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ANALYSIS OF VERBAL MATHEMATICAL COMMUNICATION IN OPEN-ENDED PROBLEM SOLVING

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ABSTRACT

The ability to communicate mathematical ideas orally is crucial for studying mathematics. One way to measure oral communication skills is by presenting an open-ended problem to students. This study aims to illustrate how students solve open-ended issues using oral mathematical communication skills. The methodology is a qualitative descriptive study; the subject of the research is grade VIII junior high school students with low, medium, and high levels of mathematical ability to communicate when working on open-ended problems. From this study, students who have a low level of communication ability have not met all the indicators optimally, because the understanding of symbols and their use is still weak. Students in the medium level that satisfy the markers of mathematical communication, because the notation used is appropriate and consistent and students can provide concise, clear, and thorough explanations. Students with high categories meet all indicators very well, because they are able to use complete and accurate mathematical symbol and students can provide concise, clear, and reflective explanations. Students in lower categories' have not fully satisfied all of the requirements for mathematical communication. The medium-level pupils satisfy the requirements for mathematical communication. Students with high categories meet all mathematical communication indicators very well.
Keywords: ability, oral communication, open-ended questions.

ABSTRAK

Kemampuan komunikasi matematis lisan dalam proses pembelajaran matematika sangatlah krusial, salah satu cara untuk mengukur kemampuan komunikasi lisan dengan menyajikan suatu permasalahan open ended kepada siswa. Penelitian ini bertujuan untuk mendeskripsikan kemampuan komunikasi matematis lisan siswa saat menyelesaikan masalah open-ended. Metode yang digunakan adalah penelitian deskriptif dengan pendekatan kualitatif. Subjek penelitian terdiri dari siswa kelas VIII SMP dengan tingkat kemampuan komunikasi matematis yang berbeda: rendah, sedang, dan tinggi ketika mengerjakan soal open-ended. Dari hasil penelitian, siswa dengan tingkat kemampuan komunikasi rendah belum memenuhi semua indikator secara optimal, karena pemahaman terhadap simbol dan penggunaannya masih lemah. Siswa pada tingkat sedang telah memenuhi indikator komunikasi matematis, karena notasi yang digunakan sesuai dan konsisten serta siswa dapat memberikan penjelasan yang ringkas, jelas, dan mendalam. Siswa dengan kategori tinggi memenuhi semua indikator dengan sangat baik, karena mereka mampu menggunakan simbol matematika secara lengkap dan akurat serta mampu memberikan penjelasan yang ringkas, jelas, dan reflektif. Siswa dalam kategori rendah belum sepenuhnya memenuhi semua kriteria komunikasi matematis. Sementara itu, siswa tingkat sedang memenuhi kriteria komunikasi matematis, dan siswa kategori tinggi memenuhi seluruh indikator komunikasi matematis dengan sangat baik.
Kata kunci: kemampuan, komunikasi lisan, soal open-ended.

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INTRODUCTION

Communication is an interaction between humans that includes transmitting information between individuals in a multi-directional manner. (Marniati et al., 2021). A school as an institution is inseparable from the interaction that takes place between the elements within it. (Lubis et al., 2023). Learning carried out in the classroom is an example of communication activities, because there are activities to exchange information in the form of messages, ideas, thoughts, understandings, and experiences about a material that is studied together, especially in mathematics learning.

Communication skills in the context of learning mathematics are a fundamental aspect that is often referred to as mathematical communication. (Simorangkir et al., 2024). Mathematical communication skills are skills that include various activities such as giving logical justifications for a claim, transforming a description into a mathematical model, and providing examples of mathematical concepts in the form of relevant descriptions. (Hartinah et al., 2019). The information in mathematical communication can be conveyed either in writing or verbally. (Ats-Tsauri et al., 2021). Mathematical communication in the context of learning mathematics is crucial. However, even so, students still have difficulty in communicating their thoughts when solving math problems. (Sandy et al., 2022). Students still have difficulty when using their language to convey ideas about one concept to another, so they are still in the low category. (Ayu et al., 2023). The problem of verbal mathematical communication among students has become a focus of attention in mathematics education, given the importance of this ability in facilitating a deeper understanding of mathematical concepts. According to research Syamsyiah et al., (2022), showing that the verbal capacity of students to convey their mathematical concepts vocally is known as mathematical communication, which plays a crucial role during learning activities, especially when it is expected of pupils to be able to solve mathematical problems systematically and clearly

The indicators used in this study were adopted from the study. Aini & Setianingsih (2022) Because the indicator has represented the other two indicators, namely: a) Using mathematical notation and its to convey concepts in actual situations or circumstances (Mathematical Expression), b) Interpreting mathematical ideas both verbally and in visual form as images or graphs (Drawing), c) Putting mathematical concepts into words in writing and verbally (Written Text).

The indicators are classified again in detail into markers of mathematical communication, both in writing and when spoken, which are as follows:

Table 1. Mathematical Communication Indicators

Written Mathematical Communication Indicators	**Indicators of Verbal Mathematical Communication**
Write with mathematical notation and its structure to present ideas in real situations or circumstances (Mathematical Expression).	Using mathematical notation and its structure orally, it is used to convey concepts in actual situations or circumstances (Mathematical Expression).

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Interpret mathematical ideas in visual form, in the form of drawings (Drawing).	Interpreting mathematical ideas orally (Drawing).
Expressing mathematical ideas in writing (Written Text).	Expressing mathematical ideas orally (Written Text).

Difficulties in oral mathematical communication were also found during an interview with a teacher in Pamekasan. The teacher revealed that pupils typically have poor verbal communication skills in mathematics, which is due to the lack of students' courage to communicate and students' hesitation to convey their ideas. There is a difference in the pattern of student interaction when solving math problems, especially between male and female students, where female students tend to be more active in asking questions about things that they do not understand. At the same time, male students tend to be silent and try to solve their problems.

One way to measure this verbal communication ability is to present an open-ended problem to students. A problem, open-ended or also called an open problem, is an issue that is designed to have several correct answers. (Natassya, et al 2023). Answers to problems epen ended it is categorized into three, namely, first there is a problem where there is one answer that can be reached in many ways, second there is a problem that can be solved using one method that results in various kinds of answers, and finally a problem is presented that can be taken by sharing ways and producing multiple answers as well. (Arilaksmi et al., 2021). Problems *Open Ended.* This can provide stimulation to students so that they can answer problems in mathematics through their ideas, and so that their mathematical communication skills can be expressed both orally and in writing. (Mulyawan et al., 2023).

Problem implementation ended. It encourages students to not only be able to write down their answers, but also to be able to communicate their thoughts orally through interviews. The presentation of the problem, open-ended in mathematics, allows students to participate actively in the problem-solving process. Students will be faced with issues that do not have a single answer, so students are encouraged to come up with various solutions and strategies that reflect their understanding. (Hadi et al., 2023). This process is essential in building verbal mathematical communication skills, as students must express and share their thoughts clearly and logically with others. (Kurniawan & Darmono, 2021).

Problem open-ended can stimulate students to think openly, so that students can express their opinions and ideas to others (Syamsyiah et al., 2022). This is consistent with studies that have been done by Noor (2020), focused on mathematical communication and problem-solving skills, open-ended, which is aimed at primary school pupils and provides them the chance to communicate their thoughts and ideas, which is the first step in learning how to communicate mathematical ideas.

Previous research has been conducted on mathematical communication skills and the application of open-ended problems through problem solving, which consists of one of the categories of answers in open-ended problems. The specifications are where this study

differs from earlier research in the discussion, which focuses on oral mathematical communication skills and the application of open-ended problems through problem solving, consisting of two categories of answers to open-ended issues. Based on the problems that have been described, the purpose of this study is to examine students' verbal mathematical communication skills in solving open-ended problems

METHOD

The research of this kind is qualitative. This research descriptively explains the ability of oral communication by providing an open-ended problem to students in class VIII-G at SMPN 2 Pamekasan. The research participation consisted of 31 students in grades VIII- G. The subjects chosen were three students in grades VIII-G with high, medium, and low levels of communication skills. The selection of research subjects uses a random technique where students are given an open-ended question test, which is then taken by one subject in each category.

The data techniques used in this research are voice recordings during interviews and video recordings of students during the interview process, which aim to collect further data so that they can dig deeper into the strategies used by students in solving open-ended problems. The interviews were also conducted to find out about students' oral communication. The information obtained is then systematically analyzed to draw a valid conclusion. This research uses a data research tool in the form of an open-ended question test. The interview guidelines and data collection tools have previously been validated by two experts who will be used during the study.

This study's data analysis is predicated on the findings of Miles and Huberman in (Harahap, 2020) Which includes data reduction, data presentation, and conclusions. The data used to be reduced in this study, namely through test methods and interviews with research subjects, were thoroughly evaluated to identify significant and relevant aspects. The categories used in the study are:

Table 2. Categories of written mathematical communication skills test

Test Result Score (X)	Category: Student Written Communication Skills
$0 \leq X < 65$	Low
$65 \leq X < 80$	Keep
$80 \leq X \leq 100$	Tall

(Febriana et al., 2024)

RESULT AND DISCUSSION

RESULT

The results of the study were obtained through observations of participants, namely three students of grade VIII. The implementation of the research was carried out in two meetings on the following days and dates: Tuesday, February 4, 2025, and Wednesday, February 5, 2025. The data obtained included the results of the examination of written communication abilities through open-ended problems and the results of interviews with each student, and in the form of video recordings during the implementation.

Based on the results of the analysis of tests and interviews that have been conducted, students who are included in the categories of low, medium, and high communication skills were selected, with one subject chosen in each category.

1. Subject S1

The S1 subject managed to solve the questions given, but the answers presented were still not correct. The results of the open-ended question test to assess the degree of mathematical communication in writing in S1 are presented in Figure 1 below.

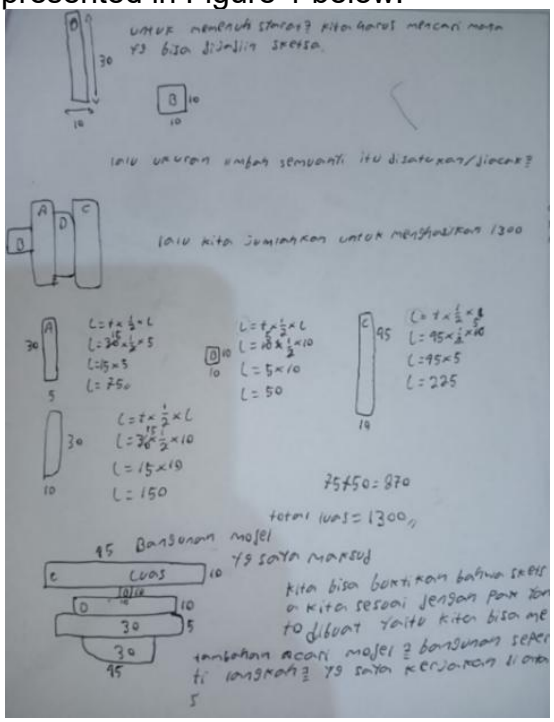

Figure 1. S1 subject's mathematical communication ability test

The findings from the examination of the mathematical communication of the S1 subject presented in Figure 1, it shows that S1 has not been able to write the answer correctly, there is a mistake in the use of the formula in finding the area so that it results in a discrepancy with the requirements of the question and produces incorrect calculations. The use of the same notation for all wood waste results in difficulties in identifying the area of the building and the accuracy when looking for the answer to the problem. S1 has not been able to describe the sketch in accordance with the requirements of the question, in meeting the overall area. It can be seen that S1 has not been able to meet the requirements due to the misuse of formulas, which has an impact on the wrong interpretation of mathematical concepts represented with sketch drawings at the time of proving the size of the sketch. S1 is not able to understand the problem as a whole. S1 can write down the steps used, but not in a sequential and structured manner. Furthermore, a deeper analysis was carried out through interviews to determine the level of oral communication abilities in mathematics of S1. These are the outcomes of interviews with researchers with low mathematical communication skills for S1 subjects.

Table 3. Interview results with S1 subjects

Researcher (P)	What information can you get from the questions?
S1	Area of wood waste A, B, C, D Overall area 1300 m^2
Researcher (P)	What is the mathematical notation you use in solving problems?
S1	Is a kind of point at which to search for the area.
Researcher (P)	Explain if there are any difficulties in writing mathematical terms and symbols when working on the problem.
S1	There is, forgetting the broad formula.
Researcher (P)	How do you relate mathematical concepts to problems?
S1	Broad
Researcher (P)	What are the ideas, strategies, or steps you

	used to solve the problem?
S1	First, drawing building models Second, looking for a wide range Third, I prove that the model building has an area of 1300
Researcher (P)	What are the steps you use to solve the problem? Do you think the explanation has been structured?
S1	Enough, but still confused about determining the area
Researcher (P)	What is this symbol, and what does it mean?
S1	L represents the area.
Researcher (P)	Why do you use this symbol?
S1	Because it is up to you to use it.
Researcher (P)	Is the information in the question enough to describe the visual shapes that represent mathematical concepts?
S1	The question should be added to the size of the area of each wood waste.
Researcher (P)	How to obtain the illustration image?
S1	Consolidating wood waste
Researcher (P)	Explain if there are any difficulties in creating drawings or sketches that are relevant to the problem.
S1	None
Researcher (P)	What image is this? Why did you choose to draw like this?
S1	Sketch drawings for building models and I use this image because I think it would be easier to depict it at an angle.

Based on the results of the interview, S1 did not fully understand the question, so he was not able to answer the interview questions appropriately and explain them sequentially. The first indicator is to communicate concepts orally using mathematical language and its structure in real situations or circumstances (Mathematical Expression). S1 recognizes the mathematical symbol (L for area) but has not fully understood and explained the mathematical structure. Subject S1 in the use of basic formulas has errors, thus hindering the proper use of notation and structure, as well as the reason for using symbols that are not based on mathematical needs, but rather personal choices that show a lack of understanding of the use of notation functions.

The second indicator is interpreting mathematical ideas orally (Drawing). Subject S1 is able to connect images using visual concepts, although they are not provided with detailed information about the shape and size of each piece. S1 explained the use of slanted sketch drawings that are personal but show that there is an initiative in visualizing concepts, even though they are not yet mathematical. There is a use of imagination in sketch models, such as building models.

The third indicator is expressing mathematical ideas orally (Written Text). The S1 subject conveyed ideas

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in solving problems orally, even though it was still relatively simple and had not yet collapsed. S1 is able to reflect on their thinking process and can provide criticism of problems. Overall, the explanation of the process is relatively easy to follow, although it is not in-depth in the mathematical aspect.

2. Subject S2

The S2 subject successfully solved the questions given, but the answers presented still need to be explored more deeply in the explanation. The results of the open-ended question test to assess the degree of mathematical communication in writing in S2 are presented in Figure 2 below.

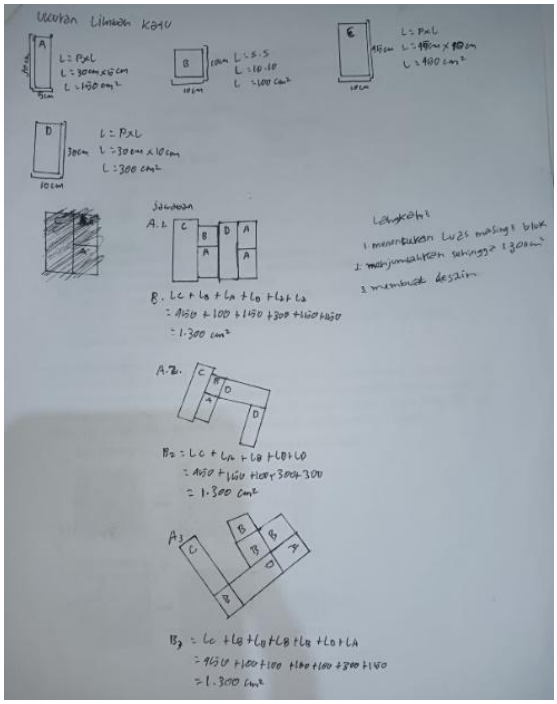

Figure 2. S2 subject's mathematical communication ability test

The results of the mathematical communication analysis of S2 subjects presented in Figure 2 show that S2 can write answers correctly, but not in full detail. S2 subjects used the same notation when looking for an area calculation for all wood waste, resulting in difficulty in identifying the area of the building and accuracy when looking for an answer to the problem. S2 adds waste information to the area of each waste to determine the overall sketch area. S2 is able to make a good and unique visualization of sketch drawings according to the requirements of the question. S2 can write down steps, but cannot explain the steps in a complete and structured way. Furthermore, a deeper analysis was carried out through interviews to determine the level of oral mathematical communication skills of S2. These are the outcomes of interviews with researchers with low mathematical communication skills for S2 subjects.

Table 4. Interview results with S2 subjects

Researcher (P)	What information can you get from the questions?
S2	Length and width A, Side B, Length and width of block C, Length and width of block D, It is required to design from the block with the number $130cm, with\ blocks\ A, B, C,$
Researcher (P)	What is the mathematical notation you use in solving problems?
S2	L is an area; each area is sought to determine the design to be made.
Researcher (P)	Explain if there are any difficulties in writing mathematical terms and symbols when working on the problem.
S2	Not
Researcher (P)	How do you relate mathematical concepts to problems?

S2	The concept of area is used to determine areas A, B, C, and D. Block A uses the rectangular area concept, Block B uses the square area concept, Block C uses the rectangular area concept, and Block D uses the rectangular area concept.
Researcher (P)	What are the ideas, strategies, or steps you used to solve the problem?
S2	Determine the area of each block, then sum it up to 1300, and make a design. The four blocks must be used, because the number of the four blocks has not met 1300, and there is more than one block.
Researcher (P)	What are the steps you use to solve the problem? Do you think the explanation has been structured?
S2	Already
Researcher (P)	What is this symbol, and what does it mean?
S2	L represents when caulating the ara fthe blo$AL_A, L_B, L_C, denote L_D$ denotes the area of block A, the area of block B, the location of block C, the area of block D
Researcher (P)	Why do you use this symbol?
S2	Using L because A symbolizes the set caol these $L_A, L_B, L_C, set L_D$ use,d to make it easier
Researcher (P)	Is the information in the question enough to describe the visual shapes that represent mathematical concepts?
S2	Yes, that's enough
Researcher (P)	How to obtain the illustration image?
S2	Using imagination
Researcher (P)	Explain if there are any difficulties in creating drawings or sketches that are relevant to the problem?
S2	There is, if we want to add up to 1300 then we need to specify the area of each of the blocks.
Researcher (P)	What image is this? Why did you choose to draw like this?
S2	Figure 1: Illustration of the shape of the wall display Figure 2: Illustration of the shape of the chair holder Figure 3: Illustration of unique shapes Use all three images to make them look unique.

Based on the results of the S2 interview. The first indicator is to use mathematical notation and its structure orally to present ideas in real situations or circumstances (Mathematical Expression). S2 uses mathematical symbols precisely and consistently, and the symbol structure used has a mathematical and consistent meaning. The explanation given by S2 shows an understanding of the structure of mathematical notation and its function in solving problems well.

The second indicator is interpreting mathematical ideas orally (Drawing). Subject S2 visualized the

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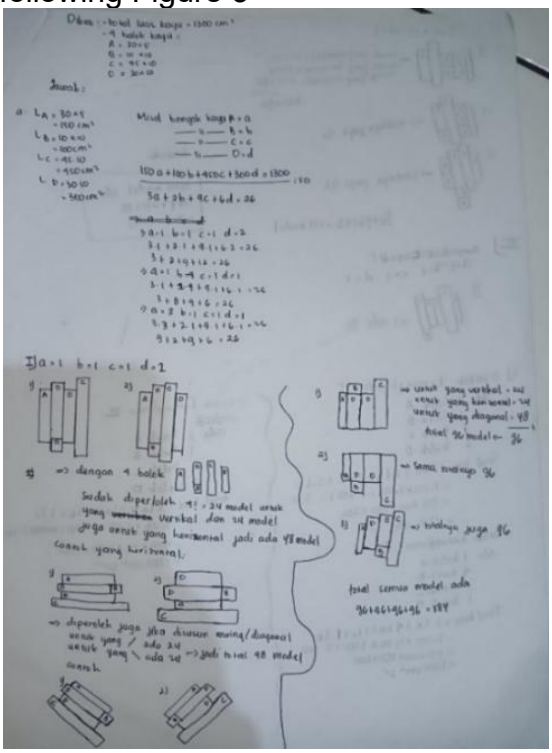
sketch image well in real form. S2 is aware that area calculations play an essential role in validating the pictures made so that they can connect the photos with mathematical concepts logically and use the basis of mathematical considerations.

The third indicator is expressing mathematical ideas orally (Written Text). S2 subjects can communicate verbally in a structured and systematic manner through the concepts, strategies, and procedures used. S2 also uses the right terms and is aware of the terms and limitations in the question.

3. Subject S3

S3 subjects completed the questions given sequentially and systematically. The results of the open-ended question test to assess the degree of mathematical communication in writing in S3 are presented in the following Figure 3



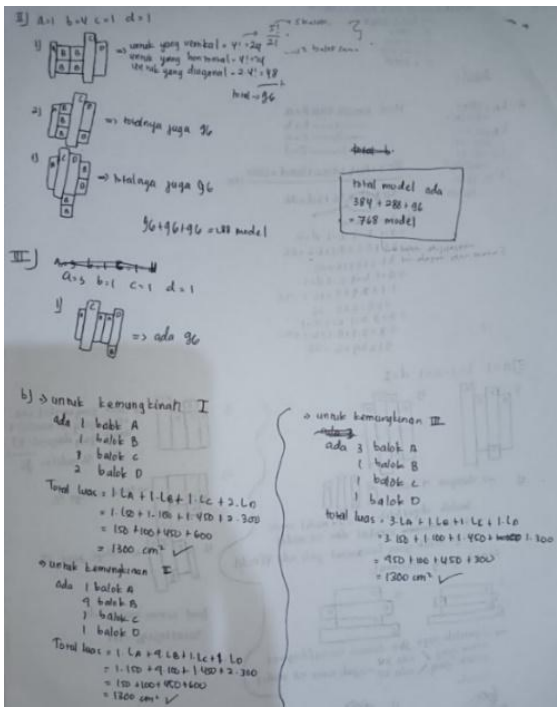


Figure 3. S3 subject's mathematical communication ability test

The results of the analysis of the mathematical communication of the S3 subjects presented in Figure 3 show that S3 can write the answers correctly and systematically. S3 subjects can use different notations for each different money example well and consistently. S3 can prove all sketches correctly according to the requirements of the question by using complete and correct area units. S3 is able to make a variety of sketches and calculate the possible number of variations in the placement of the blocks vertically and horizontally for each sketch drawing it creates. S3 is able to pour out his various ideas in the form of coherent and easy-to-understand sentences. S3 uses multiple concepts to solve existing problems, so the answers given are very unique. Furthermore, a deeper analysis was carried out through interviews to determine the level of oral communication abilities in mathematics of S3. These are the outcomes of interviews with researchers with low

mathematical communication skills for S3 subjects.

Table 5. Interview results with S3 subjects

Researcher (P)	What information can you get from the questions?
S3	Size of each wood waste The area that must be created is 1300 All four models must be present.
Researcher (P)	What is the mathematical notation you use in solving problems?
S3	L_A, L_B, L_C, L_D to represent the area Suppose there is much wood A with a, a lot of wood B with b, a lot of wood C with c, and a lot of wood D with d.
Researcher (P)	Explain if there are any difficulties in writing mathematical terms and symbols when working on the problem.
S3	None
Researcher (P)	How do you relate mathematical concepts to problems?
S3	Because the amount of area 1300 so much wood is multiplied by each area ,so that if added together ,i t will be Using the concept of rectangular and square area 1300
Researcher (P)	What are the ideas, strategies, or steps you used to solve the problem?
S3	Suppose there are many woods in each type, then find the area using the equation with each wood area multiplied by the example, and look up the number, namely 1300
Researcher (P)	What are the steps you use to solve the problem? Do you think the explanation has been structured?
S3	Structured, even though it is a bit difficult to understand
Researcher (P)	What is this symbol, and what does it mean?
S3	L_A i.e., the area A L_B i.e. the area B L_C i.e. the width of C L_D i.e. the area D a i.e. a lot of wood A b i.e. a lot of wood B c is a lot of wood C, d is a lot of wood D.
Researcher (P)	Why do you use this symbol?
S3	To make it easier to remember and not be confused
Researcher (P)	Is the information in the question enough to describe the visual shapes that represent mathematical concepts?
S3	Already
Researcher (P)	How to obtain the illustration image?
S3	It is arranged to be like a box, then rotated so that it can be changed.

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Researcher (P)	Explain if there are any difficulties in creating drawings or sketches that are relevant to the problem?
S3	Ada was confused about finding the correct size.
Researcher (P)	What image is this? Why did you choose to draw like this?
S3	Figure 1 is a picture of the clock Figure 2 is where the pencil case is
Researcher (P)	What is your thought process, so that it can be thought of to find the total model that exists?
S3	Appears on its own when working
Researcher (P)	Try to explain what the 2nd image means?
S3	Since block B has 2, we can combine them into one. Then because the blocks are arranged there are 5 arrays side by side so that there are likely to be many 5! and there are the same elements, namely 2, so it is divided by using permutations of the same element.2!

In light of the S3 interview's findings. The first indicator uses mathematical notation and its structure orally to present ideas in real situations or circumstances (Mathematical Expression). S3 is able to use notation appropriately and systematically, as well as describe the understanding of the relationship between variables and constants. The symbols used reflect the ability to think abstractly using reasoning and algebraic models.

The second indicator is Interpreting mathematical ideas orally (Drawing). The S3 subject was able to make a good visualization and relate it to the combinatoric concept; this shows that there is a deep understanding of order in the arrangement. The interpretation of sketch drawings is not only descriptive but also analytical, as the image is viewed as a mathematical representation (the sum of compositions and combinatoric concepts).

The third indicator is expressing mathematical ideas orally (Written Text). S3 subjects are able to communicate orally quite smoothly, and there is a reflection on the way they think. S3 also revealed "self-emergence while working," which is a reflective, intuitive form, where S3 realizes how solutions can evolve through the export process. S3 is able to provide an explanation that is quite understandable.

DISCUSSION

Based on the above analysis results, oral mathematical communication has a very close relationship with open-ended questions, because both support each other in developing students' thinking skills and conveying ideas (Rivai et al., 2021). Open-ended questions, with their characteristics that require the exploration of various solution strategies, encourage students to express their thought process openly through verbal explanations as well as representations of notation, and pictures (Putri et al., 2022). Verbal mathematical communication skills include not only the delivery of final answers but also symbolic

explanations, visualization of ideas, and in-depth logical argumentation (Harianja et al., 2020). Thus, open-ended questions provide a stimulus that stimulates the emergence of diverse mathematical concepts, so that students are encouraged to articulate the thought process and their solution strategy in depth (Siregar et al., 2020). This demonstrates that proficiency in mathematics communication is essential in the context of effective mathematical learning.

Research shows that students with a deep understanding of mathematical concepts tend to be able to integrate a variety of concepts and strategies, including combining knowledge from different fields such as algebra and permutation techniques into the solutions they generate when working on open-ended problems. (Sormin & Ratuanik, 2023). On the other hand, students who lack an in-depth understanding of concepts often have difficulty in composing reasoning, using proper notation, and organizing ideas systematically in oral form. (Hundeland et al., 2020). These findings confirm that mastery of mathematical concepts is a very crucial foundation in solving open-ended problems, where the ability to connect and explain various concepts is essential.

Interviews in this study show that open-ended questions can encourage pupils to communicate their mathematical concepts through symbolic explanations, pictures, and logical oral narratives, improving critical thinking skills as well as verbal mathematical communication skills, which are essential indicators in mathematics learning. (Prayitno et al., 2021). Thus, the existence of open-ended questions serves as a stimulus to develop these skills. In contrast, oral mathematical communication skills allow students to convey and account for their thought processes more clearly and creatively. (Fadhillah & Hernawati, 2019).

CONCLUTION

The data analysis findings indicated that students' verbal mathematics communication abilities in the low category did not meet all the indicators of mathematical communication in the best possible way. Additionally, the mathematical communication abilities of students in the medium category meet the indicators of mathematical communication. And students with high categories meet all mathematical communication indicators very well.

REFERENCES

Aini, A.N. and Setianingsih, R. (2022) 'Kemampuan Komunikasi Matematis Siswa SMA dalam Menyelesaikan Masalah Matematika Ditinjau dari Self-Confidence', *MATHEdunesa*, 11(3), pp. 812–825. Available at: https://doi.org/10.26740/mathedunesa.v11n3.p812-825 .

Arilaksmi, N.P.G., Susiswo and Sulandra, I.M. (2021) 'Kemampuan Berpikir Kreatif Mahasiswa Pendidikan Matematika dalam Memecahkan Masalah Open-Ended Trigonometri', *JIPM (Jurnal Ilmiah Pendidikan Matematika)*, 9(2), pp. 46–58. Available at: https://doi.org/10.25273/jipm.v9i2.8331 .

Ats-Tsauri, M.S. *et al.* (2021) 'Modul Relasi dan Fungsi Berbasis Kemampuan Komunikasi

Matematis', *JNPM (Jurnal Nasional Pendidikan Matematika)*, 5(1), pp. 109–124. Available at: https://doi.org/10.33603/jnpm.v5i1.3569

Ayu, N.M. *et al.* (2023) 'Komunikasi Matematis Lisan, Pemahaman Konseptual Dan Motivasi Belajar Dalam Pembelajaran Matematika Menggunakan Media Quizizz', *AKSIOMA: Jurnal Program Studi Pendidikan Matematika*, 12(3), pp. 3375–3386. Available at: https://doi.org/10.24127/ajpm.v12i3.7207

Fadhillah, F.M. and Hernawati, E. (2019) 'Analysis of Mathematical Communication Ability and Self Regulated Learning Mathematics Student'S of Class Ix Smp Negeri 2 Cilamaya Kulon', *(Jiml) Journal of Innovative Mathematics Learning*, 2(1), pp. 18–28. Available at: https://doi.org/10.22460/jiml.v2i1.p18-28

Febriana, N., Mairing, J.P. and Sugiharto (2024) 'Kemampuan Komunikasi Matematis Siswa pada Fungsi Eksponensial Kelas X SMA', *Jurnal Pendidikan*, 24(2), pp. 147–156. Available at: https://doi.org/10.52850/jpn.v24i2.10945

Hadi, H.S. *et al.* (2023) 'Students' Mathematical Communication Ability In View From The Numbered Heads Together (NHT) Cooperative Learning Model Using The Open Ended Approach', *Jurnal Simki Pedagogia*, 6(2), pp. 374–385. Available at: https://doi.org/10.29407/jsp.v6i2.282

Harahap, N. (2020) *Penelitian Kualitatif*, *Wal ashri Publishing*. Edited by H.S. M.A. Medan. Available at: http://repository.uinsu.ac.id/9105/1/Buku Metodologi Penelitian Kualitatif Dr. Nursapia Harahap%2C M.Hum.Pdf.f.

Harianja, J.K., Hernadi, S.L. and Indah, I. (2020) 'Students' mathematical conceptual understanding and its relation to the mathematical communication skills', *JP3M (Jurnal Penelitian Pendidikan dan Pengajaran Matematika)*, 6(1), pp. 1–12. Available at: https://doi.org/10.37058/jp3m.v6i1.1207

Hartinah, S., Suherman, S. and Syazali, M. (2019) 'Probing-Prompting Based on Ethnomathematics Learning Model : The Effect on Mathematical Communication Skills', 7(4), pp. 799–814. Available at: https://doi.org/10.17478/jegys.574275

Hundeland, P.S., Carlsen, M. and Erfjord, I. (2020) 'Qualities of mathematical discourses in kindergartens', *ZDM - Mathematics Education*, 52(4), pp. 691–702. Available at: https://doi.org/10.1007/s11858-020-01146-w

Kurniawan, H. and Darmono, P.B. (2021) 'Use of Open-Ended Student Worksheet to Improve Mathematics Communication Skills in Algebra', *International Journal for Innovation Education and Research*, 9(5), pp. 402–416. Available at: https://doi.org/10.31686/ijier.vol

9.iss5.3106.

Lubis, R.N., Meiliasari and Rahayu, W. (2023) 'Kemampuan Komunikasi Matematis Siswa pada Pembelajaran Matematika', *Jurnal Riset Pembelajaran Matematika Sekolah*, 7(2), pp. 23–34. Available at: https://doi.org/10.21009/jrpms.072.03

Marniati, Jahring and Jumriani (2021) 'Analisis Kemampuan Komunikasi Matematis Siswa Dalam Memecahkan Masalah Berdasarkan Motivasi Belajar Siswa', *AKSIOMA: Jurnal Program Studi Pendidikan Matematika*, 10(2), pp. 880–890. Available at: https://doi.org/10.24127/ajpm.v10i2.3523

Mulyawan, M.I., Setiani, Y. and Hadi FS, C.A. (2023) 'Efektivitas Pendekatan Open-Ended pada Pembelajaran Matematika untuk Meningkatkan Kemampuan Berpikir HOTS Matematis Siswa SMP', *Jurnal Cendekia : Jurnal Pendidikan Matematika*, 7(1), pp. 421–431. Available at: https://doi.org/10.31004/cendekia.v7i1.1911

Natassya, H.D., Utami, R.E. and Kusumaningsih, W. (2023) 'Analisis Kemampuan Berpikir Kritis Siswa dalam Menyelesaikan Soal Tipe Open Ended Ditinjau dari Motivasi Belajar pada Materi SPLTV', *Jurnal Kualita Pendidikan*, 4(1), pp. 47–53. Available at: https://doi.org/10.51651/jkp.v4i1.344

Noor, N.L. (2020) 'Peningkatan Kemampuan Komunikasi Matematis Peserta Didik Melalui Open Ended Problem', *ELEMENTARY: Islamic Teacher Journal*, 8(2), pp. 209–224. Available at: https://doi.org/10.21043/elementary.v8i2.8138

Prayitno, S. *et al.* (2021) 'Analyzing the Ability of Mathematics Students as Prospective Mathematics Teachers on Multiple Mathematical Representation', *Proceedings of the 2nd Annual Conference on Education and Social Science (ACCESS 2020)*, 556, pp. 309–313. Available at: https://doi.org/10.2991/assehr.k.210525.096

Putri, M.A.K. *et al.* (2022) 'Bagaimana Siswa Dapat Berkomunikasi Dalam Memecahkan Masalah Matematika?', *AKSIOMA: Jurnal Program Studi Pendidikan Matematika*, 11(4), pp. 3105–3118. Available at: https://doi.org/10.24127/ajpm.v11i4.5754

Rivai, M.A., Mardiyana and Slamet, I. (2021) 'An Analysis of Mathematical Communication Ability on Solving Open Ended Problems in Linier Equation System with Two Variables An Analysis of Mathematical Communication Ability on Solving Open Ended Problems in Linier Equation System with Two Variables', *Journal of Physics: Conference Series PAPER*, pp. 1–8. Available at: https://doi.org/10.1088/1742-6596/1776/1/012015

Sandy, D.N. *et al.* (2022) 'Pengembangan Flipbook Bermuatan Literasi Numerasi untuk Meningkatkan Kemampuan Komunikasi Matematis', *Jurnal Tadris*

Matematika, 5(2), pp. 135–148. Available at: https://doi.org/10.21274/jtm.2022.5.2.135-148

Simorangkir, R.I.S. *et al.* (2024) 'Upaya Peningkatan Kemampuan Komunikasi Matematis dan Kecerdasan InterpesonalDengan Penggunaan Pembelajaran Tutor Sebaya di SMK N 2 Medan', *Journal on Education*, 6(4), pp. 19849–19858. Available at: https://doi.org/10.31004/joe.v6i4.6021

Siregar, N., Fauzi, K.A. and Hasratuddin, H. (2020) 'Pengembangan Bahan Ajar Berbasis Pembelajaran Matematika Realistik Untuk Meningkatkan Kemampuan Komunikasi Matematis Siswa', *JPM : Jurnal Pendidikan Matematika*, 6(2), pp. 70–77. Available at: https://doi.org/10.33474/jpm.v6i2.6917

Sormin, R.P.A. and Ratuanik, M. (2023) 'Analysis Of Students' Mathematical Representation Ability In Solving Divergen Mathematics Problems In View', *Jurnal Eduscience (JES)*, 10(1), pp. 264–272. Available at: https://doi.org/10.36987/jes.v10i1.3805

Syamsyiah, Z.M., Amelia, S. and Maarif, S. (2022) 'Kemampuan Komunikasi Matematis: Sebuah Systematic Literature Review dengan Analisis Bibliometrik Menggunakan Vos Viewers', *Jurnal Pendidikan Matematika (JPM)*, 8(2), pp. 114–128. Available at: https://doi.org/10.33474/jpm.v8i2.16352