Mathematical communication ability analysis of high school students on trigonometry learning

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Abstract. Mathematical communication skills are one of the essential mathematical basic competencies of mathematics and mathematics education. The purpose of this study was to determine the mathematical communication skills of high school students in solving trigonometry problems and to reveal the difficult aspects of mathematical communication for high school students. The research design used was descriptive qualitative research involving 36 students of class X MIPA 1 as research subjects. The students were distributed into 3 groups, namely high, moderate, and low group which consisted of 12 students per group. The instrument used in this study was a test of mathematical communication skills in the form of a description. Based on the result, the average mathematical communication skills of students in all groups were in the less (inadequate) category. The results showed that students' ability to solve trigonometry problems with mathematical communication had not been achieved. It was also found that students had difficulty on resolving mathematical problems presented in the form of images, on expressing the mathematical concepts used.

1. Introduction
Mathematics is a subject given to students ranging from basic education, secondary education and higher education, mathematics subjects support an important role in the fields of education, technology, information, and communication. The principle of mathematics learning must be in accordance with the standards of basic and secondary education processes, namely increasing and balancing between hard skills and soft skills [1].

According to NCTM, there are five hard skills in mathematics learning, namely problem solving, mathematical communication, mathematical reasoning, mathematical connection, and mathematical representation [2]. NCTM describes mathematical communication skills as one of the essential of mathematical competencies from mathematics and mathematics education. Without good communication, the development of mathematics will be hampered [3].

Asikin [3] states that mathematical communication skills are curcial to be possessed by students because: (1). Through communication mathematical ideas can be explored in various perspectives, (2). Sharpen the way of thinking to improve the ability to see the relationship between mathematical contents, (3). To measure mathematical understanding, (4). Organizing ways of thinking, (5). The construction of mathematical knowledge, developing problem-solving, improving reasoning, fostering confidence, and increasing social skills, and (6). Developing the ability to think critically, rationally,
problem-solving, and socializing skills, through writing and talking. Additionally, indicators of mathematical communication skills used in this study are: (1). Declaring a situation in the form of an appropriate image is easily interpreted, (2). Express the image in a mathematical idea and solve it, and (3). Resolve the problem with an explanation of the rules used.

Based on the 2013 Curriculum, one of the mathematical concepts at the eleventh grade of high school is trigonometry. If students have not mastered this concept, they will experience difficulties in the next concepts since trigonometry used as prerequisite concept for other mathematical concepts [4]. Students experience various difficulties in learning trigonometry, that are to determine trigonometric comparisons at special angles, to use trigonometric formulas appropriately, to relate information to questions with trigonometric formulas, and to associate trigonometric identity formulas [5].

Based on the information describe about, therefore, this study attempts to analysis of mathematical communication skills of high school students in trigonometry learning at different student group category.

2. Experimental Method
This research is a qualitative descriptive study. The study subjects consisted of 36 students of class X MIPA 1 academic year 2018/2019. The study subjects were taken as representatives of 3 groups, namely high, moderate, and low groups which consists of 12 students per group. Data collection techniques are carried out using tests. The instruments used in this study were a mathematical communication skills test in the form of a description. The data are processed in three stages, namely the orientation or description stage, the reduction or focus stage, and the selection stage. The orientation or description stage, describes what is seen, heard, felt, and asked. The reduction or focus stage is reducing all information obtained to focus on certain problems. The selection phase is describing the focus that has been set to be more detailed [6]. The result of mathematical communication skills tested analysis by reference to the rubric of the session. Then, from the result of the calculation obtained given the criteria [7]. The criterion is described in the following Table 1:

| Criteria of mathematical communication skills                  | Presentation |
|---------------------------------------------------------------|--------------|
| 0 ≤ P ≤ 20                                                   | Very less    |
| 20 < P ≤ 40                                                   | Less         |
| 40 < P ≤ 60                                                   | Satisfactory |
| 60 < P ≤ 80                                                   | Good         |
| 80 < P ≤ 100                                                  | Very good    |

3. Result and Discussion
The test of mathematical communication skills consists of 5 questions using 3 indicators. Indicator 1 is to declare a situation in the form of an appropriate image so that it is easily interpreted. Indicator 2 is to express images into mathematical ideas and completing them. Indicator 3 is to solve the problem with an explanation of the rules used.

3.1. Description of each category of mathematical communication skills
The results of the test of mathematical communication skills of high school students of class X MIPA 1 on trigonometric learning are explained in Table 2 for the high group, Table 3 for the medium group and Table 4 for the low group.
Table 2. The mathematical communication skills of high group

|                | 1   | 2   | 3   | 4   | 5   |
|----------------|-----|-----|-----|-----|-----|
| The correct number of each question | 52  | 48  | 37  | 37  | 33  |
| Average of each question               | 4.33| 4.00| 3.08| 3.08| 2.75|
| Average high group score               |     |     |     |     | 17.25|

Table 2 shows the results of high group communication skills tests. The ideal score that must be obtained by students is 50. Based on the results of the test obtained an average of high group mathematical communication skills is 17.25, meaning that around 34.50% of students from high groups can mastery the mathematical communication. Based on the criteria in Table 1 it can be concluded the average test results of high group mathematical communication skills are in the less category.

Table 3. The mathematical communication skills of moderate group

|                | 1   | 2   | 3   | 4   | 5   |
|----------------|-----|-----|-----|-----|-----|
| The correct number of each question         | 35  | 36  | 34  | 33  | 32  |
| Average of each question                     | 2.92| 3.00| 2.83| 2.75| 2.67|
| Average moderate group score                 |     |     |     |     | 14.17|

Table 3 shows the results of the moderate group communication skills test. The ideal score that must be obtained by students is 50. Based on the results of the test obtained the average of moderate group mathematical communication skills is 14.17, meaning that 28.34% of students from the moderate group can mastery the mathematical communication. Based on the criteria in Table 1 it can be concluded the average test results of moderate group mathematical communication skills are in the less category.

Table 4. The mathematical communication skills of low group

|                | 1   | 2   | 3   | 4   | 5   |
|----------------|-----|-----|-----|-----|-----|
| The correct number of each question          | 31  | 29  | 29  | 27  | 24  |
| Average of each question                      | 2.58| 2.42| 2.42| 2.25| 2.00|
| Average low group score                       |     |     |     |     | 11.67|

Table 4 shows the results of a low group communication skills test. The ideal score that must be obtained by students is 50. Based on the results of the test obtained the average low group mathematical communication skills is 11.67, meaning that 23.34% of students from the low group can mastery the mathematical communication. Based on the criteria in Table 1 it can be concluded the average test results of low group mathematical communication skills are in the less category.

Based on Table 2 to 4, the average results of the communication skills test for each group was insufficient. The detail description of each category of mathematical communication skills is described below:

3.1.1. The ability to express a situation in the form an image

Students' ability to express a situation in the form of an image is analyzed from questions number 1 and number 5. In these question, students are asked to solve the problem by making a picture first, so
that the problem is easily solved. Based on Table 2 to 4 the average results of the mathematical communication skills test with indicators state a situation in the form of appropriate images so that it is easily interpreted, namely: high group 3.54, moderate group 2.80, and low group 2.29. Based on the criteria in Table 1 it can be concluded that the students' ability to express a situation in the form of an image are in the less category.

3.1.2. The ability to express images into mathematical ideas.
Students' ability in expressing images into mathematical ideas is analyzed from questions number 3 and number 4. In these question, students are asked to solve the problem from the picture given. Based on Table 2 to 4 the average results of tests of mathematical communication skills with indicators state images into mathematical ideas and solve them, namely: the average group is high 3.08, the average group is 2.79, and the group average is low 2.34. Based on the criteria in Table 1 it can be concluded that students' ability to express images into mathematical ideas are in the less category.

3.1.3. The ability to solve problems is accompanied by an explanation.
Students' ability in expressing problems is accompanied by an explanation analyzed from problem number 2. In problem number 2 students are asked to solve problems by stating the reasons for each problem solving. The maximum score for each question is 10. Based on Table 2 to 4 the average results of the mathematical communication skills test with the problem solving indicators were accompanied by an explanation of the rules used, namely: the average high group of 4.00, the average group was 3.00, and the average group was 2.42. Based on the criteria in Table 1 it can be concluded that the students' ability to state the problem along with the explanation are in the less category [8].

3.2. Description of difficulties in expressing the mathematical concepts used
The results of the study show that students in the high group, medium group, and low group have less mathematical communication skills. The difficulties students have are the difficulty of expressing mathematical problems presented in the form of images, difficulties in expressing the mathematical concepts used, and students being able to describe each problem but cannot solve the problem.

3.2.1. Difficulty in expressing mathematical problems presented in the form of images.
Based on the results of tests of mathematical communication skills, students found difficulties in solving problems presented in the form of images. The difficulties experienced by students are shown in Figure 1.

![Figure 1. A sample of students’ difficulties on mathematical problems](image)

Figure 1 shows that students draw a question on the answer sheet but cannot solve the problem, which is determining the QR value. Students answer the PQ and QR values equal to 6 cm. Then look
for the value of RP with the Pythagoras theorem. The cause of this error is the student's understanding that the PQR triangle is an equilateral triangle, so the length of PQ and QR is the same.

3.2.2. Difficulties in expressing the mathematical concepts used.
Based on the results of tests of mathematical communication skills found difficulties students in expressing the mathematical concepts used. Students justify the statement of question a, but do not explain the reason for the answer. It is found that students only answer justifying the statement of a problem, namely "Is -1 is a simple form of (cot α + csc α)(cot α − csc α)". The cause of this error is that students do not understand the use of trigonometric identities, so students only suspect by justifying the statement [9].

3.2.3. Students are able to describe each problem but cannot solve the problem.
Based on the results of tests of mathematical communication skills students found difficulties in describing each problem but could not solve the problem. It was found that students cannot solve the problem of determining the height of a tree. The cause of this error is that students err in writing the value of tangent 60. Students also use the tangent value 45 to determine the height of the tree, but there is an error in determining the side, the side should be 10 plus the initial distance.

4. Conclusion
Based on the research it can be concluded that the average mathematical communication skills of students in the high group subjects, moderate groups, and low groups are in the less category. From the research it was found that students had difficulty solving mathematical problems presented in the form of images. Students have difficulty in expressing the mathematical concepts used and some students are able to describe each problem but cannot solve the problem.

5. References
[1] Kemendikbud 2016 Peraturan Menteri Pendidikan Dan Kebudayaan Nomor 22 Tahun 2016 Tentang Standar Proses Pendidikan Dasar Dan Menengah (Jakarta: BNSP)
[2] Ashim M, Asikin M, Kharisudin I, Wardono W 2019 Perlunya Komunikasi Matematika dan Mobile Learning Setting Problem Based Learning untuk Meningkatkan Kemampuan 4C di Era Disrupsi. In PRISMA, Prosiding Seminar Nasional Matematika 2 687-697.
[3] Hendriana H, Rohaeti EE, Sumarmo U 2018 Hard Skills dan Soft skills Matematik Siswa (Bandung: PT. Refika Aditama)
[4] Rohimah SM and Prabawanto S 2019 Student’s Difficulty Identification in Completing the Problem of Equation and Trigonometry Identities International Journal of Trends in Mathematics Education Research 2;2 1 pp.34-6.
[5] Sholihah W 2018 Analisis Hambatan Belajar Pada Materi Trigonometri Dalam Kemampuan Pemahaman Matematis Siswa IndoMath: Indonesia Mathematics Education 1 2 pp.09-20.
[6] Silverman D 2016 Introducing qualitative research (US: Sage)
[7] Fatimah F and Zanthy LS 2019 Analisis Kemampuan Komunikasi Matematis Siswa MTS Pada Materi Bentuk Aljabar Journal on Education 1 3 pp.07-12.
[8] Al-Khateeb M 2018 The Effect of Teaching Mathematical Problems Solving Through Using Mobile Learning on the Seventh Grade Students' Ability to Solve them in Jordan pp.178-191.
[9] Melhuish K, Thanheiser E, Guyot L 2018 Elementary school teachers’ noticing of essential mathematical reasoning forms: justification and generalization Journal of Mathematics Teacher Education pp.1-33.
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