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THE CONNECTION BETWEEN MATHEMATICAL SELF-EFFICACY AND MATHEMATICAL REASONING IN ELEMENTARY SCHOOL STUDENTS

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ABSTRACT
This research aims to examine the connection between mathematical self-efficacy and mathematical reasoning in elementary school students. The research used a quantitative method with a pretest-posttest experimental design in one experimental group, consisting of 27 fourth-grade elementary school students. This intervention is designed to enhance students' mathematical self-efficacy through the implementation of a problem-based learning model conducted over a two-week period. The results indicate a significant increase in mathematical self-efficacy, with the average score increasing from 65.4 on the pretest to 78.2 on the posttest (t value = 6.87, p < 0.001). Students' mathematical reasoning also demonstrate a significant increase, from an average score of 62.8 on the pretest to 74.5 on the posttest (t value = 5.93, p < 0.001). furthermore, the correlation analysis indicates a significant positive connection between changes in mathematical self-efficacy and mathematical reasoning, with a correlation value (r) of 0.68 and p-value <0.01. Based on the research results, it can be concluded that the increase in mathematical self-efficacy is closely related to the improvement in students' mathematical reasoning abilities. Moreover, this research provides valuable insight for educators in designing more effective and holistic learning strategies, focusing on improving students' psychological aspects in addition to cognitive aspects.
Keywords*: Basic Education, Mathematics Learning, Mathematical Reasoning, Mathematical Self-Efficacy*

ABSTRAK
Penelitian ini bertujuan untuk mengkaji hubungan antara self-efikasi matematis dengan penalaran matematis siswa sekolah dasar. Metode penelitian yang digunakan adalah kuantitatif dengan desain eksperimen pretest-posttest pada satu kelompok eksperimen, yang terdiri dari 27 siswa kelas 4 di sebuah sekolah dasar. Intervensi ini dirancang untuk meningkatkan self-efikasi matematis siswa melalui penerapan model pembelajaran berbasis masalah yang dilaksanakan selama 2 minggu. Hasil penelitian menunjukkan peningkatan signifikan dalam self-efikasi matematis, dengan rata-rata skor meningkat dari 65.4 pada pretest menjadi 78.2 pada posttest (nilai t = 6.87, p < 0.001). Penalaran matematis siswa juga mengalami peningkatan signifikan, dari rata-rata skor 62.8 pada pretest menjadi 74.5 pada posttest (nilai t = 5.93, p < 0.001). Analisis korelasi menunjukkan hubungan positif yang signifikan antara perubahan self-efikasi matematis dan penalaran matematis, dengan nilai korelasi (r) sebesar 0.68 dan p-value < 0.01. Berdasarkan hasil penelitian dapat disimpulkan bahwa peningkatan self-efikasi matematis berkolerasi erat dengan peningkatan kemampuan penalaran matematis siswa. Penelitian ini memberikan wawasan berharga bagi pendidik dalam merancang strategi pembelajaran yang lebih efektif dan holistik, dengan fokus pada peningkatan aspek psikologis siswa selain aspek kognitif.
Kata Kunci: Pendidikan Dasar, Pembelajaran Matematika, Penalaran Matematis, Self-Efikasi Matematis.

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Introduction

Mathematics is one of the important subjects in the basic education curriculum (Fauzan et al., 2018; Taufina et al., 2019; Wiryana & Alim, 2023) good understanding of mathematical concepts from an early age greatly determines the development of students' logical and analytical thinking skills at the next level of education (Fauzan et al., 2018; Sufa & Widyahening, 2023). However, many students have difficulty in learning mathematics, which is often rooted in their fear or low confidence in facing the subject (Elendiana & Prasetyo, 2021; Setiawan et al., 2022; Thurm & Barzel, 2022). This condition indicates the need for a more holistic approach in the mathematics learning process.

One of the psychological factors that significantly influences on students' ability to learn mathematics is mathematical self-efficacy (David et al., 2021; Sagitarini et al., 2023; Vera Eunike, 2024). Mathematical self-efficacy refers to students' self-confidence in their ability to understand and solve mathematical problems (Ningrum & Rahmawati, 2022; Ningsih & Hayati, 2020; Rahayu & Harahap, 2022). Self-efficacy is a person's belief in his or her ability to organize and carry out the necessary actions to achieve a certain performance (Fashiha & Mardiana, 2023; Hakiim & Sadiyah, 2022; Heslin & Klehe, 2006; Setya Hermawan et al., 2023). In the context of mathematics education, self-efficacy plays a crucial role in determining how persistent students are in facing challenges, the level of anxiety they feel, as well as the strategies they use to solve math problems (Adelia & Wandini, 2023; Saharuddin & Dewi, 2022; Wiguna et al., 2022).

The importance of mathematical self-efficacy cannot be underestimated. High self-efficacy students are typically more self-assured and driven to take on challenges in their math classes. (Fanchamps et al., 2019; Schunk & DiBenedetto, 2021). They are more likely to use effective problem-solving strategies and show higher persistence when encountering difficulties (Mohd Dzin & Lay, 2021; Thurm & Barzel, 2020). In contrast, students with low self-efficacy tend to avoid challenging tasks and give up more quickly when facing difficulties, which ultimately has negative impacts on their academic performance (Samuel & Warner, 2021; Voica et al., 2020; Zwart et al., 2020).

Mathematical reasoning, as one of the crucial aspects of mathematics learning, involves students' ability to think logically, make generalizations, and develop valid mathematical arguments (Amelia & Ulfah, 2022; Amin et al., 2023). Mathematical reasoning includes not only the ability to solve mathematical problems, but also the ability to understand concepts, connect ideas, and apply mathematical knowledge in new situations (Negara, 2023; NTCM, 2000) .This ability is essential for students to be able to overcome various complex and applicable mathematical problems.

The problem of this research is motivated by the low mathematical ability of students in various elementary schools. Based on the learning outcomes of fourth-grade students in mathematics, it is shown that 10 (37%) of the 27 students have not yet achieved proficiency in this subject. This occurs because students feel less confident in solving math problems, which indicates low mathematical self-efficacy among students. Further, this study aims to examine the connection between mathematical self-efficacy and mathematical reasoning in elementary school students. Considering the importance of self-efficacy in improving academic achievement, a deep understanding of how mathematical self-efficacy affects mathematical reasoning can contribute significantly to more effective teaching strategies in primary schools. Thus, the results of this research are expected to provide valuable insights for educators in developing learning approaches that can improve students' self-efficacy and mathematical reasoning.

Furthermore, the study will also explore other factors that may influence the connection between mathematical self-efficacy and mathematical reasoning. Some of these factors include teaching methods (Bergqvist et al., 2020; Sides & Cuevas, 2020; Ugwuanyi et al., 2020), learning environment (Mamolo, 2022; Öztürk et al., 2020), support from parents and peers (Novianti et al., 2023; Rozgonjuk et al., 2020), as well as previous learning experiences (Ikrimah, 2023; Lutfia Fitriyani & Asih Miatun, 2022; Zay & Kurniasih, 2023). Understanding how these

factors interact with self-efficacy can provide a more comprehensive view of ways to improve students' overall math abilities (Amelia & Ulfah, 2022).

It is anticipated that this study will significantly advance the field of mathematics education, particularly with regard to raising primary school pupils' levels of mathematical reasoning and self-efficacy. The data of this research is expected to be the basis for the development of more effective and holistic learning strategies, which not only focus on cognitive aspects, but also pay attention to students' psychological and social aspects.

Method

This study uses a quantitative method with an experimental design to examine the connection between mathematical self-efficacy and mathematical reasoning of elementary school students (Creswell, 2018; Uhyat, 2013). Further, the participants of the study consits of 27 fourth-grade elementary was selected using purposive sampling technique to participate in an intervention designed to improve their mathematical self-efficacy. The study population includes all fourth-grade elementary students in one public elementary school, with a purposive sampling selected sample to ensure good representation of the population, so that the results of the study could be generalized more accurately (Gall et al., 2014).

İn addition, the design of this study employs a pretest-posttest approach with one experimental group. Prior to the intervention, all students are given a pretest to measure their mathematical self-efficacy and mathematical reasoning ability. Afterwards, students participate in an intervention consisting of training and activities designed to improve their mathematical self-efficacy for 2 weeks. After the intervention period, students are given a final test (posttest) to measure changes in their self-efficacy and mathematical reasoning. The research instruments use include a mathematical self-efficacy questionnaire, adapted from a scale developed by Bandura (1997) (Bandura, 1997), as well as a mathematical reasoning test designed based on the elementary school mathematics curriculum.

The data obtained from the pretest and posttest are analyzed using statistical tests to determine significant changes in students' mathematical self-efficacy and mathematical reasoning abilities. The Kolmogorov-Smirnov and Shapiro-Wilk tests are then used to perform the normality test in order to make sure that the data is normally distributed. Furthermore, paired t-tests are used to test the mean difference between pretest and posttest. The results of this data analysis will provide information regarding the effectiveness of interventions in improving mathematical self-efficacy and mathematical reasoning ability of elementary school students.

Results and Discussion

This study aims to examine the connection between mathematical self-efficacy and mathematical reasoning of elementary school students. This study was conducted using quantitative methods and pretest-posttest experimental design in one experimental group. The research subjects consisted of 27 fourth-grade students from an elementary school.

Additionally, following an intervention intended to raise the kids' self-efficacy, the study assessed changes in the fourth-grade students' mathematical reasoning and self-efficacy. Mathematical self-efficacy refers to students' self-confidence in their ability to understand and solve mathematical problems. Mathematical reasoning, on the other hand, includes students' ability to think logically, make generalizations, and develop valid mathematical arguments.

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Table 1
Results of the T-Test on Mathematical Self-Efficacy

Class	Pretest Results	N	Std. Dev	T value	Sig. (2-tailed)
Pretest	65,4	27	8,3	6,87	0,001
Posttest	78,2	27	7,1		

Based on Table 1, the pretest and posttest data for mathematical self-efficacy were analyzed using paired t-tests to determine significant changes. The average mathematical self-efficacy score in the pretest was 65.4 with a standard deviation of 8.3. After the intervention, the average mathematical self-efficacy score on the posttest increased to 78.2 with a standard deviation of 7.1. The t-value of 6.87 and the p-value < 0.001 showed a significant improvement in the students' mathematical self-efficacy.

The improvement in students' mathematical self-efficacy after the intervention shows that the designed intervention successfully increased students' self-confidence in understanding and solving mathematical problems. High self-efficacy is important because students with higher self-efficacy tend to be more confident and motivated in facing math challenges.

Table 2
Results of the T-Test on Mathematical Reasoning

Class	Pretest Results	N	Std. Dev	T value	Sig. (2-tailed)
Pretest	62,8	27	9,1	5,93	0,001
Postest	74,5	27	8,4		

In addition to mathematical self-efficacy, this study also measures students' mathematical reasoning before and after the intervention. Based on Table 2, the pretest results show that the average mathematical reasoning score of students is 62.8 with a standard deviation of 9.1. After the intervention, the average score on the posttest increased to 74.5 with a standard deviation of 8.4. A t-value of 5.93 and a p-value of < 0.001 show a significant improvement in students' mathematical reasoning.

The results of the analysis show that the designed intervention not only improved the mathematical self-efficacy, but also enhanced students' the mathematical reasoning abilities. Good mathematical reasoning is essential for students because it helps them in understanding mathematical concepts in depth and applying them in new and complex situations.

Table 3
Self-Efficacy Correlation Value with Mathematical Reasoning

Correlation Value (r)	p-value
5,93	0,001

This study also analyzed the connection between changes in mathematical self-efficacy and changes in students' mathematical reasoning. The correlation analysis results, which are based on Table 3, show that there is a substantial positive relationship ($r = 0.68$ and $p < 0.01$) between the two variables. This suggests that pupils' ability to reason mathematically will improve in direct proportion to their rise in mathematical self-efficacy.

The positive connection between mathematical self-efficacy and mathematical reasoning suggest that students who are more confident in their mathematical abilities tend to have better reasoning abilities. Therefore, increasing mathematical self-efficacy can be an effective strategy in improving students' mathematical reasoning abilities. Significant improvements in these two variables after the intervention provide strong evidence that a holistic approach which considers students' psychological aspects can be effective in improving their math performance. The results of

this study provide valuable insights for educators in developing more comprehensive teaching strategies.

The study revealed that high self-efficacy contributes to improved mathematical reasoning. Students with high self-efficacy are more likely to use effective problem-solving strategies and demonstrate persistence in facing mathematical difficulties. This finding supports previous research that found a significant positive correlation between self-efficacy and academic achievement in mathematics (Saharuddin & Dewi, 2022; Zay & Kurniasih, 2023).

In this study, the interventions involves training and activities designed to improve mathematical self-efficacy. As a result, students showed a significant improvement in their mathematical reasoning abilities. This is consistent with Schunk's findings, which emphasize the importance of strengthening self-efficacy through direct experience and modeling in the context of education (Schunk & DiBenedetto, 2021). The success experiences in completing a math task during the intervention is likely to contribute to an increase in students' self-efficacy.

The normality test which conducted using Kolmogorov-Smirnov and Shapiro-Wilk showed that the pretest and posttest data were normally distributed. It is important to ensure that the conducted statistical analysis, i.e. the paired t-test, can provide valid results. Moreover, the paired t-test results indicated that there was a significant difference between the pretest and posttest scores, indicating the effectiveness of the intervention in improving students' mathematical self-efficacy and mathematical reasoning abilities.

Theoretically, high self-efficacy encourages students to take risks and try various strategies to solve math problems. This has implications for improving mathematical reasoning abilities, as students become more active in exploring different ways to solve problems. These findings suggest that high self-efficacy is associated with the use of more effective learning strategies (Abdullah, 2019; Eunike, 2024).

In addition, the study also shows that strengthening self-efficacy through appropriate interventions can reduce math anxiety, which often serves as a significant barrier in learning mathematics. Reducing anxiety allows students to focus more on understanding concepts and developing mathematical reasoning skills. Further, the meta-analysis also reveals that high self-efficacy is associated with lower math anxiety and better performance in math (Sides & Cuevas, 2020; Voica et al., 2020).

The practical implication of this study is that teachers need to pay attention to the psychological aspects of students, especially self-efficacy, in the process of learning mathematics. Furthermore, providing positive feedback, recognizing students' efforts and achievements, and creating a supportive learning environment can improve students' self-efficacy. This is in line with the recommendations of Bandura and Schunk who emphasized the importance of psychological aspects in learning (Bandura, 1997; Gao, 2020; Schunk & DiBenedetto, 2021).

Overall, this study provides strong empirical evidence that interventions designed to improve mathematical self-efficacy can have a positive impact on the mathematical reasoning of elementary school students. Thus, holistic learning strategies which integrate self-efficacy enhancement with cognitive skill development are highly recommended to be applied in the mathematics curriculum. This approach will not only improve students' academic achievement but also help them develop a positive attitude towards math.

Conclusion

The study shows that interventions designed to improve the mathematical self-efficacy of elementary school students significantly improved their self-efficacy and mathematical reasoning, with the mean self-efficacy increasing from 65.4 on the pretest to 78.2 on the posttest (t-value = 6.87, $p < 0.001$), and the average mathematical reasoning increased from 62.8 on the pretest to 74.5 on the posttest (t-value = 5.93, $p < 0.001$). In addition, there is a significant positive connection between increased mathematical self-efficacy and mathematical reasoning, with a correlation value (r) of 0.68 and a p-value < 0.01. This indicates that the improvement of mathematical self-efficacy is closely related to the improvement of students' mathematical reasoning ability, providing strong evidence that a holistic approach which pays attention to

students' psychological aspects can be effective in improving their mathematical achievement. The implications of this study aim to address gaps in scientific knowledge and to serve as a foundation for future research by providing a database and evaluation framework in the field of education. This study also offers a primary reference for stakeholders, including government bodies, researchers, educational institutions, and the community, to guide efforts in fostering students' confidence and self-efficacy. Consequently, future research may explore mathematical self-efficacy across various dimensions, such as different educational levels, learning environments, and demographic factors like gender and socio-economic status. Additionally, researchers could investigate the long-term impact of self-efficacy on students' academic performance in mathematics, as well as how specific teaching methods, such as inquiry-based learning or collaborative group work, influence self-efficacy across diverse student populations. This research could also provide insights into interdisciplinary approaches to enhancing students' confidence and success in mathematics.

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