An Analysis of Mathematical Communication Ability on Solving Open Ended Problems in Linear Equation System with Two Variables

M Anwar Rivai1, Mardiyana1 and I Slamet1

1Postgraduate School of Mathematics Education, Faculty of Teacher Training and Education, Universitas Sebelas Maret, Indonesia

Corresponding email: manwarrivai@gmail.com

Abstract. Mathematical communication ability are the ability of students to convey mathematical ideas either orally, in writing or in motion, so that mathematical communication ability must be possessed by students. This research is a qualitative descriptive study that aims to describe the mathematical communication ability of junior high school students in solving open ended problems, namely where one problem has many solutions or many ways of solving. The subjects in this study were 28 students of class IX of SMP Negeri 1 Mojolaban and the instruments used were 3 test descriptions of mathematical communication ability test. The variable of this study is an indicator of mathematical communication ability. The results show that students' mathematical communication ability are quite well categorized, with the following details: student achievement in expressing real objects, situations and daily events in the form of mathematical models as much as 91.6%, student achievement in explaining mathematical ideas and models into ordinary language as much as 69.6% and student achievement in explaining and making mathematics questions learned as much as 40.47%. From the three indicators, it appears that students are still lacking in terms of explaining and making mathematical questions learned.

1. Introduction

Communication is a very important ability possessed by students in learning mathematics, both elementary and middle school students are required to have good communication ability. Mathematical communication is one of the basic goals of mathematics consisting of abilities and skill. Mathematics has a role as a symbolic language that enables effective communication. The importance of mathematics because mathematics is a very powerful, comprehensive, and oriented communication tool [1]. The purpose of mathematics learning is discusses five main standards of mathematics learning that include problem solving, reasoning and proof, communication, connections, and representations [2]. In the standard curriculum process, it is stated that the objectives of mathematics learning are as follows: (1) to solve problems consisting of the ability to understand problems, design mathematical models, solve models, and interpret solutions; (2) to communicate ideas with symbols, tables, diagrams and other media to clarify specific situations or problems; and (3) have an attitude in respecting mathematics practice in everyday life, which consists of having curiosity, attention and interest in learning mathematics, along with tenacity and confidence in solving mathematical problems [3]. However, students' mathematical communication ability currently do not meet expectations.

Communication ability is the ability of students to express their ideas, describe and discuss mathematical concepts coherently and clearly [4]. Mathematical communication is an important part of developing students' potential in solving problems. Through communication, an idea can be an object that can be reflected as material that can be discussed and changed [5]. Means that communication as a process of people with various thoughts and ideas from one person to another [6]. Therefore, mathematical communication considers the interaction of people and the exchange of mathematical ideas, which are important abilities for students in expressing their respective mathematical concepts, understanding and evaluating mathematical equations and thinking of other students [7].
Doing math communication is not easy for students. For this reason, a learning process that supports or directs students to mathematical communication ability is needed. At present there are many models and methods used in teaching mathematics to students. One such method is the Open-Ended method. In the Open-Ended method students are given the freedom to explore various strategies and ways they believe to solve a problem [8], argues that what is at the heart of learning with the Open-Ended method is learning that builds interactive activities between mathematics and students so that it invites students to answer problems through various strategies. Problems that are formulated to have correct multi-answers are called incomplete problems or also called Open-Ended [8]. In learning activities that apply Open-Ended problems, students are required to develop different methods or approaches in answering problems and not be oriented towards the final answer (outcome). Therefore, one method that accustoms students to carry out mathematical communication is the Open-Ended method.

According to Shimada [9], "Open-ended mathematical problems are problems that have many solutions and alternatives or solutions". In this case, by using open problems in mathematics, students begin to be taught to think differently and outside their habits. Students are directed to understand each problem broadly by thinking of various possible ways. Students should be given an open problem. In learning activities, it is endeavored to make students answer problems in various ways and various kinds of answers, thereby stimulating students' intellectual abilities and experiences in finding something new and different.

Foong [10], revealed that there are three criteria in open problems, namely (1) students are given the freedom to show the ability, understanding and mathematical knowledge possessed by each student, (2) can make students to reason and think to make them think from daily habits day after day, and (3) can be applied in a very broad scope concerning the approach or strategy used to obtain a solution. In this case it is clear that in solving open-ended problems students need adequate communication ability, representation and reasoning.

In learning, the teacher should give open-ended questions to improve students' thinking skills, open-ended questions with more than one answer [11]. Open ended consists of main concepts, processes and skills beyond specific instructions that can determine students' thinking skills [12]. By using open-ended questions, the basic concept can be developed, so that students not only remember certain facts but almost all the facts that might be able to solve the problem. This provides the opportunity for students to succeed in answering open questions, even when students cannot remember a certain mathematical solution, they can get several alternative ways of solving problems from everyday life [13].

According to Sullivan, P., Warrn, E., & White, P [14] in his research stated that some students assume that open-ended questions are harder than usual math problems, and students tend to find it difficult to do. In a study conducted by Payadnya [15] it was found that most students always used trial and error in working on open-ended problems and also students who were less able to give appropriate reasons. In my research, this also happened where most students experienced difficulties even when understanding the questions given. Then when working on students also confused about how to do it, and when they have found the answer students are also confused because of the answers with different answers from friends. That is because the questions he worked on were open-ended, but the students did not realize it. A factor that causes this is the lack of self-confidence of students. But the factor that influences it is because of the difficulty of open-ended questions.

In this study, researchers used three indicators, namely: stating real objects, situations and daily events in the form of mathematical models, explaining mathematical ideas and models into ordinary language, explaining and making mathematical questions learned.

2. Method
This research was conducted with a qualitative descriptive method. The method in this study is to analyze the mathematical communication ability of students of open ended problems in the material
system of two-variable linear equations. The subjects of this study were 28 students of Grade IX SMP Negeri 1 Mojolaban with heterogeneous abilities. Students are selected through purposive sampling. The data used is a description test. Mathematical communication data is conveyed through a description test which is done in 40 minutes. Next Furthermore, the data were analysed descriptively. Data analysis techniques in this study include: (1) reducing data, (2) data presentation, and (3) conclusions.

3. Result and Discussion
In this study, indicators of mathematical communication ability were synthesized by Sumarmo [16], Lomibao, Luno and Namoco [4] and Hamilton [6]. The indicators are analyzing and expressing real objects of everyday situations and events in the form of mathematical models; explain mathematical ideas and models in the form of ordinary language; and can explain and make questions from the questions learned.

The results of this study indicate the scores and percentage indicators of students' mathematical communication ability as shown in Table 1 below.

Table 1. Mathematical communication ability of open-ended problems

| No | Mathematical Communication Ability Indicators | Eq 1 | Eq 2 | Eq 3 | percentage |
|----|-----------------------------------------------|------|------|------|------------|
| 1  | Analyzing and presenting real objects of everyday situations and events into the form of mathematical models. | 96   | -    | 58   | 91.6%      |
| 2  | Explain mathematical ideas and models into ordinary language | 70   | 47   | -    | 69.6%      |
| 3  | Explain and make questions from the questions learned. | 46   | 22   | 34   | 40.47%     |

In Table 1 it can be seen that the percentage of students' success in analyzing and expressing real objects, situations and daily events in the form of mathematical models is 91.6% which shows that most of the students are able to make mathematical models of these problems. The percentage of students' success in explaining mathematical ideas and models in the form of ordinary language is 69.6% which shows that some students are quite capable of expressing a form of mathematical model of the problem at hand. Furthermore, the percentage of students' success in explaining and making questions of the questions studied was 40.47% which shows that most students are less able to understand first an existing mathematical model and then can make questions of the problem.

S1 (subject 1) working on number 1a, and S2 working on number 3a. The both of answer is the communication problem that asks students to make models of real objects, situations and daily events into the form of mathematical models. The results of S1 answers can be seen in Figure 1.

![Figure 1. Student’s answer for indicator one](image)

The following are interviews with S1 research subjects:

R : *What information do you get from that problem?*
S1: I can know the price of 7 cakes and 2 donuts is 44 thousand and 5 cakes and 4 donuts worth 43 thousand.

R: Do you understand the purpose of the mathematical model?
S1: Make mathematical equations like SPLDV right, sir

R: How many variables did you get from the problem?
S1: The variables I got were 2, i.e. x is a cake then y is a donut

R: How can you make a model like that?
S1: because I can think of the cakes and donuts as variable

R: Is it just like that?
S1: Then from the announcement so I can make two models, the first is 7x + 2y = 44,000, the second is 5x + 4y = 43,000

The results of S2 answers can be seen in Figure 2.

The following are interviews with S2 research subjects:

R: What information do you get from that problem?
S2: The price of 2 kg of wood paint and 6 kg of wall paint is IDR 36,000 and 3 kg of wood paint with 5 kg of wall paint is IDR 32,000

R: From that problem, how many variables did you get?
S2: 2 variables.

R: What are these variables?
S2: wood paint, for example c and wall paint for example d

R: Is it possible to suppose in addition to c and d?
S2: You may.

R: How can you make a model like that?
S2: Because I can split the cake and donuts into a form variable later than intended so that I can make two models

R: Are there any difficulties in making mathematical models?
S2: Nothing sir

From figure 1, it appears that students can model from a figure presented. It appears that students are able to make a problem that is the number of cakes with the symbol x and the number of donuts with the symbol y it aims to make it easier to write mathematical models. In figure 2 also shows the same thing where students can analyse and express into the form of mathematical models with the exact story problem given. It appears that students correctly classify each mathematical model of each price presented.
Figure 2 also shows students can make an example of the situation presented namely wood paint with variable c and wall paint with variable d. Then students can make precise and correct mathematical modelling of the examples and stories that have been described.

Then a S3 work on question number 2a and S4 work number 1b. Both Figures are answers to communication problems that ask students to create story problems from ideas and mathematical models into ordinary language. The results of S3 answers can be seen in Figure 3.

![Figure 3](image1)

**Figure 3.** Student’s answer for indicator two

The following are interviews with S3 research subjects:

**R**: What information did you get from the problem?

**S3**: I can know the price of 7 cakes and 2 donuts is equal to 44 thousand and 5 cakes and 4 donuts for 43 thousand.

**R**: Will you add it later? Is that only?

**S3**: I got one cake for 5,000 and the price of one donut is Rp 4,500

**R**: How do you know the price of one donut and one such cake?

**S3**: I counted it by elimination method

**R**: Later your story will only make a story from only one model?

**S3**: (silent)

The results of S4 answers can be seen in Figure 4.

![Figure 4](image2)

**Figure 4.** Student’s answer for indicator two

The following are interviews with S4 research subjects:

**R**: What information did you get from the problem?

**S4**: There are two contributions, \(6a + 2b = 39,000\) and \(4b = 43,000 - 5a\)

**R**: What variable are you suppose to be?

**S4**: (silent and confused)

**R**: How many variables did you get?

**S4**: (confused and silent)

From Figure 3 shows the students are able to create a story, but still not right with the mathematical model presented in the form of images. In addition, students only make about the story with a mathematical model of two mathematical models are presented. Figure 4 students are still experiencing difficulties to separate variables into examples of objects. And also students still have difficulty in explaining the mathematical models presented in the questions into story problems using everyday language so that the answers written are not right.
The S5 work on question number 1c, and S6 working on number 3b. The both of these answers are to communication problems that ask students to explain and make mathematical questions learned. The results of S5 answers can be seen in Figure 5.

![Figure 5](image)

**Figure 5.** Student’s answer for indicator three

The following are interviews with S5 research subjects:

- **R:** What are the first steps you have to do to make that question?
- **S5:** read the story matter and understand it
- **R:** How do you make that question?
- **S5:** because it’s easy
- **R:** explain about the problem you made?
- **S5:** (confused and not answered)

The results of S6 answer can be seen in Figure 6.

![Figure 6](image)

**Figure 6.** Student’s answer for indicator three

The following are interviews with S6 research subjects:

- **R:** How do you make that question?
- **S6:** (no answer)
- **R:** Are the questions you made in accordance with what is known?
- **S6:** (confused and not answered)
- **R:** What do you mean by x value?
- **S6:** wooden cat
- **R:** why don’t you write it down?
- **S6:** (silent)

Figure 5 shows students are not clear in making questions where students do not mention the number of cakes and donuts that will be purchased, so that the impact on solving incorrect questions. Students only add up the equation model from the initial problem, whereas in problem number 1-point c students are asked to make new questions and solve them using SPLDV. Whereas in Figure 6, it appears that students are not clear in making problems so students cannot solve the questions that have been made. The question made is simply "what is the value of x" and students solve it using only one of the linear equation models given and divided by 5y.

The overall results of the analysis of students’ mathematical communication ability show that students have not fully met the indicators of communication ability. Students easily make a mathematical model of a given situation or story. Students have no difficulty in working on indicator 1,
namely expressing real objects, situations and daily events in the form of mathematical models. However, students turned out to be difficult and made mistakes in making questions from known mathematical models. Students are too fixated on the questions given so they cannot explore to make another question. Even some students answer by giving questions that are not logical and not clear (does not fit the context of the initial problem). As for the second indicator which explains mathematical ideas and models into ordinary language, the problem given is asking students to make a story from the given one. The results of the answers to the questions that contain these indicators are correct, but some also still make stories that have nothing to do with the model given.

It can be concluded that for indicator 1, namely expressing real objects, situations and daily events in the form of mathematical models, students' mathematical communication ability can already be categorized high. Indicator 2 is to explain ideas and mathematical models into ordinary language, mathematical communication ability of students are quite categorized as medium. As for indicator 3, namely explaining and making mathematical questions that are learned, many mathematical communication ability of students who cannot answer correctly are categorized as low.

To overcome this problem, some efforts must be made by the teacher to improve students' mathematical communication ability, one of which is to provide open-ended questions in learning and questions so that students are accustomed to working on open-ended problems and explained about what are open-ended problems so that students not doubting and worrying about the answer [17]. In order for students to be abilities in solving open-ended problems more optimally, understanding of mathematical concepts and communication ability is further enhanced [17].

4. Conclusion

The results of the analysis explained the mathematical communication ability of students in SMP Negeri 1 Mojolaban on the material system of two-variable linear equations showed that the percentage of students' success in expressing real objects, situations and daily events in the form of a mathematical model was 91.6%, the percentage of success students in explaining mathematical ideas and models into ordinary language as much as 69.6% and the percentage of students' success in explaining and making mathematical questions learned as much as 40.47%. From the three indicators, it appears that students are still lacking in terms of explaining and making mathematical questions learned.

Student mistakes in solving problems is the lack of mathematical communication so students have difficulty in making a new story and making a new question. Students are also too fixated on a solution of a problem. Though the solution can use several kinds of settlement methods. Therefore the teacher is expected to give open-ended questions in learning and questions so that students are accustomed to working on open-ended problems and explained about what are open-ended problems so that students do not doubt and worry about the answers.

References
[1] Cockroft W H 1982 Mathematics Counts London: HMSO
[2] NCTM 2000 Principles and Standards for School Mathematics (Reston Virginia: NCTM)
[3] Kemendiknas 2006 Permendiknas No 22 Tahun 2006 Tentang Standart Isi Pendidikan Dasar Dan Menengah (Jakarta: Kementerian Pendidikan Nasional)].
[4] Lomibao L S, Luna C A and Namoco R A 2016 J. of education research 4 378-82
[5] Hendriana H 2009 Pembelajaran dengan Pendekatan Metaphorical Thinking untuk Meningkatkan Kemampuan Pemahaman Matematik, Komunikasi Matematik, dan Kepercayaan Diri Siswa Sekolah Menengah Pertama, Universitas Pendidikan Indonesia
[6] Hamilton C. 2011 Communication for result (9th ed.). Boston, USA: Wadsworth, Cengage Learning.
[7] Yang et al 2016 Educ. Technol. Soc. 19, 3 p. 157–169
[8] Suherman E 2003 Contemporary Mathematics Learning Strategies (in Bahasa) Bandung: PT Remaja Rosdakarya
[9] Sudiarta I G P 2005 J. of Pendidikan dan Pengajaran IKIP Negeri Singaraja 3 15-36
[10] Foong P Y 2000 Teaching and Learning 20(2) 49-57
[11] Emilya D 2010 in Jur. Pen. Matematika. 4(1) : 8
[12] Husain H, Bais B, Hussain A, and Samad S A 2002 in Procedia-social and behavioral sciences 60 : 4556.
[13] Fianti, najwa and Linuwih 2016 IOP Conf. Series: Journal of Physics: Conf. Series 824 012008
[14] Sullivan P, Warrn E and White P 2000 Mathematics Education Research Journal 12(1) 2–17
[15] Payadnya I P A A 2016 Development of Learning Designs Aided by “whatif” Questions in an Effort to Improve Students’ Ability to Handle Open Mathematical Problems (in Bahasa) Indonesia: Ganesha University of Education pp 29 -217
[16] Sumarmo 2012 National Seminar of Mathematics Education at Widya Mandira Katholic University Kupang NTT, April 2012.
[17] Mardayanti E, Zulkardi, and Santoso B 2016 J. Pendidikan Matematika 10(1) 1-14