Mathematical communication skills in solving block and cube problems

Zulhelmi\textsuperscript{1} and Anwar\textsuperscript{1}

\textsuperscript{1}Magister of Mathematics Education, Syiah Kuala University, Banda Aceh

E-mail: anwarramli@unsyiah.ac.id

Abstract. Mathematical communication skills are required for understanding the lessons given by teachers. Students’ low mathematical communication skills are due to their lacking participation in learning or they are rarely allowed to ask or express their opinions. Learning process is still only the teachers teaching in front of the classroom and assigning tasks to students resulting in mathematical communication skills have not been able to be conveyed properly. This research aims to describe students' written mathematical communication skills in solving cuboid and cube problems and to find out factors that influence mathematical communication skills. The research was descriptive means it explained and described students’ mathematical communication skills based on their indicators. The methods used were tests and non-test to see the students’ ability and to observe how students expressed opinions based on the answers they have written. The results showed that the problems faced by moderate and low ability students related to aspects of writing and drawing and the difficulty of expressing mathematical ideas. Highly qualified students had fulfilled all aspects of mathematical communication skills, namely writing, drawing, and mathematical expression in presenting mathematical ideas in solving math problems.

1. Introduction
A school is a place where an interaction between teachers and students takes place as an effort to improve the quality of education. Besides, a school is also a place where students get formal science which enable them conveying knowledge to others. In math learning, one of the skills the students need to have is mathematical communication skills. They are useful for students as they can express their thoughts both verbally and in writing in communicating ideas with symbols, tables, and diagrams, or other media to clarify the circumstances or problems [1].

Mathematical communication skills play an important role in mathematics learning; therefore students need to develop the skills. Mathematical communication skills are a way of sharing ideas and clarifying an understanding so that ideas become objects of reflection, purification, discussion, and amendment. Communication helps build meaning and immortality for ideas and make them public [2].

Communication is a way of giving students an idea to clarify an understanding which then to be reflected, improved, discussed, and developed. In this case, students will be challenged to think and design their creative ideas and be motivated to learn math. Therefore, having adequate mathematical communication skills is essential for every student and math teacher.

In the mathematics learning in school, mathematics communication can take place between teachers and students, between books and students, and between students and students as the way to present ideas
in a certain way. This has been the main reason why the skills are vital in teaching and learning mathematics in schools.

[3] argued that communication functions for teachers include: (a) being aware of the conception of teacher communication as a vehicle for developing students’ mathematical understanding, and (b) understanding how to help teachers develop practices in fostering mathematical communication. Based on some of the above opinions, it is clear that math communication skills are very important for students. Sadly, in reality, students’ math communication skills are still very low.

The interviews with mathematics teachers teaching at 8th grade of MTSS proves that the mathematical ideas of students had not been conveyed well, particularly when faced with a mathematical problem related to the image and the use of symbols or mathematical models included in geometry material. Communication is potentially a trigger for students to develop ideas and build their mathematical knowledge after knowing the aspects or indicators of such mathematical communication [4].

The indicators used in this study were as follows: (1) Understanding mathematical communication skills, (2) Indicators measuring mathematical communication skills, (3) Forms of questions that can be used to measure mathematical communication skills, and (4) Models, strategies and approaches that can be applied to develop mathematical communication skills [5].

[6] stated that in discussions conducted by researchers with some junior high school teachers, it was revealed that students are still not good at communicating, both in oral and written form. Students have difficulty expressing their opinions even though they have grasped the ideas.

Research conducted by [7] on the role of mathematical communication skills to students’ math learning achievement showed that not mastering the basic concepts contained in the math subject matter could result in fatal errors to the student's learning success that their learning results are low. This might happen when teaching is performed in a less attractive technique making it is difficult for students to understand and less interesting.

[8] said that the improvement of mathematical communication skills in mathematics learning to improve students’ ability to communicate using mathematics learned in school needs to be developed in students. It is important because one of the functions of mathematics lessons is as a way of communicating ideas practically, systematically, and efficiently.

The results of interviews with several teachers of mathematics at MTSS AL-ZAHRAH showed that in 8th grade students considered that mathematics is a difficult lesson to learn, and if possible, they will try to avoid this subject. This tendency results in the lowest motivation for learning mathematics in students since it is less likely that they have the opportunity to communicate by asking questions and responding to problems, both to teachers and to other students. By communicating, students will be able to add insight to their knowledge.

To solve the problem, the teacher must understand mathematical communication after knowing the aspects or indicators of mathematical communication. Therefore, the implementation of mathematics learning needs to be designed as best as possible so that the goal of developing mathematical communication skills can be achieved.

Based on the above explanation, the ability of mathematical communication needs to be possessed by students to provide more specific results. Therefore, researchers wanted to conduct a research on students’ mathematical communication skills in solving problems in block and cube materials.

2. Research methods

This research used a qualitative approach. It is the type of research to make systematic, factual, and accurate descriptions of the facts [9]. This study was descriptive research intending to explain and describe students’ mathematical communication skills based on mathematical communication indicators.

The research was conducted at MTSS with the subject of 10 students of 8th grade in the 2019-2020 school year. Determination of samples or data sources used purposive sampling with certain considerations and objectives [10].
From each category of test results, two students were selected in high, medium and low ability category. Students with high ability were coded T1 and T2, moderate-skilled students S1 and S2, while students with low-skilled R1 and R2.

In collecting data, researchers conducted writing tests and non-test. Researchers as key research instruments used several additional instruments to support the acquisition of data such as interview guidelines, observation sheets, and test sheets of mathematical communication capabilities. Testing was conducted as many as two cycles at different times to obtain saturated data on students’ mathematical communication skills. Two different question points were given on each test. Each question item contained several aspects of mathematical communication. The data analysis used in this study was to reduce data, present data and draw conclusions. This is in line with the statement from [11].

As the research was held amidst the Covid-19 pandemic, researchers used google meet platform to do tests and interviews. While mathematical communication skills were tested directly by monitoring students in carrying out their duties and in sending those answers to researchers –through Google form. Student questions included mathematical communication indicators, which described ideas and situations in writing, explaining images or expressing mathematical ideas, stating situations in mathematical models. Interviews were conducted afterwards so that students had opportunity to express their opinions and ideas with the answers they have written based on mathematical communication indicators.

3. Results and discussion
The results of field analysis showed that students’ answers included 3 aspects of mathematical communication skills, namely writing, drawing and mathematical expression. Highly capable students could meet all three aspects of mathematical communication, while students with moderate and low ability were only dominant in the writing and drawing aspects. The following is a percentage diagram of mathematical communication skills covering three aspects.

![Percentage Diagram of Students' Mathematical Communication Skills](image)

**Figure 1.** Percentage Diagram of Students’ Mathematical Communication Skills.

**Written Aspect**
Written mathematical communication skills of highly capable students of T1 and T2 obtained a percentage of 100% in explaining ideas, situations and mathematical relationships in writing and able to communicate their ideas to solve problems in writing. Students with moderate skill namely S1 and S2, had also fulfilled the aspects of writing on several questions by writing down the information known and asked in the question and explaining the strategy ideas in their mind through writing even though the writing was very short and less detailed. While low-skilled students only slightly met the writing aspect of some of the problems. They had low ability in explaining their ideas or solutions related to the problems presented in the question in writing as reflected in their answers.
**Drawing Aspect**

Highly capable students could explain the ideas and solutions of mathematical problems in visual form precisely and clearly so that it can be said that T1 and T2 had fulfilled the drawing aspect very well. S1 and S2 students were able to explain the idea or solution of math problems in the form of images precisely and clearly in the first cycle to the third cycle on each item of the problem. 91.66% of students with low ability could describe or express ideas and situations of problems into visual form precisely and clearly.

**Mathematical Expression.**

In the aspect of a mathematical expression, T1 and T2 were able to communicate their ideas related to situations and problems that exist into mathematical ideas well. While 33.33% of students with moderate ability (S1 and S2) only could communicate ideas into the language of symbols and mathematical models only of all problems, as they had not explained all information in the problem with a good understanding therefore it affected the problem resolution. As the result. They often missed the conclusion at the end of the answer. Low-skilled students, R1 and R2, had not been able to understand the problem and had not been able to capture the right ideas and solutions to solve problems as well as to communicate them into notations, symbols, and mathematical models correctly. One example of written answers of subjects T1, S1 and R1 on a mathematical communication ability test containing aspects of writing and mathematical expression can be seen in the questions and picture below.

1. **Known a cube with an edge of** $7\sqrt{3}$ **cm**
   a. Draw cubes based on that size.
   b. Specify the surface area of the cube
   c. Specify Cube Volume
2. **Mr. Hardin wants to make a pool in the form of blocks with a length of** 12 **m, a width of** 3 **m, and height of** 2 **m. Every 4 m$^2$, the area of the pool will spend$\frac{1}{2}$ sack of cement, the price of one sack of cement is IDR 25,000, -
   a. Calculate how much money (in rupiah) Mr. Hardin need to build the swimming pool.
   b. How to solve the problem? Explain your answer

![Figure 2. High-ability students’ answers.](image)

The answers provided by highly skilled T-1 students showed their ability to make math sentences out of the given question. T-1 also worked on the problem by drawing an illustration of the problem. T-1 had also been able to demonstrate mathematical ideas in writing using the existing knowledge. In the aspect of mathematical expression, they could communicate the ideas and solutions into mathematical
notations/symbols and models with a good understanding, develop the right mathematical model to find
the area of the pool to be created.

![Image of mathematical calculations for volume and surface area]

**Figure 3.** Answers of moderate ability students.

The answers provided by the students in moderate group showed that they were less able to reach sub-indicators so it still did not achieve the necessary answers. S1 had not yet achieved a sub-indicator in exploring mathematical ideas and visually describing them while S-2 was less able to achieve sub-indicators about demoting mathematical ideas in writing and evaluate mathematical ideas in writing as well as evaluate mathematical ideas to calculate the surface area of the pool.

![Image of mathematical calculations for volume and surface area]

**Figure 4.** Low Ability Students’ Answers.

Answers in the low group of mathematical communication skills of writing showed their low ability to reach sub-indicators and indicators due to the lack of reading and understanding of the question. In the low group, R-1 had not been able to achieve sub-indicators about exploring mathematical ideas through writing, evaluating mathematical ideas in writing, and indicators of ability to use mathematical
terms and structures to present the ideas. On the other hand, R-2 had not been able to achieve sub-indicators of the ability to export mathematical ideas in writing, visually describing mathematical ideas, and the ability to use mathematical terms and structures to present the ideas.

Based on the results of the analysis, it was found that students T-1 and T2 in high group classification obtained high scores in written mathematical communication skills as well. This suggests that subjects with high abilities had excellent mathematical communication skills [12].

Researchers first noticed the difference between T1 and T2 in solving block and cube problems. The students further demonstrated their visual skills in solving problems, such as writing down information on length, width and height by describing the geometry according to its size. Furthermore, in solving problem number two, T1 could find the surface area of the smallest pond by describing the cuboid first then arranged a mathematical model of the surface area of the smallest field while T2 tended to solve the problem directly on the mathematical model by making a mathematical model of all sides of the pool then found which side was the smallest side through the mathematical model.

Capable students were getting used to getting ahead of the answer by writing a message on the question. Students were more dominant in the drawing aspect, up to 100% percent means that the S-1 had fulfilled the drawing aspect on all the questions in each cycle. S-2 was also dominant in fulfilling the drawing aspect with a percentage of 83.33%. In the aspect of mathematical expression, moderately capable students from the first cycle to the last cycle of the tests always making errors in presenting mathematical models of the surface area of the geometry without a base or surface area without a lid. Moderately capable students did not yet have a good understanding of the formula of the surface of the cuboid or cube so it affected the resolution of the problem. By the concept or definition obtained by students in the form of geometry did not come from the results of their inventions, so students tend to learn by memorizing without being accompanied by a good understanding [13].

Low ability students appeared to be less active in answering and asking questions and tended to be silent during learning. Furthermore, they had not been able to reach the desired sub-indicators. R1 fulfilled the drawing aspect by 50% and got a very low percentage for the writing aspect and mathematical expression. Students with low ability had difficulty in understanding questions and capturing ideas in solving problems so they had difficulties to communicate any ideas in writing using notation/symbols and mathematical language. Besides, they did not yet fully understand the function and usability of volume and surface area formulas when faced with problem-solving questions, different when faced with routine questions, it was easier for low-ability subjects to communicate mathematical ideas. It can be said that the success of the subject in determining the idea affected the problem solving [14].

Based on the above expert opinions, oral and written mathematical communication skills had a significant relationship but students’ oral mathematical communication skills were less likely to be measured by the student's activeness during learning. The results showed that the mathematical communication of the student itself will be able to make the students become more active in learning. Thus, it is suggested that it is very potential to be applied in the process of learning mathematics, especially in junior high schools. In regard to the current state of our education, the results of this study are suitable for use as one of the alternatives in improving the quality of mathematics education.

4. Conclusion
Based on the research results, it can be concluded that high-ability students’ mathematical communication skills in communicating mathematical ideas are very good. They have achieved the desired indicators: writing, drawing and mathematical expression. Subjects with moderate-ability are good in writing and explaining ideas, situations and mathematical relations but they are lacking in drawing and expressing ideas visually as well as expressing mathematical understanding. Low-ability subjects are good in writing, including explaining ideas, situations and mathematical relations in writing. However, in drawing, namely expressing ideas visually, they are in the low category (expressing ideas into mathematical expressions). The low-ability students’ mathematical communication skills have not
achieved the indicators of demonstrating, describing, and interpreting mathematical ideas. Their obstacles are reading ability, prerequisite knowledge, and mathematical understanding.

**Acknowledgments**
This research was fully supported by the graduate program of Syiah Kuala University which has provided the lecture facilities and infrastructure. The authors would like to thank Dr. Anwar, M.Pd as the main supervisor, to Dr. Mailizar, S.Pd.,M.Ed and to MTSS AL-ZAHRAH for allowing the researchers to collect the data and supported this research.

**References**

[1] NCTM 2000 Shaping the Standards: “Higher Standards for Our Students, Higher Standards for Ourselves” *Math. Teach. Middle Sch.* 5 524

[2] Clark K R 2005 The Effects of the Flipped Model of Instruction on Student Engagement and Performance in the Secondary Mathematics Classroom

[3] Brendefur J and Frykholm J 2000 Promoting Mathematical Communication in the Classroom: Two Preservice Teachers’ Conceptions and Practices *J. Math. Teach. Educ.* 3 125–53

[4] C P Permata and Kartono S 2015 Analisis Kemampuan Komunikasi Matematis Siswa Kelas VIII Smp Pada Model Pembelajaran Tsts Dengan Pendekatan Scientific *journal.unnes.ac.id*

[5] Lo W W Y and Hughes J 1987 *Pertussis toxin distinguishes between muscarinic receptor-mediated inhibition of adenylate cyclase and stimulation of phosphoinositide hydrolysis in Flow 9000 cells 220*

[6] Qohar A and Sumarmo U 2013 Improving mathematical communication ability and self regulation learning of junior high students by using reciprocal teaching *J. Math. Educ.* 4 59–74.

[7] Astuti A L L 2015 Peran Kemampuan Komunikasi Matematika Terhadap Prestasi Belajar Matematika Siswa

[8] Umar W 2012 Membangun Kemampuan Komunikasi Matematis Dalam Pembelajaran Matematika *Infin. J.* 1 1

[9] Suryana 2010 *Metode Penelitian Model Praktis Penelitian Kuantitatif dan. Kualitatif* (Bandung : UPI)

[10] Sugiyono 2016 *Metode Penelitian Kuantitatif, Kualitatif, dan R&D*

[11] Dull E and Reinhardt S F 2014 An analytic approach for discovery *CEUR Workshop Proceedings 1304* pp 89–92

[12] Heryan U 2018 Meningkatkan kemampuan komunikasi matematis siswa SMA melalui pendekatan pembelajaran matematika realistik berbasis etnomatematika *J. Pendidik. Mat. Raflesia* 3 94–106

[13] Anintya Y A Pujiasutti E and Mashuri 2017 Analisis Kemampuan Komunikasi Matematis Ditinjau dari Gaya Belajar Siswa Kelas VIII pada Model Pembelajaran Resource Based Learning *Unnes J. Math. Educ.* 6 37–43

[14] Rizqi A A 2016 Kemampuan Komunikasi Matematis Siswa melalui Blended Learning Berbasis Pemecahan Masalah *Prism. Pros. Semin. Nas. Mat.* 1 191–202