure 1. In indicator 3, SMT can solve problems by discussing them with others. SMT needs to be more careful in writing, but SMT can answer correctly during the interview. In indicator 4, SMT is the same as the analysis in Figure 1.

So, based on students' high interest in learning in taking mathematical communication tests and interviews, they can fulfil indicators 1, 2, 3 and 4, namely (1) Explaining mathematical ideas to friends, teachers and others orally and in writing clearly and concisely; (2) Express mathematical ideas appropriately using mathematical language; (3) Organize and consolidate their mathematical thinking through communication; (4) Examining and assessing other people's mathematical thinking and techniques. This research (Nur'aini, 2022) supports this research, which

shows that students with a high interest in learning can achieve more mathematical communication indicators.

2. Mathematical Communication Ability Test Results for Medium Interest Students (SMS)

The following are the SMS test answers for KKM questions number 1 and number 2 shown in Figure 3 and Figure 4 below.

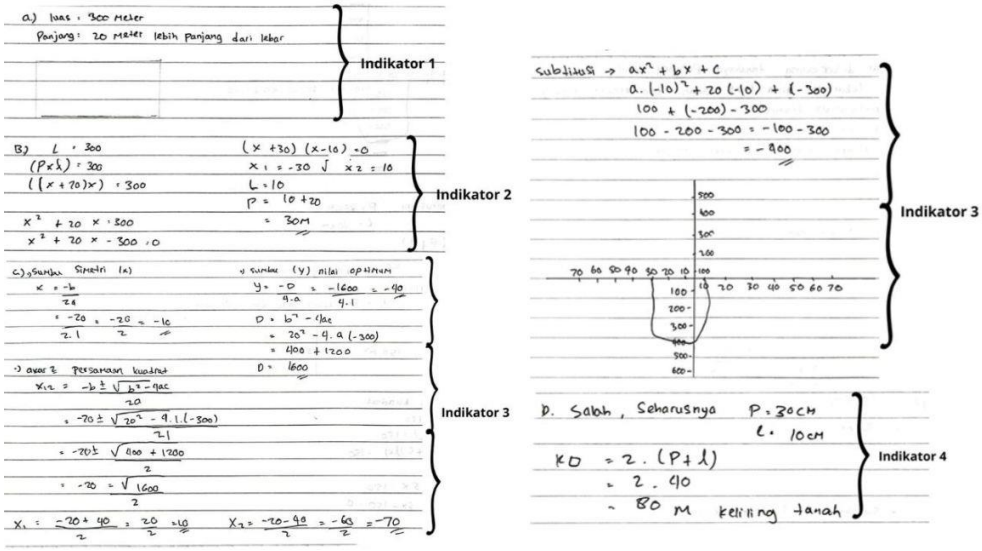

Figure 3. SMS question number 1

Below are presented the results of interview number 1 by the researcher coded "P" with the SMS subject:

P: What information can be obtained from the questions? So, do you need help illustrating this problem?

SMS: Problem number 1, which is known, is that the land area is 300 square meters, and the length of the land is 20 meters longer than its width. I need clarification about giving captions to the pictures.

P: How do you determine the quadratic equation?

SMS: I immediately entered the formula for the area of a rectangle to get the quadratic equation.

P: How do you determine the graph of a quadratic function? Are there any problems completing it?

SMS: I forgot the steps to complete it, so I discussed it with my friend.

P: Is finding the roots of the second quadratic equation correct?

SMS: It seems wrong because I saw my friend's work.

P: In your opinion, is the answer to question number 1d correct?

SMS: Wrong, because the width should be 10 m and the length 30 m. So, the circumference will be 80 meters.

Based on Figure 3 and interviews, it can be analyzed in detail based on indicators of mathematical communication skills. In indicator 1, SMS can answer what information is obtained and create an illustration of the problem, but it needs to be completed and accurate. When interviewed, SMS still needed clarification in understanding the information obtained. In indicator 2, SMS can answer questions using appropriate mathematical symbols or notation based on mathematical rules. In indicator 3, SMS can solve problems by discussing them with others, but the answers still need to be corrected. When interviewed, SMS needed clarification in explaining the arguments written. In indicator 4, the SMS can write that the statement in the question is wrong and accompanied by an argument.

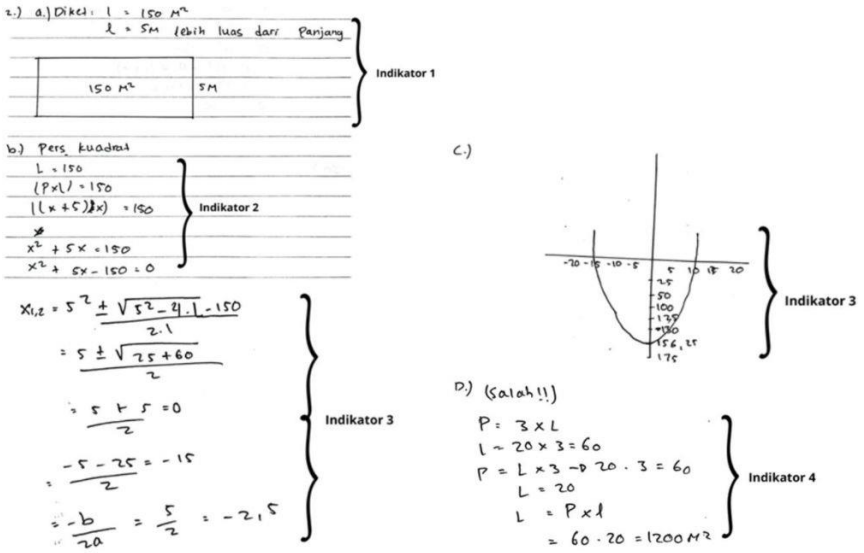

Figure 4. SMS question number 2

Below are presented the results of interview number 2 by the researcher coded "P" with the SMS subject:

P: What information can be obtained from the questions? So, do you need help illustrating this problem?

SMS: Known shelf area and shelf width. I need help to illustrate it.

P: How do you find the length?

SMS: Let me say x.

P: How do you determine the quadratic equation?

SMS: Using the formula for the area of a rectangle.

P: How do you determine the graph of a quadratic function? Are there any problems completing it?

SMS: Yes, I have difficulty graphing quadratic functions.

P: Did you solve it yourself or ask someone else?

SMS: Yes, I asked my friend.

P: In your opinion, is your answer to question number 2d correct?

SMS: Wrong, because the width should be 15 meters so the length will be 45 meters.

Based on Figure 4 and interviews, it can be analyzed in detail based on indicators of mathematical communication skills. In indicator 1, SMS is the same as the analysis in Figure 3. In indicator 2, SMS can answer questions using appropriate symbols or mathematical notation based on mathematical rules. In indicator 3, SMS can solve problems by discussing them with others, but there are errors, and the answers must be completed. When interviewed, SMS had difficulty explaining his argument. In indicator 4, SMS could not write that the statement in the question was wrong and accompanied by an argument. However, when interviewed, SMS was able to explain his argument correctly.

So, based on students' interest in learning while taking mathematical communication tests and interviews, they can fulfil indicators 2 and 4: (2) Expressing mathematical ideas appropriately using mathematical language; (4) Examining and assessing other people's mathematical thinking and techniques. This research (Nur'aini, 2022) supports this research, which shows that students with moderate interest can only achieve some mathematical communication indicators.

3. Mathematical Communication Ability Test Results for Low-Interest Students (SMR)

The following are the SMR test answers for KKM questions number 1 and number 2, shown in Figure 5 and Figure 6 below.

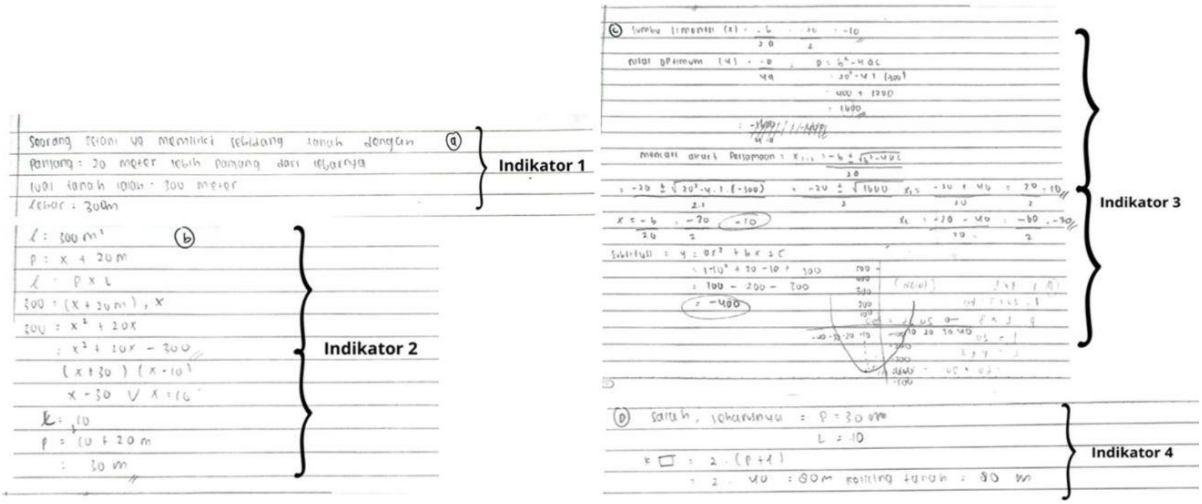

Figure 5. SMR question number 1

Below are presented the results of interview number 1 by the researcher coded "P" with the subject SMR:

P: What information can be obtained from the questions? So, do you need help illustrating this problem?

SMR: Land area, land length and width. I need clarification about illustrating it.

P: How do you determine the quadratic equation?

SMR: I immediately entered it into the formula for the area of a rectangle.

P: How do you determine the graph of a quadratic function? Are there any problems completing it?

SMR: I forgot the steps to complete it, so I looked at my friend's work.

P: In your opinion, is the answer to question number 1d correct?

SMR: It seems correct, because the width is known to be 10 m and the length 30 m. So, the circumference is 80 meters.

Based on Figure 5 and interviews, it can be analyzed in detail based on indicators of mathematical communication skills. In indicator 1, SMR can answer the information obtained and illustrate the problem, but it needs to be completed and accurate. When interviewed, SMR was still confused in answering questions. In indicator 2, SMR can answer questions using appropriate mathematical symbols or notation based on mathematical rules. In indicator 3, SMR can solve problems by discussing them with others, but there are errors, and the answers must be completed. When interviewed,

SMR had difficulty explaining his argument and the answers SMR wrote were obtained from a friend's work. In indicator 4, SMS could write that the statement in the question was wrong and accompanied by an argument. When interviewed, SMR was able to explain the argument correctly.

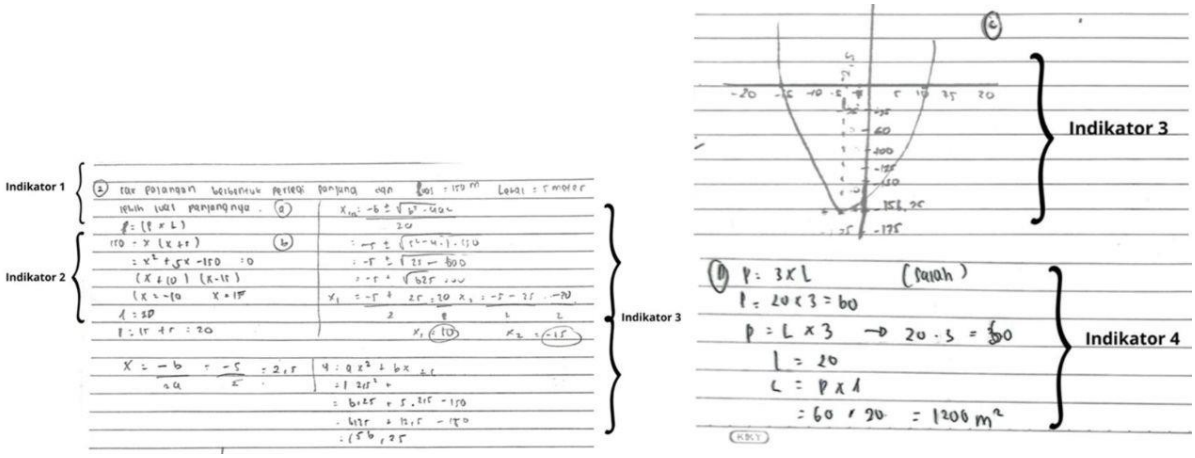

Figure 6. SMR question number 2

Below are presented the results of interview number 2 by researchers coded "P" with the subject SMR:

P: What information can be obtained from the questions? So, do you need help illustrating this problem?

SMR: Shelf area and shelf width. I had difficulty understanding the problem so I needed clarification about how to illustrate it.

P: How do you find the length?

SMR: Using an example, I will give an example with x.

P: How do you determine the quadratic equation?

SMR: Same as question number 1, enter into the formula for the area of a rectangle.

P: How do you determine the graph of a quadratic function? Are there any problems completing it?

SMR: I forgot the graph steps, so I asked my friend.

P: Is your answer to question number 2d correct?

SMR: That seems correct; because the length is three times the width, it becomes 60 meters.

Based on Figure 6 and interviews, it can be analyzed in detail using indicators of mathematical communication skills. In indicators 1, 2, and 3, SMR is the same as the

analysis in Figure 5. In indicator 4, SMR could not write that the statement in the question was wrong and accompanied by an argument. When interviewed, SMR was unable to explain his argument correctly.

So, based on students' low interest in learning in taking mathematical communication tests and interviews, they were only able to fulfil the second indicator, namely, Expressing mathematical ideas correctly using mathematical language. This finding is supported by research (Nur'aini, 2022), which shows that low-interest students experience difficulties achieving mathematical communication indicators. Researchers found different results, namely that subjects with low interest in learning could fulfil only one indicator: expressing mathematical ideas correctly using mathematical language.

CONCLUSION

Based on the results and discussion above, this research shows differences in mathematical communication abilities regarding their learning interest. Students with a high interest in learning can fulfil all indicators of mathematical communication. Students with a moderate interest in learning can fulfil some of the indicators: (2) Expressing mathematical ideas appropriately using mathematical language and (4) Examining and assessing other people's mathematical thinking and techniques. Students with low interest in learning can only fulfil one indicator, namely (2) Expressing mathematical ideas correctly using mathematical language.

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