ISSN 2502-5872 (Print)
ISSN 2622-3627 (Elektronik)

Volume 10 Number 2, May 2025, 539-553

CORRELATION OF SELF-EFFICACY IN DIFFERENTIATED LEARNING WITH STUDENTS' MATHEMATICAL COMMUNICATION SKILLS IN VOCATIONAL SCHOOL

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ABSTRACT

This study aims to determine the relationship between self-efficacy in differentiated learning and the mathematical communication skills of vocational school students. The research method employed is a quantitative approach utilizing correlational techniques. The research sample consisted of 36 vocational school students selected through random sampling. The instruments included a self-efficacy questionnaire with 29 statements and a descriptive test assessing mathematical communication skills with eight items. Data analysis techniques included normality tests, linearity tests, and Spearman correlation tests, as the data did not meet the assumptions of linearity. The results revealed a Spearman correlation coefficient value 0.995, with a significance (Sig. 2-tailed) of 0.000. This indicates a strong and significant relationship between self-efficacy and students' mathematical communication skills. This study emphasizes the importance of teachers' efforts in enhancing students' self-efficacy through differentiated learning to foster the optimal development of their mathematical communication skills.
Keywords: Self-efficacy, Mathematical Communication, Correlation.

How to Cite: Slamet., & Quensy, R. (2023). Correlation of Self-efficacy in Differentiated Learning with Students' Mathematical Communication Skills in Vocational School. *Mathline: Jurnal Matematika dan Pendidikan Matematika, 10*(2), 539-553. http://doi.org/10.31943/mathline.v10i2.955

PRELIMINARY

Mathematical communication is crucial in student learning, encompassing the ability to articulate and write about mathematics. (Kusumawardhani et al., 2024; Rahman & Wandini, 2024; Shofwani et al., 2023). Indonesia continues to have relatively poor mathematical communication skills. One proof of this can be found in the findings of the 2023 Programme for International Student Assessment (PISA) report, which indicates that Indonesian students rank low in mathematical numeracy literacy, which requires argumentation and communication. (Anim et al., 2022; Yuda & Rosmilawati, 2024). These findings emphasize that mathematical communication involves writing or speaking, reasoning, and constructing arguments. The Indonesian education policy also highlights the necessity of deliberately cultivating mathematical communication skills, as these skills form the foundation for students' broader mathematical competencies. Consequently, addressing gaps in students' communication abilities becomes essential for improving overall mathematics achievement. By the regulation (Kemendikbud, 2018), the RI Minister of Education Regulation Number 21 of 2016 about content standards for primary and secondary education states that students' ability to convey mathematical concepts effectively is one of the essential skills they need to develop. This illustrates the orientation of mathematics education in Indonesia, with one aspect being mathematical communication.

Low mathematical communication ability may stem from internal factors, including talent, motivation, cognitive and academic ability, interest, and the students' physical and mental states. External factors include facilities and infrastructure, curriculum, and the school environment. Factors like perceptions of success, motivation, and teacher support can affect students' ability to learn mathematics. (Gunur B. et al., 2024; Hofer et al., 2023). Interviews with several students and mathematics teachers at a vocational high school in South Jakarta revealed that students often encounter challenges expressing mathematical ideas clearly and systematically. These challenges in mathematical communication are not solely due to conceptual difficulties but are often linked to internal psychological factors, particularly students' self-confidence in their abilities.

One of the key internal factors influencing students' mathematical communication is self-efficacy, which is their belief in their abilities. According to (Bandura, 1997a)Self-efficacy refers to an individual's belief in achieving goals. A person's level of self-efficacy mainly shapes their feelings, thoughts, motivations, and behaviors. (Ardiansyah et al., 2023; Fitriani & Pujiastuti, 2021; Safitri M.M, 2021) Low self-efficacy, or lack of confidence in one's abilities, often leads students to avoid challenging tasks, feel resigned to learning, become pessimistic, indifferent, and unwilling to try to accomplish tasks independently. Self-efficacy positively affects proportional reasoning and is strongly associated with belief in one's talents. Because they have greater confidence in their abilities, Students with higher self-efficacy outperform those with lower self-efficacy, which may increase motivation. (Windasari & Setyaningsih, 2024). This is evident in mathematics learning, where perceptions of material difficulty and less engaging learning methods can further diminish students' motivation. Differentiated learning, a strategy that tailors education to meet individual students' needs, has become one of the efforts to enhance self-efficacy in student learning achievement.

Differentiated learning provides opportunities for each student to learn in the way that is most suitable for them. In addition to enhancing students' self-efficacy, it encourages them to become active and independent learners. (Aprima & Sari, 2022). Differentiated learning also responds to the diversity of students in the classroom, particularly in fostering critical thinking and mathematical communication skills. (Gusteti & Neviyarni, 2022; Koimah et al., 2024). Previous research (Mahis et al., 2023; Noor & Agoestanto, 2023; Uswah & Usiono, 2023) uncovered similar findings, especially a strong correlation between mathematical communication abilities and self-efficacy. Students with high self-efficacy tend to be more confident in clearly expressing and explaining mathematical concepts systematically. However, research on the connection between self-efficacy in differentiated learning and mathematical communication skills at the vocational high school level remains limited.

The proposed hypothesis suggests a significant positive relationship between self-efficacy in differentiated learning and the mathematical communication skills of vocational school students. Consequently, the researcher aims to explore the connection between mathematical communication skills and self-efficacy in differentiated learning among vocational school students. The differentiation approach to learning has not been thoroughly researched in terms of self-efficacy and mathematical communication skills. By investigating the relationship between these two variables, this study aims to contribute to developing more effective learning strategies for vocational school students, particularly in enhancing their mathematical communication skills.

METHODS

This research employs an associative quantitative methodology focused on understanding the relationship between self-efficacy in differentiated learning and students' mathematical communication abilities. Using a correlational method, the research design utilizes valid instruments based on product-moment criteria to measure the relationship between two continuous variables. Content validity is ensured through expert judgment involving one mathematics education lecturer and one vocational high school mathematics teacher. They evaluate the instruments based on criteria such as clarity of items, relevance to self-efficacy and mathematical communication constructs, and alignment with the learning objectives. Reliability is assessed using Cronbach's alpha, ensuring that the variables are measured accurately and consistently, with a requirement that the reliability coefficient exceeds 0.60.

The non-test instrument, consisting of a Self-Efficacy questionnaire, contains 29 statements, including 16 positive and 13 negative statements. It employs a 5-point Likert scale: Strongly Disagree (STS), Disagree (TS), Neutral (N), Agree (S), and Strongly Agree

(SS). This questionnaire measures several aspects, including: 1) self-confidence in understanding the material taught in various formats, 2) the ability to complete challenging tasks, 3) the ability to cooperate, 4) the courage to ask questions, and 5) the ability to self-regulate (Agumuharram & Soro, 2021).

The dimensions of self-efficacy are categorized into three main areas: cognitive, affective, and psychomotor. 1) Cognitive: Related to knowledge and understanding of mathematical concepts; 2) Affective: Related to feelings and emotions concerning mathematics, including self-confidence and motivation; and 3) Psychomotor: Related to skills in solving mathematical problems.

The test instrument includes problem-based questions to assess students' ability to express mathematical ideas in writing and explain the relationship between concepts. It consists of three sub-questions with eight items, highlighting four indicators of mathematical communication skills as listed in Table 1.

Table 1. Indicators of Mathematical Communication Abilities and Their Components

Indicator of the	Indicator of Mathematical Communication Skills	Component
1	The ability to write down what is known and asked mathematically in a math problem.	Mathematical
2	Documenting the calculation process based on the mathematical problem.	Systematization
3	Analyzing the answer and interpreting mathematical ideas alongside their solutions.	Argumentation
4	Explain the findings obtained through tables, images, models, and other tools.	Visualization

Each question has a different score weight: for question number 1, which includes 1a, 1b, and 1c, the maximum score is 15; for question number 2, which includes 2a, 2b, and 2c, the maximum score is 11; and for question number 3, which includes 3a and 3b, the maximum score is 10. Therefore, the total maximum score is 36. Using the scoring guideline of $\frac{Total\ Skor}{Skor\ Maksimal}\ x\ 10\ (Skor\ ideal\ =\ 100)$.

The scoring data and item analyses involved determining the reliability and difficulty levels. The test instrument was validated by expert mathematics lecturers and mathematics teachers at vocational schools, making it suitable for revision aid. The results of the difficulty level analysis for items measuring mathematical communication skills align with Appendix Table 2.

Table 2: Level Difficulty

Point to	Difficulty Level Index, Difficulty	Level Category
1a	0.927	Easy
1b	0.875	Easy
1c	0.697	Medium
2a	0.981	Easy
2b	0.909	Easy
3a	0.687	Medium
3b	0.773	Easy
3c	0.578	Medium

This research involved 36 tenth-grade students from a private vocational school in Jagakarsa, South Jakarta. The sample was obtained through cluster random sampling, focusing on students who actively participated in mathematics learning that aligned with differentiated instruction and were willing to complete a questionnaire and demonstrate their mathematical communication abilities.

Additionally, one student was purposefully selected from each self-efficacy category (low, medium, and high) for qualitative analysis to illustrate differences in mathematical communication. The self-efficacy levels were categorized based on questionnaire scores using Sturges' formula: low (61–85), medium (86–109), and high (110–134).

Data analysis utilized inferential statistical methods with SPSS and Microsoft Excel. A Kolmogorov-Smirnov test was performed to evaluate data normality, with $p > 0.05$ indicating a normal distribution. Linearity was assessed using ANOVA, where $p > 0.05$ for "Deviation from Linearity" implies linear data. Since the data were non-linear, Spearman's rank correlation was applied to measure the monotonic relationship between self-efficacy and mathematical communication skills. It is important to note that the data were collected from a single school, which may introduce sampling bias and limit generalizability. Future studies should consider a broader and more diverse sample. The correlation was considered significant if $p \leq 0.05$, indicating a strong and meaningful relationship between the variables.

RESULT AND DISCUSSION

Thirty-six students completed the self-efficacy questionnaire, and their scores were grouped into three levels: low, medium, and high, to aid in analyzing their relationship with mathematical communication skills. This grouping was based on the total score from the 29-item questionnaire and was calculated using Sturges' formula, resulting in the following ranges: 61–85 (low), 86–109 (medium), and 110–134 (high). The table below shows the number of students in each category according to their self-efficacy scores.

Table 3. Categories of Student Self-efficacy

Number	Category	Score Range	Number of Students
1	Low	61 – 85	5
2	Medium	86 – 109	23
3	High	110 – 134	8

The self-efficacy questionnaire scores of 36 students ranged from 61 to 134 and were classified into three categories: low (61–85), medium (86–109), and high (110–134). Based on this classification, five students fell into the low category, twenty-three into the medium category, and eight into the high category. This categorization provided the basis for analyzing the relationship between self-efficacy and students' mathematical communication skills. In addition to the correlational analysis, a Kruskal-Wallis H test was conducted to examine whether there were statistically significant differences in mathematical communication skills across the self-efficacy levels.

Kruskal-Wallis Test

Ranks

	Kategori Self-efficacy (rendah,sedang,tinggi)	N	Mean Rank
Skor Komunikasi Matematis	Rendah	5	3.10
	Sedang	23	16.98
	Tinggi	8	32.50
	Total	36	

Test Statistics^{a,b}

	Skor Komunikasi Matematis
Kruskal-Wallis H	25.446
df	2
Asymp. Sig.	.000

Figure 1. Kruskal-Wallis test and Test Statistics

The results demonstrated a statistically significant difference in mathematical communication scores among the three self-efficacy groups. The mean rank scores showed a consistent trend: students in the low self-efficacy group exhibited the lowest average rank (3.10), followed by the medium group (16.98) and the high group (32.50). This pattern suggests that students with higher self-efficacy better express mathematical ideas, supporting the notion that self-efficacy is crucial in mathematical communication. A qualitative analysis was conducted to complement the statistical findings and examine the quality of student responses across the self-efficacy categories. One student was purposively selected from each group (low, medium, high) to illustrate the contrast in mathematical communication abilities, resulting in three subjects identified by their respective codes.

Table 4. Result of Subject Selection for Research

Number Code	Category	Test Score	Students
1	Low	67	JN
2	Medium	78	FY
3	High	92	SA

Students' mathematical communication abilities were analyzed based on the quality of their responses to several questions, each designed to assess four key indicators: 1) the ability to articulate what is known and what is being asked in a mathematical problem (mathematical), 2) documenting the calculation process by the mathematical problem (systematization), 3) analyzing the produced answers or interpreting mathematical ideas along with their solutions (explanation/argumentation), and 4) providing explanations for findings achieved through the use of tables, images, models, and other tools (representation/visualization). To assess these indicators comprehensively, one of the test items focused on exponential growth and data presentation in graphical form. The following is Question 2, which was used for a deeper analysis of students' responses.

"The city's population is recorded at 10,000 people in the year 2025. The growth rate of the city's population is estimated to increase by 5% per year.

a) Determine the general formula for population growth.

b) Calculate the city's population in 2030.

c) Represent the population growth with a graph from 2025 to 2030."

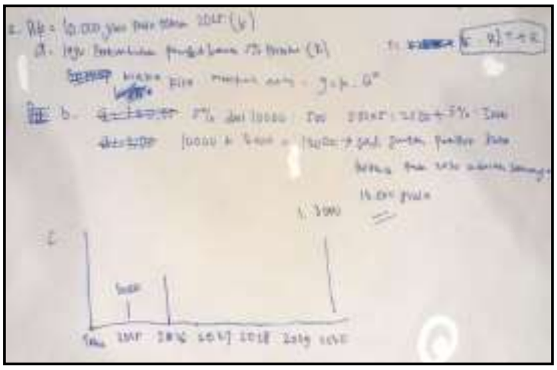

Figure 2. Response to Question number 2, JN

The student classified as having low self-efficacy, identified as JN, demonstrated significant difficulties in understanding and solving the assigned problem. Regarding the first indicator (mathematical), the student only recorded the known information without clearly expressing what was being asked. For the second indicator (systematization), JN applied an incorrect formula for exponential population growth, which led to inaccurate outcomes and an unsystematic solution process.

Regarding the third indicator (argumentation), the student demonstrated limited comprehension of the structure and requirements of the word problem, which hindered a meaningful interpretation of the solution. Finally, in the fourth indicator (visualization), the student produced a graph that did not accurately reflect the relationship between the time period and population growth, indicating a disconnect between conceptual understanding and visual representation.

These findings indicate a lack of self-confidence in problem-solving abilities and underdeveloped skills in mathematical communication, both in written expression and visual presentation. This aligns with the findings of (Sunarti, 2020), who reported that students with low self-efficacy often struggle to articulate mathematical ideas clearly, especially in writing form.

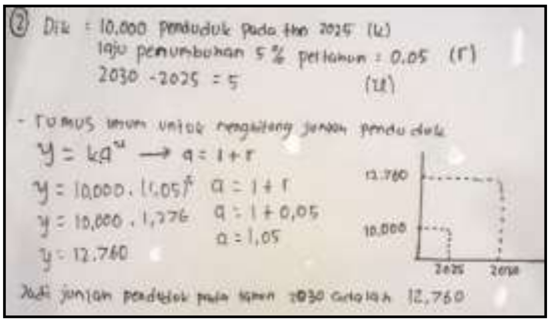

Figure 3. Response to Question number 2 FY

The student coded as FY, categorized as having moderate self-efficacy with a score of 78, demonstrated reasonable confidence in solving Question 2. This is reflected in the clarity of the written response and the logical, organized sequence of steps taken. FY correctly applied the exponential growth formula and presented the graph neatly and accurately, indicating a strong understanding of the computational aspects of the problem.

However, limitations persist in the presentation and interpretation components. FY included only 2025 and 2030 in the graph, omitting intermediate years, and did not provide a concluding statement to interpret the data. The lack of a conclusion suggests that while the student can perform calculations accurately, they may still lack confidence in interpreting results and conveying findings in an entirely manner.

This pattern aligns with (Zimmerman, 2000) view that students with moderate self-efficacy can complete academic tasks but may hesitate to justify or explain results more thoroughly when required. Therefore, while FY shows potential in problem-solving, additional support is necessary to enhance self-efficacy in constructing comprehensive mathematical explanations and conclusions.

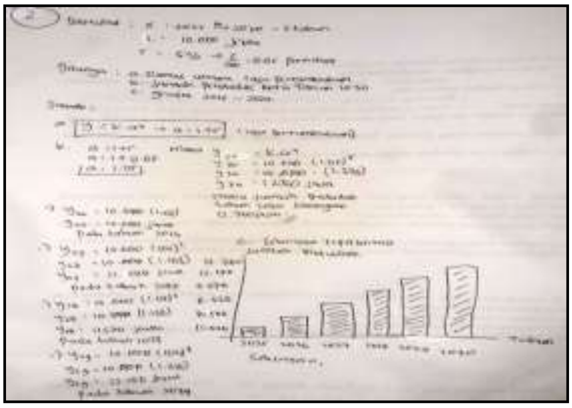

Figure 4. Response to Question number 2 SA

The student with high self-efficacy, coded as SA, demonstrated a thorough and systematic response. All stages of problem-solving were completed according to the indicators of mathematical communication: identifying known and unknown elements, selecting and applying the correct formula, performing accurate calculations, and producing a graph that clearly illustrated population growth. However, the graphical conclusion remained somewhat vague and lacked detailed interpretation. Despite this minor shortcoming, SA's overall performance demonstrates a solid conceptual understanding and the ability to connect mathematical ideas coherently. This supports (Bandura, 1997b) assertion that self-efficacy influences how individuals think, feel, and act. Students with high self-efficacy typically approach complex mathematical tasks with confidence, persistence, and effective communication strategies.

The comparison of student responses across the three self-efficacy categories: low (JN), medium (FY), and high (SA) reveals distinct differences in mathematical communication skills. Students with higher self-efficacy demonstrated more complete, structured, and conceptually accurate responses. These findings highlight the need for instructional strategies that intentionally foster self-efficacy, such as differentiated learning, positive reinforcement, and opportunities for students to experience success through various learning methods and tasks.

Following the qualitative analysis, a normality test was conducted to ensure that the data met the assumptions required for further statistical analysis. Using the Kolmogorov-Smirnov method in SPSS, compared to Microsoft Excel at a 5% significance level, the test assessed whether the data for the self-efficacy and mathematical communication variables were normally distributed. Before proceeding to the correlation analysis between the two variables, this step was a prerequisite.

One-Sample Kolmogorov-Smirnov Test		
		Unstandardized Residual
N		36
Normal Parameters[a,b]	Mean	.0000000
	Std. Deviation	4.65790576
Most Extreme Differences	Absolute	.075
	Positive	.071
	Negative	-.075
Test Statistic		.075
Asymp. Sig. (2-tailed)		.200[c,d]

Figure 5. Kolmogorov-Smirnov Normality Test

Before conducting the correlation analysis, a normality test was performed using the Kolmogorov–Smirnov method to assess whether the data were normally distributed. The decision criterion was that if the significance value exceeded 0.05, the data would be considered normally distributed. This study's result indicated a significance value greater than 0.05, suggesting that the data between variable X (self-efficacy) and Y (mathematical communication) are typically distributed.

A linearity test using ANOVA revealed that the relationship between the two variables was not linear, as the deviation from linearity value exceeded 0.05. The Pearson correlation test was considered inappropriate since the assumption of linearity was not met. Instead, the Spearman Rank Correlation test was applied, as it is more suitable for non-linear but monotonic relationships.

Supporting this decision, a scatter plot (Figure 6) illustrates a consistently increasing trend, wherein higher self-efficacy scores are generally linked to better mathematical communication abilities. Although the relationship is not perfectly linear, the overall pattern confirms a consistent positive monotonic association between the variables.

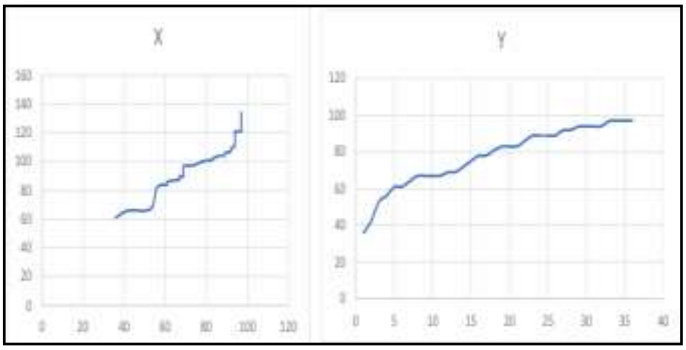

Figure 6. Scatter Plot Showing the Relationship Between Two Variables

Since the data did not meet the assumption of linearity, the analysis proceeded with the Spearman Rank Correlation test. This non-parametric test was employed to examine the monotonic relationship between self-efficacy in differentiated learning (X) and students' mathematical communication skills (Y).

Correlations

			X	Y
Spearman's rho	X	Correlation Coefficient	1.000	.995**
		Sig. (2-tailed)	.	.000
		N	36	36
	Y	Correlation Coefficient	.995**	1.000
		Sig. (2-tailed)	.000	.
		N	36	36

Figure 7. Results of the Spearman Correlation Test Using SPSS

Based on the Spearman correlation test results between self-efficacy and students' mathematical communication ability, a correlation coefficient of 0.995 was found, with a significance value (Sig. 2-tailed) of 0.000. This coefficient indicates a very strong and positive relationship between the two variables. Furthermore, the significance value being less than 0.05 confirms that the relationship is statistically significant.

The linearity assumption was not met, as shown by the linearity test, which indicated that the relationship between self-efficacy and mathematical communication ability is not linear. However, the Spearman Rank Correlation test, which does not require linearity but only a monotonic relationship, is appropriate in this context. The results suggest a consistent upward trend: as students' self-efficacy increases, their ability to communicate mathematical ideas also tends to improve.

To enhance the robustness of the analysis, the correlation was also tested using Microsoft Excel, which yielded consistent results, confirming the significant relationship. Nevertheless, it is important to critically consider the exceptionally high correlation value (r = 0.995). While it may reflect a genuine strong association, it may also be influenced by factors such as a relatively small sample size, instrument homogeneity, or limited variability in student responses. Such conditions can inflate correlation values and should be addressed in future research by involving a more diverse and larger sample, using multi-instrument triangulation, or integrating qualitative insights to validate the strength and consistency of the findings. Acknowledging this limitation does not weaken the results but strengthens the research's methodological integrity and transparency.

Table 5. Result of Spearman Correlation Tests Using MS Excel

Correlation	t-statistik	p-value	Significance Decision	Correlation Category
0.995	61.1	0	Significant Correlation	Very Strong Correlation

Table 5 presents a correlation coefficient of 0.995, along with a t-statistic of 61.1 and a p-value of 0.000. According to statistical standards, a p-value lower than 0.05 signifies a significant relationship, whereas a correlation coefficient (r) of 0.81 or higher indicates a very strong association. These findings confirm that self-efficacy in differentiated learning is positively and significantly correlated with students' mathematical communication skills in vocational schools settings.

This finding suggests that the higher the students' self-efficacy, the more developed their mathematical communication abilities. Students with greater self-efficacy demonstrate more confidence in expressing mathematical concepts both verbally and in writing. This aligns with (Bandura, 1997a) theory, which asserts that self-efficacy influences how individuals think, feel, and behave. Students with high self-efficacy tend to persevere in solving complex mathematical tasks and can convey their reasoning more clearly and systematically (Sugianto et al., 2025).

The qualitative analysis of student responses across self-efficacy categories supports this interpretation. The high-category student (SA) was able to accurately identify problem components, perform calculations systematically, and present visual representations effectively. The medium-category student (FY) demonstrated a solid conceptual understanding but lacked completeness in graph construction and conclusions. Meanwhile, the low-category student (JN) struggled with understanding the problem, selecting strategies, and visualizing solutions. These variations reinforce the idea that self-efficacy levels correspond to differences in mathematical communication quality.

This research aligns with previous findings by (Dewi & Nuraeni, 2022), who concluded that self-efficacy significantly contributes to students' mathematical communication skills at the secondary school level. Their study highlighted that students with higher self-efficacy tend to organize and communicate mathematical ideas more structurally and transparently.

Additionally, differentiated learning approaches play a crucial role in building students' self-efficacy. Instruction tailored to meet students' individual needs, readiness, and learning preferences fosters greater engagement and confidence. This aligns with (Aprima & Sari, 2022), who emphasized that differentiated instruction enhances active participation and critical thinking, ultimately supporting the development of mathematical communication skills.

However, this study has several limitations. The qualitative analysis involved only three students, one from each self-efficacy category, which may not fully represent broader patterns. Furthermore, the research was conducted at a single vocational school in South Jakarta, limiting the generalizability of the findings. Future studies should involve a larger and more diverse sample and consider additional variables, such as metacognitive strategies, classroom environment, or student motivation, to gain a more comprehensive understanding of the factors affecting mathematical communication ability.

CONCLUSION

This research conducted among tenth-grade students at a vocational school in South Jakarta revealed a strong and statistically significant relationship between self-efficacy and mathematical communication skills. Students with higher self-efficacy demonstrated a greater ability to meet the indicators of effective mathematical communication.

The results of this study suggest that students' confidence in their academic abilities enhances their willingness and ability to articulate mathematical ideas clearly and effectively. These findings support the hypothesis that self-efficacy is critical in mathematics learning, particularly in improving students' mathematical communication skills. Therefore, it is recommended that teachers implement instructional strategies such as differentiated learning and collaborative discussions that actively promote self-efficacy and encourage greater student participation engagement.

Future studies should explore additional factors influencing students’ mathematical communication abilities, such as metacognitive strategies, classroom climate, and instructional media. Moreover, including more diverse educational settings will improve the generalizability of the study findings.

ACKNOWLEDGEMENT

Thank you, Allah. The author expresses gratitude to themselves for their effort and perseverance in completing this research. The author also sincerely thanks their parents, siblings, and Eka Prasetya Ramadhan for their unwavering prayers and support, the supervising lecturer for their meaningful guidance and direction, and friends who consistently provided encouragement and assistance throughout this research process.

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