EDUMATSAINS
JURNAL PENDIDIKAN MATEMATIKA DAN SAINS
E-ISSN:2527-7235
Volume 10 Issue. 3, January 2026, pp 267-278
http://ejournal.uki.ac.id/index.php/edumatsains

The Effect of Guided Discovery Learning Model on Students' Mathematical Communication Skills

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Article Info

Article history:
Received: January 25th, 2026
Revised: January 30th, 2026
Accepted: January 30th, 2026
Available online: January 31st, 2026

https://doi.org/10.33541/edumatsains.v10i3.7823

Abstract

This study aims to determine the effect of Guided Discovery Learning model on students' mathematical communication skills. The population in this study consists of all seventh-grade students of SMP Negeri 35 Bandar Lampung in the 2025/2026 academic year totaling 87 students distributed across three classes. The sample in this study includes class VII.3 as the experimental class with 29 students and class VII.2 as the control class with 29 students selected using cluster random sampling technique. The type of research used is quasi experimental research. The design used is the pretest-posttest control group design. The data in this study is quantitative data obtained through a mathematical communication skills test. Based on the result of hypothesis test using t-test, it was found that the average N-gain score of mathematical communication skills for students who participated in Guided Discovery Learning model was 0.69, which was higher than the average N-gain score of 0.35 achieved by students who participated in conventional learning. It can be concluded that the implementation of Guided Discovery Learning model has an effect on students' mathematical communication skills.

Keywords: effect, guided discovery learning, mathematical communication

1. Introduction

Education in general can be defined as any planned effort to change a person's ignorance into knowledge through the learning process (Dimyati & Mudjiono, 2006). According to Article 1, paragraph 1 of Law No. 20 of 2003 concerning the National Education System, education is a conscious and planned effort to create a learning atmosphere and process that allows students to actively develop their potential to possess spiritual and religious strength, self-control, personality, intelligence, noble character, and the skills needed for themselves, society, the nation, and the state. Through education, humans actively develop their potential to acquire the personality, intelligence, and skills they need (Laia et al., 2024).

Mathematics is a crucial subject in education because it plays a role in developing logical, systematic, and analytical thinking skills. One of the objectives of mathematics learning, as stated in Decree No. 33 of 2022 of the Head of the Curriculum Standards and Education Assessment Agency of the Ministry of Education, Culture, Research, and Technology, is that students are able to express their mathematical ideas in symbols, tables, diagrams, or other media (Hutneriana et al., 2022). Thus, students are required to master mathematical communication skills in order to achieve the goals of learning mathematics.

Mathematical communication skills are the ability to convey, understand, and accept mathematical ideas or concepts carefully, analytically, critically, and evaluatively to sharpen understanding (Zarkasyi, 2015). In the context of mathematics learning, mathematical communication refers to students' ability to express mathematical ideas and concepts through various means, such as verbally, through pictures, writing, diagrams, symbols, or objects. Students who are able to communicate mathematical ideas or concepts well tend to have a strong understanding of the concepts being studied and are able to solve problems related to those concepts (NCTM, 2000). According to Sumarmo (Riska and Surya, 2014), the indicators of mathematical communication skills used in this study are: (1) drawing, which is the ability to represent real objects as mathematical ideas or vice versa, completely and correctly; (2) mathematical expression, which is the ability to express mathematical concepts by representing everyday events using mathematical language completely and correctly; and (3) written text, which is the ability to write answers clearly in one's own words.

In actuality, Indonesian students' mathematical communication skills are still relatively low. This is evidenced by several international studies. According to data from the 2015 Trends in International Mathematics and Science Study (TIMSS), Indonesia ranked low, ranking 44th out of 49 countries, with an average score of 397, significantly lower than the international average of 500 (IEA, 2019). One of the causes of low TIMSS scores is students' inability to communicate ideas or concepts in notation, pictures, tables, graphs, or other media to explain problems (Hadi & Novaliyosi, 2019).

The results of the 2022 Programme for International Student Assessment (PISA) mathematics study also showed alarming results. Indonesia ranked 70th out of 81 countries and received an average score of 366, significantly lower than the international average of 472 (OECD, 2023). Mathematical communication skills are essential for solving PISA problems. Critical components of the PISA assessment include communication, presenting arguments, and using symbolic operations (Fitri et al., 2023), so these PISA results indicate Indonesian students' low mathematical communication skills.

Since 2021, Indonesia has implemented the Minimum Competency Assessment (AKM) program, which aims to evaluate students' literacy and numeracy skills. Data from the 2023 Indonesian Education Report Card (APK) shows that only 40.63% of junior high school students across the country achieved the minimum numeracy competency (Pusmendikbud, 2023). Research by Akhideati et al. (2024) revealed that one of the difficulties students face when solving AKM problems is interpreting information from text into mathematical models. This indicates that students are unable to communicate ideas or concepts in mathematical models and interpret images or graphs, indicators of mathematical communication skills.

Low levels of students' mathematical communication skills were also found at SMP Negeri 35 Bandar Lampung. Based on preliminary research conducted on 30 students in class VII.2, it was found that only 10 students were able to illustrate the problem in the form of pictures correctly. Students were unable to present problems in a correct and systematic way. Furthermore, only three students were able to present problems in mathematical expressions with precise calculations and logical and systematic explanations. Students were unable to write mathematical expressions for given problems correctly, and although they could use mathematical symbols, they were not using them correctly.

An interview with a mathematics teacher at SMPN 35 Bandar Lampung revealed that students still experience difficulties communicating mathematical ideas both in writing and orally. During the learning process, many students remain passive and lack the courage to express their ideas or opinions. The teacher also revealed that the learning model used tends to be conventional, with the lecture method, where the teacher is more active in delivering the material while students merely receive information. As a result, students are less trained to construct their own knowledge and communicate their mathematical understanding. One way to improve students' mathematical communication skills is by implementing an appropriate learning model. The Guided Discovery Learning model is one that can facilitate students' development of mathematical communication skills. This learning model provides opportunities for students to discover concepts through a series of guided activities, enabling them to construct their own knowledge and communicate their understanding (Dahar, 1989).

The Guided Discovery Learning model has six stages: stimulation, problem statement, data collection, data processing, verification, and generalization. Learning begins with stimulation, where the teacher provides a stimulus that stimulates students' curiosity. In the identification stage, students identifying the problem to be solved based on the stimulus provided. Then, in the data collection and processing stage, students collect and process relevant information, data, or facts to answer the problem. In the verification stage, students review their results. Finally, in the generalization stage, students draw conclusions from their analysis. Through these stages, students are trained to identify problems, collect and process data, verify data, and draw conclusions, which are then communicated both orally and in writing (Wibowo, 2019).

Several studies have demonstrated the effectiveness of the Guided Discovery Learning model in improving students' mathematical communication skills. Research by Hastuti et al. (2022) demonstrated the effectiveness of the Guided Discovery Learning model on students' mathematical communication skills. Research by Arsynandani & Elniati (2023) also demonstrated that Guided Discovery Learning is more effective in improving mathematical communication skills compared to conventional learning. Similarly, research by Suratno et al. (2019) demonstrated that the Guided Discovery Learning model can help students actively discover concepts and improve communication skills compared to conventional models. Therefore, the purpose of applying

Guided Discovery Learning model in the hope of creating an active and effective learning atmosphere so that there is an increase in students' skills in mathematical communication.

2. Methods

The approach used in this research is a quantitative approach. The type of research is a quasi-experiment, this research is carried out to see if there is an influence by giving different actions to each class or group. This study uses two variables, namely the independent variable and the dependent variable. The independent variable in this study is Guided Discovery Learning model while the dependent variable is the mathematical communication skills of students. The research design used is pretest-posttest control group design. Pretest was conducted to measure students' mathematical communication skills before learning, then posttest was conducted to measure students' mathematical communication skills after learning in both sample classes. This research design is expressed by (Sugiyono, 2017) in the following table.

Table 1.
Research Design

Group	*Pretest*	Treatment	*Posttest*
Experiment	O_1	X	O_2
Control	O_1	C	O_2

Description:
O_1 : student mathematical communication skills pretest (experimental class and class control)
O_2 : posttest of students' mathematical communication skills (experimental class and class control)
X : guided discovery learning model
C : conventional learning

The population in this study included all VII grade students at SMP Negeri 35 Bandar Lampung in the 2025/2026 school year as many as 87 students spread across three classes ranging from VII.1, VII.2 and VII.3 classes. Of these three classes, two classes were selected to be the research sample using cluster random sampling technique. So that VII.3 class was chosen as the experimental class which was given the treatment of learning using Guided Discovery Learning model while VII.2 class became the control class which was given the treatment of learning using the conventional model.

The research was conducted 3 stages, including the preparation stage, the implementation stage, and the final stage. The preparation stage was carried out by carrying out observations along with collecting preliminary data to find out the condition of the school, determining the population and research samples, and determining the material being taught. At this stage, the preparation and testing of instruments were also carried out. In the implementation stage, a pretest was conducted before being given treatment, mathematics learning using Guided Discovey Learning model in the experimental class and mathematics learning using the conventional model in the control class, and the implementation of the posttest after receiving treatment. The treatment was conducted during 5 meetings of mathematics subjects. In the final stage, processing and analysis of research data results obtained from experimental and control classes were carried out.

The instrument used in this study is a test instrument. The test form is essay question with the material of Quadrilateral and Triangular Flat Shapes as many as 4 items. The test instrument is designed to align with competency achievement indicators for the material used and mathematical communication skills indicators. The test instrument is given individually to students as a means of measuring mathematical communication skills in experimental classes and control classes. The test questions given during the pretest were retested during the posttest in both classes. Validity and reliability tests were carried out on the test items. Validity testing with partner teachers indicated that the test instrument was valid. Based on the calculation results using the Cronbach Alpha formula, the reliability coefficient of the test instrument was 0.92, which means the test instrument is reliable. Thus, all test items are suitable for use in collecting data on students' mathematical communication skills.

The data obtained from the pretest and posttest scores were analyzed to measure the improvement of students' mathematical communication skills in experimental and control classes. Data analysis was carried out using statistical tests on the normalized gain (N-gain) score of mathematical communication skills. Before conducting statistical tests on the N-gain score, prerequisite test was carried out first, including normality test and homogeneity test.

After carrying out the normality test and homogeneity test, it was found that the results of the N-gain data came from a normally distributed population and both groups of N-gain data had the same variance. Furthermore, hypothesis testing was carried out using the equality test of two means of N-gain in mathematical communication skills of experimental and control class students using t-test statistics.

3. Result and Discussion

3.1 Initial Data Analysis of Mathematical Communication Skills

The initial data of mathematical communication skills is the pretest score obtained from the experimental class and the control class. The results of the initial data processing of mathematical communication skills in experimental and control classes are presented in Table 2.

Table 2.

Initial Data of Students' Mathematical Communication Skills

Class	Many Students	Average	Standard Deviation	Lowest Score	Highest Score
Experiment	29	16,34	5,31	10	30
Control	29	19,76	3,00	16	27

Ideal Maximum Score (IMS) = 36

In Table 2, it can be seen that the average initial mathematical communication ability of students in the control class (19.76) is higher than the experimental class (16.34) with a difference of 3.42. The standard deviation in the experimental class (5.31) is higher than the control class (3.00), which shows that the distribution of initial mathematical communication ability data in the experimental class is more diverse than the control class.

3.2 Final Data Analysis of Mathematical Communication Skills

The final data of mathematical communication skills is the posttest score obtained from the experimental class and the control class. The results of the final data processing of mathematical communication skills in experimental and control classes are presented in Table 3.

Table 3.
Final Data of Students' Mathematical Communication Skills

Class	Many Students	Average	Standard Deviation	Lowest Score	Highest Score
Experiment	29	30,41	2,01	27	34
Control	29	25,83	1,20	24	29

Ideal Maximum Score (IMS) = 36

In Table 3, it is known that the average final mathematical communication ability of students in the experimental class (30.41) is higher than the average final mathematical communication ability of students in the control class (25.83). The standard deviation of the final mathematical communication ability of students in the experimental class (2.01) is higher than that of the control class (1.20), which shows that the distribution of data on the final mathematical communication ability of students in the experimental class is more diverse. The lowest score and the highest score of the final mathematical communication ability of students in the experimental class are higher than the lowest score and the highest score in the control class.

3.3 Data Analysis of N-Gain Score in Mathematical Communication Skills

The recapitulation of students' mathematical communication skills N-gain score obtained from experimental and control classes is presented in Table 4 below.

Table 4.
N-Gain Score of Students' Mathematical Communication Skills

Class	Many Students	Average	Standard Deviation	Lowest Score	Highest Score
Experiment	29	0,69	0,16	0,20	0,92
Control	29	0,35	0,13	0,00	0,50

In Table 4, it can be seen that the average N-gain score in the experimental class (0.69) is higher than the average N-gain score in the control class (0.35). The standard deviation of the data on students' mathematical communication skills N-gain score in the experimental class (0.16) is higher than the control class (0.13), which shows that the distribution of data on students' mathematical communication skills N-gain in the experimental class is more diverse.

3.5 Achievement of Mathematical Communication Skills Indicators

The achievement of students' mathematical communication skills indicators before and after learning activities with Guided Discovery Learning model and conventional learning is presented in Table 5.

Table 5.

Achievement of Mathematical Communication Skills Indicators

Indicator	Experiment Class		Control Class	
	Initial	End	Initial	End
Drawing	54,31%	88,22%	62,93%	80,17%
Mathematical Expression	61%	79%	68%	77%
Written Text	21%	86%	34%	58%
Average	**45%**	**84%**	**55%**	**72%**

In Table 5, it can be seen that there was an increase in mathematical communication skills in both the experimental and control classes. Table 5 shows that the final average achievement of the mathematical communication skills indicator of students in the experimental class was higher than that of students in the control class. The average achievement of the mathematical communication skills indicator in the experimental class increased by 39%, while in the control class it increased by 17%. Overall, the average achievement of the mathematical communication skills indicator of students in the experimental class was higher than that of students in the control class, with an average difference of 22%. This indicates that the increase in the achievement of the mathematical communication skills indicator of students in the experimental class was higher than that of the control class.

3.6 Hypothesis Test Results of Mathematical Communication Skills

Based on the results of the normality test of students' mathematical communication skills N-gain data, it was found that the N-gain data in the experimental class came from a normally distributed population and the N-gain data in the control class also came from a normally distributed population. Next, the homogeneity test was carried out until it was found that the two populations had the same variance. Therefore, the hypothesis test carried out is a parametric statistical test using the t-test. Hypothesis test results presented in Table 6.

Table 6.

Hypothesis Test Results of Students' Mathematical Communication Skills

Class	Many Students	Average N-Gain Score	Standard Deviation	t_{table}	t_{score}

Experiment	29	0,69	0,16	1,673	8,758
Control	29	0,35	0,13		

Based on the results of the t-test with a significance level of 0.05, it is obtained that t_{score} = 8.758 > t_{table} = 1.673 then H_0 is rejected and H_1 is accepted. This means that the average score of improvement (N-gain) of mathematical communication skills of students who follow Guided Discovery Learning model higher than the average score of improvement (N-gain) of mathematical communication skills of students who follow conventional learning. This result shows that, the improvement of mathematical communication skills of students who follow Guided Discovery Learning model is higher than the mathematical communication skills of students who follow conventional learning.

3.7 Discussion

The results of hypothesis testing showed that the improvement of mathematical communication skills of students who followed Guided Discovery Learning was higher than the improvement of mathematical communication skills of students who followed conventional learning. In addition, the increase in the achievement of indicators of mathematical communication skills of students who follow Guided Discovery Learning is also higher than the increase in mathematical communication skills of students who follow conventional learning. This means that the use of Guided Discovery Learning model can improve students' mathematical communication skills. The results of this study are in line with the results of Hastuti, Anggoro, and Suri's (2022) study which used the MANOVA test and found a significant effect of Guided Discovery Learning on students' mathematical communication skills. The results of this study are also supported by the results of Asyinandani and Elniati's (2023) study which showed the effect of Guided Discovery Learning on the mathematical communication skills of eighth grade students of SMPN 22 Padang, especially on three main indicators: written explanations, symbolic expressions, and visual representations. which showed that there was an increase in each indicator of students' mathematical communication skills who followed the Guided Discovery Learning model.

The stages in the Guided Discovery Learning model have a higher opportunity to improve students' communication skills. In learning with the Guided Discovery Learning model, the initial stage is the stimulation stage. At this stage, students are given stimuli in the form of problems related to the material to be studied. Based on observations, the problems given at this stage can trigger students to develop their prior knowledge. This is in line with Syah (2004) who stated that providing stimulation can expose students to conditions that encourage exploration, and Firmansyah, Hasanuddin, and Nelson (2018) who explained that stimuli in the form of contextual problems encourage students to communicate ideas and problem-solving strategies. The problem statement stage then requires students to identify and formulate problems in their own language. Qodariyah and Hendriana (2015) stated that this stage plays a crucial role in developing mathematical communication skills because students are required to transform contextual problems into mathematical forms, thus developing writing indicators.

Next, in the data collection stage, students are directed to gather various relevant information to solve the problem. Based on observations, students were seen actively exploring various possible answers and writing down the data they found. Hastuti, Anggoro, and Suri (2022) stated that this stage provides students with the opportunity to practice communicating their understanding through various mathematical representations, while Supriadi (2015) added that this activity fosters the ability to use representational forms such as pictures, diagrams, and mathematical expressions. This stage develops mathematical communication skills in the drawing and mathematical expression indicators.

In the verification stage, students check and prove the accuracy of their solutions. Based on observations, students appear to be actively participating in discussions to confirm the solution steps and provide logical explanations for the proposed solutions. Sapitri, Masjudin, Pujilestari, and Mulianah (2023) stated that verification activities help students strengthen conceptual understanding because they need to explain their thought processes and the logical reasons for their answers. Nabilah, Khadijah, and Utari (2023) added that students practice expressing their opinions using appropriate mathematical language. This stage develops mathematical communication skills in the writing and mathematical expression indicators.

The last stage is the generalization stage, where students summarize the concepts they have discovered and relate them to other mathematical concepts. Based on their observations, students re-explain their findings using their own language and present their results. Qodariyah and Hendriana (2015) stated that the generalization stage plays a crucial role in building conceptual understanding because students actively draw conclusions and communicate their findings. Hastuti, Anggoro, and Suri (2022) emphasized that this stage strengthens mathematical communication skills through the process of expressing opinions and concluding concepts. This stage develops mathematical communication skills in writing, drawing, and mathematical expression indicators.

Unlike the class that uses Guided Discovery Learning model, the conventional Direct Instruction model is teacher-centered. During the orientation and presentation stages, the teacher explains the material directly and demonstrates solutions, but this results in students rarely asking questions because they assume the material is sufficient. Sundawan (2016) explains that Direct Instruction involves teacher coordination of the material, leading students to be passive and less involved in constructing knowledge. Slavin (2009) adds that this strategy has weaknesses in terms of active participation and critical thinking development because students are given less space to explore their own thinking. During the guided practice and feedback stages, only a few students dare to write answers on the board because they are used to being passive. During independent practice, students are accustomed to seeing examples first and experience difficulties when encountering different problems.

From the comparison of the learning process using Guided Discovery Learning model and conventional learning, it is known that the learning process in classes using the Guided Discovery Learning model has a higher opportunity to improve students' mathematical communication skills.

This is supported by the opinion of Suratno, et al., (2019) who stated that the Guided Discovery Learning model can help students actively discover concepts and improve students' communication skills compared to the conventional model.

Based on the discussion above, it can be seen that the use of Guided Discovery Learning model has a higher chance in improving students' mathematical communication skills than conventional learning. This is supported by the results of hypothesis testing which shows that the increase in mathematical communication skills of students who follow Guided Discovery Learning model is higher than the increase in mathematical communication skills of students who follow conventional learning. Thus, it can be concluded that the use of Guided Discovery Learning model affects the mathematical communication skills of students in grade VII of SMP Negeri 35 Bandar Lampung even semester of the 2025/2026 academic year.

4. Conclusion

Based on the results of research and discussion, it can be concluded that Guided Discovery Learning model has an effect on the mathematical communication skills of students in class VII of SMP Negeri 35 Bandar Lampung even semester of 2025/2026 academic year. This is based on the research results which show that the increase in mathematical communication skills of students who follow Guided Discovery Learning model is significantly higher than the increase in mathematical communication skills of students who follow conventional learning models.

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