Student Communication in Solving Tug of Taw Questions

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Abstract
Communication is a way to share ideas and information so mathematical communication becomes important to consider in the process of teaching and learning mathematics. This research is qualitative research that aims to describe mathematical communication in an interview based on the standards that have been put forward by the National Council of Teachers of Mathematics (NCTM). The subjects of this study were 6th-grade elementary school students and the instruments used is a test about systems of linear equation and also interview guidelines. The results from this study are the description of mathematical communication of the first participants is satisfied in all four of the standard communication in NCTM, which since the beginning has demonstrated high motivation in communicating mathematics. While the second participant only satisfied some standards, at the end of the interview, the second participant showed increased communication of mathematics. The second participant found a better strategy after listening to his peer’s explanation.

INTRODUCTION
Communication is a very important part of the process of learning and teaching mathematics. In the National Council of Teachers of Mathematics (NCTM) (2000), communication is one of the standard processes that must be mastered by students from pre-kindergarten to high school. It is impossible if learn mathematics takes place without regard to communication. NCTM (2000) stated that communication is teaching sharing of ideas, exchanging information, and clarifying knowledge. With the existence of communication, ideas become objects of reflection, experience improvements, are discussed, and are developed.

Program for International Student Assessment (PISA) states that mathematical communication is one of the competencies of mathematical literacy (OECD, 2013). Therefore, it is important to pay attention to communication given the weak communication skills of students at school and the demands for preparation in the future where the world of higher education requires the ability to communicate more clearly both orally and in writing.

Barody (1993) mentions two important reasons for mathematical communication...
in learning including (1) mathematics as a language, which means that mathematics is not just a tool to aid thinking, but a tool for finding patterns, solving problems, and drawing conclusions, but also a tool for communicating various ideas clearly, precisely and briefly; (2) mathematical learning as a social activity which mathematics as a means for interacting among fellow students, as well as with teachers. NCTM (2000) also stated that students who have the opportunity, encouragement, and support to speak, write, read, and listen can have two benefits: they learn mathematics through communication and they learn to communicate mathematically.

Students always developing each time, and the way of communication must also increase. The mathematics they communicate is also increasingly complex and abstract. Students exchange ideas in various ways including orally, through gestures, pictures, objects, and symbols (NCTM, 2000). Communication in mathematics is not only limited to conveying and expressing ideas but also includes absorbing and receiving information and ideas from others, such as hearing or reading. Barody, (1993) suggests that carefully listening to the statements of colleagues in a group can construct more complete and effective mathematical knowledge. Meanwhile, Parker (in Huggins & Maiste, 1999) states that writing what is thought will help students gain clarity and reveal the level of student knowledge. By speaking and writing students learn to use a more appropriate mathematical language to express mathematical ideas. Proficiency in reading, writing, listening, and communicating problems will develop and deepen students' understanding of mathematics (NCTM, 2000).

Language whether in expressing or receiving is an excellent tool and should be used to enhance the learning of mathematics. Because mathematics is sometimes conveyed in symbols, then oral and written communication of mathematical ideas is not always recognized as an important part of mathematics education. Whereas in NCTM it is stated that writing is a valuable way to reflect on what is known. By writing student work, the teacher gets information about errors that students may experience, both conceptual errors and technical errors. Through student writing, the teacher can also see how much knowledge students have acquired and the extent to which students understand the material. So student writing helps teachers in designing and implementing learning for the future. As in NCTM (2000) that students' knowledge can be a starting point for instruction.

Ningsih et al., (2020) stated in the 21st-century millennial era, success in work can be achieved if you can communicate and understand other people. It requires habituation and training communication through responses to answers that have been written as well as other students' answers to obtain meaningful learning (Wulandari & Nurdiana, 2021). This is also stated in Permendikbud Number 58 of 2014 where the purpose of learning mathematics is to instill students' ability to communicate related mathematical ideas with complete sentences, symbols, and tables, and explain problems.

Meanwhile, Qohar (2011a) explains that oral and written communication is still not good enough for junior high school students. In addition, Armiati (2009) states that there is a contradiction where students lack communication with mathematics. This is
supported by Brenner (1998) who states that the low level of students' mathematical communication is due to the short answers given by students. Students experience difficulties in expressing their opinions even though ideas that already in their minds. Students have difficulty writing solutions coherently, feel afraid in expressing ideas, and are less accustomed to communicating ideas using orally. From the description above, this research was conducted to see the gap between the importance of communication and the low ability of students to communicate. So the purpose of this research is to describe students' mathematical communication based on the standards of students' mathematical communication that have been put forward by NCTM.

**METHOD**

This research uses a descriptive qualitative approach. The stages in this study are divided into three parts include the planning stage, the implementation stage, and the final stage. In the first stage, the researcher made preparations and plans which included: (1) reviewing the background of the problem and relevant theories, this was done by collecting literature, studying and making summaries of the collected and relevant literature, then (2) determining the research subject, in this case, the researcher chose two students of The First Glagahsari Elementary School from grade 6, and (3) Construct a research instrument, in this case, the researcher compiled an instrument that contained in Figure 1. The second stage is the implementation which includes data collection and observation. Data collection was carried out by giving problems and interviewing subjects, observations were carried out during data collection. The final stage is the analysis of the data and the preparation of the report. After the data is collected, the researcher analyzes the data obtained based on the four communication standards that must be owned by Pre-Kindergarten 12 students mentioned in NCTM (2000: 60). The validity of the data using data triangulation techniques.
RESULTS AND DISCUSSION

The following is presented from the results of interviews between P (researcher) and two students of grade 6, S1 (First Student), and S2 (Second Student).

P: Try reading and doing the questions together!  
   After a while...

P: What do you think about that problem? Which group will win? [Ask S1]
S1: This one [points to the first group].

P: What do you think? [Ask S2]
S2: um... [thinking], same, the left wins.

P: What is the reason? [ask S2]
S2: um [thinking]... don't know... seems like that...

P: What do you think? [Ask S1]
S1: Because this one [points to the right group], can be replaced with this [points to the right group in the first form] and this [points to the elephant in the left group] can be replaced with this [points to the left group in the second form].

P: What do you mean?
S1: Yes, so here [points to the left group] there are five horses and one bison, and in this one [points to the right group] there are only five horses, so the left wins because of one bison excess.

The conversation regarding the tug-of-war problem at least provided benefits for the participants including expressing ideas and absorbing information. When P asked about the reasons for the participants' answers, one of them tried to communicate their thoughts clearly and convincingly (NCTM, 2000). Another found it difficult to express
his opinion, even though the idea was already in his mind, as Qohar (2011) subject 1 explains his thoughts using his language even though it's simple, for example, S1 says 'replaced' which leads to conventional mathematical language which is commonly called substitution. in more detail, for example by saying 'what it means'. Based on the conversation above, it can be said that the participants met the communication standard namely organizing mathematical thinking through communication (NCTM, 2000).

From the conversation above, it can be seen that the first participant responded and tried to explain in more detail his partner about his idea when he found out that his explanation was not sufficiently understood by his partner. As stated by Brenner (1998) that in communication one must think about how to make the message conveyed by someone else be understood by other people, either friends or teachers. Repeating attempts to explain reasons to one another helps them to clarify their thinking and focus on the essential elements of an issue. NCTM (2000) also stated that students must learn to realize whether they are convincing enough and whether other people can understand them. So that these participants can be said to meet one of the other communication standards in NCTM, namely communicating their mathematical thoughts coherently and clearly to colleagues and others.

Students must learn to ask and investigate other people's thoughts to clarify ideas that have not been developed. Armiati (2009) states that the expected listening ability is critical, this is can encourage students to think about answers while listening. As did the second participant in the conversation above, he interrupted by saying 'how come', to clarify his partner's understanding. By thinking about the claims that others make, students learn to become critical thinkers (NCTM, 2000). Through that, the second
participant has met the communication standards of analyzing the thoughts and strategies of others. It is hoped that training in conveying understanding regarding the material and its reasons will make students more comfortable with learning mathematics (Munawaroh, 2017).

![Figure 2. Subject 1 Work Result](image)

From the results of the participants' work in written form, it can be seen that the participants absorbed information by reading the questions and conveying back what was known [lines 1-4] from the questions in the form of written communication. Participants convert the pictures into mathematical language, namely by symbolizing the pictures in the more formal written mathematical language (ie using the alphabet as a variable and the 'equals' sign to show meaning and relationship), even though there are technical errors in the form of inconsistencies in symbolizing the number of elephants [row 1 with row 3]. Furthermore, participants process information, solve problems, and translate ideas in their minds into written form [lines 5-6]. And finally, participants write down their conclusions and reasons based on the manipulations that have been carried out [lines 7-9]. Parker (in Huggins & Maiste, 1999) states that writing about something that is thought can help students to gain clarity and can reveal the level of understanding of these students. From this description, it can be said that participants with an elementary education level have tried to use the language of mathematics to express mathematical ideas appropriately (NCTM, 2000).

*After writing...*

P: How? Understand with his friend? [Figure 2, pointing to S1]
S2: Got it.
P: Do you have another opinion? I mean another way... [asks S2]
S2: Um, how about that? I think there is
P: How?
S2: The elephants were replaced [pointing to the left group of form 2], then five bison were replaced by this [pointing to the left group of form 1].
The interviewer tried to provoke participant communication by exploring what the participants were thinking, for example by asking for another strategy to solve the tug-of-war problem, and it turned out that the second participant had a different strategy which the first participant recognized as a strategy that was faster and more efficient. This is in line with the NCTM statement that students are expected not only to present and explain ideas but also to analyze, and compare the meaning, efficiency, and beauty of various strategies (NCTM, 2000). Based on that, students are also expected to learn to test the methods and ideas of others to determine strengths and limits. So participant’s comments on other participants' strategies can be seen as one of the NCTM (2000) standards evaluating the thoughts and strategies of other people. Also from this part, the second participant who initially was not able to communicate the reasons for his answers and then listened to his partner's explanations actively and carefully in the end had a strategy that was considered better by his colleagues. Listening carefully to peer questions in a group can help students construct more complete mathematical knowledge and strategize for more effective answers (Tullis & Goldstone, 2020).

CONCLUSION

From the discussion that has been described, it can be concluded as follows. (1) The first participant has high motivation in communicating mathematics, and fulfills the communication standards in NCTM, namely organizing mathematical thinking through communication even in simple language. Second, the first participants communicated their mathematical thinking coherently and clearly to their peers and others. Third, the first participants used mathematical language to express mathematical ideas appropriately by starting to use written mathematical language formally, even though there were technical errors in the form of inconsistencies in writing variables. Fourth, the first participant has met the standard of mathematical communication in evaluating other people's thoughts and strategies by assessing and appreciating the opinion of the second participant as a faster strategy. (2) The second participant at first had difficulty communicating his ideas, but by listening carefully to the explanations of colleagues, the second participant at the end of the interview was able to explain a better strategy, the second participant can be said to be an active listener. The standards that the second participant met included: analyzing other people's thoughts and strategies by clarifying ideas and thinking about the claims that other people make. Second, at the end of the interview, the second participant was able to organize mathematical thinking through communication.
REFERENCES