Primary: Jurnal Pendidikan Guru Sekolah Dasar
journal homepage: https://primary.ejournal.unri.ac.id/
contents lists available at SINTA and DOAJ

Vol. 14 No. 5 (2025): October
http://dx.doi.org/10.33578/jpfkip.v14i5.p722-737

Exploring the impact of discovery learning and self-efficacy on students' mathematical reasoning skills

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Article info

Keywords:
discovery learning, mathematical reasoning, self-efficacy, elementary education

Abstract

The research aims to test the effect of discovery learning on mathematical reasoning and analyse the differences in impact based on elementary school students' self-efficacy level. This study uses a quantitative approach with a quasi-experimental pre-test-post-test control group type design. The research sample consisted of 120 elementary school students randomly divided into experimental and control groups. The experimental group was given treatment for eight meetings using the Discovery Learning model, while the control group followed normal learning. The instruments used included a mathematical reasoning test and a self-efficacy questionnaire. Data analysis was carried out using paired sample t-test and independent sample t-test to determine the effect of the learning model, as well as one-way ANOVA to analyse differences in influence based on the level of self-efficacy. The results showed that the Discovery Learning model significantly improved students' mathematical reasoning skills with a value of <0.001. In addition, there was a significant difference in the acquisition of mathematical reasoning skills based on students' self-efficacy level. These findings indicate the importance of considering academic self-confidence factors in designing effective mathematics learning in elementary schools

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DOI: http://dx.doi.org/10.33578/jpfkip.v14i5.p722-737
Received 21 July 2025; Received in revised form 05 October 2025; Accepted 05 October 2025
Available online 12 October 2025
e-ISSN 2598-5949 | p-ISSN 2303-1514

1. Introduction

Mathematical reasoning is a fundamental aspect of mathematics education at the primary level. It involves logical, analytical, and systematic thinking processes that enable students to understand and deeply apply mathematical concepts in various real-life contexts. Mathematical reasoning is crucial for supporting conceptual understanding and fostering structured thinking patterns from an early age (Third Space Learning, n.d.). Additionally, Mathnasium (2023) states that these skills can be strengthened by allowing students to solve problems in multiple ways, allowing them to build meaning rather than merely memorise formulas. Therefore, reasoning skills support academic achievement and serve as a foundation for broader critical thinking development (Arum, Rosmilawati, & Sudiatmika, 2024; Rahartiningsih et al., 2025). In line with its importance, mathematical reasoning also forms the basis for developing 21st-century skills, which are increasingly emphasised in modern education.

In facing 21st-century global challenges, students must possess various essential competencies such as critical thinking, problem-solving, and reflective and collaborative skills (Susilowati,et all, 2025). Mathematical reasoning underpins these competencies by training students to make logical decisions, evaluate arguments, and seek solutions from multiple perspectives (Almazroui, 2023). Mathematics learning connected to real-life situations and reflective practices strongly supports the development of these skills (Pangestu, Destiniar, & Sari, 2025). Mathnasium (2023) also emphasises that students who can explore multiple mathematical problem-solving methods significantly improve adaptability and critical thinking. This underscores that mathematical reasoning is a cognitive skill and a component of 21st-century literacy. Despite widespread acknowledgement in the literature, empirical findings indicate that elementary students' reasoning abilities still fall short of expectations.

Although the importance of mathematical reasoning is well-recognised, studies reveal that primary school students often struggle to develop this skill (Stylianides & Stylianides, 2021). Many rely on rote procedures and cannot explain the rationale behind their steps (Third Space Learning, n.d.). A lack of instructional approaches that guide students to think deeply and investigate patterns is a key factor contributing to low reasoning ability (Mathnasium, 2023). This is further exacerbated by classroom environments that emphasise outcomes over the thought process. Therefore, pedagogical efforts must be directed towards reasoning and logical thinking processes from an early stage. Although various learning approaches have been introduced, most previous research has focused on improving learning outcomes in general, rather than specifically strengthening mathematical reasoning in lower elementary grades through concrete strategies (Alim et al., 2024). Still, little research explicitly designs and evaluates learning activities based on simple teaching aids that stimulate mathematical reasoning from an early age. This gap is crucial to bridge so that teachers have the right strategies to improve students' final scores and foster deep understanding and sustained logical thinking skills.

Improving reasoning skills requires emphasising conceptual aspects and teaching strategies that actively engage students in the learning process, such as using concrete media, open-ended tasks, and pattern exploration through simple yet meaningful teaching aids. The low levels of students' mathematical reasoning highlight the need for learning approaches that emphasise active and participatory engagement. Innovative models are believed to provide students with the space to explore and discover mathematical concepts through questioning, experimenting, and reflecting (Almazroui, 2023). Third Space Learning (n.d.) notes that when students construct knowledge through exploration and open discussions, they are more likely to develop deeper and more sustainable reasoning. Therefore, shifting from teacher-centred to student-centred discovery-based learning is essential to facilitate reasoning skills' natural and meaningful development. Discovery Learning (DL) is one such relevant and proven-effective model.

Discovery Learning is a constructivist instructional model that places students at the centre of learning activities and encourages them to discover concepts through exploratory experiences. Bruner (1961), the pioneer of this model, emphasised that learning becomes more meaningful when students discover underlying principles themselves. In the context of mathematics education, DL allows students to ask questions, make observations, and draw conclusions based on the evidence they gather. The model includes key stages such as stimulation, problem statement, data collection, data processing, verification, and generalisation (Joolingen, 1999; Novikasari & Nuryadi, 2021). The core characteristics of DL—active, open-ended, and problem-based learning—are believed to support the development of higher-order thinking skills, especially mathematical reasoning.

One of the main advantages of Discovery Learning is its capacity to enhance students' mathematical reasoning. Through exploration and self-discovery, students are trained to think logically, organise information, and draw conclusions from identified patterns. Reasoning develops when students actively analyse relationships between concepts and formulate their own ideas (Siregar, Rosli, & Maat, 2020). In DL, students obtain answers and learn how to think to reach those answers. Ismail et al. (2021) also found that discovery-based instruction helps students build connections among mathematical representations, enhances reflection, and fosters essential questioning habits for reasoning. These findings are consistent with numerous empirical studies demonstrating that DL significantly improves mathematics learning outcomes, particularly reasoning.

Several studies have shown that implementing DL positively impacts mathematics learning outcomes, including conceptual reasoning, problem-solving, and reasoning abilities. Siregar et al. (2020) found that using DL modules in geometry enhanced students' communication, confidence, and reasoning. Similarly, Nugraha & Wulansari (2023) reported that DL encouraged critical thinking and independent problem-solving, supporting the development of higher-order thinking, including reasoning. Thus, DL effectively improves conceptual reasoning and fosters reflective and self-directed learning—two key elements of mathematical reasoning. The effectiveness of DL in enhancing reasoning skills can be seen not only from the cognitive aspect but also from affective factors, one of which is self-efficacy.

Self-efficacy refers to belief in one's ability to organise and execute actions to achieve specific performance outcomes (Bandura, 1997). Rooted in social cognitive theory, this concept highlights the role of self-perception in directing learning behaviour. Self-efficacy reflects how confident students are in completing academic tasks, including mathematics. According to Klassen & Usher (2010), self-efficacy is a strong predictor of student motivation and a key determinant of persistence, effort, and resilience in the face of learning challenges. It helps explain performance variation among students with similar cognitive abilities. Understanding self-efficacy is essential in analysing how this construct influences learning dynamics, particularly in mathematics, which demands persistence and high confidence.

Self-efficacy plays a critical role in enhancing students' mathematical reasoning abilities. Research indicates that students with high self-efficacy tend to use more effective learning strategies, persist through challenges, and approach complex problems more confidently. These students are more likely to succeed in mathematics because they believe in their capacity to overcome obstacles and apply mathematical concepts to solve problems. Studies have demonstrated that self-efficacy positively correlates with improved problem-solving skills and mathematical reasoning (Usher & Pajares, 2023; Virgolino et al., 2024). For example, Zakariya et al. (2020) found that self-efficacy improves students' confidence and enhances their ability to reason mathematically, thus enabling them to construct logical arguments and solve problems more effectively. This underscores the importance of fostering self-efficacy alongside cognitive learning strategies in mathematics education.

Research indicates that self-efficacy is critical to students’ success in mathematics. Students with high self-efficacy tend to use more effective learning strategies, persist through challenges, and feel more confident solving complex mathematical problems (Pajares & Graham, 1999; Usher & Pajares, 2009). Conversely, students with low self-efficacy tend to give up, avoid challenges, and doubt themselves even before trying. Zakariya et al. (2020) found that self-efficacy positively correlates with reasoning and problem-solving performance and is a key mediating factor between teacher instruction and learning outcomes. Thus, self-efficacy shapes students' perceptions of difficulty and provides the psychological foundation for academic success. Given its influence, instructional strategies should focus on cognitive aspects and strengthen affective dimensions like self-efficacy.

Ignoring affective factors such as self-efficacy in mathematics instruction may result in suboptimal planning and less meaningful learning experiences. In an era emphasising holistic and student-centred education, strengthening self-efficacy must become integral to learning strategies. Huang (2013) concluded that interventions enhancing student self-efficacy, such as positive feedback and success-based learning, consistently improve mathematics achievement. Karaoglan Yilmaz (2022) also emphasised that adaptive learning environments responsive to students' emotional needs can foster strong confidence in facing academic challenges. Therefore, developing self-efficacy should go hand-in-hand with cognitive development to make mathematics learning more inclusive, meaningful, and sustainable.

This research gap lies in the lack of understanding of how Discovery Learning and self-efficacy influence elementary school students' mathematical reasoning abilities, particularly in learning contexts that integrate cognitive and affective aspects. Although previous research has identified that discovery-based approaches can improve critical thinking and problem-solving skills and the influence of self-efficacy on academic achievement, research that combines the two to develop students' mathematical reasoning abilities at the elementary level is still limited. Furthermore, research on how these two factors work together to support students' mathematical reasoning abilities in solving contextual problems in elementary school has not been widely conducted, making it important to explore their contribution to improving mathematics learning outcomes in the classroom.

While numerous studies have demonstrated the positive impact of DL on mathematical reasoning, most have explored DL and self-efficacy as separate variables. Research that integrates both within a single experimental framework remains limited. Windiyani & Sofyan (2023) found that although DL and PBL improved students’ problem-solving skills, there was no significant interaction between the instructional model and students’ self-efficacy. This suggests that self-efficacy may independently influence students’ problem-solving skills regardless of the instructional model. Nugraha & Wulansari (2023) found that DL improves self-efficacy and mathematics achievement, though they did not explore its interaction with reasoning. Siregar et al. (2020) also found that DL enhanced mathematical reasoning and confidence, but did not investigate self-efficacy as a moderating or mediating variable. Unlike previous studies, this study explicitly examines the relationship between the Discovery Learning model, self-efficacy, and mathematical reasoning within a single experimental framework. This study aims not only to examine the direct effects but also to investigate whether self-efficacy acts as a mediating or moderating variable in the influence of Discovery Learning on reasoning. Thus, this study contributes to broadening theoretical and practical understanding regarding integrating cognitive and affective aspects in mathematics learning.

This study aims to analyse the effectiveness of the Discovery Learning model in improving elementary students' mathematical reasoning skills and to examine the influence of self-efficacy as an affective factor contributing to learning outcomes. Mathematical reasoning is a crucial component of the 21st-century curriculum, encouraging students to develop logical thinking, generalisation, and independent problem-solving skills. Furthermore, self-efficacy—an

[e-ISSN 2598-5949 | p-ISSN 2303-1514]

individual's belief in their skills to complete tasks—has influenced how students respond to learning challenges, including mathematics, a difficult subject.

This study examines quantitative improvements in reasoning skills and explores how students' self-efficacy interacts with the Discovery Learning approach. Thus, this study places the learning model in a more holistic context, where cognitive and affective factors simultaneously influence learning outcomes. The Discovery Learning model was chosen because it stimulates higher-order thinking processes through exploration, concept discovery, and reflection, which, in theory, can strengthen reasoning. However, the success of its implementation is likely influenced by students' self-confidence in facing learning situations that require initiative and active participation. Theoretically, this study contributes to developing an integrative learning model by combining a constructivist, discovery-based approach with student affective factors into a comprehensive conceptual framework. The findings are expected to enrich the literature on the interactive roles of instructional models and learner characteristics in achieving 21st-century mathematical competencies, particularly reasoning skills.

Practically, the results can serve as a reference for elementary educators in designing more effective and adaptive mathematics teaching strategies. By understanding the interplay between DL and self-efficacy, teachers can create learning experiences focusing on content and empowering students' confidence and engagement. Moreover, this study opens opportunities for further research using quantitative, qualitative, or mixed-method approaches across different education levels, incorporating other moderating or mediating variables such as gender, learning styles, or teacher support in fostering students' self-efficacy.

2. Method

This study used a quantitative approach with a quasi-experimental design of the pre-test-post-test control group design type. This design allows researchers to compare the measurement results before and after treatment in the experimental group and the control group, so that they can directly evaluate the effect of the intervention given (Fraenkel, Wallen, & Hyun, 2012, p. 274). The study was conducted in two public elementary schools in Bandung, West Java, from February to April 2025. The selection of the research location was based on accessibility criteria, school readiness in implementing innovative learning models, and the suitability of the curriculum with the Discovery Learning approach. The quantitative approach was chosen because it is able to provide objective, measurable results and can be used to test hypotheses systematically (Creswell, 2012, p. 13).

The research population was all second-grade elementary school students in the Bandung Kidul District in Bandung. The research sample consisted of 120 students divided into experimental and control groups. The sampling technique was carried out randomly, and the names of schools within the district were randomised to determine the research location. Furthermore, students from two selected schools were used as research subjects based on the predetermined classes. Data collection was carried out using two main instruments, namely: mathematical reasoning tests and self-efficacy questionnaires. Mathematical reasoning tests were developed based on indicators from the National Council of Teachers of Mathematics (NCTM, 2000), namely: (1) explaining mathematical concepts, (2) building representations, (3) providing logical justifications, and (4) solving contextual problems. Meanwhile, the self-efficacy questionnaire was compiled with reference to the social cognitive theory developed by Bandura (1997), which includes three main dimensions: magnitude (the level of difficulty of the task that is believed to be able to be completed), strength (the level of belief in one's own abilities), and generality (the scope of self-belief in various situations or tasks).

This study uses a quasi-experimental design with a pre-test-post-test control group design model to examine the effect of the Discovery Learning model on students' mathematical reasoning skills. The research procedure began with administering a pre-test to measure students' initial mathematical reasoning skills, accompanied by the distribution of a self-efficacy questionnaire. The intervention stage was carried out on the experimental group through eight meetings using the Discovery Learning model. Each learning session followed the Discovery Learning model's six core syntaxes: stimulation, problem statement, data collection, data processing, verification, and generalisation (Joolingen, 1999). After the treatment, students were given a post-test to measure the improvement in their mathematical reasoning skills. Quantitative data were analysed using a paired sample t-test to test the difference in scores between the pre-test and post-test in each group, and an independent sample t-test to compare the results between the experimental and control groups. In addition, an effect size analysis was carried out to determine the magnitude of the influence of the Discovery Learning model. One-way ANOVA analysis examined the relationship between self-efficacy levels and mathematical reasoning skills.

This study employs quantitative data to analyse the influence of the Discovery Learning model on students' mathematical reasoning skills and differences in influence based on self-efficacy levels. Quantitative data were obtained through two main instruments, namely a mathematical reasoning test and a self-efficacy questionnaire. The mathematical reasoning test was developed based on indicators from the National Council of Teachers of Mathematics (NCTM, 2000), including: (1) explaining concepts, (2) building representations, (3) providing logical justification, and (4) solving contextual problems. This test consists of eight open-ended essay questions given at the pre-test and post-test stages. Validity and reliability tests were also conducted on the mathematical reasoning skill assessment instrument. These tests were conducted on 50 sixth-grade students. The validity test results for the reading and writing literacy items are detailed in the table below.

Table 1. Results of the validity test of the mathematical reasoning skill

No	Items	Validity	Description
1	Question 1	0.85	Valid
2	Question 2	0.88	Valid
3	Question 3	0.92	Valid
4	Question 4	0.87	Valid
5	Question 5	0.90	Valid
6	Question 6	0.91	Valid
7	Question 7	0.89	Valid
8	Question 8	0.86	Valid
9	Question 9	0.93	Valid
10	Question 10	0.84	Valid

Based on the data above, 10 mathematical reasoning ability instrument items are declared valid. The reliability test used is the Cronbach's Alpha Reliability Coefficient technique, which yields an alpha of 0.696 for the mathematical reasoning skill, greater than 0.05. Therefore, the research instrument is considered reliable.

The self-efficacy questionnaire was compiled with reference to Bandura's (1997) social cognitive theory, which includes three main dimensions: magnitude (the level of difficulty of tasks that are believed to be able to be completed), strength (the level of confidence in one's own abilities), and generality (the scope of self-confidence in various tasks or contexts). This

[e-ISSN 2598-5949 | p-ISSN 2303-1514]

instrument consists of 15 statements with a five-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree).

Data collection was conducted in three stages:

a. Pre-intervention: implementation of pretest and self-efficacy questionnaire
b. Intervention: Implement 8 Discovery Learning-based learning sessions in the experimental class
c. Post-intervention: implementation of a post-test to measure the improvement of students' mathematical reasoning skills

All instruments have been validated by mathematics education and educational psychology experts to ensure content validity, and reliability tests have been conducted to ensure internal consistency, especially for the self-efficacy questionnaire instrument.

The data obtained were analysed and interpreted based on the objectives and formulation of the research problem. Quantitative data in the form of pre-test and post-test scores of students' mathematical reasoning skills were analysed to assess the effectiveness of the Discovery Learning model in improving these skills. The paired sample t-test was used to determine significant differences between pre-test and post-test scores in each group. In contrast, the independent sample t-test was used to compare the results between the experimental and control groups. Effect size analysis was conducted to determine the extent of the influence of the Discovery Learning model on improving students' mathematical reasoning skills. A one-way ANOVA test was used based on self-efficacy categories (high, medium, and low) to answer the second research question regarding the effect of self-efficacy levels on mathematical reasoning skills. This test aims to determine whether there is a significant difference in mathematical reasoning scores based on students' academic self-confidence levels. All analysis results were then compared with the initial hypothesis and interpreted in line with the main research objective: evaluating the influence of Discovery Learning-based learning and self-efficacy as an affective factor in achieving mathematics learning outcomes.

In Discovery Learning for geometric shapes, the teacher is a facilitator, encouraging students to discover concepts through stimulation, problem formulation, data collection, data processing, verification, and generalisation. For example, when discussing cubes and cuboids, students are stimulated by presenting real objects such as milk cartons or cardboard boxes, then asked to formulate their differences and similarities. Students make observations, note the number of sides, edges, and vertices, then process the information to find patterns. In the verification stage, students discuss their observations and compare them with those of other groups, ultimately concluding their own conclusions about the properties of geometric shapes. In contrast, in conventional learning, teachers tend to directly convey definitions, formulas, and properties of geometric shapes through lectures or explanations on the board. Students take notes, memorise, and work on exercises based on examples provided by the teacher. The fundamental difference lies in the process: Discovery Learning emphasises active exploration and concept discovery, while conventional learning focuses more on the one-way transfer of information from teacher to student.

3. Results

This section presents the research results, which consist of a general description of the data, descriptive statistical analysis, and inferential analysis to answer the formulation of the research problem. The main purpose of this analysis is to determine the differences in mathematical reasoning skills between the experimental group and the control group after treatment, and to analyse the effect of self-efficacy on students' mathematical reasoning achievements. The inferential analysis is the Independent Sample T-Test, which is applied to determine significant differences between two unrelated groups: the experimental and control groups. In addition, a one-way ANOVA test is also used to determine whether there are differences in mathematical reasoning scores based on students' self-efficacy levels (high, medium, and low).

Before presenting the analysis results, the average values and standard deviations for the post-test scores in the experimental and control classes in Table 1 are as follows.

Table 2. Description of students' mathematical reasoning skill acquisition

Group	Post-test		N
	Mean	SD	
Experimental	77.35	7.59	60
Control	69.57	9.612	60

Table 2 shows the descriptive statistics results in the average (mean) and standard deviation (SD) post-test scores of students' mathematical reasoning skills in the experimental and control groups. Each group consists of 60 students. The experimental group that received learning using the Discovery Learning model reveals an average post-test score of 77.35 with a standard deviation of 7.59, which indicates a relatively even distribution of student data around the middle value. Meanwhile, the control group that received conventional learning has an average post-test score of 69.57 with a standard deviation of 9.61. This shows that students' performance in the control group is lower and tends to be more varied than that of the experimental group.

The quite striking difference in the average between the two groups indicates the possibility of a significant effect of using the Discovery Learning model on improving students' mathematical reasoning skills. The analysis was continued with the Independent Sample T-Test to determine whether the difference is statistically significant. The results of the independent sample t-test of a description of the students' mathematical reasoning skill acquisition are shown in Table 2 as follows.

Table 3. Result of independent samples t-test

Group	t	df	*Sig. (2-tailed)*
Pre-Postest	-4.330	91	<.001

Based on the independent samples t-test table above, the significance value is <0.001 or less than α = 0.05. If the significance value is less than α, H0 is rejected and H1 is accepted. Thus, the hypothesis stating that there is a significant difference in influence between the discovery learning model and conventional learning on the achievement of students' mathematical reasoning skill scores is accepted. After it is known that there is a significant difference between the experimental and control groups regarding mathematical reasoning skill, the next analysis aims to answer the second research question: whether there is a difference in mathematical reasoning skill based on students' self-efficacy levels.

To test this, one-way analysis of variance (One-Way ANOVA) was used because the data involved more than two groups (high, medium, and low self-efficacy). This analysis aims to determine whether the average mathematical reasoning ability differs significantly between the three self-efficacy categories. The results of grouping students into these categories were obtained from the self-efficacy questionnaire scores that had been classified based on the Likert scale criteria. The following are the results of descriptive analysis and ANOVA tests on mathematical reasoning ability based on students' self-efficacy levels. The results of the ANOVA test can be seen in Table 3 as follows.

Table 4. Description of student self-efficacy acquisition

Groups	Post-test		N
	Mean	SD	
High Self-Efficacy	88.45	7.16	40
Moderate Self-Efficacy	73.36	8.43	40
Low Self-Efficacy	62.47	8.30	40

The table above shows the post-test results based on student self-efficacy groups. The High Self-Efficacy group records the highest post-test mean of 88.45 with a standard deviation of 7.16, indicating that students in this group have consistent and high results in understanding the material. The Moderate Self-Efficacy group has a post-test mean of 73.36 with a standard deviation of 8.43, indicating good results despite greater variation in their abilities. Meanwhile, the Low Self-Efficacy group records a post-test mean of 62.47 with a standard deviation of 8.30, indicating lower and more variable results. This difference in means reflects the influence of self-efficacy levels on students' academic performance, with high self-efficacy tending to show better results on math tests.

Table 5. Result of ANOVA

Group	f	df	*Sig. (2-tailed)*
Pre-Postest	45.184	2	<.001

Table 5 shows the results of one-way analysis of variance (One-Way ANOVA) to test whether there is a significant difference in mathematical reasoning ability based on students' self-efficacy levels. The level of self-efficacy is categorised into three groups: high, medium, and low. The results of the analysis show that the calculated F value = 45.184 with a significance value of $p < 0.001$. Since the significance value is much smaller than 0.05, it can be concluded that a statistically significant difference exists between students' average mathematical reasoning skills based on the self-efficacy level.

The Sum of Squares Between Groups value of 4183.283 and the Mean Square of 2091.642 indicate that the variability between self-efficacy groups contributes substantially to the difference in mathematical reasoning scores compared to the variability within groups (Within Groups = 4166.287). The total sum of squares (Total SS) is 8349.570, representing all respondents' total variation in mathematical reasoning scores. Based on the analysis of the average gain score for mathematical reasoning skills, students with high self-efficacy showed the highest achievement compared to the other two groups. This indicates that the higher the student believes in their skills, the better they are at reasoning, building logical arguments, and solving mathematical problems. Meanwhile, students with moderate self-efficacy have better mathematical reasoning skills than those with low self-efficacy, although not as optimal as the high group.

4. Discussion

This section discusses the previous research findings by connecting them to the theoretical framework, previous research results, and the context of elementary mathematics education. The discussion focuses on two main aspects: the effectiveness of the Discovery Learning model on improving students' mathematical reasoning skills and the role of self-efficacy in influencing

[e-ISSN 2598-5949 | p-ISSN 2303-1514]

mathematical reasoning achievement. Analysing statistically and practically significant results is the basis for explaining the theoretical and practical essence of the learning model used. In addition, this discussion also raises the possibility of factors that support successful learning and provides a critical interpretation of the influence of self-efficacy on students' mathematical thinking processes. Thus, this section aims to interpret the results comprehensively and relevantly to the objectives and formulate research problems.

Based on the independent samples t-test with a significant value of <0.001, using the Discovery Learning model in mathematics learning has significantly improved elementary school students' mathematical reasoning skills. This model encourages students to build knowledge through exploration, observation, and actively and independently testing ideas. In the context of mathematical reasoning, Discovery Learning allows students to think logically, construct arguments, and generalise concepts from concrete situations to abstract forms. Bruner (1961) emphasised that discovery-based learning can strengthen students' cognitive structures and increase active involvement in the learning process. This is reinforced by Zulkardi & Putri (2020), who show that students guided to discover concepts through direct experience tend to have deeper conceptual understanding and reasoning. In addition, Suparman (2022) stated that this model aligns with the principle of meaningful learning, where students associate new knowledge with the cognitive structures they already have. The effectiveness of Discovery Learning can also be seen from its ability to accommodate higher-order thinking processes, which are the foundation of 21st-century mathematics learning. Mathematical reasoning developed through this model includes explaining concepts, compiling proofs, and solving problems with flexible strategies. This is in line with the opinion of NCTM (2020), which emphasises that mathematics learning should facilitate students to think, not just calculate. Sari et al. (2021) also showed that Discovery Learning effectively improves students' critical thinking and reasoning skills because students are invited to be involved in contextual and challenging problem situations. In addition, research by Fadhilah & Sutarto (2022) found that active involvement of students in each stage of Discovery Learning has a positive impact on strengthening logical connections and reflection on the problem-solving strategies used.

Pedagogically, the Discovery Learning model is able to create a learning atmosphere that encourages students to become independent and reflective learning subjects, not just recipients of information. This is crucial because mathematical reasoning is not developed simply by following instructions, but through discovery and meaning for students. According to Widodo & Jatmiko (2021), the discovery approach allows students to form new schemata through active activities that require reasoning and testing ideas. This is in line with the view of Karatas & Baki (2013), who stated that learning that provides space for reflection and exploration has been proven to increase deep understanding and long-term resilience of concepts. Similar support was also expressed by Purnomo et al. (2021), who emphasised that in a Discovery Learning environment, students are better able to explain, justify, and defend their mathematical solutions logically.

This model encourages active engagement in learning and facilitates deeper conceptual understanding. Consistent with the current findings, Rahmadhani (2020) found that students taught through Discovery Learning demonstrated superior retention and reasoning skills, largely due to their active involvement throughout the learning process. Furthermore, Sofiyati (2022) showed that Discovery Learning was particularly effective in enhancing students' critical thinking, especially in concept-based mathematics instruction.

International studies also support these results. For instance, Capone (2022) emphasized that Discovery Learning promotes not only autonomous thinking but also the development of higher-order reasoning by allowing students to test hypotheses and reflect on their findings Similarly, a study by Alfieri et al. (2011) found that students engaged in guided discovery learning significantly outperformed peers in direct instruction settings on tasks requiring transfer and reasoning, concluding that "well-structured discovery tasks foster meaningful learning and robust problem-solving skills" (Taken together, these findings highlight the strong theoretical and empirical basis for using Discovery Learning in mathematics education, particularly when the goal is to cultivate students' reasoning abilities through inquiry, exploration, and conceptual construction) (Firmansyah, Maulida, & Marlina, 2023).

The first category, "restating the concept," refers to students' ability to articulate a mathematical idea using their own words, which reflects conceptual understanding (Hiebert & Carpenter, 1992). The second category, "classifying," involves grouping objects based on shared relevant characteristics, supporting deeper conceptual reasoning (Van de Walle, Karp, & Bay-Williams, 2018). The third category, "identifying," emphasises recognising relationships and distinctions among mathematical objects, which contributes to developing relational thinking in mathematics learning (Skemp, 1976).

The fourth category, "example," refers to the understanding that, to grasp a concept fully, students must be able to assess whether a given example fits the formal definition (Tall & Vinner, 1981). The fifth category, "non-example," involves using counterexamples to clarify a concept's boundaries and help students avoid misconceptions (Smith III & Confrey, 1994). The sixth category, "transforming," highlights how using multiple representations in mathematics helps students form stronger conceptual connections (Goldin, 2002). Lastly, the seventh category, "interpreting," refers to making sense of information presented in various representations, which is essential for mathematical literacy (Lesh, Post, & Behr, 1987).

One-way ANOVA analysis showed that self-efficacy significantly affected students' mathematical reasoning ability, supporting the finding that self-efficacy improves mathematics performance and specifically encourages the quality of students' reasoning. A study by Reeve et al. (2022) concluded that interventions targeting increased self-efficacy directly contributed to improving students' deep-thinking strategies and reflective abilities, including in complex reasoning activities. In addition, a study by Virgolino et al. (2024) found that self-efficacy was positively correlated with mathematical modelling skills very close to reasoning because they require situation analysis, hypothesis construction, and critical evaluation of solutions. Thus, these findings indicate that affective aspects such as students' self-confidence have an important influence on shaping the capacity of high-level thinking intelligence, especially mathematical reasoning.

Furthermore, the finding that high self-efficacy levels resulted in the highest mathematical reasoning scores, followed by the medium group, and the lowest in the low self-efficacy group, is consistent with meta-analysis studies showing that self-efficacy strongly predicts creativity and problem-solving ability, especially in mathematics. Research by Pantziara & Philippou (2023) also supports this, where they reported that students with high self-efficacy could better maintain problem-solving strategies even under high academic pressure. Therefore, strengthening self-efficacy improves academic performance and expands students' abilities in designing logical arguments, analysing data, and constructing testable conclusions—abilities that are the essence of mathematical reasoning.

These findings emphasise that self-efficacy is not just a supporting factor, but a crucial element in forming a deep mathematical thinking process. As stated by Usher & Pajares (2023), students with a positive perception of their abilities tend to show higher effort, persistence in completing complex tasks, and the courage to face challenges in learning mathematics. In

[e-**ISSN** **2598-5949** | p-**ISSN** **2303-1514**]

addition, Lee and Stankov (2022) emphasised that high levels of self-efficacy are directly proportional to reflective ability in logical and deductive reasoning. Another study by Wang et al. (2024) also supports these findings, showing that students who are confident in their abilities are more open to problem-solving and conceptual exploration-based learning experiences that require deep reasoning.

In elementary education, these results provide important implications for teachers and curriculum developers, especially in designing learning approaches that emphasise students' numeracy's cognitive and affective aspects (Maritim et al., 2025). Research by Talsma et al. (2023) implies that emotional support and positive reinforcement during the learning process significantly increase self-efficacy and ultimately affect academic achievement. Furthermore, according to Orosz et al. (2022), a discovery-based learning approach that allows students to experience small successes gradually can build sustainable self-confidence in solving reasoning pattern problems. Thus, the arrangement of structured yet flexible learning activities is needed to simultaneously facilitate the development of self-efficacy and reasoning skills.

Finally, it is crucial to understand that the reciprocal relationship between self-efficacy and mathematical reasoning can develop through consistent learning experiences. A longitudinal study by Raufelder et al. (2023) showed that a significant increase followed an increase in students' analytical thinking skills over time in their academic self-efficacy. This is in line with the findings by Bandura (2023), who emphasised that success in complex tasks can strengthen students' self-confidence and internal motivation in learning. Therefore, using challenging learning models, but supported by adaptive guidance, is an important strategy in optimising students' mathematical reasoning potential at various levels of self-efficacy.

This study has several limitations that need to be considered. First, the method used was quasi-experimental, so the conclusions drawn regarding the effect of Discovery Learning and self-efficacy on mathematical reasoning skill cannot be fully generalised because it did not use a pure experimental design with random assignment. Second, the study sample was limited, involving only several students from one or a few specific schools, so the results may not fully represent the wider population. Therefore, caution is needed in interpreting the findings, and further research with a larger sample and a more rigorous experimental design is recommended to validate these results.

5. Conclusion and Implications

This study reveals that the Discovery Learning model significantly improves elementary school students' mathematical reasoning skills, particularly in explaining concepts, constructing representations, providing logical reasoning, and solving contextual problems. Furthermore, students' self-efficacy plays a significant role, with high self-efficacy demonstrating better reasoning outcomes. These findings confirm that mathematical reasoning skills are influenced by a combination of learning approaches that emphasise exploration and student readiness and confidence. Therefore, teachers must integrate strategies that encourage exploration while building confidence in mathematical thinking.

The findings have several essential implications for the context of mathematics learning in elementary schools. First, the research results reinforce the urgency of using constructivist and student-centred learning models, such as Discovery Learning, as a primary strategy for developing mathematical reasoning skills. Teachers need to design learning that not only presents information directly, but also provides space for students to explore, formulate predictions, and discover mathematical concepts for themselves through real-life, contextual experiences. Second, this research confirms that affective factors such as self-efficacy should not be overlooked in mathematics learning. Teachers are expected to focus on students' cognitive outcomes and play an active role in building students' confidence in their skills through positive feedback, gradual and challenging tasks, and emotional support throughout the learning process. A safe and supportive learning environment enables students to develop confidence in critical thinking and independent problem-solving. Third, implications for education policy can be directed toward developing teacher training programs that emphasise the importance of integrating cognitive and affective aspects in learning. Training should focus on using innovative learning models and strategies to foster students' motivation and self-efficacy from an early age. Furthermore, learning evaluations need to consider students' thinking processes, not just final answers, so that teachers can provide appropriate interventions to support the ongoing development of reasoning. This study encourages a paradigm shift from procedural and outcome-oriented mathematics learning to more meaningful, reflective learning that empowers students cognitively and affectively. If implemented consistently, this approach can potentially improve the quality of elementary school students' mathematical literacy in the long term.

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