The Effect of The Guided Discovery Learning Model on Students Mathematical Reasoning Skills

Stanley Gilbert Pangaribuan[1], Nurhanurawati[2*)], Agung Putra Wijaya[3]
[1,2,3] Pendidikan Matematika, FKIP, Universitas Lampung
*) nurhanurawati94@gmail.com

Abstract

This research was motivated by the gap between the importance of mathematical reasoning skills and the reality that such skills remained relatively low among students in Indonesia. The research aimed to determine the effect of the guided discovery learning model on students' mathematical reasoning skills. This research was conducted at SMP Negeri 13 Bandar Lampung during the even semester of the 2025/2026 academic year. The eighth-grade students were distributed across 10 classes, two of which were honors classes, namely VIII-3 and VIII-4; therefore, these two classes were excluded from the research population. Consequently, the research population consisted of students in classes VIII-1, VIII-2, and VIII-5 through VIII-10, totaling 8 classes. The research sample was selected using cluster random sampling, with class VIII-2 as the control class and class VIII-7 as the experimental class. The design used was a pretest-posttest control group design. The data in this research consisted of quantitative data obtained through a mathematical reasoning skills test. Based on the results of data analysis using the Mann-Whitney-U test, it was found that the increasing in mathematical reasoning skills of students who participated in guided discovery learning was higher than students who participated in conventional learning. Thus, it can be concluded that the guided discovery learning model has an effect on students' mathematical reasoning skills.

Keywords: effect, guided discovery learning, mathematical reasoning skills.

Introduction

Education is a vital element in life that can determine the quality of human resources. This is in line with the view of Tohani and Aulia (2022), who state that 21st-century education can shape individuals who are outstanding, creative, critical thinkers, and of good character, thereby enabling them to face various challenges in the global era. In the context of Indonesia's national policy, mathematics is a mandatory component of the elementary and secondary education curriculum. This is because mathematics plays a fundamental role in developing students' logical, analytical, systematic, and critical thinking skills (Oktaviani et al., 2024). Furthermore, mathematics also functions as a universal symbolic language, thereby supporting the development of various scientific disciplines and their application in daily life (Nurhaswinda et al., 2025).

The National Council of Teachers of Mathematics (NCTM) states that reasoning and proof skills are among the primary goals of mathematics education. Furthermore, Fauzan et al. (2024) state that one of the key competencies expected to develop through mathematics education is reasoning ability. Therefore, mathematical reasoning skills are crucial in mathematics education.

Agustin (2016) states that mathematical reasoning is the skill of solving problems using logical and systematic thinking. Meanwhile, Salmina & Nisa (2018) define mathematical reasoning skill as the ability to relate problems to mathematical ideas or concepts so that the problems can be solved accurately. This is supported by the view of Khairani et al. (2023), who state that mathematical reasoning skill is the ability to draw correct conclusions based on statements or facts whose truth has been proven. Mathematical reasoning ability is the capacity to think logically, systematically, and critically in order to connect mathematical concepts, construct proofs, and draw correct and justifiable conclusions in order to solve mathematical problems as well as real-world problems modeled in mathematical form. The indicators of mathematical reasoning skills used in this study include conjecture, manipulation, proof, and conclusion.

Although mathematical reasoning skills are crucial, the reality is that these skills remain relatively low among students in Indonesia. The results of the 2022 Programme for International Student Assessment (PISA) show that Indonesia scored 362 in “formulating,” 365 in “employing,” 363 in “interpreting,” and 354 in “reasoning.” This indicates that Indonesia’s math scores remain below the OECD average, particularly in the “reasoning” category, which received the lowest score compared to the other categories. This situation indicates that Indonesian students’ mathematical reasoning skills still need to be improved.

Low mathematical reasoning skills among students were also identified in the results of a preliminary study at SMP Negeri 13 Bandar Lampung. Based on the results of the initial test, the majority of students had difficulty formulating logical hypotheses, performing mathematical manipulations, constructing proofs, and drawing accurate conclusions. Furthermore, interviews with mathematics teachers revealed that classroom instruction is still teacher-centered, resulting in students being less active in seeking information and analyzing the problems presented. Consequently, students struggle when faced with non-routine problems that require mathematical reasoning skills .It is best to avoid organizing writing into “sub-headings” in this section. However, if it cannot be avoided, the method of writing can be seen in the "Results and Discussion" section.

Given the importance of mathematical reasoning skills, effective instructional innovations are needed to enhance these skills. Furthermore, Nurhanurawati et al. (2026) state that teachers must implement learning models that guide students to actively engage in discovering and understanding the concepts they are learning. Farida et al. (2018) state that mathematical reasoning skills can be improved through student-centered learning that provides opportunities for students to demonstrate their ideas. Furthermore, Nurhanurawati, Suryadinata, & Mutmainah (2026) state that to improve students' mathematical reasoning skills, a learning model focused on knowledge construction—rather than mere knowledge transfer—is necessary. A learning model consistent with this principle is the Guided Discovery Learning (GDL) model.

Rusmana (2024) explains that GDL is a learning model that provides students with the opportunity to discover or investigate a concept under the guidance of a teacher, thereby enabling them to more easily solve the problems they face. Furthermore, Asyuri et al. (2017) state that the main characteristic of GDL is that students are guided to discover concepts in accordance with the learning steps that have been designed so that the discovery process proceeds systematically and in a controlled manner. Harianti (2018) adds that GDL provides a learning experience in which students are truly required to actively use the ideas, concepts, and skills they already possess to discover new knowledge. Thus, the GDL model is a learning approach rooted in constructivism, which positions students as active agents who discover concepts, understanding, and problem-solving strategies on their own through an exploratory process, with the teacher serving as a guide to the learning process.

The steps in the GDL consist of six stages: stimulation, problem identification, data collection, data processing, verification, and generalization. Through these stages, students not only receive information from the teacher but also actively engage in the process of discovering concepts, thereby developing their reasoning skills. Based on this description, the GDL is capable of creating a learning process that is more active, meaningful, and oriented toward developing students' reasoning skills. Therefore, this study was conducted to determine the effect of the GDL model on the mathematical reasoning skills of eighth-grade students at SMP Negeri 13 Bandar Lampung during the second semester of the 2025/2026 academic year.

Method

This research was conducted at SMP Negeri 13 Bandar Lampung during the second semester of the 2025/2026 academic year. The research population consisted of all students from eight classes: VIII-1, VIII-2, and VIII-5 through VIII-10. The research sample was selected using a cluster random sampling technique, in which two classes were randomly selected from the population using a spinner. As a result of this selection, Class VIII-7 was designated as the experimental class and Class VIII-2 as the control class.

This research used a pretest-posttest control group design, which involves two groups: an experimental class and a control class. The experimental class received instruction using the GDL model, while the control class received conventional learning. Each class participated in five instructional sessions.

The research data consisted of quantitative data in the form of students' initial mathematical reasoning skills obtained from pretest scores and their final mathematical reasoning skills obtained from posttest scores. These data were collected through testing. Tests were used to collect data on mathematical reasoning skills via pretests and posttests administered to both the experimental and control classes.

The instrument to be used in this research is an essay-type test. Before being used in the research, a pilot study was conducted to assess the instrument's suitability, including tests of validity, reliability, discriminative power, and difficulty level. The validity test used was content validity to measure the alignment of the test content with the indicators being measured, as well as to assess the appropriateness of the language and the difficulty level of the questions. The reliability test was conducted to measure the extent to which the questions can produce consistent results when administered at different times. The discriminant validity test was conducted to measure the extent to which the questions can distinguish between students with high skills and those with low skills. The difficulty level test was conducted to determine the test's difficulty level. Based on the results of the pilot test data analysis, it was found that all test items were valid and suitable for use in the research. The results of the pilot test analysis are presented in Table 1.

Table 1. Summary of Test Instrument Pilot Test Results

No		Validity	Reliability	Discriminating Power	Difficulty Level	Conclusion
1	a	Valid	0,82 (Reliable)	0,27 (Enough)	0,38 (Currently)	Suitable for use
	b			0,23 (Enough)	0,33 (Currently)	
	c			0,23 (Enough)	0,36 (Currently)	
2	a			0,25 (Enough)	0,29 (Hard)	
	b			0,24 (Enough)	0,22 (Hard)	
	c			0,21 (Enough)	0,21 (Hard)	

Based on the mathematical reasoning test, pretest and posttest scores were obtained. These data were then processed to yield normalized gain scores. According to HAKE (as cited in Wahab et al., 2021), the magnitude of the gain is calculated using the following formula for normalized gain:

$$N - GAIN = \frac{posttest\ score - pretest\ score}{ideal\ score - pretest\ score}$$

The data were then analyzed using statistical tests. Before conducting the statistical tests, it was necessary to perform prerequisite tests, including tests of normality and homogeneity. These tests were conducted to determine whether the sample data were drawn from a normally distributed population and whether they had equal variances. The results of the normality test for the N-Gain data are presented in Table 2.

Table 2. Result of the Normality Test

Class	χ^2_{count}	χ^2_{table}	Test Decision	Conclusion
Experiment	9,8	7,81	H_0 accepted	Normally Distributed
Control	41,715	7,81	H_0 accepted	Normally Distributed

Based on Table 2, it is evident that the N-Gain data on students' mathematical reasoning abilities in the experimental and control classes are not normally distributed. Therefore, the hypothesis test was conducted using a nonparametric statistical test, namely the Mann-Whitney U test.

Results and Discussion

Based on the results of the data analysis, it was found that the average initial mathematical reasoning skills of students in the experimental class were higher than those of students in the control class. Similarly, the average final mathematical reasoning skills of students in the experimental class were higher than those of the control class. The average N-Gain for mathematical reasoning skills in the experimental class was also higher than that of the control class. This indicates, descriptively, that the class that participated in the GDL program experienced a greater increase in mathematical reasoning skills.

Data on the increase in achievement for each indicator of mathematical reasoning skills show that the experimental class achieved higher scores than the control class. These data are presented in Table 3.

Table 3. Percentage of Achievement of Mathematical Reasoning Skills Indicators

No	Indicator	Experiment		Control	
		Pretest	***Posttest***	***Pretest***	***Posttest***
1	Conjecture	28,37%	40,87%	32,69%	37,98%
2	Manipulation	14,42%	78,37%	12,02%	39,90%
3	Proof	8,65%	13,46%	6,73%	7,69%
4	Conclution	21,25%	40,87%	12,5%	26,83%
Average		18,17%	43,39%	15,99%	28,10%

Based on Table 3, it can be seen that the experimental class and the control class differ in their achievement of the mathematical reasoning skills indicators. Students in the experimental class had a higher average percentage of achievement on the final mathematical reasoning skills assessment by 15.29% compared to students in the control class. This indicates that students in the experimental and control classes had different average initial and final levels of mathematical reasoning skills. The data also show that the increase in achievement across all indicators of students' mathematical reasoning skills was greater in the class that participated in GDL.

Hypothesis testing was conducted using the Mann-Whitney U test. The results of the hypothesis test data analysis showed that at a significance level of 0.05, the calculated $Z_{value} = -4{,}06\ and\ -Z_{table} = -1{,}64$ so H_0 was rejected. This indicates that the median N-Gain for mathematical reasoning skills of students who followed the GDL model was higher than the median N-Gain for mathematical reasoning skills of students who followed conventional learning. Based on these results, the increase in mathematical reasoning skills of students who followed the GDL model was higher than that of students who followed conventional learning. Thus, the guided discovery learning model has an effect on students' mathematical reasoning skills.

Based on the results of the data analysis, it was found that the guided discovery learning (GDL) model has an effect on students' mathematical reasoning skills. The increase in mathematical reasoning skills of students who participated in GDL was also greater than that of students who participated in conventional learning. This indicates that the GDL model is effective in helping students develop their mathematical reasoning skills.

The guided discovery learning, which took place over five sessions, was carried out in six stages. This learning process was conducted with the aid of worksheets that students completed in groups of 5–6 students. In the first stage, students were given a stimulus in the form of a picture of a right triangle and were then asked to identify the elements of a right triangle and the relationships between the sides of the right triangle through group discussion. This was intended to engage students and help them recall previous lessons as a foundation before receiving new instruction. Next, students were given a problem presented in the worksheet to examine. Based on this observation and discussion process, students are encouraged to develop curiosity about the given problem, reactivate their prior knowledge, and relate it to the new situation they are facing. This is in line with the view of Mufida & Agus (2020), who state that during the stimulus stage, students are presented with a contextual problem to arouse their curiosity and motivate them to solve the problem.

In the second stage, students identify the problem that has been presented. After reading the problem, the teacher instructs students to refer to the worksheet and then answer the questions by discussing them with their group members. During each group's discussion, students are constantly monitored and occasionally given guidance so they can more accurately identify relevant information. Guidance is provided both directly and through guiding questions on the worksheet. The teacher also guides students by directly illustrating the problem, such as by demonstrating the positions of the floor, wall, and board in front of the class, with the teacher acting as the board resting on the floor and leaning against the wall. After successfully identifying the problem, during several sessions students also proposed initial hypotheses for solutions to the presented problem by answering questions on the worksheets. These questions guided students to express their opinions regarding solutions to the given problem, such as explaining the relationships between the sides of a right triangle, determining the longest side, and estimating whether the length of the rope or fence does not exceed a certain measurement. This is in line with the view of Kurniasih & Sani (in Median et al., 2021), who state that during the problem-identification stage, students identify information in the given problem and then select or construct a hypothesis as a tentative answer to the problem.

Based on this description, the stimulus stage and the problem-identification stage develop students' skills to formulate conjectures. Students in classes participating in GDL are already able to formulate conjectures and provide logical reasoning for the problems presented. This occurs because, during the stimulus stage, students are encouraged to actively engage in learning, activate their prior knowledge, and begin thinking to formulate hypotheses regarding the given problems. Thus, at this stage, students begin to develop mathematical reasoning skills, specifically as indicated by the hypothesis-formulation indicator. During the problem-identification stage, students actively discuss and share their respective opinions with one another. Consequently, students actively discuss, express their opinions, and formulate tentative hypotheses regarding the solution to the given problem. This aligns with Median's (2021) view, which states that during the stimulus and problem-identification stages, students are able to formulate hypotheses as tentative answers, thereby generating initial conjectures regarding the solution to the problem.

In the third stage, students in groups collect the data needed to solve the problem. Students begin working by following the steps outlined in the worksheet, such as redrawing the illustration of the given problem, filling out tables, creating models of the given problem, and taking measurements or performing calculations according to the provided instructions. At this stage, students in groups actively discuss the problem during each session. Next, the teacher circulates and approaches each group to monitor the students' work process within the group. After confirming their work process, the teacher helps students arrive at the correct answer, either through direct guidance or through guiding questions in the worksheet. Specifically, during the third session, the teacher prepares several pieces of paper shaped like four identical right-angled triangles and one small square; when put together, they form one large square. The teacher then approached each group one by one and demonstrated that when the four pieces are put together, they form one large square. This activity helped students learn how to determine the area of a square using two different methods. This aligns with Handayani's (2024) view, which states that at this stage, students gather and discover information to build their own understanding so they can provide solutions to problems.

The next stage involves students analyzing the data they have collected. Students then use the data obtained in the previous stage to answer follow-up questions in the worksheet. To answer these questions, students in groups are guided to perform mathematical operations on the data they collected earlier. At this stage, students are seen actively discussing in their groups during each session. In the first session, students identified the triangles they had drawn earlier. In the second session, students compared several numbers they had obtained earlier and then drew conclusions about the relationships between those numbers. Next, in the third session, students compared the areas of the two squares they had calculated and then simplified the equations to derive the Pythagorean theorem. In the fourth and fifth sessions, students applied the Pythagorean theorem to find the length of the object they were investigating. Students were observed during each discussion and given guidance if any group had difficulty connecting the data they had obtained to problem-solving. At this stage, students gained new knowledge about alternative solutions that require logical proof (Hastuti, 2022).

The next step is verification. After successfully processing the data, students double-check whether the results they obtained match the problem at hand. At this stage, students review the solution steps they have written in the worksheet and compare them with the information provided in the problem. In the first session, students check whether the results they obtained match the definitions provided in the worksheet. In the second session, students check whether the Pythagorean theorem they derived applies to the given problem. Next, during the third session, students check whether the Pythagorean theorem applies to the sides of a specific right triangle. During the fourth and fifth sessions, students verify whether the hypotheses they proposed at the beginning of the activity align with the results they obtained. After students write their answers in the worksheet, the activity continues by selecting one group to present the results of their discussion in front of the class. This aligns with the view of Romadhona & Purnomo (2025), who state that during the verification stage, students engage in reflection and verification through calculations to validate their results, thereby encouraging them to substantiate their answers by manipulating the data and reviewing the solution steps they have taken.

The final stage is generalization. After presenting their answers, students validate the correctness of their solutions to the problems discussed by reviewing the steps they took to solve the problems in the worksheet together with the entire class. Students are reminded of the key parts of the problem-solving process they have gone through, so they can see the connection between the steps they took and the concepts being studied. Through a series of activities in the worksheet—ranging from observing the problem, identifying known and unknown information, collecting and processing data, to verifying the results—students are then guided to draw conclusions from the problems they have solved. Students discussed their findings again in groups and wrote down their conclusions in the final section of the worksheet. According to Yansaputra & Anjarini (2023), this stage aims to formulate general conclusions by providing students with the opportunity to express their opinions openly. This is in line with the view of Putrayasa et al. (2014), who state that during the generalization stage, students formulate conclusions based on the results obtained from the learning process, thereby developing their ability to draw conclusions.

The stages of data collection, data processing, and verification enhance students' skills in the manipulation indicator. Students in classes participating in GDL are already able to accurately perform mathematical manipulations on the given problems. This occurs because, during the data collection activity, students strive to gather various necessary pieces of information from their observations, drawings, and calculations as a basis for solving the given problems. Meanwhile, during the data processing stage, students gradually process the data they have gathered to arrive at a solution to the given problem. Subsequently, during the verification stage, students can compare their results with those of other groups while ensuring that the hypotheses formed in the previous stage align with the solutions obtained. Consequently, during the data collection, data processing, and verification stages, students develop mathematical reasoning skills, specifically the manipulation indicator. This aligns with Utami's (2020) view, which states that during the data collection, data processing, and verification stages, students formulate problem-solving steps, thereby encouraging them to manipulate the data they have obtained.

The verification stage also enhances students' skills in the "proof" indicator. As previously explained, during the verification stage, students compare their results with those of other groups while ensuring that the conjectures formed in the previous stage align with the solutions they have obtained. Students conduct a thorough examination to verify the accuracy of their conjectures or calculations. As a result, students actively develop their mathematical reasoning skills, specifically the proof indicator. However, research findings indicate that the improvement in the proof indicator among students participating in GDL remains low. This suggests that some students still struggle to construct proofs correctly. These errors generally occur because students focus too much on the calculations to find a solution, rather than on developing proof strategies. As evidenced by the students' answer sheets, some students still make mistakes in applying proof strategies. This aligns with Lithner's (2017) observation that many students struggle with constructing proofs.

Furthermore, the verification and generalization stages enhance students' abilities regarding the "conclusion" indicator. Students participating in GDL are already able to draw conclusions from their calculations and thus provide solutions to problems. This occurs because, during the verification stage, students review the results of their calculations and the hypotheses they have formed, then compare them with the given facts or problems. Through these activities, students are trained to determine the validity of the results obtained and to draw conclusions based on the problem-solving process they have carried out. Subsequently, during the generalization stage, students write down conclusions that are the result of the discovery process they conducted independently throughout the learning activity. This is done so that the learning process yields a shared conclusion regarding the correct solution. As a result, students develop mathematical reasoning skills, specifically the "conclusion" indicator. In line with these findings, Putri et al. (2019) state that students' ability to synthesize all calculations to arrive at a statement that serves as the solution to a problem is included in the "conclusion" indicator.

The GDL implementation process went very well. The students appeared very enthusiastic and actively participated in every stage of the learning process. However, there were a few challenges during the implementation. During the first session, students were given one worksheet per group. This caused the group discussions to not proceed as smoothly as they should have. To address this, in the following session, each group was given two worksheets. The teacher also went around to each group to monitor and provide guidance to the students. Another challenge was the time students took to complete the worksheets. During the first session, some groups took too long to finish them. This caused the teacher's guidance to be somewhat hindered. To address this, in subsequent sessions, the teacher set time limits for completing the worksheets at each stage. The teacher also approached each group to monitor the progress of the group discussions and provide guidance to the students in each group. Thus, although there were some challenges at the beginning of the implementation, the research process proceeded smoothly after improvements were made and more effective learning management was implemented in each session.

Conclusion and Suggestion

Based on the research findings and discussion, the GDL model has an effect on the mathematical reasoning skills of eighth-grade students at SMP Negeri 13 Bandar Lampung during the second semester of the 2025/2026 academic year. This conclusion is based on research findings showing that the improvement in mathematical reasoning skills of students who participated in the GDL model was greater than that among students who participated in the conventional learning model.

Based on the research findings and discussion, the following recommendations are offered.

1. Teachers who plan to use the guided discovery learning model are advised to adjust the distribution of worksheets to each group and set time limits for each stage of the learning process so that students remain actively engaged in discussion and the learning process proceeds more effectively.
2. For future researchers, it is recommended to further develop the application of the guided discovery learning model by adding variations in learning activities that emphasize the formulation of logical reasoning and step-by-step proof strategies so that all indicators of mathematical reasoning akilla improve evenly. In addition, it is also recommended to examine different subject matter and grade levels to obtain a broader picture of the impact of GDL on students' mathematical reasoning skills.

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