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The influence of self-efficacy on sixth graders' mathematical communication skills

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ABSTRACT

Mathematical communication skills are essential for students' success in problem-solving, critical thinking, idea articulation, and addressing challenges. These skills are a key component of 21st-century competencies, supporting mathematical literacy from an early age. This study investigates the effect of self-efficacy on students' confidence in completing academic tasks and the mathematical communication skills of grade VI elementary school students. Using a quantitative approach with an ex post facto method, data were collected via questionnaires to assess self-efficacy and tests to measure mathematical communication skills. The results showed a significant positive effect of self-efficacy on mathematical communication skills, with a significance value and a positive coefficient. The R Square value indicates that self-efficacy accounts for the variance in mathematical communication skills. These findings highlight the critical role of self-efficacy in enabling students to confidently and competently communicate mathematical concepts. To enhance students' mathematical communication skills, teachers should employ learning strategies that build confidence and reinforce self-efficacy. Strengthening self-efficacy boosts academic performance and equips students with the tools to excel in mathematics and related challenges.

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ABSTRAK

Kemampuan komunikasi matematis tidak hanya berperan dalam keberhasilan peserta didik menyelesaikan soal-soal matematika, tetapi juga mendukung kemampuan berpikir kritis, menyampaikan ide, serta memecahkan masalah. Di era yang menuntut kompetensi abad ke-21 ini, kemampuan komunikasi matematis menjadi salah satu pilar utama untuk mendukung literasi matematika peserta didik sejak dini. Penelitian ini bertujuan untuk menganalisis pengaruh self-efficacy terhadap kemampuan komunikasi matematis peserta didik kelas VI Sekolah Dasar. Self-efficacy, mengacu pada keyakinan diri peserta didik dalam menyelesaikan tugas-tugas akademik, dipandang sebagai salah satu faktor penting yang memengaruhi keberhasilan pembelajaran matematika. Pendekatan penelitian yang digunakan adalah kuantitatif dengan metode ex post facto. Data dikumpulkan melalui kuesioner untuk mengukur tingkat self-efficacy dan tes kemampuan komunikasi matematis. Hasil uji regresi linear menunjukkan signifikansi dengan koefisien self-efficacy sehingga dapat dikatakan bahwa self-efficacy peserta didik berpengaruh positif secara signifikan terhadap kemampuan komunikasi matematis peserta didik. Nilai R Square menunjukan bahwa self-efficacy peserta didik berpengaruh terhadap kemampuan komunikasi matematis peserta didik. Temuan ini menunjukan bahwa self-efficacy memiliki peran penting dalam meningkatkan rasa percaya diri peserta didik dalam mengomunikasikan konsep matematis. Sehingga guru perlu menguatkan self-efficacy peserta didik melalui strategi pembelajaran yang menumbuhkan kepercayaan diri dan meningkatkan kemampuan komunikasi matematis.

Kata Kunci: *komunikasi matematis; pembelajaran matematika; peserta didik SD; self-efficacy*

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INTRODUCTION

Mathematical communication skills are an essential part of numeracy skills because numeracy not only includes counting skills and mathematical operations but involves understanding, interpreting, and applying mathematical concepts in various real-life contexts. Indonesia's education policy explicitly supports the development of mathematical communication skills as part of efforts to improve the quality of education. This is reflected in the Kurikulum Merdeka, which emphasizes the development of numeracy literacy competencies, namely the ability to understand, use, and communicate mathematical concepts in various real-life situations. In addition, the Asesmen Nasional (AN), one of the educational evaluation instruments, places numeracy literacy as one of the main focuses to measure students' ability to solve problems and communicate the results of mathematical thinking. This policy aligns with the demands of the 21st century, where critical thinking and communication skills are essential to prepare students for global challenges. In the local context, the government also encourages contextual-based learning approaches and technology integration to help students understand mathematics in an applicable and relevant way to everyday life. This shows the government's commitment to building human resources who can utilize mathematics as a strategic thinking and communication tool. Field observations show that students have not achieved these abilities optimally. Indonesia's mathematics score based on the Program for International Student Assessment (PISA) dropped from 379 in 2018 to 366 in 2022. PISA data indicate that many Indonesian students have not reached the basic numeracy competency level. This includes understanding basic mathematical concepts, reading graphs, and performing simple calculations in everyday contexts. This condition significantly impacts the following levels of education, with many junior and senior high school teachers expressing concern over the low basic numeracy skills of incoming students, often viewing it as a problem inherited from earlier educational stages.

At the elementary school level, particularly in grade VI, the development of mathematical communication skills is critical, as students are in the preparatory stage for higher education. This stage demands a stronger foundation in numeracy and the ability to articulate and apply mathematical concepts effectively in more complex problem-solving and real-world contexts. Without these skills, students will likely struggle with advanced mathematical reasoning, critical thinking, and communication in higher grades. In the specific context of SDN 2 Kayuambon, challenges in numeracy development are particularly evident. Many grade VI students at this school cannot explain mathematical reasoning or engage in discussions involving mathematical concepts. Teachers at SDN 2 Kayuambon report difficulties in guiding students to understand and communicate basic mathematical principles effectively, with gaps in their ability to connect mathematical concepts to practical, everyday scenarios. These issues are exacerbated by limited resources and the need for a more targeted approach to developing self-efficacy in mathematics, which is crucial for enhancing numeracy and communication skills.

This raises the question of what psychological factors might contribute to students' mathematical communication skills. Among these factors, self-efficacy has been shown to play a pivotal role in academic performance. Many researchers have conducted studies on self-efficacy, demonstrating its influence or relationship with student learning achievement, reading ability, and problem-solving in science. A study conducted at Kristen Kondo Sapata Elementary School in Makassar, Indonesia, found that self-efficacy contributed 61.8% to students' mathematics learning outcomes, emphasizing its role in building confidence and enhancing academic performance. Various models can be an alternative to improve Mathematics learning outcomes (Hasibuan, 2024; Moko et al., 2022). This concept is highly relevant to current research on mathematical communication skills (Rahman, 2020).

Similarly, the effect of self-efficacy on the problem-solving abilities of fifth-grade students in science was explored, demonstrating that higher self-efficacy levels improved problem-solving skills, further underlining

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its potential to facilitate mathematical reasoning and problem articulation (Fauziana, 2022). Additionally, a study highlighted a strong positive correlation between self-efficacy and mathematics learning outcomes, with self-efficacy accounting for 65.3% of the variance in achievement, reinforcing the importance of developing self-efficacy to enhance both academic performance and the ability to communicate mathematical concepts effectively (Fitriani & Pujiastuti, 2021). Moreover, research examining self-efficacy's impact on elementary students' mathematical problem-solving abilities revealed that self-efficacy explained 66.8% of their performance, providing a basis for investigating its influence on sixth-grade students' ability to communicate mathematical ideas as part of effective problem-solving (Amaliyah et al., 2023).

These studies collectively emphasize the significant role of self-efficacy in various academic domains, providing a strong rationale for this research. This study builds on prior findings by focusing on self-efficacy's role in enhancing mathematical communication skills in sixth-grade students. It addresses a critical need in elementary education. Students with high self-efficacy are more likely to achieve better results, while those with low self-efficacy often experience anxiety and hesitation, hindering their communication skills. However, the relationship between self-efficacy and mathematical communication skills remains underexplored, particularly among elementary students. The results of these studies indicate that students with high self-efficacy tend to get better learning outcomes. In contrast, students with low self-efficacy often feel anxious or hesitant in conveying their understanding, thus potentially hampering their abilities and achievements. However, no research thoroughly examines the relationship between students' self-efficacy and mathematical communication skills, especially among elementary school students. This study offers a scientific novelty by investigating the role of self-efficacy in developing mathematical communication skills in sixth-grade students. The specific contribution of this research to the educational literature is to clarify how self-efficacy levels influence students' ability to communicate mathematical ideas effectively. Furthermore, this study complements and extends previous findings by addressing mathematical communication skills within the local context, where cultural, linguistic, and educational practices may shape students' learning experiences. Conducting the research in a specific local setting provides nuanced insights into how self-efficacy interacts with contextual factors to influence students' ability to articulate mathematical concepts. Additionally, this study aims to provide practical insights for educators in designing culturally relevant and context-sensitive learning strategies that enhance students' self-confidence and foster effective mathematical communication, thereby positively impacting their learning outcomes.

Recognizing the gap from prior studies, this research explores the relationship between self-efficacy and mathematical communication skills among sixth-grade elementary students. The study seeks to contribute to a deeper understanding of the psychological factors that facilitate the development of mathematical communication skills. The findings are expected to serve as a foundation for future researchers conducting studies on similar topics and provide educators with insights to design learning strategies that enhance students' self-efficacy, fostering improved mathematical communication skills in elementary students. This study starts from the hypothesis that self-efficacy positively and significantly influences elementary school students' mathematical communication skills. This hypothesis is based on previous findings showing that self-efficacy is essential in improving students' academic success and problem-solving abilities. However, studies on its relationship with mathematical communication skills are still limited. Thus, this study aims to examine the extent to which self-efficacy can be a determining factor in developing students' abilities to express, explain, and apply mathematical concepts effectively.

The study focuses on three core aspects: it assesses the level of self-efficacy among sixth-grade students at SDN 2 Kayuambon in mathematics learning, evaluates their mathematical communication skills in the context of multiplication and division of fractions, and investigates the influence of self-efficacy on their mathematical communication skills.

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This study analyzes the relationship between self-efficacy and mathematical communication skills in grade VI students at SDN 2 Kayuambon. Specifically, it aims to measure students' self-efficacy levels in learning mathematics, assess their mathematical communication skills in multiplication and division of fractions, and determine the significant influence of self-efficacy on mathematical communication skills. The results of this study are expected to provide new insights for educators to design effective learning strategies to improve students' self-efficacy and mathematical communication skills.

LITERATURE REVIEW

Definition of Self-efficacy and its indicators

Self-efficacy refers to an individual's confidence in their ability to plan, execute, and manage actions required to achieve specific outcomes. This concept is deeply rooted in Albert Bandura's Social Cognitive Theory, which emphasizes the role of self-belief in influencing human behavior. This concept, rooted in Albert Bandura's Social Cognitive Theory, emphasizes the role of the belief in human behavior. Bandura defines self-efficacy as "an individual's belief in their capacity to perform actions necessary to attain goals or handle certain situations." It is critical in shaping a person's thoughts, emotions, and behaviors, particularly when confronting obstacles or difficulties (Lianto, 2023). This psychological construct highlights the significance of self-perception in determining motivation and persistence in overcoming challenges. One of the basic concepts of self-efficacy theory is self-confidence in a person's ability to control their thoughts, feelings, and behavior. Self-efficacy consists of high and low forms (Ferdyansyah et al., 2020).

In mathematics education, self-efficacy influences how students think, feel, motivate themselves, and act when faced with mathematical tasks. Students with high levels of self-efficacy tend to be more confident in solving math problems and more persistent in their efforts (Yang et al., 2024). Self-efficacy is also closely related to students' attitudes and interest in mathematics. Higher self-efficacy correlates with more positive attitudes and greater interest in mathematics (Hernández de la Hera et al., 2023). Another opinion states that self-efficacy prioritizes mastery of cognitive aspects to produce good performance and achieve its goals as well as desired. Self-efficacy has a significant relationship or can make a major contribution to the achievement of students' mathematical abilities (Nurhayati et al., 2021).

Building on Bandura's definition, self-efficacy extends beyond objective abilities to include individuals' perceptions of their potential to succeed in specific tasks. Individuals with high self-efficacy tend to have greater motivation, perseverance, and resilience because they believe they can overcome these challenges. In contrast, individuals with low self-efficacy are more likely to feel anxious, hesitant, and give up quickly when facing difficulties due to a lack of confidence in their abilities.

To better understand self-efficacy, Bandura identifies three key indicators of confidence and capability in addressing tasks (Oktariani & Ekadiansyah, 2020).

1. Level of task difficulty (Magnitude)
   This indicator relates to the degree of difficulty of the task where the individual feels capable or not. Suppose a person faces a task arranged according to the difficulty level. In that case, the person's self-efficacy will be limited to low, medium, or even tasks with a high difficulty level. All depend on the abilities possessed by each individual. Individuals with high self-efficacy will feel confident and optimistic in completing every task.
2. Generalization (Generality)
   This indicator relates to the field of tasks, how broadly individuals have confidence in generalizing previous tasks and experiences when facing a task or job, for example, whether individuals can make the experience an obstacle or a lesson and make failure a motivation to keep developing and evaluating every process that has been passed to be used as a lesson.

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3. Strength
   This indicator relates to the level of belief about one's ability to show one's resilience in completing tasks and remaining consistent in doing their tasks or work. Even though they encounter obstacles and difficulties, someone with high self-efficacy feels confident that they can complete the task well and never give up even though they face a difficult task.

The author used the three indicators to develop an instrument in a questionnaire containing 20 statements, 13 positive and seven negatives, to measure the self-efficacy of grade VI students of SDN 2 Kayuambon in learning mathematics.

Basic Principles Linking Self-Efficacy to Mathematical Communication

Self-efficacy is the development of self-confidence in learning, where high levels of self-efficacy among students can enhance their ability to absorb learning material more effectively. Students' abilities in mathematics are essential components of the learning process, contributing to the overall quality of primary school education. Self-efficacy significantly influences children's mindset, particularly regarding their confidence in solving mathematical problems and tackling other academic subjects (Wiguna et al., 2022). Students with high self-efficacy tend to exhibit greater self-confidence, increased motivation to complete tasks, better emotional regulation, and effective abilities management (Indirwan et al., 2021).

Several key points regarding the relationship between self-efficacy and mathematical communication skills can be derived from this literature.

1. Confidence in communicating: Students with high self-efficacy tend to be more confident in conveying their mathematical ideas. This allows them to more actively participate in class discussions, ask questions, or explain concepts to peers or teachers.
2. Resilience in the face of adversity: Self-efficacy affects students' resilience when facing complex math tasks. Students who believe in their abilities will put more effort into understanding complex concepts and improving their mathematical communication skills.
3. Motivation to learn: High self-efficacy boosts students' intrinsic motivation to learn math more deeply. With better understanding, students can explain mathematical concepts more effectively.

Definition of mathematical communication ability and its indicators

In mathematics learning, Bandura's theory can be linked to mathematical communication skills because students' self-efficacy affects how they construct arguments and communicate solutions to mathematical problems. In mathematics learning, self-efficacy can significantly impact students' ability to express and interpret mathematical concepts effectively. Mathematical communication skills, therefore, play a crucial role in fostering more profound understanding and confidence. These skills enable students to structure explanations, articulate procedures, construct logical arguments, and present results clearly and comprehensively. Mathematical communication is vital in fostering a deeper conceptual understanding while supporting collaborative discussions and interactions in mathematics education. This ability is essential for enhancing students' critical thinking and problem-solving competencies within the learning process.

Mathematical communication ability consists of oral communication and written communication. Oral mathematical communication is a person's ability to convey information and mathematical ideas through discussions and presentations delivered clearly and systematically. As for writing, mathematical communication is one's ability to express mathematical ideas through pictures/graphics, tables, and equations in writing with the student's language (Lubis et al., 2023). Mathematical communication involves

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reading, understanding, and deciphering math problems appropriately. Using appropriate mathematical language, students can identify relevant information and clearly understand what is being asked in the problem (Suhenda & Munandar, 2023).

Mathematical communication skills are considered one of the essential standards in mathematics education, as emphasized by the National Council of Teachers of Mathematics. These skills focus on students' ability to structure and effectively convey mathematical concepts. NCTM identifies three key aspects of mathematical communication: the ability to interpret information in various formats, the capability to provide logical and coherent explanations, and the use of accurate and suitable mathematical language (Baehaqi et al., 2023). Mathematical communication skills depend on understanding, collecting, organizing, and explaining thoughts and discovering what is known and what is not (Noor & Ranti, 2019).

According to Losi, the characteristics of mathematical communication skills can be identified through three key indicators (Rasyid, 2019):

1. Drawing ability: This refers to students' capacity to represent mathematical ideas through visual forms, such as diagrams, graphs, tables, pictures, or algebraic expressions.
2. Written text: This involves articulating mathematical explanations and reasoning using precise, accurate, and easily understandable written language.
3. Mathematical expression ability: This pertains to the ability to develop mathematical models that effectively represent real-world problems or abstract concepts.

The author uses the three indicators to develop instruments in the form of description questions totaling three questions to measure the mathematical communication skills of grade VI students of SDN 2 Kayuambon on the material of multiplication and division of fractions.

Interaction between Self-Efficacy Indicators and Mathematical Communication Skills in the Context of Mathematics Learning

As previously described, according to Bandura, there are three indicators of self-efficacy: Strength, Magnitude, and Generalization (Generality) (Oktariani & Ekadiansyah, 2020). Meanwhile, the indicators of mathematical communication revealed by Losie consist of drawing ability, text-writing ability, and mathematical expression ability (Rasyid, 2019). Based on these two theories and some previous research, the interaction between self-efficacy indicators and mathematical communication skills in the context of mathematics learning can be described as follows:

1. Strength and Mathematical Expression Ability
   As described earlier, one of the basic concepts of self-efficacy theory is a person's confidence in his ability to control his thoughts, feelings, and behavior (Ferdyansyah et al., 2020). Therefore, students confident in overcoming difficulties in learning mathematics are more confident in expressing their understanding through complex mathematical representations, such as formulas or equations. They are not only able to solve problems but can also communicate their processes in the form of symbols and explicit mathematical expressions.

2. Magnitude and Drawing Ability
   As previously stated, students with high levels of self-efficacy tend to be more confident in solving math problems and more persistent in their efforts (Yang et al., 2024). Thus, they tend to be more confident when facing more complicated tasks. Thus, they can develop visual representations that help them solve problems more systematically. When they believe in their abilities, they do not hesitate to use diagrams or drawings to visualize and explain their mathematical ideas more clearly.

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3. Generalization (Generality) and Written Text
   As previously described, generalization is related to the task field, namely the extent to which individuals have the confidence to generalize previous tasks and experiences when facing a task or job (Oktariani & Ekadiansyah, 2020). So, self-efficacy in the form of generalization can affect students' ability to produce written text. Students who have the confidence to generalize their experiences across various learning contexts will be able to support their ability to compose written explanations that are logical and easy to understand. They can use appropriate mathematical language to express their understanding of complex mathematical concepts.

Previous Research Results

Understanding the role of self-efficacy in elementary education is crucial for identifying effective strategies to enhance learning outcomes. Table 1 summarizes previous research findings on the impact of self-efficacy on elementary students' academic performance, offering insights into its significance across various contexts.

Table 1. Results of Previous Research Related to Self-efficacy of Elementary Students

No	Title	Researcher	Year	Research Results	Relevance to this Research
1.	"The Impact of Self-Efficacy on Mathematics Learning Outcomes: A Study of Third-Grade Elementary School Students at Kristen Kondo Sapata, Makassar, Indonesia"	Rahman H.	2020	The research highlights the significant role of self-efficacy in mathematics learning outcomes, contributing 61.8% to academic performance. This finding underscores the importance of fostering confidence in young learners to improve their achievement in core subjects.	This research emphasizes the significant impact of self-efficacy on mathematics learning outcomes, which is directly related to understanding how self-efficacy can enhance sixth graders' mathematical communication skills by building confidence in core mathematical tasks.
2.	"Self-Concept and Self-Efficacy in Math: Longitudinal Interrelations and Reciprocal Linkages with Achievement"	A. Katrin Arens; Anne C. Frenzel & Thomas Goetz	2020	This research found that mathematics self-concept influences subsequent self-efficacy, suggesting that broader perceptions of competence lay the foundation for specific task-oriented confidence. This progression highlights a developmental pathway crucial for educators to consider.	The study's findings on the development of mathematics self-concept and self-efficacy suggest a foundation for improving sixth graders' communication in mathematics through a focus on competence perceptions.
3.	""I Can Math!": Reducing Math Anxiety and Increasing Math Self-Efficacy Using Mindfulness and Growth Mindset-Based Intervention in First-Year Students"	Tashana S. Samuel & Jared Warner	2021	Although Samuel & Warner's (2019) study focuses on college students, its findings offer valuable insights. Reducing anxiety and improving self-efficacy through mindfulness and growth mindset interventions may inspire similar approaches for younger learners.	Although this study focuses on college students, its insights on reducing math anxiety and boosting self-efficacy through interventions may inform strategies to improve mathematical communication among younger students.

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No	Title	Researcher	Year	Research Results	Relevance to this Research
4.	"The Effect of Self-efficacy on Mathematics Learning Achievement of Elementary Students in Online Learning"	Pramesthi Ningrum, Rina Dyah Rahmawati	2021	Self-efficacy has been found to positively and significantly impact students' achievement in elementary mathematics within the context of online learning. This indicates that higher levels of self-efficacy contribute to improved academic performance in mathematics during virtual education settings.	The positive impact of self-efficacy on mathematics achievement during online learning highlights its potential role in enhancing sixth graders' ability to express mathematical reasoning and problem-solving online.
5.	"The Effect of Self-efficacy on Science Problem Solving Ability"	Fauziana	2022	Self-efficacy significantly impacts the problem-solving abilities of fifth-grade science students. This suggests that students with higher levels of self-efficacy are more capable of effectively solving science-related problems.	The research linking self-efficacy to problem-solving in science can be extended to mathematics, suggesting its influence on sixth graders' problem-solving and communication abilities in mathematical contexts.
6.	"The Effect of Self-efficacy and Learning Motivation on Learning Achievement of Fifth Grade Students of Mi Nw Kawo"	Havifa Nurhijatina, Ar rosikh.	2022	Self-efficacy and learning motivation contribute 73.3% of the variance in student learning achievement, with the remaining portion influenced by factors not explored in this study.	The study's findings on self-efficacy and motivation's contribution to learning achievement are relevant because they show how self-efficacy can impact performance and the ability to articulate mathematical concepts.
7.	"The Relationship between Self-efficacy and Learning Achievement of Grade III Students in Hybrid Learning in Elementary Schools Hybrid Learning in Elementary School"	Putri Dwi Ramadhani Syam, Andi Makkasau, Siti Raihan.	2023	A positive correlation exists between self-efficacy and the learning achievement of third-grade students at SD Gugus VI, Rappocini District, Makassar City, during the 2020/2021 academic year.	The positive correlation between self-efficacy and learning achievement underlines the importance of fostering self-confidence in sixth graders to improve mathematical communication.
8.	"The Effect of Self-Efficacy on Mathematics Learning Outcomes"	Ria Nur Fitriani, Heni Pujiastuti	2021	The study concluded that self-efficacy significantly influenced mathematics learning outcomes. Furthermore, self-efficacy demonstrated a strong and positive correlation with mathematics achievement, accounting for 65.3% of the variance. The remaining 34.7% was attributed to other factors not examined in this research.	This study's evidence of a strong correlation between self-efficacy and mathematics learning outcomes directly supports the focus on mathematical communication as a learning outcome influenced by self-efficacy.

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No	Title	Researcher	Year	Research Results	Relevance to this Research
9.	"The Effect of Self-efficacy on Mathematical Problem Solving Ability of Elementary School Students"	Fitriyah Amaliyah, Jody Setya Hermawan, Desti Puspita Sari.	2023	The self-efficacy variable explains or influences 66.8% of students' problem-solving ability in mathematics, while the remaining 33.2% is influenced by other factors unrelated to self-efficacy.	The link between self-efficacy and mathematical problem-solving abilities offers a foundation for examining how self-efficacy impacts sixth graders' communication of mathematical solutions.
10.	"Good Student Self-efficacy Can Improve Student Learning Achievement in the Classroom"	Ni Putu Lidya Ariswari, Putu Sukma Megaputri.	2023	Students with higher levels of self-efficacy tend to show more significant improvements in their academic performance.	The finding that good self-efficacy improves academic performance supports the hypothesis that enhancing self-efficacy could directly improve sixth graders' ability to communicate mathematical ideas effectively.

Source: Researcher Construction (2024)

The studies summarized in Table 1 consistently demonstrate the significant influence of self-efficacy on elementary students' academic performance. These findings provide a foundation for further exploration in the current research, focusing on the interplay between self-efficacy and mathematical problem-solving skills.

METHODS

Research methods are the procedures and schemes used in research. This study employs an ex post facto research design; the word ex post facto is taken from Latin, meaning "after the fact." This means data is collected after the phenomenon/event under study occurs. This research has no direct intervention because the events have already occurred. The researchers do not conduct direct experiments or manipulate the independent variables but observe the relationships between variables. The research was conducted at SDN 2 in Lembang District, West Bandung Regency, West Java Province, during the first semester of the 2024/2025 academic year. This location was chosen due to the availability of data, ease of access to research, and student characteristics that follow the research objectives.

This study's population consisted of 30 sixth-grade students at SDN 2 Kayuambon during the 2024/2025 academic year. The sampling technique used in this research was purposive sampling. The research instruments included a mathematical communication ability test with three descriptive questions and a self-efficacy questionnaire with 20 statements.

Before use, a validity test is carried out on the instrument. According to Sugiyono, the validity test is used to test the accuracy of a measuring instrument in measuring something that should be measured. Researchers conducted a validity test by distributing self-efficacy questionnaires to sixth-grade students at one of the elementary schools in Lembang District. Using the help of SPSS version 29 software, the validity test results were obtained as a significance value of each item smaller than 0.05. Based on the results of the quantitative analysis of the trial data, empirical statistical data will be obtained regarding the items that meet the criteria for item validity and scale reliability so that the measuring instrument can be used in research. Then, the reliability test was carried out with the help of SPSS software, and the test output showed that Cronbach's alpha value was 0.722, more significant than 0.6. So that the instrument is reliable. Self-efficacy questionnaires were distributed to sixth-grade students at one of the elementary schools in Lembang District.

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The data collection methods employed included questionnaires and tests. The data were analyzed using regression analysis t-test, with the assistance of SPSS software. Simple linear regression analysis was used because this research is included in causal associative research that wants to see the causal relationship between the independent and dependent variables. Causal associative research is designed to identify the relationship between two or more variables, mainly focusing on cause-and-effect interactions (Jailani et al., 2024).

The steps in simple linear regression analysis begin with formulating a hypothesis. The null hypothesis (H0) states that there is no linear relationship between the independent variable (X) and the dependent variable (Y). In contrast, the alternative hypothesis ($H1$) states a linear relationship between the two variables. Next, assumption tests were conducted to ensure a linear relationship, absence of autocorrelation, and normality of residuals. Then, relevant data was collected, including the values of the independent and dependent variables, to build a regression model using the equation.

$$Y = a+bX$$

Description
a = Constant
b = regression coefficient
b are estimated using the least squares method.

The significance test is conducted to evaluate whether the relationship between X and Y. The regression coefficient is considered significant if the p-value is smaller than 0.05. The coefficient of determination ($R2$) is also calculated to measure the proportion of Y variability that X can explain. The final step is interpreting the results, where the value of a indicates the value of Y when X = 0 and b indicates the change in Y for every one unit change in X.

The significance test evaluates the relationship between X and Y. The regression coefficient is statistically significant if the p-value is smaller than 0.05. The coefficient of determination (R^2) is also calculated to measure the proportion of variability in Y that X can explain. The final step involves interpreting the results, where the value of aaa represents the predicted value of Y when X = 0, and b indicates the amount of change in Y for every one-unit increase in X.

When interpreting the results, the regression coefficient (b) describes the direction and the magnitude of the independent variable's effect on the dependent variable. For instance, if b=1.5, it implies that every one-unit increase in X results a 1.5-unit increase in Y. The relationship is deemed statistically significant if the p-value for b is less than 0.05. Additionally, the value of R^2 provides insight into the proportion of variance in the dependent variable explained by the model.

A simple linear regression model was applied for the analysis. Before conducting the regression analysis, the normality test Kolmogorov-Smirnov was performed. A linearity test scatterplot was performed on the questionnaire data regarding self-efficacy and the test data on students' mathematical communication skills. The test consisted of three descriptive questions developed by the researcher based on the characteristics of mathematical communication, which were assessed through three indicators: drawing ability, written communication ability, and mathematical expression ability (Rasyid, 2019).

The normality test aimed to determine whether the data were distributed normally, a fundamental assumption for linear regression analysis. A p-value greater than 0.05 in the Kolmogorov-Smirnov test would indicate that the data follow a normal distribution, satisfying this prerequisite. Similarly, the linearity test examined whether a linear relationship exists between self-efficacy and mathematical communication skills. The scatterplot was visually analyzed to ensure the data points followed a straight-line pattern, confirming linearity. Fulfilling these assumptions provides confidence in the validity of the regression results and ensures that the model's interpretations are statistically robust. The chosen methodology,

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including validated instruments and regression analysis, ensures that the study effectively addresses its research objectives.

RESULTS AND DISCUSSION

The calculation of questionnaire scores related to self-efficacy in grade VI students of SDN 2 Kayuambon, which were analyzed using SPSS software, showed that the data could be categorized into high, medium, and low. The categorization method is based on the assumption that the self-efficacy score data is usually distributed. This allows the application of statistical formulas to establish the boundaries of categorization based on the mean (average) and standard deviation values. In general, students with scores above the mean plus one standard deviation fall into the high category, scores within the range of mean minus one standard deviation to mean plus one standard deviation fall into the medium category, while scores below the mean minus one standard deviation fall into the low category. **Table 2** shows the self-efficacy score categorization formula.

Table 2. Self-efficacy Score Categorization Formula

Low	X < M-1SD
Medium	M-1SD ≤ X < M + 1SD
High	M+1SD ≤ X

Source: Researcher Construction (2024)

Description:
X: Self-efficacy score obtained by students.
M: Mean/average student self-efficacy score.
SD: Standard Deviation.

Mean and standard deviation were calculated using SPSS software version 29, and **Table 3** shows the output.

Table 3. SPSS Descriptive Output of Student Self-efficacy Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Skor Self-Efficacy	30	50	85	67.00	9.830
Valid N (listwise)	30				

Source: Output Descriptive statistics from SPSS Software version 29 (2024)

As shown in Table 3, the mean self-efficacy score of students was 67 (SD = 9.8), with the lowest score being 50 and the highest score reaching 85. This indicates a relatively moderate variation in self-efficacy levels among the students. Based on the classification, the distribution of students' self-efficacy scores is presented in the following frequency distribution in **Table 4**.

Table 4. SPSS Output Frequency Distribution of Student Self-efficacy Categories

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Rendah	5	16.7	16.7	16.7
	Sedang	20	66.7	66.7	83.3
	Tinggi	5	16.7	16.7	100.0
	Total	30	100.0	100.0	

Source: SPSS Software version 29 (2024)

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Table 4 illustrates the frequency distribution of self-efficacy scores, categorizing students into three groups: low (n = 5), medium (n = 20), and high (n = 5). The medium category had the most significant proportion, suggesting that most students possessed average levels of self-efficacy. This category distribution arises because normally distributed data reflects the natural patterns of many psychological phenomena, including self-efficacy. According to Bandura, self-efficacy is an individual's belief in their ability to organize and carry out the actions necessary to achieve specific results. Self-efficacy is influenced by four primary sources: mastery experiences, vicarious experiences, social persuasion, and emotional and physiological states. Thus, the distribution of self-efficacy score data in the high, medium, and low categories can be explained through differences in students' access or exposure to these sources of self-efficacy.

For example, students in the high category may have more experiences of success in challenging academic tasks, get positive social support from teachers and peers, and can manage emotions and stress well. In contrast, students in the low category may experience more failures, lack positive role models, or face emotional distress that interferes with their belief in self-efficacy. Furthermore, Bandura's theory also emphasizes that self-efficacy affects how one sets goals, perseveres in adversity, and assesses success and failure. Therefore, students with high self-efficacy tend to be more confident in overcoming academic challenges and more motivated to achieve. In contrast, students with low self-efficacy may feel doubt or fear of failure, which may ultimately limit their achievement.

This analysis demonstrates the importance of understanding the factors that influence students' self-efficacy and the significant role of the learning environment, including teachers and families, in providing positive experiences and support. By increasing access to self-efficacy resources, teachers and school authorities can help students strengthen their self-efficacy beliefs to shift towards a higher overall distribution of self-efficacy categories. The students' mathematical communication ability test scores are categorized using the same method applied to their self-efficacy scores. The mean and standard deviation for the students' mathematical communication ability test scores are as follows in **Table 5**.

Table 5. SPSS Descriptive Statistics Output of Students' Mathematical Communication Ability

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Kemampuan Komunikasi Matematis	30	33	100	59.17	23.392
Valid N (listwise)	30				

Source: SPSS Software version 29 (2024)

The findings in **Table 5** show that the average score of students' mathematical communication ability test is 59.17, with a standard deviation of 23.39. The average score indicates that students' mathematical communication skills are intermediate overall. The large standard deviation (23.39) indicates a significant variation in students' mathematical communication skills. This means that some students have excellent skills, while others may still struggle with mathematical communication. This significant variation also shows that factors such as level of understanding, how students practice, or other external factors can affect test results. The lowest score was 33, indicating that some students had significant difficulties conveying mathematical ideas. On the other hand, the highest score of 100 indicates that some students are very competent in communicating mathematically. They could clearly explain mathematical concepts and convey solutions systematically and efficiently.

The results of the SPSS output of students' mathematical communication ability categories are shown in **Table 6**.

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Table 6. SPSS Output of Frequency Distribution Category Students' Mathematical Communication Ability

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Rendah	15	50.0	50.0	50.0
	Sedang	6	20.0	20.0	70.0
	Tinggi	9	30.0	30.0	100.0
	Total	30	100.0	100.0	

Source: SPSS Software version 29 (2024)

The findings in **Table 6** show a clear difference in students' mathematical communication skills. Out of the total number of students, 15 students had low mathematical communication skills, indicating that they may have difficulty in conveying mathematical ideas clearly or systematically. Meanwhile, six students were at an intermediate level of ability, indicating that they could already communicate mathematically, although there was still room for improvement to be more effective. On the other hand, nine students had high mathematical communication skills, indicating that they could express mathematical ideas and solve problems in a structured and transparent way. These findings reflect the importance of teaching approaches that can help improve mathematical communication skills across groups of students by providing additional support for those at low to intermediate levels. The influence of students' self-efficacy on their mathematical communication ability was analyzed through the following steps and corresponding results.

Normality Test

Normality tests of students' self-efficacy scores and test results of students' mathematical communication skills were performed using SPSS software, with a significance level of 0.05. The normality test output is shown in **Table 7**.

Table 7. SPSS Output of Normality Test

One-Sample Kolmogorov-Smirnov Test

			Unstandardized Residual
N			30
Normal Parameters[a,b]	Mean		.0000000
	Std. Deviation		19.66494368
Most Extreme Differences	Absolute		.119
	Positive		.119
	Negative		-.062
Test Statistic			.119
Asymp. Sig. (2-tailed)[c]			.200[d]
Monte Carlo Sig. (2-tailed)[e]	Sig.		.334
	99% Confidence Interval	Lower Bound	.321
		Upper Bound	.346

Source: SPSS Software version 29 (2024)

Based on the analysis results in **Table 7**, the Asymp. Sig. (2-tailed) the value obtained is 0.334. Since this value is more significant than 0.05, it can be concluded that the residual data in this study are typically distributed. The analyzed data show no violation of the normality assumption. This conclusion indicates that the residual distribution conforms to the normality assumption, an important requirement for valid parametric statistical tests.

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Linearity Test

The linearity test of student self-efficacy scores and student mathematical communication ability test results were done using SPSS software, with a significance level of 0.05. The output of the linearity test is in **Table 8**.

Table 8. SPSS Output of Linearity Test

ANOVA Table

			Sum of Squares	df	Mean Square	F	Sig.
Komunikasi_Math * Self-Efficacy	Between Groups	(Combined)	13262.500	20	663.125	2.290	.101
		Linearity	4653.576	1	4653.576	16.074	.003
		Deviation from Linearity	8608.924	19	453.101	1.565	.249
	Within Groups		2605.667	9	289.519		
	Total		15868.167	29			

Source: SPSS Software version 29 (2024)

Based on the analysis results in **Table 8**, the significance value of the deviation from linearity obtained is 0.249. Since this value is more significant than 0.05, it can be concluded that there is no significant deviation from linearity, which means a linear relationship exists between self-efficacy and students' mathematical communication skills. In other words, the data shows that these two variables are linearly related, which supports a structured relationship between self-efficacy and students' mathematical communication skills.

Linear Regression Test

Linear regression test on student self-efficacy scores and mathematical communication ability test results using SPSS software with a significance level of 0.05. The linear regression test output is in **Table 9**.

Table 9. SPSS Output of Linear Regression Test (Coefficients)

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	-27.178	25.593		-1.062	.297
	Self-Efficacy	1.289	.378	.542	3.409	.002

a. Dependent Variable: Komunikasi_Math

Source: SPSS Software version 29 (2024)

Based on the analysis results in **Table 9**, the significance value obtained is 0.02, smaller than 0.05. This indicates that students' self-efficacy has a significant influence on students' mathematical communication skills. In addition, the coefficient of self-efficacy is 1.289 (positive), which indicates that every one-unit increase in self-efficacy will correspond to an increase in mathematical communication skills by 1.289 units. Thus, it can be concluded that self-efficacy significantly impacts students' mathematical communication skills. The magnitude of the effect of students' self-efficacy on students' mathematical communication skills can be seen in the following output.

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Table 10. SPSS Output of Linear Regression Test (Model Summary)

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.542[a]	.293	.268	20.013

a. Predictors: (Constant), Self-Efficacy

Source: SPSS Software version 29 (2024)

Based on the analysis results in **Table 10**, the R Square value obtained is 0.268, which means that students' self-efficacy affects students' mathematical communication skills by 26.8%. The remaining 73.2% is influenced by other factors not examined in this study. The R^2 value of 0.268 indicates that self-efficacy explains a moderate proportion of the variance in mathematical communication skills, which indicates that other significant factors have not been analyzed in this study.

Discussion

Based on the research results obtained, data shows that student self-efficacy affects students' mathematical communication skills. This follows Bandura's Social Cognitive Theory (Lianto, 2019). Self-efficacy, which means students' belief in their ability to learn mathematics and do math tasks or problems, is essential in influencing how students think, feel, and act, especially when faced with challenges or difficulties in mastering mathematical communication skills. The extent to which students' self-efficacy affects their mathematical communication skills, as shown by this study, is about 26.8%. This finding differs from previous research, which reported that the relationship of self-efficacy to students' mathematics learning outcomes was 33.1%, and the rest (66.9%) was influenced by other factors (Taufik & Komar, 2021). Similarly, another study found that there was a significant relationship between self-efficacy and self-leadership variables on learning outcomes, and the effective effect of self-efficacy and self-leadership variables together on learning outcomes was 25%, with details of the effective effect of self-efficacy of 18.3% and self-leadership of 6.7% (Ulfah, 2023). Although the reported effects vary, the difference between this study and the previous two studies is insignificant.

This study makes a unique contribution by explicitly focusing on the relationship between self-efficacy and mathematical communication skills, highlighting the importance of confidence in student's ability to express mathematical ideas effectively. Unlike other studies focusing on overall mathematics achievement or problem-solving skills, this research sheds light on how self-efficacy explicitly influences the articulation and understanding of mathematical concepts. The finding that self-efficacy accounts for 26.8% of the variance in mathematical communication skills adds new insights into the role of psychological factors in improving students' ability to communicate mathematically, a crucial aspect of their overall mathematical competence. This unique focus on communication skills in mathematics provides valuable information for educators seeking to develop targeted interventions that boost mathematical performance and enhance students' ability to express their understanding of mathematical concepts clearly.

The findings of this study also reinforce research conducted previously using four years of data (from grade 6 to grade 9) from 3,209 secondary school students in Germany, which states that self-efficacy has a stronger relationship with math test scores than math grades because tests are more demanding of students' confidence in completing specific tasks (Arens et al., 2020). A significant difference from the results of this study was found in Amaliyah's research, which stated that the problem-solving ability variable could be explained or influenced by the self-efficacy variable by 0.775 or 77.5% (Amalia & Sari, 2024). This difference shows that although related to math skills, math communication skills have different

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characteristics and components. Mathematical communication skills concern how students express mathematical concepts, which requires linguistic skills and symbolic understanding. In contrast, problem-solving skills focus more on critical thinking and problem-solving, which may be more closely related to self-efficacy in finding solutions. The main difference between the effect of self-efficacy on mathematical communication (26.8%) and problem-solving skills (77.5%) in the study conducted in class VII of SMP Negeri 5 Cimahi is due to the unique characteristics of each skill and the complexity of the aspects involved. Mathematical communication and problem-solving skills, although both rooted in mathematical ability, have different cognitive, linguistic, and social demands, so the level of influence of self-efficacy on each skill is also different (Amalia & Sari, 2024).

1. Characteristics of Mathematical Communication

   Mathematical communication involves a student's ability to express mathematical ideas, reasoning, and solutions orally or in writing clearly and logically and understand others' mathematical arguments. This characteristic requires integrating mathematical and linguistic abilities, including grammar, vocabulary, and the skills to structure coherent arguments. Bandura states that self-efficacy is an individual's belief in their ability to accomplish a particular task. In mathematical communication, students must not only be confident in their mathematical ability but also have confidence in their language ability to explain concepts appropriately. The lower level of influence of self-efficacy on mathematical communication can be caused by:

   a. Linguistic Complexity: Mathematical communication requires linguistic skills often not explicitly taught in mathematics lessons. Students who feel less confident in language use tend to experience barriers in communicating mathematical ideas despite a good understanding of concepts.

   b. Limited Experience: Students may rarely have the opportunity to practice mathematical communication intensively, thus lacking mastery experiences that can increase their self-efficacy.

   c. Social Context: Mathematical communication is often done in front of others, such as classmates or teachers. For students who feel anxious or not confident in public speaking, this is a factor that limits the influence of their self-efficacy.

2. Characteristics of Problem-Solving Skill

   On the other hand, problem-solving skills focus on students' ability to analyze, formulate strategies, and find solutions to mathematical problems. This characteristic is more internal, prioritizing the ability to think logically and systematically without involving linguistic aspects or communication with other parties. In this context, the influence of self-efficacy is higher (66.8%) because students only need to believe in their cognitive abilities without having to think about how to convey or explain solutions. The more significant influence of self-efficacy on problem-solving skills can be explained by:

   a. Cognitive Focus: Problem-solving skills involve more internal thinking activities, so students' success depends more on their confidence in completing the task, which is the core of self-efficacy.

   b. Exposure and Practice: School mathematics learning often emphasizes problem practice and problem-solving strategies over mathematical communication. This gives students more successful experiences that support their self-efficacy in problem-solving.

   c. Lack of External Barriers: Problem-solving skills do not involve linguistic challenges or social pressure as in mathematical communication so that students can focus more on their mathematical abilities.

3. Implications of Bandura's Theory

   Bandura's self-efficacy theory states that the four primary sources of self-efficacy are experiences of success, vicarious experiences, social persuasion, and physiological/emotional states. In mathematical

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communication, students may experience limitations in success experiences and positive social support, especially if learning lacks opportunities to practice these skills. In contrast, problem-solving skills are more often supported by successful experiences, such as solving problems correctly, directly impacting self-efficacy.

4. Study Context and Other Studies

   This study, which analyzed general self-efficacy in grade VI students of SDN 2 Kayuambon, provided a global picture of students' confidence levels in their abilities. However, previous research showed how self-efficacy affects specific aspects, such as mathematical communication and problem-solving skills. (Amalia & Sari, 2024). This difference in context shows that self-efficacy is domain-specific, meaning that students' confidence can differ depending on the specific task or skill.

Self-efficacy is critical in influencing students' problem-solving skills, as it directly impacts their ability to think independently and pursue solutions effectively. The role of self-efficacy in mathematical communication, however, is nuanced. While self-efficacy contributes to students' confidence in conveying mathematical ideas, its influence may be less pronounced in this context than other factors, such as language proficiency. This is particularly true since mathematical communication requires understanding the mathematical content and articulating it clearly. This task depends on linguistic capabilities in addition to cognitive skills. The findings of this study highlight that self-efficacy plays a significant role in enhancing mathematical communication skills. However, the extent of its impact is limited, accounting for only 26% of the variance. This indicates that while self-efficacy does contribute to students' perceived competence and confidence in communicating mathematical concepts, it is just one of many variables that influence this ability. The study suggests that other factors not examined here may be equally or more influential in fostering mathematical communication skills. Further research is needed to identify other influencing variables and to explore how these variables interact with self-efficacy. For example, previous research has shown that positive teacher-student relationships can improve problem-solving skills, with self-efficacy being a key mediator in this process (Zhou et al., 2020).

Such research emphasizes the importance of fostering self-efficacy in mathematics learning, mainly through supportive and encouraging classroom environments. Thus, teachers should focus on nurturing students' self-efficacy in mathematics as part of a broader strategy to improve their mathematical communication abilities. However, it is essential to recognize that the development of mathematical communication is a multifaceted process that involves various cognitive, linguistic, and affective components. Therefore, a comprehensive approach to teaching is needed to address all the factors contributing to this skill. The findings also show that mathematical communication ability is influenced by many factors besides self-efficacy. This suggests that a comprehensive approach needs to be taken to improve mathematical communication ability, involving other factors such as learning environment, teaching methods, and language skills. This study may have limitations regarding sample size or characteristics, and it did not conduct direct experiments or control the independent variables; instead, it observed the relationship between variables. Experiments with specific learning scenarios may provide a deeper understanding of the direct influence of self-efficacy on mathematical communication. While this study confirms the importance of self-efficacy in mathematical communication, it underscores the need to address other contributing factors, emphasizing a holistic approach to skill development in mathematics education.

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CONCLUSION

This study aims to examine the effect of self-efficacy on the mathematical communication skills of grade VI students. The results of the linear regression test revealed a significance value of 0.02 (smaller than 0.05), confirming that the hypothesis stating self-efficacy has a positive and significant influence on communication mathematical skills was accepted. Self-efficacy accounted for 26.8% of the variance in mathematical communication skills, indicating a moderate positive relationship. This finding aligns with previous research highlighting self-efficacy as a critical psychological factor in academic performance. The study found that the average mathematical communication skills of grade VI students of SDN 2 Kayuambon on the topic of multiplication and division of fractions were 59.17, with a standard deviation of 23.39. Students with high self-efficacy (5 out of 30) tended to exhibit high mathematical communication skills, while students with moderate self-efficacy (20 out of 30) often showed lower-than-expected abilities. This suggests that a moderate level of self-efficacy may not be sufficient to achieve optimal outcomes. The results highlight the importance of fostering higher levels of self-efficacy to enhance performance, as students with high self-efficacy demonstrate greater confidence and capability in expressing mathematical ideas clearly and logically. Conversely, low self-efficacy was associated with emotional barriers that hindered performance. These findings underscore the necessity of targeted interventions to improve self-efficacy, particularly for students with low or moderate abilities. Enhancing self-efficacy can help bridge the gap in mathematical communication skills, enabling more students to reach higher performance levels. Learning strategies that integrate the relationship between self-efficacy and communication skills are essential to achieve optimal learning outcomes. Based on the results of this study, several recommendations are proposed. Teachers can implement collaborative learning strategies to foster self-efficacy and communication skills simultaneously. These approaches have been shown to enhance individual confidence and peer-supported learning outcomes.

Future research could explore the impact of self-efficacy interventions on specific sub-skills of mathematical communication, such as symbolic representation or verbal explanation, to identify which aspects benefit most from increased self-efficacy. In addition, adopting different methodological approaches, such as experiments with control group designs or in-depth qualitative methods, could provide a more comprehensive understanding of the relationship between self-efficacy and mathematical communication skills. Expanding the scope of future studies to include a more diverse population in terms of geographical area, socio-economic background, and educational level is recommended. This broader scope would enhance the generalizability of the findings and provide deeper insights into the influence of self-efficacy across various educational contexts. Such research could also inform the development of more effective policies and strategies to improve learning outcomes in diverse school settings.

By addressing these areas, future research and educational practices can build on the current findings to further explore and strengthen the critical role of self-efficacy in enhancing students' mathematical communication skills.

AUTHOR'S NOTE

The authors declare that there is no conflict of interest related to the publication of this article and emphasize that the data and content of the article are free from plagiarism.

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