**The Effect of the GeoGebra-Assisted Discovery Learning Model on Mathematical Communication Abilities**

**Abstract**

Mathematical communication skills are essential for every student to face the challenges of today's globalization and information era. In reality, the mathematical communication skills of seventh-grade students at SMPN 1 Ampek Angkek are still low. This study aims to describe the development of students' mathematical communication skills while learning using the GeoGebra-assisted Discovery Learning model and to analyze whether the mathematical communication skills of seventh-grade students at SMPN 1 Ampek Angkek who learn using the GeoGebra-assisted Discovery Learning model are better than those who learn using conventional learning models. This study was quasi-experimental with a Nonequivalent posttest-only control Group Design. The study population was seventh-grade students at SMPN 1 Ampek Angkek in the 2024/2025 academic year. The sampling technique used was simple random sampling. The sample in this study was students from grade VII.2 as the experimental class and grade VII.6 as the control class. The instruments used were a quiz and a final test of mathematical communication skills. The data analysis in this study included quiz data and final test scores using normality tests, homogeneity tests, and t-tests. The results showed improvement during implementing the GeoGebra-assisted Discovery Learning model, as seen from the average quiz scores for each meeting. A t-test of the final test scores for both samples indicated that the average final test score for mathematical communication skills for those taught using the GeoGebra-assisted Discovery Learning model was higher than that for those taught using the conventional learning model. This suggests that mathematical communication skills for those taught using the GeoGebra-assisted Discovery Learning model were better than those taught using the traditional learning model.

**Keywords**: Mathematical Communication Skills, Discovery Learning Model, GeoGebra, Conventional Learning Model

**Introduction**

Mathematics is generally defined as the field of science that studies the structure, change, and patterns in space. It is also usually defined as a field of science encompassing logic regarding arrangement, quantity, shape, and related designs (Hariwijaya, 2009). Mathematics plays a crucial role in everyday life and various fields of science. Every mathematical theory must consider mathematics's strengths, namely its application in other sciences and its inherent beauty. Mathematics can train students' thinking skills and shape their character, fostering specific skills.

One of the goals of mathematics learning is mathematical communication, enabling students to convey mathematical ideas or solutions in writing and orally using appropriate symbols and terminology. The National Council of Teachers of Mathematics (NCTM) states that the general goals of mathematics learning are learning to communicate, reason, solve problems, connect ideas, and present ideas (NCTM 2000). Thus, it is understandable that mathematical communication skills are important for students.

In mathematical communication, students are given the opportunity, motivation, and support to speak, write, read, and listen to mathematical expressions. They can also interact mathematically because mathematics is often conveyed through symbols, writing, and speaking. This aligns with the statement (Talaumbanua & Harefa, 2020), which states that mathematical communication is often given in symbolic communication, written communication, and oral communication containing mathematical ideas. Mathematical communication skills also have the potential to make it easier for students to solve problems. Jung & Reifel (Classroom, 2003) stated that mathematical communication is important to develop because it can train students' conceptual understanding, thinking, problem-solving skills, and mathematical reasoning. Thus, mathematical communication skills are important to develop because they involve symbolic, written, and oral expressions, making it easier for students to solve problems and train conceptual understanding, thinking, problem-solving skills, and mathematical reasoning.

However, many students currently still have low mathematical communication skills. This is due to their lack of active participation during learning. This low mathematical communication skill is evident in the 2018 PISA results. Indonesia scored 379 for mathematics, out of an international average of 500. Students' low mathematical communication skills can be seen in research conducted by Hariati, Sinaga, and Mukhtar (2022), which states that the lack of student participation, where students tend to have low learning motivation, and the view that mathematics is a complex subject, can contribute to this problem. This impacts students' reluctance to be actively involved in learning, thus hampering their mathematical communication skills. The results of research conducted by Ahid, Waluya, and Kharisudin (2019) stated that several students at SMA Negeri 1 Lasem still experience difficulties interpreting problems in the form of story problems into mathematical symbols or images. This proves that students still experience difficulties in mathematical communication skills.

Overall performance remains relatively low based on in-depth observations at SMP Negeri 1 Ampek Angkek in the 2024/2025 academic year. Interim test results also found that many students scored below the maximum on the mathematical communication skills test, indicating that their mathematical communication skills are still relatively low. This observation indicates that students' mathematical communication skills remain low. Furthermore, observations of the learning process also revealed that, in general, students' active participation in the learning process and their reliance on teacher explanations resulted in less than optimal understanding of the classroom material.

Various factors influence students' low mathematical communication skills. One contributing factor is the lack of implementation of innovative active learning models. Conventional learning often does not allow students to think critically and collaborate effectively. Furthermore, difficulties understanding mathematical facts, concepts, operations, and principles further hinder students' ability to communicate their ideas orally and in writing. This problem is still relatively complex due to students' limitations in reading and interpreting mathematical symbols, especially in materials such as plane figures (Hariati, Sinaga, and Mukhtar 2022). This is in line with the opinion of Maulida, Ningsih, and Bastian (2018), who stated that one of the causes of students' low mathematical communication skills is their limited ability to use mathematical representations. Students often have difficulty expressing mathematical ideas through symbols, graphs, tables, or other representations, which are important elements of mathematical communication. Explain in detail.

Furthermore, limited learning media that are less engaging and irrelevant to students' needs also contribute to low student interest in learning, thus hindering their understanding of mathematical concepts (Salmah, Hamidah, and Kusuma 2024). Good learning media are essential to help students grasp concepts in depth, as a strong conceptual understanding is a crucial foundation for communicating mathematical ideas (Lestari, Zubainur, and Suhartati 2019). The limited availability of less engaging and relevant learning media and a weak understanding of mathematical concepts contribute to students' poor mathematical communication skills. Therefore, educators must understand students' mathematical communication skills in mathematics lessons (Pratiwi, Sari, and Burhanudin 2024). By understanding students' mathematical communication skills, educators can track and investigate the extent of their mathematical understanding and difficulties in learning mathematics (Hariati, Sinaga, and Mukhtar 2022).

One way to improve students' mathematical communication skills is by applying more innovative learning models. Many learning models are available, including the Discovery Learning model. Discovery Learning is a learning model used to generate ideas through discovery. It allows students to actively participate in learning (Fahmi, Sutiarso, S., & Coesamin, 2019). By discovering and investigating independently, students can explain or communicate their findings in writing and verbally and retain them longer (Sabariah, Ayu, and Yenti 2021). Discovery Learning can be applied to solve problems intensively under the supervision of educators, guiding students to answer or solve problems, emphasizing the process of developing students' learning styles, activating students, and being student-oriented, where students discover and investigate independently, and consistently emphasizing self-development (Subagio, Karnasih, and Irvan 2021).

As research conducted by Lubis, Fitriani, and Sariningsih (2023) shows, implementing the Discovery Learning model can improve students' communication skills. These findings align with research by Hakim, Fitriani, and Nurfauziah (2024), which concluded that students' abilities can improve using the Discovery Learning model. Besides enabling students to work on and solve problems independently, students also interact extensively with their group mates, which makes them more active and improves their communication skills.

Correspondingly, the increased use of technology, such as learning software, and providing more opportunities for students to engage actively and think critically (Salmah, Hamidah, and Kusuma 2024) are also needed as learning aids, primarily to facilitate students' understanding and observation of objects. However, conventional learning often fails to utilize interactive media to enhance learning effectiveness. As a result, learning becomes monotonous, and students experience difficulties imagining, observing, and drawing objects (Aprilia & Fitriana, 2022). One medium that can be used in mathematics learning is GeoGebra.

GeoGebra is software capable of visualizing various mathematical objects quickly, precisely, and efficiently. This aligns with Purnomo's (2021) opinion, which states that GeoGebra is the right choice for representing various mathematical objects because it is dynamic geometry software. GeoGebra software allows users to construct points, lines, and even geometric shapes that can be modified. Japa, Suarjana, and Widiana (2017) state that GeoGebra is a computer program designed for learning mathematics, specifically geometry, algebra, and calculus. Thus, GeoGebra is an effective interactive medium for mathematics learning, helping students better understand and observe objects, especially in learning contexts that are often monotonous and conventional.

Research conducted by Asmira, Rusdyi, and Rusmin R. M. Saleh (2023) shows that the application of geometry learning with the help of GeoGebra can improve students' mathematical communication skills with high category achievements (>0.7) of 56%, with the medium category (0.3 ≤ x ≤ 0.7) obtaining a percentage of 34%, while the low category (<30) obtained a presentation of 9.4%. This aligns with research conducted by Habib et al. (2022) showing that students can apply complex geometric concepts easily using GeoGebra.

In addition, GeoGebra provides students with hands-on learning experiences, helping them overcome difficulties in creating images, including manual drawing. Fitriasari (2017) stated that GeoGebra can help visualize mathematical materials such as algebra and geometry, making it easier for students to understand abstract concepts. Thus, GeoGebra is an effective medium in improving students' mathematical communication skills, facilitating the visualization of abstract concepts, and helping them understand geometry and algebra interactively. Therefore, systematic and in-depth research is essential to combine innovative learning models involving mathematical applications to improve students' mathematical abilities. Therefore, the primary focus of this research is to answer the question "How does the GeoGebra-assisted Discovery Learning model influence students' mathematical communication?"

**Research Method**

The research used a quasi-experimental design, using two groups: experimental and control groups (Untrari, 2018). The experimental group received treatment using the GeoGebra-assisted Discovery Learning model, while the control group received conventional learning. The research design used the "Nonequivalent Posttest-Only Control Group Design." In this design, two classes were assigned: the experimental class and the control class, and both classes were given treatment. The experimental design can be seen in Table 1 below:

Table 1. Research Design: Nonequivalent Posttest-Only Control Group Design

|  |  |  |
| --- | --- | --- |
| Group | Treatment | Post Test |
| Experiment | X | O |
| Control | - | O |

Description:

X: Learning using the Discovery Learning model with the assistance of GeoGebra

O: Posttest scores for the experimental and control classes

-: Learning using the conventional learning model

The population in this study was all 268 seventh-grade students at SMP Negeri 1 Ampek Angkek. The sample used in this study was selected using a simple random sampling technique after the homogeneity of the entire population was tested using statistical tests. Based on this technique, the sample in this study was class VII.2 with 29 students (as the experimental class) and class VII.6 with 28 students (as the control class).

The data in this study were obtained using a test technique. The test instrument was designed based on indicators of mathematical communication skills (Sumarmo, 2016). Before the final Test was administered to the sample class, the instrument was validated statistically using expert judgment. After the analysis and the questions were declared suitable for use, the trial questions were administered to the sample class. The data analysis technique compared the average mathematical communication ability test scores between students in the experimental and control classes. This data analysis used Minitab software.

**Results and Discussion**

In this study, tests were administered several times to ensure the measurability of the observed indicators. Based on the tests administered during the learning process, the data obtained are as shown in Table 2 below:

 Table 2. Average Test Scores for Each Learning Session

|  |  |
| --- | --- |
|  **Tes** | **Average** |
| 1 | 57,09 |
| 2 | 56,32 |
| 3 | 62,84 |
| 4 | 69,73 |
| 5 | 75,48 |
| 6 | 78,93 |

Based on Table 2 above, it is known that the average test scores across the six meetings experienced both increases and decreases. This is evident in the second Test, which saw a decrease of 0.77 from the first Test. Then, from the second to the third Test, there was an increase of 6.52. Therefore, students' mathematical communication skills have developed. The development of students' mathematical communication skills can be seen based on the average scores for each mathematical communication ability indicator at each meeting, as shown in Table 3.

Table 3. Average Scores for Each Communication Ability Indicator

|  |  |
| --- | --- |
| Indicators  | **The number of Test-** |
| **I** | **II** | **III** | **IV** | **V** | **VI** |
|  1 | 1.93 | 2.08 | 2.27 | 2.32 | 2.52 | 2.54 |
| 2 | 1.89 | 2.04 | 2.00 | 2.00 | 2.44 | 2.46 |
| 3 | 1.70 | 1.76 | 2.04 | 2.18 | 2.33 | 2.36 |

Description:

Indicator 1: Connecting real objects, pictures, and diagrams to mathematical ideas

Indicator 2: Explaining mathematical ideas, situations, and relationships using real objects, pictures, graphs, tables, and algebra

Indicator 3: Expressing everyday events in mathematical language or symbols

Table 3 shows that each indicator experienced an average change, either an increase or a decrease, at each meeting. Although there was a decrease in some meetings, the average score for each indicator increased in subsequent meetings. Therefore, it is understandable that students' mathematical communication skills increased during implementing the GeoGebra-assisted Discovery Learning model.

A comparison of the mathematical communication skills of students learning using the GeoGebra-assisted Discovery Learning model (experimental class) with those learning using the conventional learning model (control class) can be seen from the mathematical communication skills test results. The Test used essay questions with three items. Each question contained one indicator of mathematical communication skills. The Test was administered at the end of the study, on May 28, 2025, in the experimental class. Twenty-nine students participated in the experimental class, and 28 participated in the control class. The test results are shown in Table 4.

Table 4. Results of the Mathematical Communication Ability Test for the Sample Class

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Class | Number of Students  | Standard Deviation  | Standard Deviation  | Highest Score  |  Lowest Score |
| Experiment | 29 | 68,20 | 1,79 | 100 | 33,33 |
| Control | 28 | 51,98 | 1,83 | 88,89 | 22,22 |

Table 4 shows that the experimental class obtained an average score of 68.20, while the control class obtained an average score of 51.98. Therefore, the experimental class's average test score was higher than the control class's. The highest score for the experimental class was 100, while the control class's highest score was 88.89. The lowest score for the experimental class was 33.33, while the control class's lowest was 22.22. This indicates that students in the experimental class who learned using the GeoGebra-assisted Discovery Learning model scored higher than those in the control class who learned using the conventional model.

The average scores for each indicator in Table 5 provide more detailed data on the communication skills test for students in the sample class.

Table 5. Comparison of Student Averages on the Mathematical Communication Skills Test

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **No** | **Indicators**  | Max Score  | Average Grade of Experimental Class  | Average Grade of Control Class |
| 1 | Connecting real objects, pictures, diagrams, and tables to mathematical ideas | 3 | 67.78 | 51,19 |
| 2 | Explaining mathematical ideas, situations, and relationships using real objects, pictures, graphs, tables, and algebra | 3 | 74.44 | 61,90 |
| 3 | Expressing everyday events in mathematical language or symbols | 3 | 62.22 | 42,86 |

Table 5 shows that the average scores for the three indicators in the experimental class using the GeoGebra-assisted Discovery Learning model were higher than those in the control class using the conventional learning model. This suggests that the mathematical communication skills of students in the experimental class using the GeoGebra-assisted Discovery Learning model were superior to those in the control class using the conventional learning model. The following graph presents a comparison of the average test scores for each indicator of students' mathematical communication skills in Figure 1:

Figure 1. Average Scores of Students in the Sample Class

Figure 1 shows that the average score of students in the experimental class on each mathematical communication ability test indicator was higher than that of students in the control class. This indicates that the students in the experimental class demonstrated better mathematical communication ability than the control class.

More detailed test data for students in the sample class can be seen through each test item, corresponding to the mathematical communication ability indicator studied. Students' abilities in each indicator were scored according to the mathematical communication ability test assessment rubric. A score of 1 was converted into a grade point average (GPA) of 33.33. A score of 2 was scored as a GPA of 66.66, and the maximum score was 3, with a score of 100. The following is the percentage of students in the experimental and control classes for each indicator score, as shown in Table 6.

Table 6. Distribution of Number and Percentage of Students

|  |  |  |  |
| --- | --- | --- | --- |
| **Class** | **Indicators** |  **Number of questions** | **The number of students** |
| **Score 3 (%)** | **Score 2 (%)** | **Score 1 (%)** | **Score 0 (%)** |
| **Experiment** | 1 | 1 | 9 | 13 | 7 | 0 |
| 29.03 | 41.94 | 22.58 | 0.00 |
| 2 | 2 | 13 | 10 | 6 | 0 |
| 41.94 | 32.26 | 19.35 | 0 |
| 3 | 3 | 4 | 16 | 9 | 0 |
| 12.90 | 51.61 | 29.03 | 0 |
| **Control** | 1 | 1 | 4 | 9 | 13 | 2 |
| 12.12 | 27.27 | 39.39 | 6.06 |
| 2 | 2 | 6 | 12 | 10 | 0 |
| 18.18 | 36.36 | 30.30 | 0.00 |
| 3 | 3 | 1 | 9 | 15 | 3 |
| 3.03 | 27.27 | 45.45 | 9.09 |

Based on Table 6 above, the total scores of students on the mathematical communication ability test for each indicator are shown. This data supports the hypothesis that the mathematical communication abilities of students learning using the GeoGebra-assisted Discovery Learning model are better than those learning using conventional learning models in grade VII of SMPN 1 Ampek Angkek.

The final Test administered in this study was structured based on three indicators of mathematical communication skills: (1) connecting real objects, images, and diagrams into mathematical ideas; (2) explaining mathematical ideas, situations, and relationships with real objects, images, graphs, tables, and algebra; and (3) expressing everyday events in mathematical language or symbols. Students in the experimental class performed better than those in the control class. The final Test consisted of three questions, each covering one indicator of mathematical communication skills. These questions provided a statistical analysis of students' mathematical communication skills.

The results of the hypothesis testing indicated that the mathematical communication skills of students learning using the GeoGebra-assisted Discovery Learning model were superior to those of students learning using conventional learning. This was evident from the average final test score for mathematical communication skills in the experimental class, 68.20. The average final test score was higher than the average mathematical communication test score in the control class, which was 51.98.

In the first meeting, students were still adapting to the learning model. This was because they were not yet accustomed to using the GeoGebra-assisted Discovery Learning model and were still accustomed to conventional learning models. This required time for students to adjust to the learning model. Furthermore, in the second meeting, students began to adapt to the learning model, leading to active discussions. In the third meeting, students became interested in learning using the GeoGebra-assisted Discovery Learning model because they could present and express their ideas in front of their peers. Furthermore, in the fourth and sixth meetings, students tended to experience improvements in their learning process.

The hypothesis test results also concluded that the average mathematical communication skills of students learning using the GeoGebra-assisted Discovery Learning model were better than those of students learning using the conventional learning model. Therefore, implementing the Discovery Learning learning model assisted by GeoGebra impacts students' mathematical communication skills.

**Conclusion**

Based on the research findings, the mathematical communication abilities of students learning using the GeoGebra-assisted Discovery Learning model are superior to those of students learning using conventional models. Therefore, this study indicates that the GeoGebra-assisted Discovery Learning model impacts students' mathematical communication abilities. This is evident from the results of the mathematical communication ability test of grade VII students at SMPN 1 Ampek Angkek in the 2024/2025 academic year. Based on the research conducted, the researcher suggests that mathematics educators can implement the GeoGebra-assisted Discovery Learning model as an alternative in mathematics learning to improve students' mathematical communication. Furthermore, educators or researchers who will implement the GeoGebra-assisted Discovery Learning model should design the learning more carefully and systematically to obtain an accurate comparison with this research.

**COMPETING INTERESTS DISCLAIMER:**

Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

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