Analysis of students’ mathematical communication skill in calculus course

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Abstract. The purpose of this research is to analyse the mathematical communication skill of student by using essay test. The method of this research is a quantitative approach with descriptive. We assess the communication skill from the students who take calculus course. The results showed the percentage of achievement of mathematical communication skill indicators of students were: 1) 45.7% students can express mathematical ideas in oral or written form into images, algebraic expressions, and graphics; 2) 34.3% students can state mathematics problem in daily life into a symbol or model in mathematics; and 3) 51.4% students can interpret figures into mathematical ideas. Based on the percentage, the mathematical communication skills of students in calculus course is still low and need to be improved for further research.

1. Introduction

Communication is an important section of mathematical teaching and learning. Communication is defined as the process of restating information, ideas, emotions, abilities, and others through the use of symbols like words, pictures, numbers, and so forth [1]. Communication skill ease the student to convey mathematical ideas and problems hence the idea and problem could be easily understood by themselves and others including teachers or lecturers. Students with good communication skill are able to restating the problem they face in class to other.

Mathematical communication is the skill of a student to deliver statement, reason, and explanation in the argument through tables, diagrams, notations or formulas to solve mathematical problem [2]. Communication ability is the very essential tool for improving students’ mathematical thinking, conceptual understanding, problem-solving skills and reasoning [3].

However, communication ability of university students was low proved by our preliminary study. The results of middle examination for calculus course showing that students’ mathematical communication skills are classified as low. This can be seen from the answer sheet analysis, only 10% of students answered questions and 90% of students did not answer questions that measured mathematical communication skills. The researcher observed that students had difficulty in understanding the problem so that it was difficult to express an idea and mathematical relation into a graph. According to previous research, students’ mathematical difficulties are characterized by weakness in interpreting secondary numerical symbols related to the whole number, relations, which is influenced by experience [4]. Students have difficulties to understanding the problem and articulating reason [5].

There are 5 mathematical communication skill’s indicators: a) delivering ideas, situations and mathematical relations both orally and in writing, and describing them visually in the form of real
objects, images, graphics, and expressions; b) representing real objects, images, and diagrams in the form of mathematical ideas and symbols; c) creating mathematical models of daily experience in the form of symbols, terms, and structures in mathematics; d) constructing conjectures, arguments, formulate definitions and generalizations; e) reexpress a mathematical description or paragraph in her/his own language [6,7]. We used 3 indicators for our study which are:

a. Expressing mathematical ideas in oral or written form into figures, diagram, or algebraic expressions;
b. Stating mathematics problem in daily life into mathematical model or symbol;
c. Converting figures into ideas of mathematics.

2. Experimental Method
The method of this research was a quantitative approach with descriptive. The subject of this research was the students who take calculus course. There are thirty-five students in a class. The topic in this research is absolute value inequality. Data of mathematical communication skill were obtained through essay test and analysed based on mathematical communication skill’s indicator.

3. Result and Discussion
The following table showed the achievement percentage of mathematical communication skill of students.

| Table 1. The Achievement Percentage of Mathematical Communication Skill’s Indicator |
|--------------------------------------------|---------------------------------|------------------|
| Indicator                                    | Number of students who answered correctly | Percentage |
| expressing mathematical ideas in oral or written form into figures, diagram, or algebraic expressions | 16 students | 45.7 % |
| stating mathematics problem in daily life into a symbol or a model in mathematics | 12 students | 34.3 % |
| converting figures into mathematical idea | 18 students | 51.4 % |

The level of achievement of mathematical communication skill in calculus course based on Table 1 is still low and need to be enhanced. Because a half students of the class cannot answer correctly for each questions based on mathematical communications’ indicators. It can be seen from analysis of students’ answer as follows:

1. The first question for the first mathematical communication’s indicator is “Find the solution of this absolute value inequality $|2x - 3| < |x + 2|$ and show the solution in real line!”.

There are 16 students who answered correctly. Figure 1 shows that the students do not understand about the concept of absolute value inequality. Many students do not know how to eliminate the absolute value symbol in both sections. They do not understand the definition of absolute value symbol. They have to remember this concept $(|x| < |y| \leftrightarrow x^2 < y^2)$. In fact, they only eliminate the absolute value symbol without squaring both sections and then do the operation to find the solution.
They can’t get the correct solution and it makes their solution in real line wrong. Moreover, most of the students do not understand how to express mathematical ideas into graphics / algebraic expression.

Figure 2 shows that the students cannot express the solution into real line. They do not understand the meaning of $x \geq -5$. So that, they shaded the wrong area in real line and cannot express the solution in interval. This reflects how far students’ understanding the concept of absolute value inequality. Students’ error in determining the solution are: a) forgetting the properties of absolute value; b) calculation error; c) not understanding the inequality [8]. Students have a mistake to determine an interval sign and solution area [9].

![Figure 1](image1.png)

**Figure 1.** The example of student’s answer for the first question

![Figure 2](image2.png)

**Figure 2.** The example of student’s answer for the first question

2. The second question for the second mathematical communication’s indicator is “The normal voltage distributed by PLN to homes is 220 volts. But the real stress in tolerated homes may differ by at most 11 volts from the normal 220 volt voltage. Write an inequality to display this situation. Find the solution of this inequality to determine the range of real stresses that PLN can tolerate?"

There are 12 students who answered correctly. Figure 3 shows that the students do not understand how to state mathematics problem in the daily life into a symbol or model in the mathematic. They have to use the concept of absolute value inequality. They do not communicate what the meaning of symbol $x$ of their answer and also they can’t get the correct solution and it makes their solution in real line wrong. There are so many students did not answer this problem. Figure 4 shows that the students can state the problem into mathematic model. They give the explanation of symbol $x$ correctly. It
means that they understand what the problem it is. But, they cannot express the solution into real line correctly.

The students’ mistakes in expressing the solution into real line reflect that students have difficulties in mathematical communication. It is because students’ difficulties in understanding and transforming the problem into mathematical model [7]. Students actually can understand the problem, but do not have appropriate concept and experience to process the solution. Students have some difficulties to understand open-ended problem [10]. Based on previous research, the lowest enhancement of mathematical communication skills is occurred in the expressing situation of mathematics or relation into mathematical models (mathematical expressions, graph, and figure) [11].

![Figure 3](image3.png)

**Figure 3.** The example of student’s answer for the second question

![Figure 4](image4.png)

**Figure 4.** The example of student’s answer for the second question

3. The third question for the third mathematical communication’s indicator is “Interpret this real lines (look figure 5) into interval or mathematical ideas!.”
There are 18 students who answered correctly. It means more than half students of this course can answer this question correctly. Figure 6 shows that the students could not converting figures into mathematical ideas. The students did not understand what the meaning of symbol (parenthesis and square brackets) in real lines. Based on students’ answer in part (c), we can see that the students do not know how to interpret an arrow symbol. An arrow symbol in real lines mean that positive infinite and negative infinite.

Based on the analysis of students’ answer, the researcher can see the mathematical communication of students in calculus course, especially in absolute value inequality, are still low. Students do not memorize the properties of absolute value and do not understand the concept of inequality. We suspect that students were not used to deliver ideas in solving the problem.

Based on qualitative analysis about mathematical communication skill in previous research, it can be concluded: 1) Students with high ability could communicate mathematically well; 2) Average ability students are less capable to communicate; 3) Low-ability students could not communicate well; 4) The major problem was the students were difficult to understand the problems, use the concepts and take the steps needed to solve problems; 5) The blank answer sheet showed that students could not understand and solve the problem, use and apply the counting operation, [12]. Moreover, students cannot memorize the formula that can be used, careless, not ready to follow the examination, and do not have enough times to finish the test [13].

It is important for lecturer to unpack the meanings inherent in symbols to enhance mathematical communication. There is positive correlation of mathematical communication skills of the students toward the mathematics learning achievement [14]. Mathematical communication skills provide opportunities for students to develop the ability to communicate ideas through language and symbols for solving a mathematical problem. Interesting problem situation, challenging, and contextual can inspire students to develop ideas creatively to ask or make mathematics questions with varying degrees of complexity.
Lecturer should teach and encourage the students to openly deliver mathematic ideas not only in the verbal manner but also in the form of writing. Learning in class should be communicative because class interaction is good for exploring mathematical communication skills of students to be more developed. Development of students’ thinking process cannot only be through the application of strategies or learning models, but also based on learning tools that can develop student thinking skills [15].

4. Conclusion
Based on the result and discussion, it can be concluded that the achievement of students' mathematical communication skill in calculus course was still low. So the students’ skill of mathematical communication need to be improved for further research. One of the ways to improve students’ skill of mathematical communication is by implementing appropriate learning strategies, approaches, techniques, methods, or models and producing the learning tools (lesson plan and student worksheets) that covered students with various characteristics of learning. The teachers should create the learning process meaningfully, students centered, and make class discussion. Discussion class can increase students’ skill of mathematical communication because it can develop students’ speaking and understanding skills. In addition, discussion class can make students active, increase students’ interest, and develop student’ thinking skill.

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