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

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Abstract

This quasi-experimental study aimed to analyze the effect of implementing the guided inquiry learning model on students' mathematical communication skills. The research population consisted of all eighth-grade students of SMP Negeri 2 Sekampung Udik, East Lampung, in the 2025/2026 academic year, totaling 184 students. The sample of this study comprised students from classes VIII.3 and VIII.5, with 30 and 28 students respectively, selected using the cluster random sampling technique. The research design employed was a posttest-only control group design. The data analyzed were quantitative data on students' mathematical communication skills obtained through an essay test on the topic of Systems of Linear Equations in Two Variables (SPLDV). Data analysis was conducted using a t-test. The results showed that students who learned using the guided inquiry learning model had higher mathematical communication skills than those who participated in conventional learning. Therefore, it can be concluded that the implementation of the guided inquiry learning model has a significant effect on students' mathematical communication skills.

Keywords: *effect, guided inquiry, mathematical communication skills*

Introduction

Education plays a major role in responding to changes and increasingly complex demands that arise along with the advancement of the times (Mardhiyah et al., 2021). According to Law No. 20 of 2003, education is defined as a conscious and well-planned effort to create a learning process that enables students to actively develop their potential, including spiritual strength, self-control, intelligence, noble character, and the skills required for social, national, and civic life. Tasbih & Andriani (2024) state that education plays a crucial role in improving the quality of human resources so that individuals are able to compete and adapt to global demands.

One of the fields of study that contributes significantly to the development of human resource quality is mathematics (Simbolon, 2020). Mathematics is taught at every level of education and serves as an essential foundation for the advancement of science (Putri et al., 2022). Fauzan dan Anshari (2024) state that mathematics functions as a tool for logical and scientific thinking and contributes to the development of both the exact sciences and the social sciences. According to Naibaho et al., (2021) mathematics is a universal discipline that plays a role across various fields of study, strengthens human thinking skills, and underlies the development of modern technology.

Mathematics learning is an interaction process between teachers and students that takes place in a structured manner in studying mathematical concepts, enabling students to acquire, understand, and communicate the knowledge they have learned (Efriani et al., 2015). The BSKAP of the Ministry of Education, Culture, Research, and Technology (2025) states that mathematics learning directs students to express ideas through various forms of representation, including visual, symbolic, and mathematical models. One of the objectives of mathematics learning formulated by the *National Council of Teachers of Mathematics* (2020) is to enable students to develop mathematical communication skills.

Mathematical communication skills play an important role in supporting successful learning, as they enable students to construct and accurately convey their understanding of the concepts being studied (Lubis et al., 2023). Through these skills, students are able to communicate ideas, strategies, and problem-solving procedures using mathematical language, symbols, or notation, both orally and in writing (Nabila et al., 2024). Qomariyah & Setianingsih (2021) define mathematical communication skills as students' ability to communicate ideas, strategies, and procedures for solving mathematical problems, including transforming real-life situations into mathematical symbols or models. In addition, Afifah et al. (2020) state that strong mathematical communication skills facilitate students' understanding of problems and their ability to determine appropriate solution steps, thereby positively influencing comprehension and academic achievement.

However, numerous international studies indicate that Indonesian students' mathematical communication skills remain at a relatively low level. The results of the Trends in International Mathematics and Science Study (TIMSS) 2015 show that Indonesia obtained a score of 397, which is below the Low International Benchmark, and ranked 44th out of 49 participating countries (IEA, 2016). In TIMSS, this ability is assessed through constructed-response items that require students to present answers accompanied by explanations and the use of diagrams to represent mathematical thinking processes (IEA, 2016). Therefore, the low achievement indicates the weakness of students' mathematical communication skills.

Similar findings are also reflected in the results of PISA 2022, which report that the average mathematics score of Indonesian students was 366, far below the OECD average of 472, placing Indonesia 63rd out of 81 participating countries (OECD, 2023). In addition, only 18% of Indonesian students reached Level 2, which is considerably lower than the

OECD average of 69% (OECD, 2023). One of the fundamental competencies assessed in PISA is mathematical communication skills, as reflected in constructed-response items that require students to explain strategies, models, and logical reasoning in problem solving (OECD, 2023). The low achievement at higher proficiency levels indicates that students still experience difficulties in clearly expressing mathematical ideas and thinking processes (Machmuda et al., 2024).

The low level of mathematical communication skills was also identified among eighth-grade students at SMP Negeri 2 Sekampung Udik, East Lampung. This finding is supported by the results of a preliminary study, which indicate that most students still experience difficulties in accurately presenting data, writing calculation steps systematically, and expressing reasoning and problem-solving processes using their own language. Classroom observations show that students actually demonstrate high enthusiasm and curiosity when engaged in discussions of solutions. However, learning activities that are still dominated by the teacher's role limit students' opportunities to express ideas, share opinions, and actively participate in the learning process. This condition highlights the need for the implementation of a learning model that provides broader opportunities for students to actively construct understanding and effectively communicate mathematical ideas.

The implementation of the guided inquiry learning model has the potential to enhance students' mathematical communication skills because it provides opportunities for students to actively participate in exploring, investigating, and constructing knowledge through direct learning experiences. According to Muhazira et al. (2024) the guided inquiry learning model emphasizes students' active involvement in the learning process, in which students are encouraged to explore, investigate, and discover knowledge through firsthand experiences during learning activities. Meanwhile, the teacher acts as a facilitator, motivator, and guide throughout the learning process (Ningtias & Soraya, 2022). Wandini et al. (2024) explain that the guided inquiry learning model allows students to build their understanding and communicate their ideas through inquiry activities with teacher guidance. The learning process in the guided inquiry model proceeds systematically through interrelated stages, namely orientation, problem formulation, hypothesis development, data collection, hypothesis testing, and conclusion formulation (Wiyoko & Astuti, 2020; Ilhamdi et al., 2020). This sequence of stages provides a structured learning environment that enables students to develop mathematical communication skills through activities such as expressing ideas, writing strategies, and presenting investigation results both orally and in written form.

Based on this rationale, this study examines the effect of the guided inquiry learning model on students' mathematical communication skills.

Method

This study employed a quasi-experimental method with a posttest-only control group design. The research population consisted of all eighth-grade students of SMP Negeri 2 Sekampung Udik, East Lampung, in the 2025/2026 academic year, totaling 184 students. The research sample was selected using a cluster random sampling technique, resulting in class VIII.3 being assigned as the experimental group, which received instruction using the guided inquiry learning model, and class VIII.5 as the control group, which received direct instruction.

The instrument used was a test in the form of three open-ended questions on the topic of Systems of Linear Equations in Two Variables, developed based on indicators of mathematical communication skills, including written text, drawing, and mathematical expression. The indicators of mathematical communication skills applied in this study are presented in Table 1.

Table 1. Indicators of Students' Mathematical Communication Skills

Indicator	Description
Written text	Explaining and writing ideas or solutions to a problem using one's own words.
Drawing	Explaining ideas or solutions to a problem in the form of pictures, diagrams, graphs, or tables.
Mathematical Expression	Expressing ideas or problem situations in the form of mathematical symbols or models, and solving them

Before being used, the instrument was piloted and analyzed in terms of content validity, reliability, discriminating power, and difficulty level. A summary of the instrument testing results is presented in Table 2.

Table 2. Recapitulation of Instrument Testing Results

Item	Validity	Reliability	Discriminating Power	Difficulty Level	Conclusion
1	valid	0,80 (reliable)	0,41 (good)	0,45 (medium)	Used
2a			0,43 (good)	0,48 (medium)	
2b			0,43 (good)	0,43 (medium)	
2c			0,40 (good)	0,32 (medium)	
3a			0,42 (good)	0,58 (medium)	
3b			0,43 (good)	0,31 (medium)	

The research procedure involved administering a treatment to the experimental class using the guided inquiry learning model and to the control class using conventional instruction, followed by the administration of a posttest to both classes. The data were analyzed through prerequisite tests, namely the normality test and the homogeneity test. Based on the results of these prerequisite tests, it was found that the data on students' mathematical communication skills were drawn from a normally distributed population and had homogeneous variances. Therefore, the analysis of mathematical communication skills in this study employed the t-test.

Results and Discussion

The results of this study aim to determine the effect of the guided inquiry learning model on students' mathematical communication skills. The research data were obtained from posttest scores of mathematical communication skills from both the experimental and control classes. The posttest results are presented in Table 3.

Table 3. Posttest Data on Students' Mathematical Communication Skills

Class	Number of Student	Mean	Lowest Score	Highest Score	Standard Deviation
Guided Inquiry	30	16,33	6	26	4,46
Conventional	28	13,25	2	23	5,55

Based on Table 3, it can be seen that the mean posttest score of students' mathematical communication skills in the experimental class was higher than that in the control class. The experimental class achieved a mean score of 16.33, while the control class obtained a mean score of 13.25. In addition, the larger standard deviation in the control class indicates a more varied distribution of scores, whereas the experimental class shows a more stable score distribution.

Prior to testing the posttest scores of students' mathematical communication skills, prerequisite tests consisting of normality and homogeneity tests were conducted. The normality test was performed using the chi-square test at a significance level of 0,05 which showed that the data from the experimental class ($\chi^2_{calculated} = 1{,}63 < \chi^2_{critical} = 7{,}81$) and the control class ($\chi^2_{calculated} = 1{,}19 < \chi^2_{critical} = 7{,}81$) were drawn from normally distributed populations. Subsequently, the homogeneity test was carried out using an F-test at a significance level of 0,05. The results indicated that $F_{calculated} = 1{,}55 < F_{critical} = 2{,}12$, leading to the conclusion that the two classes had homogeneous variances.

Based on the results of the prerequisite tests, the analysis was continued using a t-test to compare the mean posttest scores of students' mathematical communication skills. The t-test results yielded a value of $t_{calculated}$ = 2,34 and $t_{critical}$ = 1,67 indicating that

$t_{calculated} > t_{critical}$. This result indicates that the mean posttest score of students' mathematical communication skills taught using the guided inquiry learning model was higher than that of students taught using conventional instruction. Therefore, it can be concluded that the guided inquiry learning model has a significant effect on students' mathematical communication skills.

Furthermore, the results of the analysis of the percentage achievement for each indicator of mathematical communication skills show that students taught using the guided inquiry learning model achieved higher percentages than those taught using conventional instruction. The detailed achievement of each indicator of students' mathematical communication skills is presented in Table 4.

Table 4. Achievement of Students' Mathematical Communication Skill Indicators

Indicator	Guided Inquiry	Conventional Learning
Drawing	62,22%	46,83%
Mathematical Expression	79,63%	69,05%
Written Text	38,52%	33,33%
Average	60,12%	49,74%

As shown in Table 4, the analysis of achievement on the indicators of mathematical communication skills demonstrates the superiority of the experimental class across all measured indicators, namely drawing, mathematical expression, and written text. The average percentage of indicator achievement in the experimental class reached 60.12%, which was higher than that of the control class at 49.74%. This advantage was consistently observed across each indicator, indicating that the guided inquiry learning model not only improved overall outcomes but also supported the development of all three indicators of mathematical communication skills.

The achievement of students' mathematical communication skills in the class that implemented the guided inquiry learning model is closely related to the effective implementation of the learning stages, namely orientation, problem formulation, hypothesis development, data collection, hypothesis testing, and conclusion formulation. All of these stages were integrated into learning activities contained in the Student Worksheet (LKPD), which functioned as instructional material to guide students in understanding the content and carrying out the learning process in a structured manner (Sari & Rahmawati, 2023).

At the orientation stage, students are introduced to contextual problems through the Student Worksheet (LKPD), directing their attention to the issues to be examined. This stage plays an important role in building students' initial understanding and motivating them to actively engage in the learning process (Endahwuri, 2015). Through group discussions, students begin to express initial ideas and consider problem-solving steps, thereby cognitively preparing them to think systematically and in a structured manner before proceeding to the next stage (Wandini et al., 2024).

At the problem formulation stage, students construct questions that lead toward problem solving after examining the problems presented in the Student Worksheet (LKPD). This process helps students identify essential information and clearly communicate their initial understanding, thereby making the direction of the inquiry more structured (Ningtias & Soraya, 2022; Pedaste et al., 2015).

At the hypothesis development stage, students formulate tentative answers relevant to the problems presented in the Student Worksheet (LKPD) using their own words. These hypotheses train students to express ideas and understanding in solving problems (Wandini et al., 2024). In addition, students connect their prior knowledge with information from the problems to construct provisional answers. Such prior knowledge helps students think systematically and develop relevant tentative solutions (Panggabean & Tamba, 2020).

At the fourth stage, data collection, students actively work with their groups to search for and gather information to solve the problems in the Student Worksheet (LKPD), and then present the data in the form of tables, narratives, or graphs. The information obtained helps students understand the problems and verify the validity of the hypotheses that have been formulated (Pujiana et al., 2024). Furthermore, students discuss the collected data with group members to ensure the adequacy of the information. This activity indicates that students begin to organize data systematically and communicate their findings using their own language, thereby fostering the development of mathematical communication skills (Na'im & Mukhlis (2024).

Next, at the hypothesis testing stage, students analyze the data that have been collected to solve the problems. This stage encourages students to critically examine the validity of the hypotheses with teacher guidance (Wandini et al., 2024). In addition, students formulate final answers and compare them with the previously proposed hypotheses as part of testing the inquiry results. This process helps students evaluate hypotheses based on the obtained data, leading to more accurate understanding (Pedaste et al., 2015). During this activity, the teacher provides guidance through prompting questions and directs students to keep the discussion focused. This is in line with (Lazonder & Harmsen, 2016) who emphasize that in guided inquiry learning, the teacher’s role is to provide scaffolding through guiding questions so that students' thinking processes remain well directed. Furthermore, students are given the opportunity to present the results of their group discussions in front of the class to communicate the problem-solving processes and outcomes that have been discussed. This activity enables students to express ideas and exchange perspectives, thereby strengthening their understanding of the solutions (Sasongko & Lefrida, 2024).

Finally, at the conclusion formulation stage, the teacher and students collaboratively formulate conclusions related to the learning activities that have taken place. This activity trains students to communicate the results of their thinking clearly and coherently, thereby ensuring that learning ideas are well organized (Wandini et al., 2024). Subsequently, the teacher guides students to review the problem-solving steps and the results obtained so that students understand the relationship between the process and the solution. Teacher guidance helps students reflect on their thinking processes and understand problem-solving strategies (Lazonder & Harmsen, 2016). Students then formulate conclusions based on their understanding and record them in the Student Worksheet (LKPD) through discussion and teacher guidance. This activity aims to reinforce learning outcomes and align students' understanding toward accurate problem solving (Pedaste et al., 2015).

Based on the analysis of the achievement of each indicator of mathematical communication skills, the posttest scores of students who were taught using the guided inquiry learning model were higher than those of students who received conventional instruction. For the drawing indicator, the difference in posttest scores was 15.39%, with the guided inquiry class outperforming the conventional class. This occurred because most students in the guided inquiry class were able to express mathematical ideas through drawings, graphs, or tables in accordance with the given problems. This ability developed as students were trained to express mathematical ideas using various forms of representation during problem solving, which helped them become more accustomed to communicating mathematical ideas more effectively (Riyadi et al., 2022). This finding is consistent with Wandini et al. (2024) who explain that the guided inquiry model enhances students' ability to use various forms of mathematical representation to convey ideas.

For the mathematical expression indicator, the difference in posttest scores was 10.58%, with the implementation of the guided inquiry learning model outperforming conventional instruction. This advantage occurred because students taught using the guided inquiry model were better able to write and formulate mathematical notation accurately. This learning model positions students as active participants in expressing mathematical ideas from problem formulation to problem solving, thereby accustoming them to using mathematical language and symbols in a structured manner (Wandini et al., 2024). In addition, learning activities that encourage students to express ideas through the use of symbols, formulas, and various forms of representation when presenting problem solutions promote a more systematic development of mathematical communication skills. This finding is consistent with the study by Samsidar (2018) which showed that the guided inquiry model improves students' ability to accurately translate real-life situations into mathematical symbols or language.

For the written text indicator, the difference in posttest scores was 5.19%, with the class that implemented the guided inquiry learning model achieving higher results. This was because most students in the guided inquiry class were better able to write mathematical ideas and arguments in a coherent manner compared to students in the conventional class. According to Yana et al. (2021), in this learning model, students are accustomed to composing written explanations based on the results of inquiry activities, resulting in a more systematic flow of mathematical ideas. This habituation occurs through recording discussion results and writing justifications in the Student Worksheet (LKPD), which trains students to construct explanations and arguments in a structured way. In addition, the activity of writing down reasoning and problem-solving processes during guided inquiry learning encourages students to communicate mathematical ideas clearly and logically (Salsabila et al., 2025).

The differences in learning outcomes between the two classes, as viewed from the posttest scores of mathematical communication skills, were influenced by the different learning models applied. In the class that implemented the guided inquiry learning model, students were actively involved in inquiry and discussion activities throughout the learning process. The stages of the guided inquiry model encourage students to express ideas and opinions and to explain problem-solving strategies both orally and in writing. Through this process, students become accustomed to communicating mathematical ideas using their own language and appropriate symbols, tables, or diagrams. This is consistent with Fara et al. (2019) who explain that improvements in mathematical communication skills in guided inquiry learning occur because students are given opportunities to construct understanding, present arguments, and write down their thinking outcomes through LKPD-based activities.

In contrast, in the class that implemented conventional instruction using the direct learning model, the learning process tended to be teacher-centered. The teacher delivered the material and sample problems, while students mostly listened, took notes, and imitated the demonstrated solution steps. This learning approach was conducted in a structured manner with the teacher serving as the primary source of information (Gusmaneli et al., 2024). As a result, students' opportunities to express opinions and independently explain mathematical ideas were relatively limited, leading to less optimal development of mathematical communication skills. Nabila et al. (2025) state that although direct instruction supports content understanding, it provides fewer opportunities for students to develop mathematical communication skills compared to guided inquiry.

Based on the discussion above, the implementation of the guided inquiry learning model provides greater opportunities to enhance students' mathematical communication skills compared to conventional instruction. Through learning stages designed to actively engage students in observing, discussing, and communicating their thinking outcomes, students are trained to express mathematical ideas. This is consistent with Salsabila et al. (2025) who explain that the implementation of the guided inquiry model is able to improve students' mathematical communication skills because it emphasizes discussion, exploration, and the communication of ideas during learning. Thus, the guided inquiry learning model not only focuses on final outcomes but also habituates students to systematically communicate their mathematical thinking processes.

Conclusion and Suggestion

Based on the research findings and discussion, it was found that the mathematical communication skills of students who were taught using the guided inquiry learning model were higher than those of students who received conventional instruction. It can be concluded that the implementation of the guided inquiry learning model has a significant effect on students' mathematical communication skills. For future researchers who intend to conduct similar studies, it is recommended that the use of Student Worksheets (LKPD) be implemented gradually through clear guidance and structured scaffolding, so that students become accustomed to the stages of learning and are able to express their ideas in an organized manner. This approach is expected to ensure that the learning process remains focused, conducive, and systematic.

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