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IMPROVING STUDENTS' MATHEMATICAL COMMUNICATION SKILLS THROUGH THE GUIDED INQUIRY LEARNING MODEL WITH DESMOS

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ABSTRACT One of the essential skills students must develop in mathematics learning is mathematical communication. However, field observations indicate that students still exhibit weaknesses in this area. Therefore, it is necessary to implement a learning model supported by digital media that facilitates students in expressing and communicating mathematical ideas more effectively. The guided inquiry learning model, when integrated with interactive media such as Desmos, offers a promising alternative. Desmos is a dynamic graphing application that allows students to explore mathematical concepts visually and interactively, thereby supporting deeper conceptual understanding and communication. This study employed a quasi-experimental design aimed at examining the improvement of students' mathematical communication skills through the implementation of a guided inquiry learning model with Desmos. The population consisted of all ninth-grade students at SMP Negeri 45 Bandar Lampung in the 2024/2025 academic year, totaling 107 students across four classes. The samples were selected using a cluster random sampling technique and comprised class 9.3 (27 students) as the experimental group and class 9.2 (26 students) as the control group. The research design used was a posttest-only control group design. Quantitative data were collected through a mathematical communication skills test. Based on hypothesis testing using an independent sample t-test at a significance level of $\alpha = 0.05$, the results showed that t-count > t-table (2.08 > 1.67). Thus, it can be concluded that the application of the guided inquiry learning model with Desmos significantly improves students' mathematical communication skills.

Keywords: mathematical communication, guided inquiry learning, desmos application

ABSTRAK Salah satu keterampilan penting yang harus dikembangkan siswa dalam pembelajaran matematika adalah komunikasi matematis. Namun, hasil observasi di lapangan menunjukkan bahwa siswa masih mengalami kelemahan dalam keterampilan ini. Oleh karena itu, diperlukan penerapan model pembelajaran yang didukung oleh media digital yang dapat memfasilitasi siswa dalam mengungkapkan dan mengkomunikasikan ide-ide matematis secara lebih efektif. Model pembelajaran inkuiri terbimbing yang diintegrasikan dengan media interaktif seperti Desmos menawarkan alternatif yang menjanjikan. Desmos merupakan aplikasi grafik dinamis yang memungkinkan siswa mengeksplorasi konsep-konsep matematika secara visual dan interaktif, sehingga mendukung pemahaman konseptual yang lebih mendalam serta komunikasi yang lebih baik.

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Penelitian ini menggunakan desain kuasi-eksperimen yang bertujuan untuk mengkaji peningkatan keterampilan komunikasi matematis siswa melalui penerapan model pembelajaran inkuiri terbimbing dengan bantuan Desmos. Populasi penelitian ini adalah seluruh siswa kelas IX SMP Negeri 45 Bandar Lampung tahun ajaran 2024/2025, sebanyak 107 siswa yang tersebar di empat kelas. Sampel dipilih menggunakan teknik cluster random sampling, terdiri dari kelas 9.3 (27 siswa) sebagai kelas eksperimen dan kelas 9.2 (26 siswa) sebagai kelas kontrol. Desain penelitian yang digunakan adalah posttest-only control group design. Data penelitian berupa data kuantitatif yang diperoleh melalui tes keterampilan komunikasi matematis. Berdasarkan uji hipotesis menggunakan uji-t independen pada taraf signifikansi $\alpha = 0{,}05$, diperoleh hasil t hitung > t tabel (2,08 > 1,67). Dengan demikian, dapat disimpulkan bahwa penerapan model pembelajaran inkuiri terbimbing dengan bantuan Desmos secara signifikan meningkatkan keterampilan komunikasi matematis siswa.

Kata-kata kunci: komunikasi matematis, pembelajaran inkuiri terbimbing, aplikasi Desmos

INTRODUCTION

Mathematics is a fundamental science that is closely related to and supports various scientific disciplines and aspects of everyday life (Sari et al., 2019). In line with this, Khaesarani & Hasibuan (2021) state that mathematics serves as a primary science that functions as a tool for understanding other disciplines, as nearly all fields of science utilize mathematical concepts. Thus, mathematics becomes a basic foundation that supports students in learning various areas of knowledge and addressing real-life problems.

In the context of mathematics education, students are expected to achieve certain competencies, one of which is the ability to express problems using symbols, tables, and diagrams, and to represent those problems through appropriate mathematical models. Accordingly, one essential competence that students must master is mathematical communication ability, as emphasized in the Decree of the Head of BSKAP No. 008/H/KR/2022.

The Ministry of Education and Culture (2022) also stresses the importance of mathematical communication skills as one of the essential 21st-century skills students must possess. Hafidhoh & Marlina (2021) argue that this skill is highly significant in mathematics learning because it enables students to communicate mathematical ideas clearly and to solve problems effectively. Similarly, the National Council of Teachers of Mathematics (NCTM), as cited in Purnama & Afriyansyah (2016), highlights that students must develop mathematical communication skills in order to articulate and explain mathematical ideas across various contexts and phenomena.

Despite its importance, Indonesian students generally exhibit low levels of mathematical communication skills. This is evident from Indonesia's 2022 PISA mathematics score, which was only 366—well below the OECD average of 472—and a decrease of 13 points compared to the previous cycle. According to the OECD (2018), the mathematical competencies assessed in PISA include logical reasoning, conceptual understanding, procedural fluency, and the application of mathematical tools to describe, estimate, and analyze phenomena. These competencies are closely linked to mathematical communication, which involves expressing ideas through concepts, algebraic representations, images, or diagrams. This aligns with Prayitno et al. (2013), who define mathematical communication as the ability to convey and utilize mathematical ideas in written form, pictures, tables, diagrams, formulas, or demonstrations. Therefore, Indonesia's low PISA performance may be attributed in part to students' limited mathematical communication abilities.

This issue is also reflected in the local context at SMP Negeri 45 Bandar Lampung, based on the results of an initial assessment. The findings revealed that only 8% of students (2 out of 25) were able to answer the questions correctly, while the remaining 92% (23 out of 25) failed to provide appropriate and comprehensive responses. Students struggled to articulate their ideas, relate their answers to the problems posed, and present their solutions in a structured written form. This indicates that students' ability to express mathematical ideas—particularly in connecting real-life contexts to mathematical concepts and in explaining solutions systematically—is still significantly lacking.

The lack of students' mathematical communication skills at SMP Negeri 45 Bandar Lampung is further supported by the results of interviews and classroom observations. Interviews with mathematics teachers revealed that the implementation of learning models in the classroom remains suboptimal, with instruction still largely teacher-centered. Observational data indicated that teachers primarily conveyed learning objectives, explained the material, and assigned practice problems, but did not actively guide or monitor students' learning processes. According to Sibarani et al. (2022), teacher-centered learning does not provide adequate opportunities for students to develop and express their mathematical reasoning. As a result, students tend to struggle with using mathematical symbols accurately, presenting contextual problems in mathematical form, and articulating their ideas coherently in solving problems. This suggests that current learning practices at SMP Negeri 45 Bandar Lampung have not sufficiently facilitated the development of students' mathematical communication skills, particularly in expressing ideas and explaining solutions in written form.

To address these challenges, it is necessary to apply a learning model that offers students the opportunity to express mathematical ideas while solving contextual problems. One such model is the guided inquiry learning model, which promotes active student engagement through questioning and articulating ideas in response to teacher-facilitated prompts (Anam, 2016). Purnomo (2021) asserts that mathematics learning becomes more effective when students are actively involved in exploring, working on, and independently solving mathematical problems. Moreover, Haqiki et al. (2016) explain that the guided inquiry model is designed to foster communication skills by requiring students to express their thoughts on

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unfamiliar topics, investigate unusual phenomena, and scientifically describe and compare facts (Silfi & Umatin, 2019).

Despite its strengths, guided inquiry has a notable drawback—namely, the complexity and time required for teachers to design and implement it effectively (Faelani, 2020). To overcome this limitation and support students in developing stronger mathematical communication skills, it is essential to incorporate appropriate learning media. As Simanullang (2023) suggests, effective media can help students understand and solve problems more efficiently. Wahyuningtyas & Sulasmono (2020) also argue that suitable media can ease instructional burdens while making learning more effective and time-efficient. In this context, Desmos presents a promising solution to complement guided inquiry and enhance mathematical communication.

Desmos is a digital platform that provides mathematical tools, curriculum resources, and interactive activities accessible via smartphones or web browsers (Kristanto, 2021). It integrates multiple mathematical domains—such as algebra, geometry, statistics, and calculus—into a single user-friendly interface. The platform also features intuitive graphing tools that allow students and teachers to visualize abstract mathematical concepts more clearly (Ishartono et al., 2018). According to Desmos Inc. (2017), the platform offers three main features: (1) a graphing calculator for real-time visualizations of function equations; (2) slider tools for adjusting variable values dynamically and observing their effects; and (3) data tables that automatically generate corresponding graphs from user-inputted values. These features support students in developing conceptual understanding and communicating mathematical ideas effectively.

Several studies have demonstrated the potential of Desmos to enhance mathematical communication skills. Ramadhan & Setyaningrum (2024) reported that Desmos promotes active engagement, collaboration, and exploration—three essential components of effective mathematical communication. Students using Desmos are encouraged to create graphs, solve problems, and explain concepts, while also sharing ideas with peers in interactive settings. Similarly, Sihite et al. (2023) found that students with prior experience using interactive tools such as Desmos tend to express their mathematical reasoning more logically and systematically. In contrast, Heriyanto et al. (2022) observed that students in classrooms lacking interactive media tended to rely on rote learning and unsystematic problem-solving approaches, which ultimately limited their ability to communicate mathematical ideas effectively.

In light of these findings and challenges, this study aims to examine the effectiveness of the guided inquiry learning model integrated with Desmos in enhancing students' mathematical communication skills. The research seeks to determine whether the combination of active learning and interactive digital tools can provide a more supportive environment for students to articulate mathematical concepts, reason logically, and communicate their ideas with clarity.

METHODS

This research employed a quasi-experimental design with a quantitative approach. The study population consisted of 107 ninth-grade students at SMP Negeri 45 Bandar Lampung, distributed across four classes: 9.1 to 9.4. The sample was selected using a cluster random sampling technique. Based on the sampling process, two classes were chosen: class 9.3 as the experimental group, which received instruction using the guided inquiry learning model integrated with Desmos, and class 9.2 as the control group, which received the same learning model without Desmos integration. The design implemented in this study was a posttest-only control group design, selected based on the results of an initial assessment, which indicated that students' mathematical communication skills across the ninth-grade classes were relatively equivalent prior to the intervention.

The data collection technique used in this study was a test. This test was administered in both the experimental and control groups to measure students' mathematical communication skills after the implementation of the respective learning models. The test instrument used was a posttest in the form of descriptive questions. The instrument underwent a validation process and was found to be valid, reliable, and met quality criteria in terms of discriminatory power (sufficient to good), as well as difficulty level (moderate to difficult).

The data analysis procedure began with assumption testing, which included normality and homogeneity tests. The results showed that the data for students' mathematical communication skills in both the experimental and control groups were normally distributed and homogeneous in variance. Therefore, hypothesis testing was conducted using the independent samples t-test to compare the means between the two groups.

The research hypotheses were formulated as follows:

$H_0: \mu_1 = \mu_2$

There is no significant difference between the average mathematical communication scores of students who received guided inquiry learning with Desmos and those who received guided inquiry learning without Desmos.

$H_1: \mu_1 > \mu_2$

The average mathematical communication score of students who received guided inquiry learning with Desmos is significantly higher than that of students who received guided inquiry learning without Desmos.

The formula for the independent samples t-test used in this study, based on Sudjana (2005, p. 243), is as follows:

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$$t = \frac{\bar{x}_1 - \bar{x}_2}{s\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$$

with

$$s^2 = \frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{n_1 + n_2 - 2}$$

Description:

$\overline{x_1}$: Average score of experimental class students

$\overline{x_2}$: Average score of control class students

n_1 : The number of experimental class students

n_2 : Number of control class students

s_1^2 : Variance of the experimental class

s_2^2 : Variance of the control class

s^2 : Combined variance

The decision rule is:

Accept H_0 if $t_{count} < t_{table}$ with $t_{table} = t_{(1-\alpha)(n_1+n_2-2)}$ and $\alpha = 0{,}05$.

FINDING AND DISCUSSION

Data on students' mathematical communication skills, obtained through posttest scores in both the experimental and control classes, are presented in Table 1.

Table 1. Posttest Results of Students' Mathematical Communication Skills

Class	Number of Students	Mean	Standard Deviation	Lowest Score	Highest Score
Experimental	27	23.92	6.08	10	35
Control	26	20.54	6.01	8	30

As shown in Table 1, the mean score of mathematical communication skills in the experimental class, which implemented the guided inquiry learning model with Desmos, was higher (M = 23.92) than that of the control class, which applied the guided inquiry model without Desmos (M = 20.54). In terms of score variability, the standard deviation in the experimental class (SD = 6.08) was slightly greater than that of the control class (SD = 6.01), indicating a more varied distribution of students' performance in the experimental group.

Further analysis was conducted to assess the achievement of each indicator of mathematical communication skills. The percentage results for each indicator in both groups are summarized in Table 2.

Table 2. Percentage of Indicator Achievement in Mathematical Communication Skills

No	Indicator	Experimental	Control
1	Written Text	73%	64%
2	Mathematical Expression	70%	57%
3	Drawing	63%	50%

Table 2 shows that for all three indicators—written text, mathematical expression, and drawing—the experimental group consistently achieved higher percentages than the control group. The achievement gap between the two groups was 9% for written text, 13% for mathematical expression, and 13% for drawing. These findings indicate that students who received instruction through the guided inquiry learning model integrated with Desmos demonstrated better performance across all aspects of mathematical communication compared to those in the control group.

Prior to hypothesis testing, assumption tests were conducted to ensure that the data met the criteria for parametric analysis. The results of the normality and homogeneity tests confirmed that the data from both groups were normally distributed and had homogeneous variances. Consequently, an independent samples t-test was employed to evaluate the research hypothesis.

The t-test results at a significance level of 0.05 revealed that the calculated t-value (t = 2.08) exceeded the critical value (t_table = 1.67). Based on this result, the null hypothesis (H_0) was rejected, and the alternative hypothesis (H_1) was accepted. This indicates that the average score of students' mathematical communication skills in the group taught with the Desmos-assisted guided inquiry model was significantly higher than that of students in the group taught without Desmos.

Based on the results of hypothesis testing, it was found that the mathematical communication skills of students who participated in guided inquiry learning assisted by the Desmos application were higher than those of students who received guided inquiry learning without the use of Desmos. Additionally, the achievement of each indicator of mathematical communication skills was also superior in the experimental group. These findings suggest that technological support through Desmos contributes positively to enhancing students' mathematical communication abilities. This aligns with the findings of Heriyanto et al. (2022), which showed that mathematics learning integrated with the Desmos application significantly improved students' mathematical communication skills compared to learning without Desmos support.

In terms of indicator-specific performance, the experimental class demonstrated higher percentage achievements across all indicators. For the drawing indicator, students in the experimental group were able to represent mathematical ideas

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through images more clearly and accurately than those in the control group. This improvement is attributable to the structured use of Desmos in student worksheets (LKPD), where students were guided to explore and visualize geometric objects. During presentations, students also demonstrated the effective use of Desmos features to arrive at and communicate their solutions. These findings are consistent with Faradisa et al. (2019), who reported that the use of Desmos fosters greater student confidence in addressing abstract mathematical problems and facilitates a clearer understanding of geometry—an area that is often challenging to represent manually due to accuracy and neatness issues.

For the written text indicator, students engaged in Desmos-assisted guided inquiry were better able to articulate key information and provide clear explanations. The integration of Desmos encouraged students to describe and reflect on their activities and observations within the application, thereby enhancing their ability to express mathematical reasoning in a structured manner. This finding is supported by Ramadhan & Setyaningrum (2024), who emphasized that Desmos enables users to create clear and interactive visualizations, allowing for more comprehensive communication of mathematical ideas—both orally and in written form.

With regard to the mathematical expression indicator, students in the experimental group were more capable of presenting ideas and real-world situations using accurate and complete mathematical models. In each learning session, they were encouraged to input equations directly into Desmos, facilitating their understanding of the relationship between algebraic expressions and graphical representations. This practice not only improved their symbolic fluency but also supported appropriate use of mathematical notation. This observation aligns with Nisa et al. (2025), who highlighted the benefits of Desmos in modeling mathematical equations dynamically, particularly in secondary mathematics education.

The use of Desmos played a pivotal role during the implementation of guided inquiry learning, particularly in supporting the data collection process. Its ability to visualize mathematical concepts clearly and interactively contributed to the effectiveness of each learning stage. Furthermore, Desmos fostered collaborative learning environments by enabling students to discuss and share their findings with peers and teachers. Through these interactions, students were given the autonomy to explore multiple problem-solving strategies, which deepened their conceptual understanding and strengthened their communication skills.

However, several challenges were encountered during implementation. Some students required additional time to become familiar with Desmos, which posed time management difficulties for the teacher and affected classroom conduciveness. To address this issue, it is recommended that teachers provide supplementary learning resources, such as tutorial videos, that students can access outside of class hours to reinforce their understanding. This approach is in line with Fransiska et al. (2024), who emphasized that learning resources serve as important tools for conveying information and supporting teachers in delivering learning materials more effectively. Peer support can also be leveraged, whereby students who have mastered the application assist others, reducing dependency on the teacher and maintaining classroom flow.

In contrast, the control class, which utilized guided inquiry without Desmos and relied on textbooks and visual aids such as maps, demonstrated some improvement in understanding geometric concepts. Nevertheless, the lack of active student participation—reflected in limited questioning and low engagement in discussions—led to less dynamic classroom interactions. Moreover, issues such as unpreparedness in using drawing tools, difficulty in constructing accurate geometric representations, and messy illustrations contributed to the low achievement on the drawing indicator. These limitations hindered students' ability to visually express their ideas, indicating that their visual mathematical communication had not yet developed optimally.

CONCLUSIONS AND RECOMMENDATIONS

The results of this study demonstrate that the application of the guided inquiry learning model integrated with Desmos significantly improves the mathematical communication skills of ninth-grade students at SMP Negeri 45 Bandar Lampung during the even semester of the 2024/2025 academic year. Students in the experimental group showed higher levels of achievement across all indicators—written explanation, visual representation, and mathematical modeling—compared to those in the control group. The use of Desmos enabled students to visualize abstract mathematical concepts, explore multiple representations, and communicate their reasoning with greater clarity and structure. Additionally, the integration of Desmos fostered collaborative learning and increased student engagement during the problem-solving process. These findings highlight the importance of combining inquiry-based pedagogies with technological tools to support students' ability to express mathematical ideas effectively. In light of this, it is recommended that teachers provide introductory learning resources or demonstrations to help students become familiar with Desmos before its classroom implementation, thereby ensuring that learning activities run more efficiently and meaningfully.

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