



The Effect of Inquiry-Based Learning (IBL) on Junior High School Students' Mathematical Communication Skills and Creativity in Algebra

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Abstract

This research aims to describe; the effect of the Inquiry-Based Learning (IBL) model on students' mathematical communication skills and creativity; the instructional model that has a greater effect between the Inquiry-Based Learning (IBL) model and the Direct Instruction model on students' mathematical communication skills; the instructional model that has a greater effect between the Inquiry-Based Learning (IBL) model and the Direct Instruction model on students' creativity. The population in this study consisted of all seventh-grade students at SMPN 1 Sampung. This research is a quasi-experimental study. The samples were class VII A and VII B students. Class VII A was the experimental class using the Inquiry-Based Learning (IBL) model, and class VII B was the control class using the Direct Instruction model. The data collection methods used were a mathematical communication skill test and a creativity questionnaire. The reliability of the instruments was confirmed using Cronbach's Alpha. To determine the influence of the applied instructional models, Hotelling's T^2 test was used. To compare which instructional model had a greater effect, an independent samples t-test was employed. The results of the study show that: the Inquiry-Based Learning (IBL) model had an effect on students' mathematical communication skills and creativity; the Inquiry-Based Learning (IBL) model had a greater effect than the Direct Instruction model on students' mathematical communication skills; the Inquiry-Based Learning (IBL) model had a greater effect than the Direct Instruction model on students' creativity.

Keywords: *Inquiry-Based Learning (IBL); Direct Instruction; Mathematical Communication; Creativity*

Introduction

Learning is one of the core activities in schools, involving both teachers and students. Learning is a systematic effort to create a potential learning environment and produce a learning process that leads to the development of students' potential (Khadijah, 2013). The learning outcomes will be used as a reference for the next learning process (Makki & Aflahah, 2019). The learning outcomes will show how students' abilities have developed at school. To develop students' abilities, there are several subjects that students can study at school.

In learning activities, one of the subjects studied by students at school is mathematics. Mathematics learning in the classroom is an important part because it is not only about numeracy skills,

but also about students' ability to think critically and logically in solving problems. Learning mathematics can help students get used to thinking systematically, scientifically, logically, and critically, as well as increasing their creativity (Haerudin, 2022). Although it is an important subject, mathematics is considered a difficult subject by students. According to research conducted by Salsabila et al. (2023) that as many as 88% of Junior High School students do not like mathematics and the remaining 12% of students like mathematics. The percentage of students who do not like math is more than that of students who like math. One of the reasons is the difficulty of understanding the material.

One of the materials on mathematics that is considered difficult by students is algebra. Algebra is a material that is taught in the seventh grade of Junior High School. In algebra material, what is learned is about various rules, symbols, and operating systems, and this material is a prerequisite material in learning materials such as PLSV, SPLDV, etc (Klorina & Prabawanto, 2023). Therefore, algebra material is important to be taught in schools and students are expected to understand algebra material because the concept of algebra material will be related to subsequent materials.

However, students feel that algebra is difficult, and there are still students who make mistakes in solving algebra problems. Based on research conducted by Putra et al. (2018), one of the factors causing students' difficulties in solving problems on the topic of linear equations is their weak ability in algebraic operations, which leads to incorrect answers. Algebra is a fundamental or prerequisite material. Therefore, if students do not yet understand algebra, they will have difficulty in solving other problems related to it. Of course, teachers play an important role in mastering the material delivered to students.

One thing that teachers need to consider when teaching is the learning model to be used. The use of various learning models can be an alternative, so that teachers can choose the appropriate and effective learning model to be applied so that educational goals can be achieved (Albina et al., 2022). Therefore, teachers need to pay attention to the selection of learning models. One learning model that can be applied is Inquiry-Based Learning (IBL).

Inquiry-Based Learning (IBL) is a learning model related to the constructivist approach, in which students construct their own knowledge (Aidoo et al., 2022)). Research conducted by Baeti & Mikrayanti (2021) explains that the use of the Inquiry-Based Learning (IBL) learning model has a positive effect on students' mathematics learning outcomes and contributes to the achievement of students' mathematics learning outcomes. Kusmaryono & Setiawati (2013) explain that Inquiry-Based Learning (IBL) aims to improve students' intellectual abilities, especially higher-order thinking skills, train students' problem-solving abilities systematically, create learning conditions where students feel the need to learn, achieve high learning outcomes, and improve students' communication skills. Therefore, based on these studies, the Inquiry-Based Learning (IBL) model is considered effective for mathematics learning in the classroom.

One of the abilities in learning mathematics that needs to be improved is mathematical communication skills. According to NCTM (2000), one of the goals of mathematics learning is to enhance students' abilities, namely: (1) problem solving; (2) mathematical reasoning; (3) mathematical communication; (4) mathematical connections; and (5) mathematical representation. Mathematics learning enables students to think critically in managing diverse information, think creatively in solving various problems, communicate with peers during the learning process, and ensure that each of their ideas can be understood by others (Wulandari et al., 2020). These abilities are important to develop, one of which is mathematical communication skills.

Mathematical communication skills refer to the capacity to convey mathematical ideas either orally or in written form, through representations such as pictures, algebra, or diagrams (Nurlaila et al., 2018). Students have the ability to express their ideas and perspectives in diverse ways, for example through mathematical representations, written words, and other forms of writing. This allows students to

better understand their own ideas and perspectives by engaging in discussions with their peers (Tong et al., 2021).

In mathematics subjects, communication skills play an important role. However, there are still students whose mathematical communication skills are relatively low. Based on research by Faizah & Sugandi (2022), it was found that some students fall into the category of having low mathematical skills, as they were unable to write answers in accordance with the established indicators. Similarly, the study by Hapsoh & Sofyan (2022) showed that there are still students with low mathematical communication skills who are unable to solve equations, construct mathematical models, and evaluate them.

In addition to mathematical communication skills, another important aspect to consider in mathematics learning is creativity. Creativity is a process of developing potential that is sensitive to problems, gaps, missing elements of knowledge, and disharmony, followed by creating solutions to these gaps, formulating temporary answers, and ultimately communicating the results (Purnama et al., 2017). Creativity is necessary for students so that they can choose and apply appropriate paths and methods to solve the problems they encounter effectively (Padliah & Pujiastuti, 2020).

However, there are still students with low levels of creativity. As explained by Trilaksono et al. (2018), students' creativity has not yet been developed, as indicated by their reliance solely on textbooks, which makes it difficult for them to expand the knowledge gained through learning, as well as their lack of courage in developing ideas, imagination, or opinions. Hartiningrum et al. (2020) also states that students' mathematical creativity remains relatively limited because they depend only on what is provided by the teacher without further developing their knowledge based on what they have received. Since students' level of creativity is still considered low, this issue requires teachers' attention.

Based on the previous explanation, this study will examine the effect of the Inquiry-Based Learning (IBL) model on junior high school students' mathematical communication skills and creativity in algebra. The research questions in this study are as follows:

1. Does the Inquiry-Based Learning (IBL) model have an effect on students' mathematical communication skills and creativity?
2. Does the Inquiry-Based Learning (IBL) model have a greater effect on students' mathematical communication skills more than the Direct Instruction model?
3. Does the Inquiry-Based Learning (IBL) model have a greater effect on students' creativity more than the Direct Instruction model?

Methods

This study employed a quantitative approach using a quasi-experimental method. This study will be conducted at SMPN 1 Sampung, located at Jl. Raya Sampung No. 96, Sampung Kidul, Sampung, Kec. Sampung, Kab. Ponorogo, East Java, during the first semester of the 2024/2025 academic year. The sample in this study consists of class VII A and class VII B, with each class comprising 30 students. Both classes share the same characteristics, namely being taught by the same teacher and studying algebra material. The sampling technique used in this study was simple random sampling. The application used to analyze the research results is RStudio.

This study involves two classes, namely the experimental class and the control class. The two classes were given different instructional models. The experimental class was taught using the Inquiry-Based Learning (IBL) model, while the control class was taught using the Direct Instruction model. Both

classes were then administered, a pretest and a posttest. The pretest and posttest consisted of essay test items and a questionnaire. The test items were used to measure students' mathematical communication skills, while the questionnaire was used to measure students' creativity. The instrument grid for the pretest and posttest on mathematical communication skills is presented in Table 1.

Table 1. Indicators Grid for Mathematical Communication Skills Test

No.	Indicator	Question Item
1.	Expressing problems into mathematical ideas or symbols	1
2.	Presenting problems with visual representations	2
3.	Formulating problems into mathematical models and solving them	3
4.	Writing calculation steps in detail according to the objectives of the question	4
5.	Understanding information and drawing conclusions in one's own words	5

Meanwhile, the questionnaire instrument in this study was used to measure students' creativity. The questionnaire consisted of statements related to aspects of students' creativity. There were four answer choices available for students: Never (TP), Rarely (J), Often (S), and Very Often (SS). The grid for the student creativity questionnaire is presented in Table 2.

Table 2. Indicator Grid of the Creativity Questionnaire

No.	Indicator	Criteria	Statement Number	
			Positive	Negative
1.	Fluency	- Providing many answers, solutions, ideas, or questions - Being independent in learning mathematics	1 3, 4, 5	2 6
2.	Flexibility	- Producing answers or questions - Seeking many different alternatives	7 9, 10, 11	8 12, 13, 14
3.	Originality	- Having a strong desire to solve mathematical problems - Being able to provide new methods or expressions	15, 16, 17 20	18, 19 1
4.	Elaboration	- Being active in completing tasks and asking questions - Having the willingness to find methods or answers	22, 23, 24 27, 28	25, 26 29, 30

The measurement in this questionnaire used a Likert scale, which can be seen in more detail in Table 3.

Table 3. Likert Scale

Response Options	Statement Score	
	Positive	Negative
Never (TP)	1	4
Rarely (J)	2	3
Often (S)	3	2
Very Often (SS)	4	1

In addition to tests and questionnaires, there was also a learning implementation observation sheet. The observation sheet was used to ensure that the steps in carrying out the learning activities using

the Inquiry-Based Learning (IBL) and Direct Instruction models were properly implemented. This observation sheet contained activities carried out by both teachers and students during the learning process. It also served to determine whether the learning activities were conducted in accordance with the designed plan.

The validity of the instrument used was content validity, which was measured through expert judgment, while the reliability of the research instrument was measured using Cronbach's Alpha. Hotelling's T^2 was employed to examine the effect of the applied learning models, while the t-test was used to compare which model had a greater effect.

Results

Results of Learning Implementation

The implementation of learning using the Inquiry-Based Learning (IBL) model to enhance students' mathematical communication skills and creativity was carried out from October 1, 2024, to October 28, 2024. The results of the learning implementation can be seen in Table 4.

Table 4. Learning Achievement Percentage

Session	Day/Date	Teacher's Activities	Student's Activities
2	Tuesday, October 8, 2024	65%	65%
3	Monday, October 14, 2024	76%	76%
4	Tuesday, October 15, 2024	88%	82%
5	Monday, October 21, 2024	100%	100%
6	Tuesday, October 22, 2024	100%	100%
Average		86%	85%

Based on Table 4, the average percentage of teacher activities was 86%, while the average percentage of student activities was 85%. This indicates that the implementation of the learning process was carried out effectively.

Furthermore, the implementation of learning using the Direct Instruction model for students' mathematical communication skills and creativity was conducted from October 3, 2024, to October 24, 2024. The results of the learning implementation achievements can be seen in Table 5.

Table 5. Learning Achievement Percentage

Session	Day/Date	Teacher's Activities	Student's Activities
2	Friday, October 4, 2024	65%	65%
3	Thursday, October 10, 2024	82%	65%
4	Friday, October 11, 2024	88%	88%
5	Thursday, October 17, 2024	100%	100%
6	Friday, October 18, 2024	100%	100%
Average		87%	84%

Based on Table 5, the average percentage of teacher activities was 87%, while the average percentage of student activities was 84%. This indicates that the implementation of learning was carried out properly.

Result of Research Data

The data on mathematical communication skills were obtained from the results of the pretest and posttest administered to the students. The pretest and posttest data from both classes can be seen in Table 6.

Table 6. Data Hasil Pretest dan Posttest Kedua Kelas

Keterangan	Kelas Eksperimen		Kelas Kontrol	
	Pretest	Posttest	Pretest	Posttest
Ideal Maximum Score	100	100	100	100
Nilai Maximum Score	65	95	65	95
Ideal Minimum Score	0	0	0	0
Ideal Minimum	20	70	20	70
Average Score	36,17	84,83	35,83	80,33
Variance	159,47	42,47	151,81	38,22
Standard Deviation	12,84	6,63	12,53	6,29

Based on Table 6, it was found that the experimental class using the Inquiry-Based Learning (IBL) model had a higher average posttest score than the control class. Furthermore, the data on students' creativity was obtained from the results of the pretest and posttest conducted with the students. The results of the questionnaire for both classes can be seen in Table 7.

Table 7. Results of Pretest and Posttest for Both Classes

Description	Experimental Class		Control Class	
	Pretest	Posttest	Pretest	Posttest
Ideal Maximum Score	120	120	120	120
Nilai Maximum Score	72	101	74	96
Ideal Minimum Score	30	30	30	30
Ideal Minimum	59	79	58	75
Average Score	64,67	90,47	65,43	85,13
Variance	14,67	35,38	20,78	38,52
Standard Deviation	3,83	5,95	4,56	6,21

Based on Table 12, the experimental class experienced a greater improvement compared to the control class.

Results of Data Analysis

Multivariate Mean Vector Comparison Test

The multivariate mean vector comparison test was conducted to examine the effect of the Inquiry-Based Learning (IBL) model on students' mathematical communication skills and creativity. The test used was Hotelling's T^2 , with a significance level of $\alpha = 0.05$. The results of the Hotelling's T^2 test in this study can be seen in Table 8.

Table 8. The results of the Hotelling's T^2

Description	Hotteling's T^2	p - value
Before treatment	0,481	0,786
After treatment	15,877	0,00036

Based on Table 8, before the treatment, the results obtained were Hotelling's $T^2 = 0.481$ and p-value = 0.786, which is > 0.05 . This indicates that the learning model had no effect on students' mathematical communication skills and creativity before the treatment was applied. After the treatment, the results were Hotelling's $T^2 = 15.877$ and p-value = 0.00036, which is < 0.05 . This indicates that the learning model had a significant effect on students' mathematical communication skills and creativity after the treatment was applied.

Univariate t-Test

The univariate t-test was used to examine the mean scores of the learning models in this study. From these mean scores, the more effective learning model between the Inquiry-Based Learning (IBL) model and the Direct Instruction model can be determined. The results of the univariate t-test in this study can be seen in Table 9.

Table 9. t-Test Results

Variable	t-Test	p - value
Mathematical Communication	2,698	0,009
Creativity	3,341	0,001

Based on Table 9, the results show that for mathematical communication skills, the t-test value was 2.698 with a p-value of 0.009, which is < 0.05 . This indicates that the Inquiry-Based Learning (IBL) model is more effective than the Direct Instruction model in improving students' mathematical communication skills. For student creativity, the t-test value was 3.341 with a p-value of 0.001, which is < 0.05 . This indicates that the Inquiry-Based Learning (IBL) model is more effective than the Direct Instruction model in enhancing students' creativity.

Discussion

The Effect of the Inquiry-Based Learning (IBL) Model on Students' Mathematical Communication Skills and Creativity

The results of the statistical analysis showed that the experimental class using the Inquiry-Based Learning (IBL) model experienced an improvement, indicating that students' abilities increased after the treatment was applied. Based on observations of the learning implementation, it was shown that the learning activities were conducted effectively. Although at the beginning of the learning process, an adaptation between the teacher and students regarding the Inquiry-Based Learning (IBL) model was necessary. This aligned with Alvionita et al. (2022), who stated that initially, teachers may encounter difficulties in implementing the Inquiry-Based Learning (IBL) model; however, once adaptation occurs, it can be carried out effectively.

Furthermore, observations indicated that the IBL model was implemented according to its steps, and statistical analysis confirmed its effect on students' mathematical communication skills and

creativity. This is likely because, in the Inquiry-Based Learning (IBL) model, students are actively involved in the learning activities.

In the experimental class using the Inquiry-Based Learning (IBL) model, there were students with high scores in both mathematical communication skills and creativity. This indicates that when students can express mathematical ideas effectively, their thinking skills are also trained. Furthermore, when students have high creativity, they have more ideas to convey, which enhances their communication skills. This aligns with the study conducted by Azizah et al. (2017), which stated that in Inquiry-Based Learning (IBL), students are required to engage in analytical activities related to the material, while the teacher acts only as a facilitator and provides guidance.

This approach encourages students to be more active and helps improve their abilities. Additionally, research by Doz et al. (2025) shows that the effectiveness of the Inquiry-Based Learning (IBL) model can significantly enhance student learning outcomes across all knowledge domains, especially in solving mathematical problems and complex tasks. This demonstrates that the Inquiry-Based Learning (IBL) model can positively influence students' abilities.

The Advantages of the Inquiry-Based Learning (IBL) Model Based on Students' Mathematical Communication Skills

Mathematical communication has five indicators. In the mathematical communication skills test, there were five questions, each representing one of the mathematical communication indicators. Based on the results of the study, the average scores for the mathematical communication indicators in both classes increased. However, the experimental class using the Inquiry-Based Learning (IBL) model showed a greater improvement.

This is in line with the research conducted by Kurniawati et al. (2021), which showed that the Inquiry-Based Learning (IBL) model has an effect on students' mathematical communication. In that study, after conducting observations, mathematical communication skills tests, learning style questionnaires, and interviews, it was found that students, based on their learning styles and using the Inquiry-Based Learning (IBL) model, showed improvement in each indicator of mathematical communication skills.

The implementation of the Inquiry-Based Learning (IBL) model in classroom instruction has an impact on students' abilities. This is because, in Inquiry-Based Learning (IBL), students are required to be more active and independent since the teacher acts only as a facilitator, giving students a greater role in learning independently. As a result, students' mathematical communication skills in understanding the material improve.

With the improvement of students' mathematical communication skills, there is also an impact on their understanding of the material and their problem-solving abilities. This aligns with the findings of Samawati & Ekawati (2021), which showed that students' mathematical communication skills correlate with their ability to solve story problems, the higher each student's mathematical ability, the higher their mathematical communication and problem-solving skills. Research by Nahar & Machado (2025) also indicates that the Inquiry-Based Learning (IBL) model has a transformative effect on developing students' skills. Thus, students who frequently engage in communication activities or discuss ideas with peers and teachers will experience improvements in their abilities.

The Advantages of Inquiry-Based Learning (IBL) Model Based on Student's Creativity

Based on the research, both learning models have an impact on students' creativity. However, the Inquiry-Based Learning (IBL) model produces better results than the Direct Instruction model. According to the research findings, the average creativity indicators in both classes increased. Nevertheless, the experimental class showed a higher increase than the control class.

This demonstrates that the experimental class outperformed the control class in terms of student creativity. This aligns with the research conducted by Bicer (2021), which stated that in the Inquiry-Based Learning (IBL) model, students are expected to make observations and then are given time to conduct their own mathematical investigations by observing and experimenting. Thus, the Inquiry-Based Learning (IBL) model can enhance students' mathematical creativity

In Inquiry-Based Learning (IBL), students are encouraged to explore the material they study and then solve problems. Students do not just receive information passively; they are also actively engaged in finding solutions and developing strategies to understand concepts. This aligns with Sam (2024), who explained that the IBL model promotes active student engagement, critical thinking, and deeper conceptual understanding. Moreover, it shifts the focus to active exploration, training students to take responsibility for their own learning journey. This approach not only enhances mastery of the material but also fosters essential skills such as problem-solving, collaboration, and information literacy. Consequently, this process can stimulate students' creativity in learning and problem-solving.

Research by Panjaitan & Siagian (2020) explains that using the Inquiry-Based Learning (IBL) model enhances students' scientific creativity, enabling them to discover and solve new problems as well as formulate hypotheses, which usually involve prior knowledge. In line with the study by Rodríguez et al. (2019), the results show that Inquiry-Based Learning (IBL) has great potential and can promote skill development, including creativity. The implementation of Inquiry-Based Learning (IBL) in learning can increase creativity in finding solutions to existing problems.

Conclusion

Based on data analysis and discussion, the conclusions that can be drawn:

1. There is an effect of the Inquiry-Based Learning (IBL) model on students' mathematical communication skills and creativity. This can be seen from the value of Hotelling's $T^2 = 15.877$, $p\text{-value} = 0.00036$, thus showing that the Inquiry Based Learning (IBL) learning model and Direct Instruction learning model affected the mathematical communication skills and creativity of students.
2. The Inquiry-Based Learning (IBL) model has a greater effect than the Direct Instruction model on students' mathematical communication skills. This can be seen from the t-test result for mathematical communication skills, namely 2.698 with a $p\text{-value} = 0.009$, thus showing that the Inquiry Based Learning (IBL) learning model is superior to the Direct Instruction learning model in terms of students' mathematical communication skills.
3. The Inquiry-Based Learning (IBL) model has a greater effect than the Direct Instruction model on students' creativity. This can be seen from the t-test result for students' creativity, namely 3.341 with a $p\text{-value} = 0.001$, thus showing that the inquiry Based Learning (IBL) learning model is superior to the Direct Instruction learning model in terms of student creativity.

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