Students mathematical communication ability in geometry

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Abstract. The aim of this study is to describe the communication ability of grade 8 students in Euclidean solid space topics based on Prior Mathematical Ability (PMA). The subject of this study consisted of 30 students. This research approach was quantitative with a descriptive method. Data collected by the test which developed based on indicators of mathematical communication. The indicators of mathematical communication used in this study are: (1) expressing a mathematical idea to the form of image; (2) expressing real objects or image to the form of mathematics; (3) state daily events in a language or mathematical symbol; (4) explain ideas, situations, and pictures in writing to mathematical form. The results showed that the average percentage of communication ability of all students was 47.68%. While the average percentage of students achieving in a high category was 62.5%. That was above the overall average of students. The average percentage of student achievement in a moderate category was 45.54%, and the percentage of students achievement in a low category was 45.00%.

1. Introduction
Mathematics is an important subject to be taught for students at each level of education [1,2]. Cockcroft suggests the importance of mathematics taught to students because mathematics is always used in aspects of life also because mathematics is a communication tool even use internationally [3]. Sumirattan et al mentioned the reason for mathematics being taught in school so that students' abilities increase [4]. The intended ability is not only the ability to understand mathematical material but also mathematical reasoning ability, mathematical connection, mathematical representation and mathematical communication [5].

NCTM and Van De Walle state that one of the standard abilities that students have to possess is communication ability [6,7]. Communication abilities are very beneficial for the future [8]. One of the futures is the working world. The world of working increasingly demands teamwork, collaboration, and communication [6].

Communication in mathematics is recognized as an important aspect of mathematics learning [9]. Mathematical communication skills include the ability to express an idea in oral, written and the form of images. The importance of mathematical communication ability is mentioned also by Hoyles in his research, namely mathematical communication ability encourages students’ mathematical conceptual understanding abilities [10]. Baxter et al and Kostos & Shin also suggested that mathematical communication helps students develop mathematical thinking and problem-solving skills, and helping students to correct misconceptions about mathematical concepts [11,12]. Mathematical communication also has a positive effect on the mathematical performance of low-achieving students and at-risk students [11]. Then, the importance of mathematical communication written in
Permendiknas No. 22 Tahun 2006 about *Standar Isi*, students have to possess the ability to communicate an idea with a symbol, table, diagram or other media to explain the condition or problem [13].

NCTM revealed a standard “communication” from early childhood schools to 12th grade Middle Schools, should prepare students to 1) organize and strengthen mathematical thinking with communication skills; 2) communicate mathematical thinking coherently and clearly to peers, teachers, and others; 3) analyze and evaluate other people’s mathematical thinking and mathematical strategies; and 4) use mathematical language to express mathematical ideas appropriately [10].

According to Hoyles, encouraging students to communicate their mathematical thoughts or ideas not only help express thought processes but also shift teacher-directed mathematics teaching to student-centered constructive learning [10]. By providing opportunities and facilities for students to express ideas, knowledge, and even their lack of understanding something will develop their thinking processes. Thus, students can construct their knowledge.

The explanation above shows the importance of communication ability developed within students. But in mathematics learning in the classroom, there are problems in mathematical communication ability students. When students were giving tests about problem-solving in geometry topic, students could not solve the problems because they were not able to depict the problem to the form of image which is one of the easiest ways to understand the problem so students could solved the problem. Students also had difficulty to change image into a mathematical form. These are including an indicator of mathematical communication ability [14].

Based on the explanation, this study was constructed to analyze the mathematical communication ability of students in grade 8 in Bandung. The results of this study are expected to give contribution to the teacher to design learning aimed at improving students’ communication ability.

2. Methods
This study examines students’ mathematical communication ability in Euclidean solid space material. This study used a quantitative approach with a descriptive method. The subjects in this study were 30 students of grade 8 in Bandung. The students were classified into high, moderate, and low prior mathematical abilities. The classifying of students was done by giving a test on the prerequisite material of Euclidean solid space material i.e. shape, roots, and quadratic. The researcher categorized students by comparing student scores with the mean and standard deviation of the class (see Table 1).

Then, students were given a test of mathematical communication ability in Euclidean solid space material. Before giving the test, prior mathematical ability test and mathematical communication ability test had been tested for validity, reliability, level difficulty and discrimination power.

The test of mathematical communication was arranged based on indicators of mathematical communication ability which adapted from NCTM, namely 1) expressing a mathematical idea to the form of image; 2) expressing real objects or image to the form of mathematics; (3) state daily events in a language or mathematical symbol; (4) explain ideas, situations, and pictures in writing to mathematical form [14]. Then, students test results of mathematical communication were analyzed based on indicators of mathematical communication ability.

| Criteria                                      | Category |
|----------------------------------------------|----------|
| $X \geq \bar{x} + s$                         | High     |
| $\bar{x} - s \leq X < \bar{x} + s$          | Medium   |
| $\bar{x} - s \leq X$                        | Low      |

With, $X = \text{score}, \bar{x} = \text{mean}, s = \text{Deviation Standard}$
3. Result and Discussion

Based on the test that has been done, data obtained from the students’ mathematical communication ability from each of the indicators, as shown in Table 2. In Table 2, it can be seen that the results in measuring students’ mathematical communication ability. The percentage of communication ability of all students on the first indicator that is expressing a mathematical idea into the form of an image is 93.30%. On the second indicator, expressing the real object or image into the mathematical model is 38.30%. Furthermore, the third indicator, states daily events into language or mathematical symbol is 40.80%. For indicator explaining ideas, situations and pictures in writing in the form of mathematics is 18.30%.

Table 2. The Percentage of Grade 8 Student’s Mathematical Communication Ability

| Category    | Number of Students | Students’ achievement in each indicators | Average |
|-------------|--------------------|------------------------------------------|---------|
|             |                    | Question Number                          |         |
|             |                    | 1 for indicator 1                        | 2 for indicator 2 | 3 for indicator 3 | 4 for indicator 4 |         |
| All students| 30                 | 93.30 %                                  | 38.30 %           | 40.80 %           | 18.30 %           | 47.68%  |
| High        | 4                  | 100 %                                    | 56.25 %           | 62.50 %           | 31.25 %           | 62.50%  |
| Moderate    | 21                 | 94.05 %                                  | 36.90 %           | 34.52 %           | 16.67 %           | 45.54%  |
| Low         | 5                  | 85.00 %                                  | 30.00 %           | 50.00 %           | 15.00 %           | 45.00%  |

Source: Based on data of this research

Then, the average percentage of all students on the four indicators is 47.68%. The average percentage of achievement of high category students is 62.50% which was highest from moderate and low category. The average percentage of students’ achievement in the moderate category is not much different from the students in the low category, which is 54.45% while the low category is 45%.

3.1. Mathematical communication ability of students in indicator 1

Based on Table 2, students’ ability in expressing mathematical situations or ideas to the form of images are very good with average 93.30%. This is different from result of research which conducted by Sari. Sari found that students in stating a situation, ideas, and mathematic correlation into images, graphics, or algebraic expressions are low with percentage 35% [16]. The researchers presume that is because the level of difficulty of both question are different.

Then, based on the results of the mathematical communication ability test, four students in the moderate category and one of low category could not fulfill this indicator well. That student could not properly state the situation in the form of images. The one low category student could not depict the situation as a beam but depicted a rectangle. From students' answers, it appears that students do not understand the concept of beam volume properly. The student wrote the wrong formula and did incorrect calculations. But overall it can be stated that high, moderate and low category students are able to express mathematical situations or ideas to the form of images.

3.2. Mathematical communication ability of students in indicator 2

Based on Table 2 students with high, moderate, and low category cannot meet indicator 2 well. This means that students have not been able to express a real object or image into a mathematical form. This result was different from Fatimah and Zanthy's research on Algebra material, where students’ achievement on indicator connecting real objects, images or diagram into mathematical forms was very good with a percentage of 83.10%, and from the 4 indicators that were considered, student achievement on this indicator was the highest [17].

Table 2 also shows that high category students’ ability is the best from moderate and low category students. Moderate category students’ ability is better than low category students. The difference in
achieving high and low category students looks quite far away. High category students reach 56.25% while students in the moderate and low category are not having far differences.

When viewed from student achievement scores, it was finding that only one student from a high category that was able to express images in mathematical form perfectly, while students with moderate and low category, no one could fulfill them perfectly. From the answers of one of the high category students, it can be seen that students cannot state the relationship between the image with the volume of the pyramid and the surface area of the pyramid. The student was mistaken in using the pyramid volume formula. The student uses the pyramid formula with \(1/6 \times \text{width of the base} \times \text{height of the pyramid}\). The researchers suspects that the student remembered that the volume of the pyramid was one-sixth of the volume of the cube.

One of the answers of the students in the moderate category indicates that the student can show the relationship between the image and the volume of the pyramid in algebraic expressions (mathematical forms) but student fails in doing mathematics in linear equation. The student also cannot express the relationship between the image and the surface area of the pyramid, it can be seen that student does not complete it. Then, the student with low category can recognize the building well but fails to state the relationship between the image with the pyramid volume and the pyramid surface area. The student only writes the known elements.

From the explanation above, it means that mathematical communication ability is supported by other mathematical abilities as understanding ability, reasoning, basic mathematical ability. Then, it can be revealed that students in the high, moderate and low categories cannot express the images in the mathematical form properly.

3.3. Mathematical communication ability of students in indicator 3
Based on Table 2, students’ achievement in the third indicator of mathematical communication ability is still not good. In this indicator, the mathematical communication ability of high category students is the best from the medium and low category students. Interestingly, the low category students are better than the medium category students.

When viewed from students’ test scores, two students of the high category, one student of the moderate category, and two students of the low category can fulfill this indicator perfectly, others could not. If seen from the student answer sheet, we can see the differences in students' abilities on this indicator more clearly. Following some students’ answers, it can be concluded that students can express daily events into mathematical forms. The student with a moderate mathematical ability category is failing to describe the daily problem in the form of images. The student cannot solve the problem because the student failed to identify the image at the first step. The Student identifies the image on the problem by building a beam so that to determine the volume of water in the pool, the student uses the beam volume formula. Then, the student with a low category is still mistaken in expressing daily events in the form of images. But the student can identify the image on the problem was a prism. So the student uses the prism volume formula to solve the problem and do it right.

3.4. Mathematical communication ability of students in indicator 4
Based on Table 2, it is found that the achievements of students are low. In this indicator the high category students are the best from the moderate and low category students, and the communication abilities of the moderate students are better than the low students.

When viewed from the results of the test, all students with high, moderate and low categories, none of them could fulfill this indicator perfectly. It can be revealed that students cannot explain well mathematical situations or images into mathematical forms.

It can be seen that students with high category do not explain each process carried out. The student does mathematics without communicating ideas or intentions to be conveyed through writing in detail and clearly. So the student makes mistakes in solving this problem. While, the student in the Moderate category can describe the mathematical situation in the problem but do not provide information on the image. The student also does not solve this problem. Then, the student with a low category only
describes the problem in the form of an image but does not make a solution to problem number 4. The student fails to explain the mathematical ideas or images into mathematical form.

From the results of the study, students with the categories of the high, medium, and low prior mathematical abilities have good abilities in expressing mathematical ideas to the form of an image. The results also show that students with high, moderate and low categories cannot explain the situation ideas and images in their own language or mathematical form. This is in line with the results of research conducted by Lutfianannisak and Sholihah, namely students with high mathematical abilities have not been able to explain logically mathematical ideas or mathematical situations in a mathematical form seen from the results of their work, as well as students with moderate and low categories.

Then, students tend to be able to express daily events into a mathematical form but it is difficult to express real objects or images in mathematical form, and students are unable to explain a mathematical idea or picture in writing into a mathematical form. The results of the Lutfianannisak and Sholihah study also state that students of high, medium and low abilities do not meet 1 indicator of the 7 indicators of mathematical communication skills, namely in explaining the problem situation and expressing the problem solution in the form of writing properly and correctly [18].

4. Conclusion
Based on the results and discussion as a whole, it can be concluded that the communication abilities of students in solving mathematical problems on the topic of Euclidean solid space in grade 8 with high, moderate and low categories in all indicators are still low with average 47.68%. All students meet indicator 1 which are to express mathematical ideas in images but do not fulfil the fourth indicator well, which are to explain ideas, situations, and pictures in writing to mathematical forms. This is because students are not used to communicating clearly each process that is done in solving the problem. For that reason, it is important to design learning that encourages students to communicate clearly each process that is done in solving problems.

5. References
[1] Adolphus T 2011 Problem of teaching and learning of geometry in secondary schools in Rivers State, Nigeria International Journal of Emerging. Science 1 2 pp 143–152
[2] Nasional S P 2003 Undang-Undang Republik Indonesia Nomor 20 Tahun 2003 (Jakarta: Depertemen Pendidikan Nasional Republik Indonesia)
[3] Rohmah M and Sutiarsro S 2018 Analysis problem solving in mathematical using theory Newman Eurasia Journal of Mathematics, Science and Technology Education 14 2 pp 671–681
[4] Sumirattana S Makanong A and Thipkong S 2017 Using realistic mathematics education and the DAPIC problem-solving process to enhance secondary school students' mathematical literacy Kasetsart Journal of Social Science 38 3 pp 307-315
[5] Tinungki G M 2015 The Role of Cooperative Learning Type Team Assisted Individualization to Improve the Students' Mathematics Communication Ability in the Subject of Probability Theory Journal of Education and Practice 6 32 pp 27-31
[6] National Council of Teachers of Mathematics 2000 Principles and standards for school mathematics (VA: Reston)
[7] Van de Walle J A 2006 Elementary and middle school mathematics: Teaching developmentally. Sixth edition. Addison-Wesley Longman, Inc., 1 Jacob Way, Reading, MA
[8] Wichelt L 2009 Communication: A vital skill of mathematics
[9] Santos L and Semana S 2014 Developing Mathematics written communication through expository writing supported by assessment strategies Springer: Educational Studies in Mathematic 88 1 pp 65-87
[10] Lee J 2015 “Oh, I just had it in my head”: Promoting mathematical communications in early childhood. Contemporary Issues in Early Childhood, 16 3 pp 284-287
[11] Baxter J, Woodward J and Olson D 2001 Effects of reform-based mathematics instruction in five third-grade classrooms. *Elementary School Journal* **101** 5 pp 529–547
[12] Kostos K and Shin E K 2010 Using math Journal to enhance second graders communication of mathematical thinking *Early Childhood Education Journal* **38** 3 pp 223-231
[13] Indonesia PM 2006 *Nomor 22 Tahun 2006 tentang Standar isi untuk satuan pendidikan dasar dan menengah* (Jakarta: Departemen Pendidikan Nasional Republik Indonesia)
[14] Hendriana H, Rohaeti E E and Sumarmo U 2017 *Hard Skills dan Soft Skills: Matematika Siswa* (Bandung: PT Refika Aditama)
[15] Lestari K E and Yudhanegara 2015 *Penelitian Pendidikan matematika* (Bandung: PT Refika Aditama)
[16] Sari D S Kusnandi K and Suhendra S 2017 A Cognitive Analysis of Students’ Mathematical Communication Ability on Geometry *International Conference on Mathematics and Science Education (ICMSe)* Journal of Physics. Ser. **895** 1 p 012083
[17] Fatimah and Zanthry L S 2019 Analisis Kemampuan Komunikasi Matematis Siswa MTS pada Materi Bentuk Aljabar *Journal on Education* **1** 3 pp 107-112
[18] Lutfianannisak and Sholihah U 2018 Kemampuan komunikasi Matematis Siswa dalam Menyelesaikan Soala Materi Komposisi Fungsi Ditinjau dari Kemampuan Matematika *Jurnal Tadris Matematika* **1** 1 1-8

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