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Analysis of Mathematical Communication Skills Reviewed from Self-Efficacy

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ABSTRACT
Effective mathematical communication plays a crucial role in the resolution of mathematical problems. Despite efforts to enhance mathematical communication, the success rate among students remains relatively low, a situation that is closely associated with their levels of self-efficacy. The purpose of the study was to describe students' mathematical communication skills based on self-efficacy. The research adopts a descriptive qualitative method. The subjects of this study consisted of seventh-grade students who had studied the material on flat shapes. According to the outcomes of the self-efficacy questionnaire, students are classified into three categories: high, medium, and low. Each category was taken by one student as a respondent with the purposive sampling technique. Data collection techniques include tests, questionnaires, and interviews. Data analysis techniques include data reduction, data presentation, and conclusion. The analysis indicated that students exhibiting higher levels of self-efficacy displayed enhanced mathematical communication skills when compared to their peers who possessed lower levels of self-efficacy. This study revealed a significant relationship between mathematical communication and self-efficacy. Students with elevated levels of self-efficacy display enhanced proficiency in mathematical communication skills in comparison to their peers who possess medium and low levels of self-efficacy.

INTRODUCTION

According to Rapsajani & Sritresna (2021), the advancement of a nation is shaped by a multitude of factors, with education being a significant contributor. To foster quality education, both educators and students need to possess strong communication skills. Communication, on a global scale, is defined as the process of transmitting information to others, ensuring that the recipients comprehend the conveyed message (Rapsanjani & Sritresna, 2021).In the context of education, the effectiveness of the learning process can experience a significant increase through intensive communication and interaction between teachers and students (Inah, 2015).

Mathematical communication refers to the skills to convey or describe a solution to a problem in precise and clear language. This includes students' skills to compose and explain problems in various forms, such as pictures, diagrams, graphs, words, sentences, and tables (Berliana & Sholihah, 2022). In addition, mathematical communication skills in the context of problem-solving, as expressed by the National Council of Teachers of Mathematics (Pratiwi, 2015) suggests that the effectiveness of mathematical education can be assessed by evaluating students' abilities to analyse and critique the mathematical reasoning and strategies employed by their peers. In addition, students are also expected to be able to use mathematical language to convey mathematical ideas appropriately and accurately.

Mathematical communication skills refer to students' proficiency in conveying ideas using symbols, tables, diagrams, graphs, or images (Nuraeni & Afriansyah, 2021). These communication skills include students' skills in conveying mathematical concepts both orally and in writing (Hodiyanto, 2017; Syah & Sofyan, 2021). In addition, mathematical communication also plays a role as a social activity (speaking) and a thinking aid (writing) which is recommended by experts to continue to be developed among students (Umar, 2012; Maulani & Sundayana, 2017; Purnamasari & Afriansyah, 2021). Consequently, proficiency in mathematical communication skills is essential for effective learning in the field of mathematics. Baroody (Luritawaty, 2016) suggests that there are two main reasons why mathematical communication is important. Mathematics serves not only as a cognitive tool for identifying patterns, resolving issues, and drawing conclusions, but it also acts as an invaluable medium for conveying a variety of concepts in a clear, accurate, and succinct manner. The second, learning mathematics is a social activity that also functions as a means of interaction between students and students, as well as between teachers and students.

According to the National Council of Teachers of Mathematics (NCTM) (2000), which was then further reviewed by Dewi and Nuraeni (2022), mathematical communication skills include the ability to formulate mathematical reasoning in a structured manner, communicate mathematical concepts clearly and logically to others, and critically evaluate ideas and methods used by others. Furthermore, this cap skill encompasses the utilization of mathematical terminology to convey concepts with precision. The significance of mathematical communication skills is well acknowledged; however, their effective integration into the learning process remains suboptimal (Sumartini, 2019). Research conducted by validators who act as teachers shows that students often face difficulties in providing correct, clear, and logical explanations for answers to questions asked by teachers.

Given the importance of communication skills that students must have, an initiative emerged to analyze their mathematical communication skills. According to Kholil & Putra (2019), mathematical abilities encompass a range of competencies that students should develop, including (1) the skills to connect tangible objects, images, and diagrams through the application of mathematical concepts; (2) the capacity to articulate mathematical ideas, scenarios, and relationships both verbally and in writing, utilizing real objects, images, graphs, and algebraic expressions; (3) the skill to translate everyday occurrences into mathematical language or symbols; (4) the proficiency in listening, engaging in discussions, and composing written work related to mathematics; (5) the cap skills to read and comprehend mathematical texts; (6) the aptitude for making conjectures, constructing logical arguments, and formulating definitions and generalizations; (7) the skills to explain and pose questions regarding mathematical topics that have been previously discussed. Collectively, the aspects highlighted by Sumarmo underscore the significance of adopting a comprehensive approach to the learning of mathematics. The cultivation of these skills in students enhances not only their mathematical abilities but also their critical, creative, and communicative thinking skills. All of these aspects contribute to the development of students as individuals who are ready to face challenges in an increasingly complex real world. Through effective mathematics education, students are prepared to not only master mathematical concepts but also to apply them in their daily lives and careers.

This study delineates the primary indicators of mathematical communication skills as articulated by Hendriana et al. (2017), specifically: (1) written text, (2) drawing, and (3) mathematical expression.

An assessment rubric intended to evaluate the proficiency of these mathematical communication skills is presented in Table 1.

Table 1. Mathematics Communication Assessment Rubric

Indicator	Description
Written Text	Providing answers using one's language, including models of situations or problems using mathematical models in the following forms: oral, written, concrete, graphic, and algebraic, explaining and asking mathematics questions that have been studied, listening, discussing, and writing about mathematics, making predictions, building arguments and generalizations.
Drawing	Reflecting real objects, pictures, and diagrams into mathematical ideas, and vice versa.
Mathematical Expression	Expressing mathematical concepts by stating everyday events in mathematical language or models

Mathematical communication skills are critical components of academic success; however, a significant number of students still struggle to master these skills (Rapsanjani & Sritresna, 2021). One contributing factor to the inadequacy of students' mathematical communication is their difficulty in articulating mathematical concepts during the learning process (Rapsanjani & Sritresna, 2021). This challenge often stems from a lack of self-confidence in their abilities, which is intricately linked to the affective domain of learning. Specifically, self-confidence in one's capabilities is influenced by the affective aspect of self-efficacy.

In a study conducted by Purwati (2016), a significant correlation has been identified between students' mathematical communication skills and their levels of self-efficacy. Subsequent research by Rapsanjani and Sritresna (2021) Students with high self-efficacy demonstrate stronger mathematical communication skills than those with moderate or low self-efficacy. As articulated by Bandura (1997), self-efficacy refers to an individual's confidence in their capacity to effectively organize and execute the necessary tasks to attain specific outcomes. Self-efficacy is a significant factor that can impact an individual's performance in reaching their goals (Wiharso & Susilawati, 2020).

To enhance mathematical communication skills and self-efficacy, it is essential to implement a learning approach that promotes active student engagement, alleviates anxiety, and fosters a positive learning environment. The quality of interaction between students and educators, along with the skills to integrate existing knowledge with new concepts in the context of solving mathematical problems, is of paramount importance (Wiharso & Susilawati, 2020). Therefore, further research is needed to be able to analyze these two variables. Through learning methods such as reading and group discussions, students can improve their mathematical communication skills and increase their confidence in solving mathematical problems, because there is interaction between friends that can strengthen self-efficacy.

Several studies have been conducted before, including research by Hendriana and Kadarisma (2019) explaining the correlation between self-efficacy and mathematical communication skills. The results of the study show that the self-efficacy aspect has a strong influence on improving mathematical communication skills. The learning used should adopt methods that can increase self-efficacy. If the self-efficacy aspect increases, then mathematical communication skills also increase. In line with what was done by Viki and Handayani (2020), it is also shown that communication skills are influenced by two different dimensions of self-efficacy, namely internal and external self-efficacy. The influence of external self-efficacy has an influence percentage of more than 50%. Research by Berliana and Sholihah (2022) explains the characteristics of mathematical communication skills from self-efficacy. The indicators used include connecting real objects in mathematical ideas, understanding and evaluating ideas, conveying ideas in writing, and writing conclusions. This study uses an open-ended type of question.

The difference between this study and the previous one is that the indicators used include written text, drawing, and mathematical expression. In addition, the problems used are contextual and related to student life. This will provide opportunities for students to interpret the learning that has been done in the classroom. This study aimed to describe the profile of students' mathematical communication skills based on their self-efficacy in solving context-related problems.

RESEARCH METHOD

This study employs a qualitative descriptive approach to examine students' mathematical communication skills concerning their self-efficacy. According to Yuliani (2018), qualitative descriptive is a term often used in qualitative research for descriptive studies. This study also uses a naturalistic approach that is used to understand the phenomena being experienced by the research subjects, which is carried out at each subject's home. The subjects of this study consisted of three seventh-grade students of SMP Negeri Satu Atap 1 Cimanggu who had studied shape material. The technique in selecting respondents used the purposive sampling technique. Based on the self-efficacy questionnaire results, one student from each category high, medium, and low was selected as a respondent. The selection was based on specific criteria, including participation in learning, discipline, effective communication, and strong academic performance.

In this study, data collection techniques employed triangulation, utilizing a combination of various instruments. These included tests assessing mathematical communication skills, self-efficacy questionnaires, and structured interviews. Meanwhile, to measure mathematical communication skills, the questions given are descriptive test questions with shape material, while the self-efficacy questionnaire consists of 15 questions with five alternative answers, namely very appropriate (SS), appropriate (S), less appropriate (KS), not appropriate (TS), and very never (STS). The interview instrument is used to produce more accurate data on student self-efficacy. The data generated from the mathematical communication skills test are then assessed according to the previously determined assessment rubric. The results of the questionnaire are also given a score for each answer choice, where for positive statements the scores are given in sequence are 5, 4, 3, 2, 1, while for negative statements the scores are 1, 2, 3, 4, 5. The assessment results from the questionnaire are then interpreted according to the predetermined categories, namely low, medium, and high. The data analysis techniques used in this study, namely the mathematical communication skills test was assessed using a rubric, the results were analyzed descriptively quantitatively (average, median, mode, and percentage), the self-efficacy questionnaire score was calculated based on the Likert scale, then categorized (low, medium, high) and analyzed descriptively, interviews were analyzed qualitatively through data reduction, data presentation, and concluding.

RESULTS AND DISCUSSION

Results

Self-Efficacy

Data on self-efficacy in this study were obtained from two subjects through a questionnaire consisting of 15 questions, covering 5 indicators of self-efficacy. The findings of the study are illustrated through student score images, as detailed in Table 2.

Table 2. Interpretation of Self-Efficacy Level

Intervals	Interpretation
25 – 50	Low
51 - 75	Medium
76 - 100	High

Based on Table 2, the results of each subject's score can be grouped into low, medium, and high criteria.

Table 3. Self-Efficacy Questionnaire Score Obtained

Student	Sum	Criteria
AN	84	High
DW	68	Medium
FS	45	Low

Based on Table 3, it can be observed that AN, with a score of 84, falls into the High category. This finding is strengthened by the results of the analysis of interviews in the field which show that AN has a strong belief in completing every task he faces. AN also has high confidence in his abilities, this is reflected in an attitude that shows resilience and does not give up easily in solving problems and mastering the material.

Meanwhile, DW with a score of 68 is classified as medium while FS with a score of 45 is classified as Low. The results of the field interview analysis support this finding, showing that confidence in task completion skills is still low. This low confidence can be seen from the attitude that tends to give up quickly when facing questions and in the process of mastering the material.

Mathematical Communication Skills

a. Analysis of Mathematical Communication Skills of Students with High Self-Efficacy Level

The results of the analysis regarding the mathematical communication abilities of students demonstrating a high level of self-efficacy, specifically AN, are presented in Fig. 1.

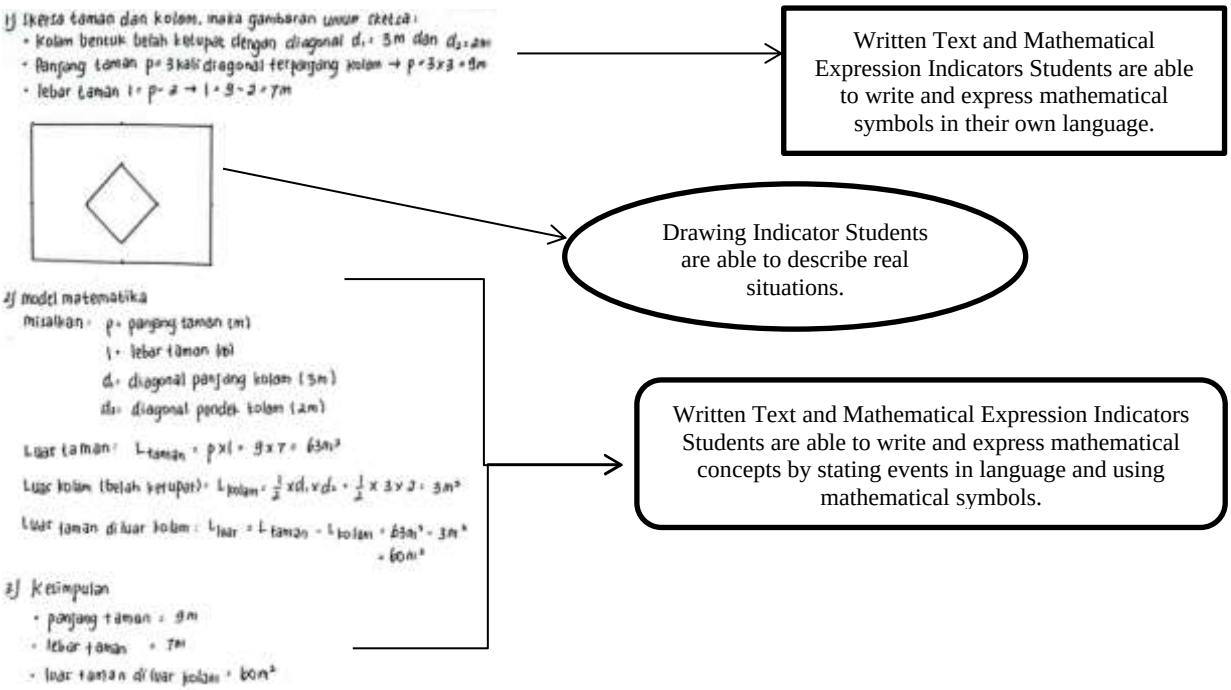

***Fig. 1** AN's answer results*

Based on Fig. 1, it can be concluded that AN can solve the problems he faces in the right way. The solution process carried out by AN began by making a list of known information, questions asked, and answers obtained, until finally arriving at the final result. From the existing indicators, it can be seen that AN did not have difficulty in solving the problems and was able to fulfil 3 indicators of mathematical communication skills.

b. Analysis of Students' Mathematical Communication Skills with Medium Self-Efficacy Levels

The results of the analysis of students' mathematical communication skills with medium self-efficacy levels, namely DW can be seen in Fig. 2.

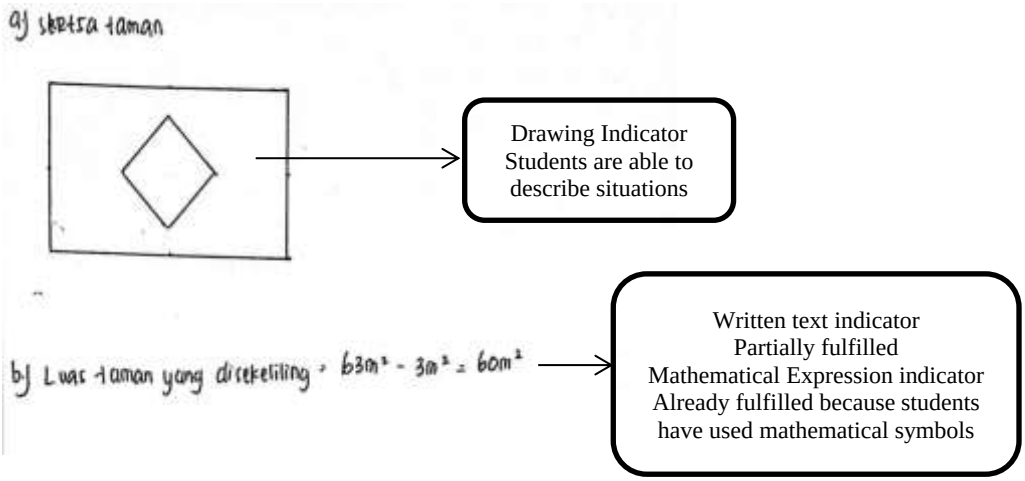

Fig. 2 *DW's answer results*

Based on Fig. 2, it can be seen that DW successfully solved one of the questions correctly. DW was only able to fulfil two indicators of mathematical communication skills, namely the drawing and mathematical expression indicators, for the written text indicator only some of them were fulfilled.

c. Analysis of Students' Mathematical Communication Skills with Low Self-Efficacy Levels
The analysis of students' mathematical communication skills has yielded results indicating low levels of self-efficacy, specifically in the area of FS.

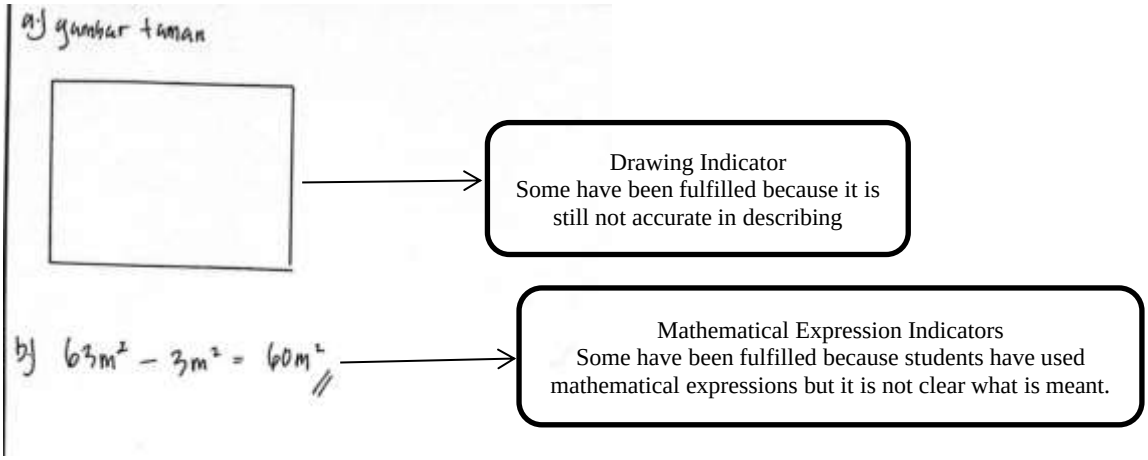

Fig. 3 *FS's answer results*

Based on Fig. 3, it can be seen that FS has not been able to solve the problem correctly. FS has not been able to fulfil all the indicators in mathematical communication skills optimally, be it written text, drawing, or mathematical expression.

Discussion
The results of this study indicate that AN has high mathematical communication skills, while DW shows mathematical communication skills at a moderate level. From the self-efficacy indicator, subjects with a high level of self-efficacy are more capable of solving problems that test mathematical communication skills compared to subjects with moderate and low levels of self-efficacy, because they can complete all three indicators well. On the other hand, students exhibiting a moderate level of self-efficacy are capable of completing two indicators: drawing and mathematical expression.

In contrast, students with low levels of self-efficacy face obstacles in achieving all indicators of mathematical communication optimally. In the analysis of the problem, DW was only able to describe it correctly while the answer only included the answer without including information on where the results were obtained, and FS was also unable to describe it correctly and only provided an answer without explaining. The interview results showed that DW and FS tended to want to complete the task quickly, so they were hasty and not careful in completing the problems they faced, only occasionally included and mentioned the problems, and were less able to communicate mathematical ideas in learning, and also had lower self-confidence in proving a statement compared to students with high levels of self-efficacy.

Research conducted by Raspanji & Sritresna (2021) concluded that students with high levels of self-efficacy tend to have high mathematical communication skills as well. This also applies to students with medium and low levels of self-efficacy, where their mathematical communication skills are also at the appropriate levels, namely medium and low. A further study that corroborates this finding is the research conducted by Juhrani et al. (2017). Their findings indicate that students classified with low self-efficacy often experience elevated levels of anxiety, which adversely affects their academic performance.

According to Chalim et al. (2019), Students with high self-efficacy demonstrate excellent mathematical communication skills, while those with moderate self-efficacy exhibit average skills. Meanwhile, students with low self-efficacy tend to have weak mathematical abilities. Research conducted by Sugandi and Akbar (2020), also stated that students with high self-efficacy have better mathematical communication skills compared to students with moderate and low self-efficacy.

CONCLUSION

Based on the results of the research and analysis that have been conducted, it can be concluded that students' mathematical communication skills are greatly influenced by their level of self-efficacy and have a significant correlation. Hal ini kanadar dari hasil tes komunikasi mathematis, di mana siswa dengan tingal self-efficasi tinggi kebuatan kepehansi yang lebih baik komunikasi mathematis dengan dengan siswa dengan tingal self-efficasi mediang dan rehna. Students with high levels of self-efficacy can master three indicators of mathematical communication skills well. Students with moderate self-efficacy levels were only able to master two indicators of mathematical communication skills, namely drawing and mathematical expression. Meanwhile, students with low self-efficacy levels were unable to master the three indicators of mathematical communication skills well.

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