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Correlation Between Self-Efficacy and Students' Mathematical Communication Skills

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ABSTRACT

This study is motivated by the low level of students' mathematical communication skills and the suboptimal level of self-efficacy, both of which require special attention in the learning process. Mathematical communication skills are essential as they enable students to express and interpret mathematical ideas clearly, both orally and in writing. Self-efficacy plays an important role in shaping students' confidence to actively participate, complete tasks, and express their opinions. This study aims to determine the relationship between self-efficacy and students' mathematical communication skills using a quantitative approach with a correlational method. The participants were 25 eighth-grade students of SMPN 5 Tarogong Kidul selected through purposive sampling. The research instruments consisted of a self-efficacy questionnaire and a mathematical communication skills test based on the indicators of each variable. The data were analyzed using Pearson correlation analysis. The results showed a correlation coefficient of 0.544 with a significance value of 0.005, indicating a positive and significant relationship between self-efficacy and students' mathematical communication skills. These findings suggest that higher levels of self-efficacy are associated with better ability in communicating mathematical ideas. This study also contributes by providing a comprehensive analysis supported by prerequisite statistical tests, thereby strengthening empirical evidence regarding the relationship between the two variables at the junior high school level. Therefore, affective aspects, particularly self-efficacy, need to be considered in improving the effectiveness of mathematics learning through supportive and interactive learning strategies.

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Introduction

The 21st century has brought significant transformations to various aspects of life, including education, which requires the development of highly competent human resources to achieve optimal outcomes (Mardhiyah et al., 2021). In this context, student-centered learning has become an essential approach in modern education (Muliastrini, 2020). This approach does not merely position students as recipients of information but also provides them with autonomy and responsibility to manage their own learning processes. Therefore, students need to develop relevant skills to address the challenges of 21st-century learning. To meet these demands, students are expected to possess at least four key competencies: critical thinking, creative thinking, communication, and collaboration (Hanisyah & Munahefi, 2024).

Communication is a crucial skill that students need to develop in order to participate actively in 21st-century learning. In mathematics education, this skill is referred to as mathematical communication, which reflects students' ability to express mathematical ideas orally and in writing (Sundanah & Rahmadiansyah, 2022). Saidah & Mardiani (2021) further emphasize that mathematical communication involves several interrelated activities, including speaking, explaining, describing, listening, asking questions, clarifying, sharing ideas, writing, and reporting what has been learned. Therefore, students' mathematical communication skills need to be continuously strengthened because they function not only as social activities, such as talking and discussing, but also as cognitive tools, particularly through writing (Purnamasari & Afriansyah, 2021). Students with strong mathematical communication skills are able to present reasoning in a structured manner, explain ideas clearly, and deepen their conceptual understanding.

However, in practice, students' mathematical communication skills remain insufficient. Many students experience difficulties in expressing mathematical ideas clearly, both orally and in writing. This condition is consistent with Suhenda & Munandar (2023), who reported that students' mathematical communication skills in Indonesian mathematics education are still relatively low. Similarly, a study conducted by Ismayanti & Sofyan (2021) in Kampung Cigulawing found unsatisfactory results, as most students did not meet all indicators of mathematical communication skills. Hakiki & Sundayana (2022) also reported that many students still struggle to solve problems involving images, graphs, and other visual representations. These difficulties may be influenced by several factors, including fear of making mistakes, limited experience in explaining solution processes, and learning practices that emphasize final answers rather than reasoning and problem-solving processes. Therefore, systematic efforts are needed to strengthen the factors that support students' mathematical communication skills.

The importance of mathematical communication skills in mathematics learning is closely related to students' affective aspects, as emphasized by the Ministry of National Education (Syah & Sofyan, 2021). Mathematics learning is not only directed toward conceptual mastery but also toward the development of positive attitudes, including self-efficacy (Wida et al., 2022). Prajono & Gunarti (2022) define self-efficacy as an individual's belief in their ability to plan, carry out, and achieve desired goals. In mathematics education, self-efficacy is closely associated with how students evaluate their own abilities to understand concepts, solve problems, and engage in mathematical communication activities (Samsuddin & Retnawati, 2022).

Self-efficacy is a key factor that influences how students learn and achieve expected outcomes. Wida et al. (2022) explain that self-efficacy contributes significantly to learning success because students who believe in their abilities tend to be more persistent, more willing to face challenges, and better able to maintain motivation when encountering difficulties. In

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mathematics learning, self-efficacy also plays an important role in students' mathematical communication skills. Gunur et al. (2023) found that students with high self-efficacy tend to demonstrate stronger mathematical communication skills. This finding is consistent with Firdaus et al. (2022), who reported that higher self-efficacy is associated with better mathematical communication skills. Conversely, students with low self-efficacy often feel insecure, fear making mistakes, and tend to be passive during the learning process. Thus, the relationship between self-efficacy and mathematical communication skills is not incidental. The role of self-efficacy in shaping students' attitudes, motivation, and learning behavior indicates that affective aspects deserve attention alongside cognitive aspects in mathematics learning.

Several previous studies have demonstrated a positive relationship between self-efficacy and mathematical communication skills. These findings are relatively consistent in showing that higher levels of self-efficacy are associated with better mathematical communication skills. However, most existing studies have focused mainly on measuring the general relationship between the two variables, without providing a more operational explanation of the mathematical communication indicators used in the learning process. In addition, studies that examine this relationship among eighth-grade junior high school students using comprehensive prerequisite statistical analyses remain limited.

Based on this gap, the present study aims to strengthen empirical evidence regarding the relationship between self-efficacy and mathematical communication skills through a more comprehensive analytical approach. Mathematical communication skills are measured based on indicators such as written expression of ideas, explanation of problem-solving processes, and visual representation. Meanwhile, self-efficacy is constructed based on the dimensions of level, magnitude, and strength. Therefore, this study does not merely confirm the relationship between the two variables but also provides a more operational description of how self-efficacy is related to students' mathematical communication skills at the junior high school level.

The findings of this study are expected to provide pedagogical implications for designing mathematics learning that is oriented not only toward conceptual understanding but also toward strengthening students' self-efficacy in communicating mathematical ideas. By considering cognitive and affective aspects simultaneously, mathematics learning can be designed more effectively to support students' conceptual understanding, confidence, and active participation.

Method

Research Design

This study employed a quantitative approach with a correlational research design. This design was selected because it enables the researcher to examine the strength and direction of the relationship between two main variables, namely self-efficacy and mathematical communication skills. In this study, self-efficacy was positioned as the predictor variable, while mathematical communication skills were positioned as the outcome variable. A correlational design is appropriate when the purpose of the study is to investigate the relationship between variables without providing treatment or manipulating the research conditions. The relationship between the two variables was tested using the Pearson product-moment correlation because the data were measured on an interval scale and met the assumptions required for parametric analysis.

Participants

The population of this study consisted of all eighth-grade students at SMPN 5 Tarogong Kidul in the second semester of the 2024/2025 academic year. The sample comprised 25 students selected using a purposive sampling technique. The selection was based on several considerations, including class readiness, accessibility, and alignment with the research objectives. The sample consisted of 12 male and 13 female students. Although the sample size was relatively limited, it was considered acceptable for an initial correlational study, provided that the assumptions for parametric analysis were met.

Instruments

This study employed two instruments: a mathematical communication skills test and a self-efficacy questionnaire. The mathematical communication skills test consisted of four essay questions developed based on indicators of mathematical communication, including the ability to express mathematical ideas in written form, explain problem-solving processes, and represent information visually through graphs, diagrams, or other mathematical representations. Meanwhile, the self-efficacy questionnaire consisted of 30 statements, comprising 15 positive and 15 negative items. The questionnaire was developed based on three main dimensions of self-efficacy: level, magnitude, and strength. A four-point Likert scale, ranging from Strongly Agree to Strongly Disagree, was used to encourage students to provide clear responses without selecting a neutral option. Prior to implementation, the instruments were subjected to content validation by two expert lecturers to ensure the alignment between the items, the measured variables, and the research objectives. The instruments were then tested for empirical validity and reliability. Item validity was examined by comparing the calculated t-values with the t-table value at the 5% significance level. The reliability of the instrument was examined to determine the consistency of the measurement results.

The item validity test for the mathematical communication skills test showed that the t-values for items 1 to 4 were 6.61, 11.56, 7.36, and 7.87, respectively. These values exceeded the t-table value of 2.06, indicating that all items were valid. The reliability test yielded a coefficient of 0.699, indicating an acceptable level of reliability. Furthermore, the discrimination index analysis showed that items 1 and 2 obtained a value of 0.21, which was categorized as moderate; item 3 obtained a value of 0.35, also categorized as moderate; and item 4 obtained a value of 0.44, which was categorized as good. The difficulty index analysis indicated that items 1, 2, and 4, with values of 0.55, 0.61, and 0.53, respectively, were in the moderate category, while item 3, with a value of 0.27, was categorized as difficult. Overall, the pilot test results indicated that the mathematical communication skills test met the criteria for validity, reliability, discrimination power, and difficulty level.

Data Collection and Analysis

The data collection procedure was conducted in several stages. First, the instruments were prepared by developing the self-efficacy questionnaire, constructing the mathematical communication skills test items, and conducting content validation with two expert lecturers. Second, the self-efficacy questionnaire and mathematical communication skills test were administered to all participants in a controlled classroom setting. Third, the collected data were checked, scored, and coded. Students' responses to the mathematical communication skills test were scored based on the predetermined scoring rubric, while responses to the self-efficacy questionnaire were converted into numerical data according to the Likert scale. Finally, the data were organized and processed using SPSS for statistical analysis. Before hypothesis testing,

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prerequisite analyses were conducted, including normality and linearity tests. The normality test was performed using the Shapiro-Wilk test because the sample size was fewer than 50 participants. The linearity test was conducted to ensure that the relationship between self-efficacy and mathematical communication skills followed a linear pattern. After these assumptions were met, the analysis proceeded with the Pearson product-moment correlation test to determine the direction and strength of the relationship between the two variables.

Research Findings

Descriptive Statistics

The data obtained in this study consisted of two main variables, namely self-efficacy as the independent variable (X) and mathematical communication skills as the dependent variable (Y). This section presents a descriptive overview of the data collected during the research process, aiming to provide an initial understanding of the characteristics of each variable as well as the potential relationship between them. The results of the descriptive statistical analysis for both variables are presented based on the output of IBM SPSS Statistics 22, as shown in Table 1.

Table 1. Descriptive Statistics of Self-Efficacy and Mathematical Communication Skills

		Self_Efficacy	**Mathematical Communication**
N	Valid	25	25
	Missing	0	0
Mean		81,52	82,64
Std. Deviation		8,917	8,765
Minimum		66	65
Maximum		99	97

Based on Table 1, data from 25 respondents indicate that the self-efficacy variable (X), which consists of three dimensions level, magnitude, and strength had a minimum score of 66 and a maximum score of 99. The mean score was 81.52 with a standard deviation of 8.917. For the mathematical communication skills variable (Y), the minimum score was 65 and the maximum score was 97. The average score obtained by students was 82.64 with a standard deviation of 8.765.

Descriptive Statistical Analysis

To better understand the responses provided by participants for each variable, the data were presented using descriptive statistics. This analysis aims to provide a general overview of the data distribution and the tendency of the observed values. The data were then organized and summarized in the form of tables, figures, and simple numerical representations to enhance clarity and interpretation.

Self-Efficacy

The total self-efficacy scores of students were classified into three categories: high, moderate, and low. This classification was determined using interval ranges as the basis for grouping the measurement results. The distribution of self-efficacy data is presented in Table 2.

Table 2. Self-Efficacy Categories

Category	Criteria	Frequency
Low	$30 \leq x \leq 60$	0
Moderate	$61 \leq x \leq 90$	21
High	$91 \leq x \leq 120$	4

Furthermore, this classification was used as a basis for comparing students' mathematical communication skills. Figure 1 illustrates the percentage distribution of students' self-efficacy across categories.

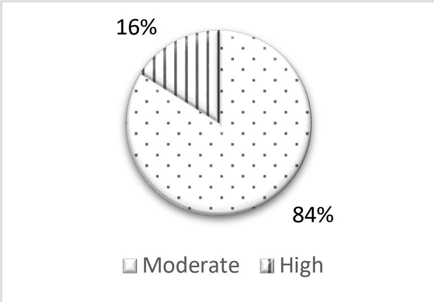

Figure 1. Percentage Distribution of Students' Self-Efficacy

Figure 1 shows that no students were classified as having low self-efficacy. In contrast, the majority of students were in the moderate and high categories, indicating that students generally possess a positive level of self-efficacy. However, only 16% of students were categorized as having high self-efficacy.

Mathematical Communication Skills

The distribution of data for the mathematical communication skills variable is presented in Table 3.

Table 3. Categories of Mathematical Communication Skills

Category	Criteria	Frequency
Moderate	$56 \leq x \leq 70$	3
High	$71 \leq x \leq 85$	12
Very High	$86 \leq x \leq 100$	10

Based on Table 3, the percentage of each category of students' mathematical communication skills is visualized in Figure 2.

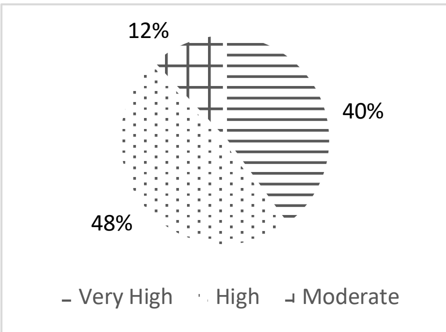

Figure 2. Percentage Distribution of Mathematical Communication Skills

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Figure 2 shows that the majority of students (48%) fall into the high category of mathematical communication skills. In addition, 40% of students are classified in the *very high* category, indicating that nearly half of the respondents are able to communicate mathematical concepts very effectively through written representations, visual forms such as diagrams, and oral explanations. Meanwhile, 12% of students fall into the moderate category, indicating that a smaller proportion of students are still able to communicate mathematical ideas adequately. No students were categorized as having low or very low mathematical communication skills. Overall, these results indicate that students generally demonstrate good mathematical communication abilities. This condition also suggests that most students have mastered basic skills in formulating mathematical ideas, interpreting information in graphical or diagrammatic forms, and explaining problem-solving procedures systematically. However, there is still room to increase the number of students who achieve the *very high* category.

Inferential Statistical Analysis

Before conducting the main hypothesis testing, prerequisite tests were performed to ensure that the data met the required statistical assumptions. In this study, two prerequisite tests were applied: the normality test and the linearity test. Both analyses were conducted using IBM SPSS Statistics 22. The normality test was conducted to determine whether the data for each variable were normally distributed. In this study, the Shapiro–Wilk test was used with a significance level of 0.05 and a sample size of 25 students. This test was applied to both instruments, namely the mathematical communication skills test and the self-efficacy questionnaire. The summary of the normality test results is presented in Table 4.

Table 4. Results of Normality Test for Self-Efficacy and Mathematical Communication Skills

Variable	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	**df**	**Sig.**	**Statistic**	**df**	**Sig.**
Self-Efficacy	0,094	25	0,200*	0,961	25	0,445
Mathematical Communication Skills	0,210	25	0,006	0,931	25	0,093

The results of the normality test indicate that the self-efficacy variable obtained a significance value of 0.445, while the mathematical communication skills variable obtained a significance value of 0.093. Since both values are greater than 0.05, it can be concluded that the data for both variables are normally distributed. Therefore, the assumption of normality was satisfied, and the data were suitable for further analysis using parametric tests. After confirming normality, a linearity test was conducted to examine whether the relationship between self-efficacy (X) and mathematical communication skills (Y) followed a linear pattern. This test is essential to determine the appropriateness of using a correlational model in this study. The results of the linearity test are presented in Table 5.

Table 5. Results of Linearity Test between Self-Efficacy and Mathematical Communication Skills

			Sum of Squares	df	Mean Square	F	Sig.
Mathematical Communication Skills* Self-Efficacy	Between Groups	(Combined)	1315,093	18	73,061	,829	,652
		Linearity	544,872	1	544,872	6,184	,047
		Deviation from Linearity	770,221	17	45,307	,514	,869
	Within Groups		528,667	6	88,111		
	Total		1843,760	24			

Based on Table 5, the significance value in the *Linearity* row is 0.047, which is less than 0.05, indicating that there is a linear relationship between self-efficacy and students' mathematical communication skills. Meanwhile, the significance value for *Deviation from Linearity* is 0.869, which is greater than 0.05, indicating that there is no significant deviation from linearity. Therefore, the linear model is considered appropriate for describing the relationship between the two variables.

The results of the prerequisite tests indicated that both variables, self-efficacy and mathematical communication skills, were normally distributed. Therefore, the analysis of the relationship between the two variables was conducted using the Pearson Product-Moment correlation test. This test was used to determine the direction and strength of the linear relationship between the variables. The analysis was performed using IBM SPSS Statistics 22 with a significance level of $\alpha = 0.05$. The results of the correlation analysis are presented in Table 6.

Table 6. Correlation between Self-Efficacy and Mathematical Communication Skills

		Self-Efficacy	**Mathematical Communication Skills**
Self-Efficacy	Pearson Correlation	1	,544**
	Sig. (2-tailed)		,005
	N	25	25
Mathematical Communication Skills	Pearson Correlation	,544**	1
	Sig. (2-tailed)	,005	
	N	25	25

**. Correlation is significant at the 0.01 level (2-tailed).

Based on the results of the Pearson correlation test, the significance value obtained was 0.005, which is lower than the threshold of 0.05. Therefore, the null hypothesis (H_0) was rejected, indicating that there is a statistically significant relationship between self-efficacy and students' mathematical communication skills. The correlation coefficient of 0.544 indicates that the strength of the relationship between the two variables falls into the moderate category. Furthermore, the positive value of the Pearson correlation coefficient shows that the relationship is positive in nature, meaning that an increase in self-efficacy is associated with an increase in mathematical communication skills. In other words, higher levels of students' self-confidence tend to be followed by better quality of mathematical communication.

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Discussion

The results of this study indicate a positive relationship between self-efficacy and students' mathematical communication skills. This finding suggests that students' confidence in their own abilities plays an important role in encouraging them to express mathematical ideas, explain solution procedures, and participate actively in mathematical discussions. This result is consistent with Elindra et al. (2023), who reported that self-efficacy is associated with students' ability to communicate mathematical ideas in both written and oral forms. In the context of eighth-grade junior high school students, self-efficacy may be particularly relevant because students at this level are developing greater academic independence and confidence in expressing their thinking. Similarly, Zulfa et al. (2021) found that students with higher self-efficacy tend to be more confident in explaining their mathematical reasoning to others.

Theoretically, these findings are consistent with Bandura's view that self-efficacy influences individuals' motivation, persistence, and cognitive strategies when completing academic tasks. In mathematics learning, students who believe in their abilities are more likely to express their reasoning, engage in problem-solving activities, and persist when facing difficulties. Recent studies also show that self-efficacy plays an important role in supporting students' engagement in mathematical thinking and problem-solving activities (Handayani et al., 2024). However, the moderate correlation found in this study indicates that mathematical communication skills are not determined by self-efficacy alone. Other factors, such as prior mathematical knowledge, teaching strategies, classroom interaction, learning environment, and teacher support, may also contribute to students' mathematical communication performance. This interpretation is in line with A'yuni et al. (2024), who emphasize that mathematical communication is influenced by cognitive factors, affective factors, and instructional practices.

The findings of this study are also consistent with previous studies by Nurhanurawati et al. (2021), Wida et al. (2022), and Rapsanjani & Sritresna (2021), which reported a positive association between self-efficacy and mathematical communication skills. More recent research also shows that students with higher self-efficacy tend to be more active in explaining solution procedures and expressing mathematical ideas systematically (Putri & Setianingsih, 2024). In addition, students' self-efficacy has been linked to the quality of mathematical representations used in communication processes (Novianti & Wayudi, 2024). However, the present study extends these findings by examining the relationship between self-efficacy and mathematical communication skills among eighth-grade students at SMPN 5 Tarogong Kidul in a regular classroom context without a specific learning intervention. Thus, this study contributes empirical evidence showing that the relationship between the two variables can also emerge in everyday mathematics learning settings.

Furthermore, this study measured mathematical communication skills through several indicators, including the ability to explain problem-solving processes, express mathematical ideas in written form, and represent information visually. The use of these indicators provides a more operational understanding of the communication aspects being assessed. Putri & Setianingsih (2024) similarly state that students' mathematical communication skills can be observed through their ability to express ideas in writing, explain solution steps, and use mathematical representations such as symbols, tables, diagrams, or graphs. While many previous studies have examined the general relationship between self-efficacy and mathematical communication, the present study situates mathematical communication within concrete classroom-based activities. This strengthens the practical relevance of the findings because students' communication skills are not treated as abstract abilities, but as observable actions in solving and explaining mathematical problems.

From a pedagogical perspective, these findings imply that the development of mathematical communication skills should be supported by efforts to strengthen students' affective aspects, particularly self-efficacy. Mathematics teachers should not focus only on the correctness of students' answers, but also provide opportunities for students to explain their reasoning, present different solution strategies, and use multiple representations. A psychologically safe classroom environment is also important because students are more likely to communicate their ideas when they do not fear making mistakes. Recent studies indicate that learning environments that provide opportunities for discussion and presentation can enhance both students' confidence and their mathematical communication skills (Novianti & Wayudi, 2024). Therefore, motivational support, constructive feedback, and active communication opportunities can serve as important strategies for fostering students' self-efficacy while improving their mathematical communication skills.

Conclusion

The findings of this study indicate that self-efficacy is significantly associated with students' mathematical communication skills. This suggests that students' confidence in their own abilities plays an important role in encouraging them to express mathematical ideas, explain problem-solving procedures, and use various forms of representation in mathematics learning. Therefore, mathematics instruction should not only focus on conceptual understanding but also support the development of students' self-efficacy through supportive and interactive learning activities, such as classroom discussions, presentations, and opportunities to express mathematical ideas. However, this study has several limitations. First, the sample size was relatively small, which may limit the generalizability of the findings. Second, the study was conducted in only one school, so the results may not fully represent students with different characteristics or learning environments. Therefore, future research is recommended to involve larger and more diverse samples. Further studies may also consider additional factors that influence students' mathematical communication skills, such as prior mathematical ability, teaching strategies, classroom interaction, and learning motivation, in order to obtain a more comprehensive understanding of this relationship.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

N.D. conceived the research idea, collected the data, developed the theoretical framework and methodology, and performed data organization and analysis. U.I., as the research supervisor, actively contributed to the discussion and provided approval for the final version of the manuscript. All authors have read and approved the final version of the manuscript. The contribution percentages for conceptualization, writing, and revision of this manuscript are as follows: N.D.: 50% and U.I.: 50%.

Data Availability Statement

The authors declare that the data supporting the findings of this study are available from the corresponding author (N.D.) upon reasonable request.

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