Mathematical Communication Based on Maslow's Theory: A Study of Learning Motivation in Elementary School Students

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Abstract
Mathematical communication skills are of utmost importance for students to effectively solve mathematical problems. However, the evidence suggests that elementary school students still exhibit very low levels of communication skills. Communication skills are influenced significantly by various factors, and one of these factors is learning motivation. This study aims to describe and analyze the mathematical communication abilities of students in the topic of linear equations of two variables, taking into account their learning motivation based on Maslow’s theory. The research design employed in this study is descriptive qualitative. The data collection instruments consist of written tests on the topic of a two-variable linear equation system, non-test instruments in the form of questionnaires to assess students’ learning motivation based on Maslow’s theory, and semi-structured interview guidelines. The subjects of the study were fifth-grade students at SDN Kedungsari Purworejo, and a sample of six students was selected using purposive sampling. The data analysis technique involved data reduction, data visualization, and drawing conclusions. The research findings indicate that students who fulfill all aspects of Maslow’s theoretical hierarchy exhibit higher learning motivation. This is evident in the differences observed in their responses to the questions. Students who fulfill all aspects of Maslow’s theoretical hierarchy put in more effort to provide detailed and clear answers, while students who only fulfill some aspects of Maslow’s theoretical hierarchy tend to answer questions more straightforwardly without providing a more elaborate explanation.

INTRODUCTION
Mathematics is a discipline taught to students from elementary school, junior high school, senior high school, and even at the tertiary level. This is due to the significant role of mathematics in advancing society. Mathematics education plays a crucial role in developing students’ abilities to convey information through various forms, such as oral, written, diagrams, and graphs (Nurlaila et al., 2018; Sabroni, 2017). The main objective of mathematics education is to equip students with problem-solving skills, including the ability to understand problems, design mathematical models, solve models, interpret obtained solutions, and develop perseverance and confidence in problem-solving (Wardhani, 2008).

One essential skill required in solving mathematical problems is communication. Communication skills for students involve the ability to express ideas, describe, and discuss mathematical concepts coherently and clearly (Kaya & Aydin, 2016; Lomibao et al., 2016). This ability encompasses students’ capability to explain and justify actions in procedures and processes both orally and in writing. Strayer & Brown (2012) emphasized that interactions and communications play a vital role in the learning process. This view is supported by Bruner (1966), who argued that communication skills play a central role in the development of cognitive structures and that language serves not only to represent experiences but also to transform ideas. Mathematical communication involves skills in conveying and elaborating mathematical ideas and concepts using meticulous, analytical, critical, and evaluative...
Effective communication skills in mathematics can support the learning process, enabling students to better comprehend mathematical concepts. This allows students to actively engage in conveying explanations and expressing mathematical ideas through the use of mathematical symbols both orally and in writing, through the use of formulas, drawings, diagrams, graphs, and other mathematical elements.

Methods (Pratama et al., 2017; Kirom, 2022). This ability can be applied both orally and in writing, through the use of formulas, drawings, diagrams, graphs, and other mathematical elements.

Further, mathematical communication aids in consolidating and organizing students' thoughts, enhancing their mathematical knowledge and problem-solving abilities (Astiswijaya, 2020; Rhamdania & Basuki, 2021). When students encounter a mathematical concept, they actively contemplate their ideas, write or speak, and listen to other students when sharing ideas, facilitating the transformation of information from one individual to another. With good communication skills, students can easily master mathematical concepts and make learning active and engaging, avoiding monotony. Communication skills also enable students to connect and interpret the meaning of mathematical problems related to everyday life and express them in the form of materials under study, such as mathematical models, diagrams, graphs, or other forms. Thus, mathematical communication is a crucial skill in solving mathematical problems (Aulia, 2021).

The mathematical communication ability in Indonesia has been a matter of concern due to its persistently low levels. A study conducted by Ekasari & Khotimah (2018) indicated that the low mathematical communication ability can be observed through the results of the TIMSS (Trends in International Mathematics and Science Study) survey in 2015. The survey ranked Indonesia at 45th out of 50 countries. Additionally, another survey placed Indonesia at 69th out of 76 countries. This survey was conducted by PISA (Program for International Student Assessment), which assesses the skills and abilities of students starting from the age of 15. Within the PISA assessment, mathematical literacy is evaluated, encompassing students' abilities to analyze, provide reasoning, and effectively communicate ideas, as well as to formulate, solve, and interpret mathematical problems in various forms and situations.

One of the factors contributing to students' low mathematical communication ability is their level of learning motivation. Learning motivation encompasses both internal motivations originating within individuals and external factors that drive individuals to take a series of actions in their efforts to learn new things (Arianti, 2019). Learning motivation serves to maintain continuity and direction in the learning process, thereby enabling the achievement of desired goals optimally. The motivational theory proposed by Maslow (1954) suggests that human behavior is influenced by two factors, internal and external. Maslow's theory also states that humans possess a unique ability to make and carry out their choices (Maslow, 1954). In his theory, Maslow describes five hierarchies of human needs, namely physiological needs, safety needs, belongingness and love needs, esteem needs, and self-actualization needs.

Hence, a more in-depth research is necessary to examine students' mathematical communication ability, especially in the context of the material on systems of linear equations with two variables, and its relation to the level of students' learning motivation based on the hierarchy of Maslow's theory. This research will divide students into two groups: those who fulfill all aspects of Maslow's hierarchy and those who only fulfill some aspects. The objective of this research is to describe and analyze students' mathematical communication ability in three categories: high, moderate, and low, while considering the level of students' learning motivation, either fulfilling all aspects or some aspects of Maslow's hierarchy. This study is expected to provide a deeper understanding of the factors influencing students' mathematical communication ability and contribute to the development of learning motivation theory in the context of mathematics education.
METHODS

This research was conducted at SDN Kedungsari Purwerejo, with fifth-grade students as the research subjects in the academic year 2022/2023, first semester. The sample size for this study consisted of 6 students. The method employed in this research was qualitative descriptive. The researcher analyzed and described students' mathematical communication ability based on Maslow's theory of learning motivation.

Data sources for this study included non-test instruments, test instruments, and semi-structured interviews. The data were obtained from questionnaires on students' learning motivation based on Maslow's theory, a written test consisting of questions related to systems of linear equations with two variables, observations, semi-structured interviews, and documentation.

The sampling technique used was purposive sampling, which involves selecting research samples based on specific considerations. The considerations in this study were students' mathematical communication ability and their level of learning motivation based on Maslow's hierarchy.

Data were collected using questionnaires in the form of surveys, written tests with open-ended questions, and semi-structured interviews. The categorization of learning motivation fulfilling all aspects and those fulfilling some aspects of Maslow's hierarchy was determined by looking at the three highest scores in each aspect of Maslow's hierarchy, namely physiological needs, safety needs, love needs, esteem needs, and self-actualization needs.

Data validation was conducted using the method of triangulation, which involved cross-checking data from various sources, such as questionnaires, tests, and interviews. To assess the level of students' mathematical communication ability (high, moderate, or low), their scores from various research instruments were used as the basis for evaluation.

RESULTS AND DISCUSSION

Based on the researcher's analysis, it was found that 6 students fulfilled all aspects of Maslow's hierarchy, while the remaining 30 students only fulfilled some aspects of Maslow's hierarchy. Subsequently, the researcher randomly selected 3 students from each category to be the subjects of the study. The mathematical communication abilities of these subjects were then analyzed using a test instrument, resulting in the classification into three different levels: high, moderate, and low. After completing the mathematical communication test, the researcher collected and processed the data. The subjects used in the study can be seen in Table 1.

<table>
<thead>
<tr>
<th>No.</th>
<th>Students who fulfill all aspects of Maslow's hierarchy</th>
<th>Students who fulfill some aspects of Maslow's hierarchy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Subject 1</td>
<td>Subject 2</td>
</tr>
<tr>
<td>2</td>
<td>Subject 3</td>
<td>Subject 4</td>
</tr>
<tr>
<td>3</td>
<td>Subject 5</td>
<td>Subject 6</td>
</tr>
</tbody>
</table>

Table 2. Levels of Research Subjects in Students' Mathematical Communication Ability

<table>
<thead>
<tr>
<th>No.</th>
<th>Subject</th>
<th>Score</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Subject 1</td>
<td>93,33</td>
<td>High</td>
</tr>
<tr>
<td>2</td>
<td>Subject 2</td>
<td>86,67</td>
<td>High</td>
</tr>
<tr>
<td>3</td>
<td>Subject 3</td>
<td>60</td>
<td>Medium</td>
</tr>
<tr>
<td>4</td>
<td>Subject 4</td>
<td>60</td>
<td>Medium</td>
</tr>
<tr>
<td>5</td>
<td>Subject 5</td>
<td>46,67</td>
<td>Low</td>
</tr>
<tr>
<td>6</td>
<td>Subject 6</td>
<td>33,33</td>
<td>Low</td>
</tr>
</tbody>
</table>
After determining the subject, a mathematical communication test instrument was carried out with the material of a system of two-variable linear equations. Table 2 are the results of the test instruments obtained. The different mathematical communication abilities of students at each level can be seen from the way they answer the questions, especially in the graphic questions where the differences in answers from the three levels of mathematical communication ability can be clearly seen. This will be described in the following discussion.

Figure 1. Results of Subject 1’s Answers

In this study, the research subjects for high-level students’ mathematical communication skills were Subject 1 and Subject 2. The answers of the two students can be seen in Figure 1 and Figure 2. Subjects that fulfill all aspects of Maslow’s theory hierarchy are Subject 1 and which only partially fulfill the hierarchical aspect of Maslow’s theory is Subject 2. Figure 2 shows the answers showing that both are able to express and describe ideas in graphical form.

Figure 2. Results of Subject 2’s Answers

From Figure 2 it appears that the two subjects were able to state and describe mathematical ideas from what was asked in the questions in the form of answers in the form of writing. This can be seen from the way he answers questions by giving reasons based on his language and thoughts. Both of them are also able to state mathematical models of real events, to describe mathematical ideas in the form of combined methods from questions related to real events.
Figures 3 and 4 represent the responses of the two subjects with moderate mathematical communication abilities, indicating that both of them are unable to clearly state the reasons for choosing the equations. However, both subjects are able to express mathematical ideas based on real-life events. Furthermore, these two subjects with moderate communication abilities are also capable of expressing and depicting mathematical ideas using combined methods based on real-life events. However, the final answer obtained by Subject 4 is incomplete.

Moving on to the subjects with low mathematical communication abilities, they are Subject 5 and Subject 6. In the graph-related question, it can be observed that both of these subjects are unable to express and depict mathematical ideas using the graphical method.
Based on the analysis conducted by the researchers, it is found that 6 subjects have fulfilled all aspects of Maslow's hierarchy, while the remaining 30 subjects have only fulfilled some aspects of Maslow's hierarchy. The researchers then randomly selected 3 students from each category to be the research subjects. These subjects' mathematical communication abilities were analyzed using a test instrument to categorize them into three different levels: high, moderate, and low.

From Figure 5, it is known that both subjects with moderate mathematical communication abilities are able to state their reasons using their own language. However, Subject 5's answer lacks details, particularly regarding whether the two variables mentioned are the same or not. On the other hand, Subject 6's answer is detailed. In the subsequent question based on real-life events, both subjects are able to state the mathematical model based on the events, but neither of them completes the answer. Subject 5 fails to find the value of variable y, while Subject 6 only writes the mathematical model without completing the solution.

In the previous analysis of mathematical communication abilities, it was observed that subjects with high communication abilities are capable of expressing mathematical ideas in writing and using graphical methods. They are also able to state real-life events in the form of mathematical models and solve problems using complex approaches. Teachers use various strategies such as providing real-life examples, using question-answer techniques, and implementing group-based learning methods to encourage effective mathematical communication in the classroom. In the literature, the question-answer technique and providing real-life examples have been proven effective in enhancing effective mathematical communication in the classroom (Mooney et al., 2009; Chapin et al., 2003). Through the communication process, mathematical ideas become objects of reflection, refinement, discussion, and revision. This communication process helps build meaning and makes these ideas more widely known to many people (Pertiwi et al., 2020).

Meanwhile, subjects with moderate communication abilities are able to state and solve problems from real-life situations using complex approaches. However, they still have limitations in effectively conveying their understanding and ideas through writing or speaking (Yilmaz & Ozen, 2014). Hence, they tend to provide simpler answers without in-depth explanations.

Lastly, subjects with low communication abilities can only express real-life events in the form of mathematical models. This ability may not always be sufficient to handle mathematical problems effectively, as effective communication in describing mathematical understanding is not fully achieved (Yilmaz & Ozen, 2014). Lack of communication skills can hinder students from understanding and solving mathematical problems through the appropriate concepts.

The research also shows that subjects who fulfill all aspects of Maslow's hierarchy have higher learning motivation. Similar research conducted by Aufa (2019) also found that Abraham Maslow's theory can enhance students' learning motivation. Subjects who fulfill all aspects of Maslow's hierarchy appear more enthusiastic and strive to provide answers with detailed and clear explanations.
On the other hand, subjects who only fulfill some aspects of Maslow's hierarchy tend to give shorter answers without in-depth explanations.

The study indicates that students’ mathematical communication abilities can be influenced by their level of learning motivation based on Maslow's hierarchy. Subjects with high learning motivation tend to have better mathematical communication abilities, while subjects with low learning motivation tend to have limited mathematical communication abilities. Therefore, it is essential for educators to understand the role of learning motivation in enhancing students’ mathematical communication abilities and to design appropriate learning strategies to improve both aspects.

**CONCLUSION**

The research findings indicate that subjects who fulfill all or only some aspects of Maslow's hierarchy have the ability to express mathematical ideas in the form of mathematical models and solve problems based on real-life situations. However, subjects who fulfill all aspects of Maslow's hierarchy are capable of answering questions with correct steps and methods, producing accurate answers, and expressing mathematical ideas using their own language and understanding. They are also able to represent mathematical ideas using graphical methods more comprehensively. On the other hand, subjects who only fulfill some aspects of Maslow's hierarchy are able to answer questions with correct steps, but they tend to make mistakes in obtaining the final answer. Furthermore, they have not yet mastered the ability to express mathematical ideas in writing with their own language and understanding perfectly. Both types of subjects lack the ability to draw graphs accurately. Subjects who fulfill all aspects of Maslow's hierarchy can represent and illustrate mathematical ideas using graphical methods, although their graphs may not be perfect. Meanwhile, subjects who only fulfill some aspects of Maslow's hierarchy lack the ability to represent and illustrate mathematical ideas using graphical methods. Both of them can only answer questions up to the stage of finding coordinate points.

**REFERENCES**


