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STUDENTS' MATHEMATICAL COMMUNICATION SKILLS IN FINDING THE CONCEPT OF DIRECT AND INVERSE PROPORTIONS THROUGH DISCOVERY LEARNING

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Abstract
The purpose of the study is to know students' mathematical communication skills in finding the direct and inverse proportions through discovery learning. The data is obtained based on the work of students in solving the problems that measure students' mathematical communication skills. The data is categorized on 5 levels (the lowest level is 0 and the highest level is IV) which refer to the quantitative criteria for scoring mathematical communication and analyzed descriptively. From the leveling result, it is obtained that students on level II are 31.25% and level III are 68.75% in mathematical communication skills. The results reveal that the Discovery Learning can foster the mathematical communication skills of junior high school students especially in concepts of the direct and inverse proportions.

Keywords: *Mathematical communication, the concepts of direct and inverse proportions, discovery learning.*

INTRODUCTION

Mathematical communication is one of the important mathematical skills to be mastered by students in learning mathematics (Baroody, 2000; Ginsburg, Inoue, & Seo, 1999; Rubenstein & Thompson, 2002; Whitin & Whitin, 2003). It can be viewed in the National of Council of Teachers of Mathematics (NCTM, 2000) which highlighted five mathematical abilities, that is problem solving, reasoning and proof, communication, connections, and representation. This is in line with that listed in the *Kurikulum Tingkat Satuan Pendidikan (KTSP)* (Depdiknas, 2006) mathematics, namely: (1) understanding the mathematical concepts, explaining the connection between the concepts and applying the concepts or algorithms flexibly, accurately, and efficiently in problem solving; (2) using the reasoning in the patterns and characteristics, performing mathematical manipulations in making generalizations, compiling the proof or explaining mathematical ideas and statements; (3) problems solving that include the ability to understand the problems, designing a mathematical model, solve the model and interpret the obtained solutions; (4) communicating the ideas with symbols, tables diagrams or other media to clarify the situations or problems; and (5) having respect for the usefulness of mathematics in life, having the curiosity, concern and interest in learning mathematics, as well as the tenacious attitude and confidence in solving the problems.

The importance of mathematical communication skill have also been described by some experts, such as Greenes and Schulman (1996, p. 168) who stated that the mathematical communication is: (1) a central force for students in formulating the concepts and strategy of mathematics, (2) capital

success for students to approach and solution in exploring and investigating of mathematics, (3) a container for students in communicating with their friends to obtain the information, sharing their thoughts and discoveries, brainstorming, assessing and sharpening ideas to convince others. Pugalee, et al. (2003, p. 238) also stated that communication is an essential element in the teaching and learning of mathematics. Therefore, it can be seen that the students' mathematical communication skills are indeed needed to be grown in mathematical learning in the school.

The reality indicates that the mathematical communication of Indonesian students is still low. It can be seen from the results of a survey conducted by the OECD (2012) that Indonesia got a very low ranking of the PISA results, Indonesia received a score 375 on the mathematical skills in PISA results in 2012. While the average score set by the OECD is 494. It brings Indonesia to 64th rank of 65 countries took part in PISA 2012. The OECD suggested that the overall math PISA arranged on 6 levels where 6 is the highest and 1 is the lowest level. The high level questions ask students to apply mathematical concepts and operations to communicate how they can find out a solution. Meanwhile the low level questions require students to solve problems in a sequential process. In addition, the results Qohar (2009) also revealed that students' mathematical communication skills are lacking, either in terms of communicating verbally or in writing. One of the efforts to overcome these problems is the implementation of appropriate learning models.

Discovery learning is a learning model that can develop students' mathematical communication skills (Abdurrachman, 2014). The model gives students a chance to participate actively (Bruner, 1968; Kara & Ozgun-Koca, 2004; Kipnis, 2005). The advantages of applying discovery learning according to Kemdikbud (2013) is to help students strengthen their concepts, since obtaining the trust to cooperate with others, and make students more active in issuing ideas. Even the teachers can act as a student and investigator during the discussion.

Based on the explanation on the background, the research question in this study is: "How are students' mathematical communication skills in finding the concept of direct and inverse proportions through discovery learning?"

METHODS

The study is held as a trial research of the implementation of discovery learning to see the students' mathematical communication skills in finding the concepts of direct and inverse proportions for 3x40 minutes. The subjects of this study are 16 students in grade 8 SMPN 1 Banda Aceh. The mathematical communication indicators in this study is the adaptation of the NCTM (2000), they are:

- A skill to express mathematical ideas through oral, written, and visually demonstrate and describe it;
- A skill to understand, interpret, and evaluate the mathematical ideas, either orally, in writing, or in other visual forms;
- A skill to use terms, notations of mathematics and its structures to present ideas, describe relationships with situation models.

The data of students' mathematical communication skills in finding the concepts of the direct and inverse proportions obtained from the test results of mathematical communication skills that are assessed based on the rubric in Table 1. The data was analyzed descriptively. The rubric for students' mathematical communication skills are as follows.

Table 1. Rubric of written mathematically communication skills

Score	*Written text*	*Drawing*	*Mathematical expression*
0	No answer, if there is the answer, and then it only shows that the student does not understand the concept so the information provided is not useful.		
1	There are only a few correct things on explanations.	There are only a few correct things on figure, diagram or table.	There are only a few correct things on mathematical model.
2	The explanations are mathematically logic, but partially of them are complete and correct.	Make a diagram, figure or table but it is less complete and correct.	Make a mathematical model correctly but it is wrong in getting solutions.

Table 1 continued…

3	The explanations are mathematically reasonable and true although they are not arranged logically or there are a few error languages.	Make diagram, figure or table completely and correctly.	Make a mathematical model correctly, do the calculations or get a solutions completely .and correctly
4	The explanations are mathematically reasonable, clear, and arranged logically		
	Max score = 4	Max score = 3	Max score = 3

Adapted from Cai, Lane, and Jakabcsin (1996) and Ansari (2004).

RESULTS AND DISCUSSION

Based on the data analysis, we obtained that mathematical communication skills of students on level I is 0%, level II is 31.25%, level III is 68.75% and level IV is 0%. These results indicate that students' mathematical communication skills in junior high school that were the subjects of the study are already quite good. Learning Mathematics by discovery learning setting gives a positive impact in fostering students' mathematical communication skills. This is similar to the results study of Wijayanto (2014) who reveals that students mathematical communication skills that implement the discovery learning is higher than students mathematical communication skills that implement conventional learning.

There are 68.75% of the students are on level III. It shows that in written text, most of the students have been able to provide mathematical representation in giving the solutions of the problems given although they are still not arranged logically and there are some error languages. In drawing, most of the students have also been able to describe the chart completely and correctly. In mathematical expression, most of the students have also been able to create mathematical representations properly and do the calculations or get a solution completely and correctly.

There are 31.25% of other students are on the level II. It shows that in written text, the students can provide mathematical representation, but only partially are complete and correct. In drawing, students can describe chart but still incomplete and incorrect. While in mathematical expression, most students can create mathematical representations correctly, but still wrong in getting a solution.

Figure 1 illustrates how students' mathematical communication in providing solutions of the problems related to the concept of the direct proportions and Figure 2 is related to the concept of the inverse proportions. The students provide solutions in their own way without prior explanation from the teacher, but based on the two figures can be seen that students are able to explain systematically in providing solutions but in Figure 2 there is little error language in which student assumes that $\frac{4}{6} = \frac{24}{x}$ equivalent with $\frac{6}{4} = \frac{x}{24}$. We know that both of these statements are different. But the rest of the students have been able to provide explanations and calculations correctly.

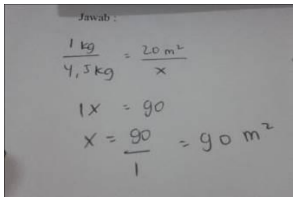

Figure 1. Student's solution related to direct proportion.

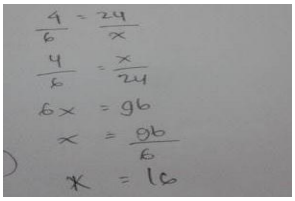

Figure 2. Student's solution related to inverse proportion.

Figure 3 and 4 illustrate how students' mathematical communication in making the graph that corresponds with the solutions they got. Figure 3 is a graph related to the concept of direct proportion and Figure 4 is a graph related to the concept of inverse proportion. Both of these pictures show that students can give the description of relationship between the two variables. These graphs are basically aimed to help students to better understand the differences between the concepts of the direct and inverse proportions. However, Figure 4 does not show the conditions that arise from the relationship between the variable x and y which characterizes the inverse proportions. The graph that illustrates the concept the inverse comparison should be curved. Thus, teachers have to strengthen the concept of students, especially the concept of inverse proportions.

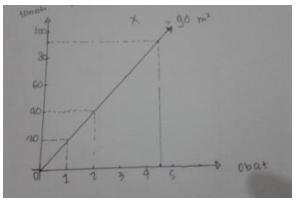

Figure 3. Graph related to direct proportion.

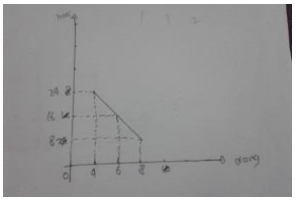

Figure 4. Graph related to inverse proportion.

CONCLUSION

Based on the results of the trial study in grade 8 SMPN 1 Banda Aceh on the concept of the direct and inverse proportions by implementing discovery learning, students on level II is 31,25% and level III is 68, 75% in mathematical communication skills. The results reveal that the discovery learning can foster mathematical communication skills of junior high school students especially in concepts of the direct and inverse proportions.

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