Students’ Mathematical Communication in Solving Combination Problems

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Abstract. The purpose of this study was to describe students’ mathematical communication ability in solving combination problems. This study involved 27 students majoring in mathematics, Mathematics and natural science faculty who took discrete mathematics subject. Students were asked to solve combination problems. Based on students’ works results, the ability of students were categorized into three categories, namely high ability, medium ability, and low ability. From each ability group, one student was chosen to describe their mathematical communication ability. The research results showed that the student with high ability was able to do written text well, do mathematical expressions well, and gave the correct final answer. while the student with medium ability was only able to do mathematical expressions. The student with low ability was not able to do written text, was unable to do mathematical expressions, and was unable to provide the correct final answer.

1. Introduction

According to [1] communication is needed in the process of teaching and learning. Communication in learning occurs between the teacher and students and between student and student. In mathematics learning students are required to be able to solve problems, develop patterns and draw conclusions, connect between concepts, and also communicate mathematical ideas clearly and precisely, so mathematical communication becomes an important part of mathematics learning [2].

According to [3] there are five standards in learning mathematics, namely: a) problem solving; b) communication; c) connection; d) reasoning and verifying; and e) representation. The objective of mathematics learning according to [3] is expecting students to be able to communicate ideas, reasoning and be able to compile mathematical evidence by using complete sentences, symbols, tables, diagrams or other media to clarify the situation or problem. Based on the two opinions, mathematical communication skill is very important for students to master.

Mathematical communication is an important ability that students must master [4]. Mathematical communication is the ability to express mathematical ideas coherently to friends, teachers, and others through spoken or written language. Mathematical ability in writing is needed by students to be able to convey ideas or opinions in solving problems given by the lecturer in writing [5].

But in reality the Mathematics Department students, FMIPA, State University of Malang who take discrete Mathematics courses still have difficulties to convey their mathematical ideas in writing when solving combination problems. Students tend to only write the final answer when solving a combination problem Whereas to solve mathematical problems, the ability of written communication is required [6].
Students' mathematical communication skill is measured by using the ability in the form of 1) Written text, namely the ability to explain ideas or solutions of the problems faced by using their own language, 2) Mathematical expression, namely to express daily problems or events in the mathematical model language, and 3) Correct final answer namely the ability to use the right formula and the ability to do the correct calculation.

Based on the importance of mathematical communication ability and problems faced by students majoring in mathematics in delivering ideas when solving combination problems, it is important to study the mathematical communication ability of students majoring in mathematics, FMIPA, State University of Malang in solving combination problems.

2. Method
This study involved 27 Mathematics Department students who follow Discrete Mathematics courses. Students were required to solve a combination problem as follows: “ten teachers will be assigned to three schools, namely school A, school B, and school C respectively 2, 3 and 5 teachers. How many ways are there to assign the ten teachers? Students' work results were examined and grouped into three groups of abilities, namely high, medium, and low ability groups. Each group had the ability to select one student to describe their mathematical communication skill. To measure the students' written mathematical communication ability in solving combination problems, the students' ability criteria were used in terms of 1) written text, 2) mathematical expression, and 3) final answer.

3. Result and Discussion
The results of examining students' works in solving combination problems based on students' abilities can be seen in Table 1.

| No | Category of student’s ability | Value range (x) | Number of Students | Percentage (%) |
|----|-------------------------------|-----------------|--------------------|----------------|
| 1  | Low                           | $0 \leq x < 55$ | 14                 | 52             |
| 2  | Medium                        | $55 \leq x < 80$| 9                  | 33             |
| 3  | High                          | $80 \leq x \leq 100$ | 2                 | 15             |

Of the three categories of students’ abilities above, one student was chosen for each category, namely subject T for high ability category, subject S for medium category and subject R for low category. For the analysis of students' mathematical communication ability in solving combination problems in writing, the criteria of students’ ability in terms of 1) written text, 2) Mathematical expression, and 3) final answer were used. The analysis results of the students' mathematical communication ability in solving combination problems are as follows.

3.1. Subject T (subject with high ability)
Subject T had good written text ability because subject T was able to explain the idea or solution of the problem faced by using his own language. It was proven when solving a combination problem faced. Subject T began by writing down many possible ways to assign the teacher to school A namely $10C2$. Because 10 teachers had been assigned to school A, there were still 8 teachers so the possible ways to assign teachers to school B were $8C3$. Because 3 of 8 teachers had been assigned to school B, the remaining were 5 teachers, so that the possible ways to assign teachers to school C were $5C5$. The ability of subject T to write problems with his own language can be seen in Figure 1.
Many possible ways to assign teachers to school A: $^{10}C_2$
Many possible ways to assign teachers to school B: $^8C_3$ (because it has taken 2 out of 10 then the remaining 8)
Many possible ways to assign teachers to school B: $^5C_5$ (because it has taken 3 out of 8 then the remaining 5)

Figure 1. Subject T's work in writing down the problem

By writing down the ways to put teachers into school A, school B and school C using the appropriate combination formula, it indicated that subject T already had good ability of written text. It is in accordance with the opinion [1] that says that students who have high ability tend to be able to communicate well.

Subject T already had good mathematical expression ability because subject T was able to write many ways of assigning teachers to school A, school B and school C in mathematical expression, namely by using the appropriate combination formula. Subject T was able to write many ways to assign teachers to school A using mathematical expression $^{10}C_2$, while to assign teachers to school B, subject T was able to write mathematical expression $^8C_3$, and to assign teachers to school C, subject T was able to write mathematical expression $^5C_5$ correctly.

Subject T was also able to write mathematical expression $^{10}C_2$. $^8C_3$. $^5C_5$ to state that there were many ways to assign 10 teachers to school A, school B and school C in which each school had 2, 3 and 5 teachers respectively. Mathematical expressions written by subject T were correct, that was subject T used the combination formula to solve the problem at hand because to assign teachers to a school there was no need to pay attention to the sequence, so the problem faced was a combination problem. The work result of subject T is as in Figure 2.

Figure 2. The ability of subject T to write mathematical expression

Subject T was able to write mathematical expressions well because the combination problem faced was in accordance with the real context faced by students. Because the problem faced by subject T was in accordance with the real context, subject T was able to do mathematical communication well. This is in accordance with [7] who state that mathematical communication of students will develop well if the teacher always gives real problems to students to finish them.

Subject T was able to give the final answer correctly because subject T was able to write that the problem faced was a combination problem, so subject T used a combination formula. Subject T was also able to understand that assigning teachers to 3 different schools was a related problem, so he used a multiplication rule. It seemed that subject T mastered the problem very much. He was able to apply the formula correctly and was able to do calculation correctly.

3.2. Subject S (subject with medium ability)
Subject S’s work result in solving the combination problem is given as in Figure 3.
Subject S’s work result in solving the combination problem

From Subject S’s work result as in Figure 3, it seemed that subject S had not been able to do written text. Subject S immediately solved the problem given by using a combination formula. Subject S did not write down ideas or solutions to the problems faced by using his own language.

Subject S was able to do Mathematical expression since he stated everyday problems or events in a mathematical model language. Subject S had been able to determine that the problem faced was a combination problem, so subject S used a combination formula. Subject S was able to determine that assigning teachers to school A, B and C were interrelated events, so subject S used multiplication rule. The result of the subject S's work was correct, but no conclusion was made.

3.3. Subject R (Subject with low ability)

Subject R’s work result in solving the combination problem is shown in Figure 4.

Based on Figure 4 about the Subject R’s work result in solving the given combination problem, it seemed that subject R had not been able to do written text properly because subject R did not write down the idea or solution of the problem faced by using his own language. Subject R immediately solved the problem faced by using formula.

Subject R had been able to do Mathematical expression, but the formula used was incorrect. The problem faced by subject R was a combination problem, but subject R solved it using permutation. Subject R viewed that many ways of assigning teachers to school were events that required sequencing, so that subject R saw the problem faced as a matter of permutation. This misconception caused subject R to be wrong in solving the given problem. The error experienced by subject R that solved a combination problem by using permutation according to [8] was called interference.

Subject R was unable to give the correct final answer. Subject R viewed the combination problem faced as a permutation problem, so that subject R solved it using a permutation formula. It was because subject R did not have the ability to use the right formula and was not able to do the correct calculation.

4. Conclusion

A student with high ability is able to do mathematical communication well, namely being able to do written text properly, being able to do Mathematical expressions well and being able to provide the
correct final answer. A student with medium ability has not been able to perform mathematical communication properly because the student with medium ability is able to do mathematical expressions, but not able to perform written text and unable to provide the correct final answer. A Student with low ability is unable to do mathematical communication properly because the student with low ability is not able to do written text properly, unable to do mathematical expressions well, and unable to provide the correct final answer.

For teachers who will train students’ mathematical communication ability need to provide contextual problems that are close to the students’ environment. The teachers also need to start from giving simple problems, so students are able to solve problems that are given correctly so that they have the ability to do mathematical communication well.

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