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Research Article

Analysis of students' mathematical communication ability in solving mathematical problems

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Abstract

The aim in study was to analyze the characteristics and levels of mathematical communication of students in solving mathematical problems. This study used a qualitative descriptive study with 6 of prospective teacher, 3 students from STIKIP Bangkalan and 3 prospective teacher students from STIKIP Al Hikmah Surabaya, Indonesia. Research data collection techniques through documentation of teaching preparation assignments, and video recordings during learning to obtain verbal mathematical communication. The comparison method is still used to analyze the data through the stages of data condensation, data display, conclusion drawing, and verification. The results show that the characteristics of mathematical communication consist of accurate, complete, smooth, and systematic. Each subject has different characteristics. The prospective teacher students with high-level communication can explain accurately, completely, fluently, and systematically facts, concepts, procedures, operations, and principles. For prospective teacher students with intermediate levels of mathematical communication can explain accurately, fluently, and systematically facts, concepts, procedures, operations, and mathematical principles. Whereas for low-level prospective teacher students, they can explain mathematics accurately.

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Introduction

Humans are social creatures that cannot possibly live naturally individual (Bartz, 2018). This consequence causes humans to be able interact and communicate with others, so that aspects of communication skills are very important for humans. Students are the nation's successor who must be provided with something that will be useful in their life, especially in socializing. One aspect that needs to be taught to students is how they are able to express their thoughts both in writing and in speech, so that later they are able to interact with the community.

Content standards for primary and secondary education units for mathematics subjects (Fuadi, Johar, & Munzir, 2016) states that one of the objectives of learning mathematics is that students have the ability to communicate ideas with symbols, tables, diagrams, or other media to clarify the situation or problem. For that, teachers need to have good communication skills so that they can be transmitted to students.

According to Farrell (2009), teacher communication in the classroom is used to develop relevant knowledge for students, ask questions and answer questions with students, and tell meaningful experiences in the classroom. In class and learning mathematics the knowledge developed is mathematical ideas and ideas. These mathematical ideas and knowledge can be in the form of facts, concepts, principles, and skills (Gagne & Dick, 1983). This is in line with the results of a study which states that 86% of teachers agree, the communication process during the teaching and learning

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process of mathematics occurs when the teacher explains mathematical concepts, and student and teacher questions and answers (Rahman & Lee, 2014).

According to Poladian & Zheng (2016) some mathematical communication skills that must be mastered are explaining concepts, running procedures smoothly, using strategies, and making arguments. Included in mathematical communication skills, namely the ability to explain the meaning of symbols, diagrams, graphs, and other variations (Morgan, Craig, Schuette & Wagner, 2014). Communication in mathematics learning is unique because it uses many mathematical symbols (Caniglia, Borgerding, & Meadows, 2017). Based on several opinions that have been described, it is concluded that a teacher's mathematical communication skills are needed to explain mathematical facts, concepts, operations, and principles, ask questions, answer questions, and guide discussions in the classroom.

The quality of a teacher's mathematical communication will affect the quality of teaching and learning mathematics (Kurniawan, Yuwono, Irawan, & Susanto, 2018). Good mathematics communication can improve student achievement, understanding of concepts, and reduce student anxiety (Lomibao, Luna, & Namoco, 2016). Teachers who have excellent communication skills, can explain math material well, are easy to understand by students. In addition, the quality of teacher communication can help students convey their ideas to others, encourage students to construct mathematical ideas, and solve math problems. Good mathematical communication has the characteristics of being accurate, precise, and systematic (Harianja, Hernadi, & Indah, 2020), accurate, clear, precise, and correct (Vale & Barbosa, 2017). The accuracy could be described by considering the accuracy of mathematical notation and terminology, the correct concept explanation, the procedure with clear and logical algebra manipulation, the calculation process, and also rigorous final result (Zahri, Budayasa, & Lukito, 2019). From some of these descriptions it is concluded that the teacher's mathematical communication that is accurate, precise, correct, and systematic not only helps students understand the material, but can also improve students' ability to solve problems, construct mathematical ideas, and create conducive learning in the mathematics classroom.

The goal of increasing the level of teacher mathematical communication skills is to raise the level of teacher communication skills to a high level (Kar, 2016). Cristobal & Lasaten (2018) stated that there is a relationship between the level of oral communication and student academic achievement. In practice, mathematical communication carried out by a teacher in learning includes oral and written communication. In line with (Tok, 2010), that during teaching practice, prospective teacher students must plan, also communicate when explaining material, giving questions, and answering student questions. Meanwhile, teaching practice is the pinnacle of education for prospective teachers (Tok, 2010). For this reason, the development of teacher communication skills includes written and oral communication in order to prepare teaching preparation and explain material during learning.

To improve teachers' mathematical communication skills, it is necessary to precede the process of mapping the level of teacher communication skills as a reference for developing training programs. If the teacher's mathematical communication skills improve, it is believed that it will improve the quality of learning mathematics, and in general it will improve the quality of education. Several researchers have started the research process for mathematical communication separation, namely the level of written communication with student subjects (Lim & Pugalee, 2004), the level of oral communication as part of the ability to solve problems with student subjects (Hirschfeld-Cotton, 2008), and (Sample & Sample, 2009) with student research subjects to describe the level of communication in relation to the ability to solve problems both orally and in writing. Through mathematical communication in solving mathematics problems, prospective teacher students can develop positive attitudes in learning, acquire and integrate knowledge, expand and perfect knowledge, use knowledge meaningfully, and develop productive thinking habits. The level of mathematical communication and the ability to solve mathematical problems is very important to the success of learning mathematics.

Method

The model of research is a qualitative descriptive study. Research using this method aims to describe the conditions that occur during the research. This research was written to analyze and describe the mathematical communication skills of prospective teachers in solving math problems.

The subjects of this study were students who are prospective mathematics teachers at STKIP PGRI Bangkalan and STKIP Al Hikmah Surabaya, Indonesia. The difference in campus culture is not a consideration in determining the subject of this study. Two research subjects at each high, medium, and low level of mathematical communication were selected based on the snowball method with the criteria for ranking scores of mathematics and Indonesian language subjects.

The task of oral communication in this research is the task to teach in grade 7 of junior high school with one variable linear equation and inequality material. The subject explains the material of linear equations and inequalities

of one variable, within a span of 2 × 35 minutes. Meanwhile, written communication tasks are teaching preparation documents in the form of lesson plans, ppt, and notes on the blackboard during learning. To obtain oral mathematical communication data, a video recording is carried out during the learning process from the beginning to the end of the lesson. Then the data was triangulated.

The data processing technique uses a modified level and the characteristics of the mathematical communication level, which are as follows:

Table 1.
Levels and Characteristics of Valid and Reliable Mathematical Communication Levels

Communication Level	Characteristics	Description
High	Accuracy	Express mathematical facts, concepts, procedures, operations and principles accurately
	Completeness	Complete mathematical facts, concepts, procedures, operations and principles
	Smoothness	Express mathematical facts, concepts, procedures, operations and principles fluently, without stuttering, with no long pauses
	Systematic	Express mathematical facts, concepts, procedures, operations and principles systematically
	Accuracy	Express mathematical facts, concepts, procedures, operations and principles accurately
Intermediate	Incompleteness	Disclose mathematical facts, concepts, procedures, operations, and principles incompletely
	Smoothness	Express mathematical facts, concepts, procedures, operations and principles fluently, without stuttering, with no long pauses
	Systematic	Express mathematical facts, concepts, procedures, operations and principles systematically
	Accuracy	Express mathematical facts, concepts, procedures, operations and principles accurately
Low	Incompleteness	Disclose mathematical facts, concepts, procedures, operations, and principles incompletely
	Non-fluency	Disclosing mathematical facts, concepts, procedures, operations, and principles smoothly, there is a long delay
	Unsystematic	Disclose mathematical facts, concepts, procedures, operations, and principles in an unsystematic way

Results

The results of this study are written and oral mathematical communication that will be analyzed to describe the characteristics and levels of mathematical communication of prospective teacher students in solving mathematical problems. Figure 1 is the written answer of prospective teacher students as research subjects with a high level of mathematical communication in solving linear inequality problems of one variable. The subject of this study solves this linear inequality problem on the blackboard in the first semester class of junior high school during learning.

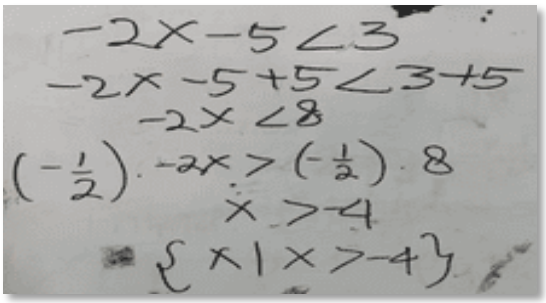

Figure 1.
One-variable Linear Inequality Solution

Data in figure 1 shows, that a high-level subject can write mathematical facts, the number notation -2, 5, 3, 8, $\frac{1}{2}$, and 4 , the x variable, the addition symbol +, the subtraction simbol -, the inequality notation >, and the set symbol { ... } accurately. The linear inequality -2x-5<3 is written accurately. In the second line, the subject adds both sides of the inequality by 5, which is the inverse of -5, then simplifies it to -2x<8. In the fourth line, both sides of the inequality are multiplied by - $\frac{1}{2}$, and reverse the sign of the inequality because it is multiplying by a negative number. The solution to this inequality is written completely { x | x > -4 }. These are some procedures, and principles in mathematical operations that are expressed accurately, completely, and systematically.

Data analysis of video recordings of high-level subjects can also explain solving linear inequalities problems verbally fluently and clearly. Subjects can express facts, and mathematical concepts clearly, and completely, explain operations, and procedures systematically and smoothly without pauses. Likewise for the second high level subject consistently expresses and writes the solution of linear inequalities accurately, completely, fluently and systematically.

The results of this data analysis have shown that high-level research subjects can explain facts, concepts, operations, procedures, and mathematical principles accurately, completely, fluently, and systematically.

The second level research subject is intermediate level mathematical communication, which must solve of $2n + 5 > 16$, n natural numbers. Figure 2 is the written answer of prospective teacher students in solving linear inequality problems of one variable.

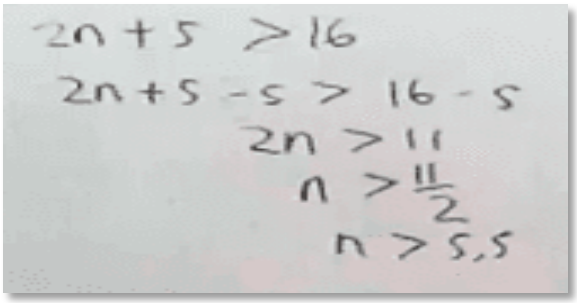

Figure 2.
One-variable Linear Inequality Solution

The subject has written accurate operations and procedures, reducing the right and left sides by 5, and divided both sides by 2. In the fourth line, the right-hand side of the inequality is divided by 2, while on the left-hand side it is not written completely. If the process is completed then the fourth line will be in the form of $\frac{2n}{2} > \frac{11}{2}$. After simplifying, we get the form $n > \frac{11}{2}$. The solution to this mathematical problem is also incomplete because at the end, the solution set in the form { n|n >5.5, n natural number} is not presented. Mathematical problem solving has been written and explained accurately, fluently, and systematically by intermediate level subjects, but the answers are not complete. Analysis of video recordings showed that the subject's oral communication was fluent, but did not explain the set of completions. Based on this analysis, it is concluded that the research subject at the intermediate level has the characteristics of accurate, fluent, systematic, and incomplete mathematical communication.

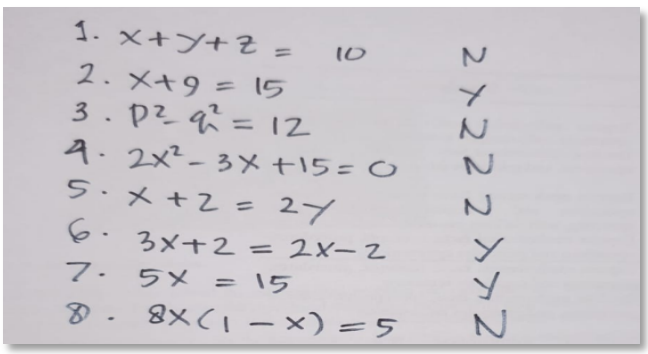

Figure 3.
Examples and non-examples of one-variable linear equations

In Figure 3, subjects with low levels have accurately determined examples and non-examples of linear equations of one variable, with yes or no answers without giving a complete explanation. The answers are written randomly and not systematically because they do not sort from the simplest to the most complex. For example, the answers can be sorted as follows $5x = 15, x + 9 = 15, 3x + 2 = 2x - 2, x + 2 = 2y, x + y + z = 10, p^2 - q^2 = 12, 2x^2 -$

$3x + 15 = 0,\ 8x\ (1 - x) = 5$. Subjects solve mathematical problems smoothly so that all questions can be solved according to the time that has been set. Solving mathematical problems is not complete because the answers are only yes and no, without a clear explanation. So, the research subjects of low-level mathematical communication only have accurate characteristics, and do not meet fluency, completeness, and systematicity

Based on this analysis, the results of this study shows that the mathematical communication characteristics of prospective teacher students consist of accurate, complete, fluent, and systematic. Each subject with different levels has different characteristics, high-level subjects have four characteristics of mathematical communication, medium-level have three characteristics, while low-level subjects meet only one characteristic.

Discussion and Conclusion

The novelty of the results of this study, there are two, namely the characteristics of mathematical communication produced is a combination of oral and written mathematical communication characteristics. Second, the mathematical communication level of prospective teacher students is determined to be the main objective of research, and is developed based on the combined characteristics of oral and written communication. This is different from (Mujiasih, Waluya, Kartono, & Mariani, 2018) who examined the development of geometric reasons for prospective teacher students in terms of their communication skills. (Junsay, 2016) examined the effect of student teacher student reflective learning on communication skills. Meanwhile, (Wenglinsky, 2000) examined the relationship between teacher communication skills and student achievement.

The characteristics of the mathematical communication level of the results of this study are a combination of oral and written characteristics, each of which has 3 characteristics. There are many pairs of combined oral and written communication characteristics for each level of communication. This becomes a sea of knowledge to be studied gradually, more completely and deeply. Based on a study in the field of psychology, the researcher originated from the theory of Bee (2012) which states that effective communication is very important for teachers in the learning process, classroom management, and classroom interactions. Farrell (2009) states that communication in the classroom is used by teachers to develop and increase relevant knowledge, to ask and answer student questions, and to explain various good experiences that can be conveyed in class.

Meanwhile Lomibao et al. (2016) stated that oral and written communication in the field of mathematics can help students understand deeper. In line with this opinion Sample (2009) states that oral communication and tls can help understanding and the process of regrouping mathematical concepts. (ElSheikh & Najdi, 2013) stated that communication is an essential thing in mathematics education. From some of these theories, it is concluded that communication is very important in learning mathematics. Communication in mathematics learning can enhance a deeper understanding of the concept.

In mathematical communication, there are communication characteristics as stated by Lim and Pugalee (2004), namely clear, detailed, precise, correct, and the use of appropriate algorithms or procedures. In line with (Lim & Pugalee, 2004) the characteristics of mathematical communication are accurate, clear, and correct (Hirschfeld-Cotton, 2008). Meanwhile (Sample & Sample, 2009) states that the characteristics of communication consist of effective, correct, systematic, and smooth. This is in line with the opinion of (Wilson, 2009) which states that the characteristics of mathematical communication consist of being accurate, clear, clear, true, and complete. From these opinions, it can be concluded that effective mathematical communication has the characteristics of being accurate, complete, smooth, and systematic.

From the results above, the characteristics of high-level mathematical communication consist of accuracy, completeness, fluency, and systematic. Mathematical facts, terminology, concepts, examples of concepts, procedures, operations and mathematical principles can be expressed accurately, completely, fluently, and systematically by subjects with a high level of mathematical communication. The characteristics of high-level mathematical communication are composed of high-level oral mathematical communication characteristics, namely accuracy, completeness, and fluency with high-level written mathematical communication characteristics, namely accuracy, completeness and systematization. The characteristics of accuracy and completeness appear as characteristics of oral and written communication, fluency characteristics only appear in oral communication, while systematic appears in the characteristics of written communication only.

Meanwhile, the characteristics of medium level mathematical communication consist of accuracy, fluency, and systematization. Subjects with moderate level mathematical communication can express mathematical ideas and knowledge accurately, fluently, and systematically. Medium level mathematical communication characteristics are formed from medium level oral mathematical communication characteristics, namely accuracy and fluency, with

medium level writing characteristics, namely accuracy and systematization. The characteristics of accuracy appear consistently in oral and written communication, fluency in oral communication, systematic in written communication, while completeness is not found in both.

Furthermore, low-level mathematical communication has only one characteristic, namely accuracy, both orally and in writing. Subjects with low-level mathematical communication can express mathematical ideas, concepts and knowledge accurately both orally and in writing

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