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## Improving Students' Mathematical Reasoning Ability through the Use of the Joyful Learning Model Assisted by GeoGebra

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### ABSTRACT

The mathematics learning process in schools often faces challenges such as low student engagement, limited conceptual understanding, and the dominance of less interactive teaching approaches. These conditions hinder the development of higher-order thinking skills, particularly students' mathematical reasoning ability. Therefore, innovative and technology-assisted learning models are required to improve the effectiveness of mathematics instruction. This study aims to examine the improvement of students' mathematical reasoning ability through the implementation of the Joyful Learning model assisted by GeoGebra. The research employed an experimental method using a One Group Pretest–Posttest Design. The population consisted of all seventh-grade students of SMP 3 Al-Muhajirin, while the sample comprised 29 students from Class VII E selected using a simple random sampling technique. Data were collected using an essay-based test designed to measure mathematical reasoning ability and administered before and after the learning intervention. Statistical analysis was conducted using normality testing and the Wilcoxon signed-rank test with the support of IBM SPSS Statistics 24. The results indicate a statistically significant difference between pretest and posttest scores, showing an improvement in students' mathematical reasoning ability after the implementation of the Joyful Learning model assisted by GeoGebra. This improvement reflects students' enhanced ability to propose conjectures, identify patterns, apply mathematical manipulation, and draw logical conclusions. These findings suggest that the integration of the Joyful Learning model and GeoGebra is an effective instructional approach for fostering mathematical reasoning ability and creating a more engaging mathematics learning environment.



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## Introduction

Education is a crucial factor in determining the development of a nation's civilization and plays a vital role in shaping generations capable of keeping pace with scientific advancements, including mathematics (Rachmatika & Wardono, 2019). Mathematics education in schools frequently encounters various challenges that affect students' understanding and learning interest, one of the main issues being the use of ineffective teaching methods (Wiryananda & Alim, 2023). Therefore, serious efforts are required to improve the effectiveness of mathematics learning, particularly through the development of innovative and technology-based instructional models. Improving learning effectiveness is expected to create a more enjoyable learning experience that reduces students' boredom, increases their motivation to participate in learning activities, encourages active interaction during the learning process, and ultimately improves students' learning outcomes (Dewi & Prihatnani, 2022).

Mathematics is a fundamental discipline that plays an important role in daily life as well as in the advancement of science and technology (Rachmatika & Wardono, 2019). In this context, there is a close relationship between the mastery and application of mathematical concepts to ensure that the objectives of mathematics education are achieved optimally. This is in accordance with the Regulation of the Minister of National Education of the Republic of Indonesia No. 58 of 2014, which states that the objectives of mathematics education include enabling students to understand mathematical concepts and describe the relationships among them, apply logical, efficient, and accurate algorithms or concepts, use reasoning in patterns and properties through mathematical manipulation to make generalizations and construct proofs, communicate ideas using symbols, tables, diagrams, or other media to clarify situations or problems, and demonstrate appreciation of the relevance of mathematics by showing perseverance and self-confidence in problem solving. Based on these objectives, one of the key competencies that students are expected to develop in mathematics learning is mathematical reasoning ability.

Zaenab states that mathematical reasoning ability encompasses students' expertise, skills, competencies, and intellectual capacity in engaging in mathematical thinking processes to draw conclusions or formulate statements (Rahmawati & Astuti, 2022). Similarly, Akuba et al. (2020) define mathematical reasoning ability as an individual's skill in using logical thinking to draw conclusions based on accepted mathematical premises by identifying relationships among those premises. This view is reinforced by Copi's assertion that "reasoning is a special kind of thinking in which inference takes place, in which conclusions are drawn from premises." Accordingly, reasoning can be understood as a mental process through which individuals develop thought based on existing conditions and premises to evaluate the validity of the conclusions produced (Pamungkas & Yuhana, 2016). The indicators of mathematical reasoning ability include proposing conjectures, identifying patterns or characteristics of mathematical phenomena to form generalizations, applying mathematical manipulation, and drawing conclusions, collecting evidence, and providing justification or proof for the correctness of solutions (Suprihatin et al., 2018). This ability is a crucial aspect of mathematics education in schools, as it involves not only mastery of mathematical concepts but also the capacity to apply them contextually and communicate mathematical ideas effectively.

Several factors may contribute to students' low levels of mathematical reasoning ability, including difficulties in recalling previously learned material, a lack of ideas in problem solving, insufficient accuracy in understanding problem statements, difficulty in selecting appropriate formulas, and limited conceptual understanding of the material being studied (Aprilianti & Zanthly, 2022). One mathematics topic that requires a high level of reasoning

ability is solid geometry with flat surfaces. In the Merdeka Curriculum, this topic is taught at the seventh-grade level.

Students' mathematical reasoning ability needs to be enhanced through instructional innovation, including improvements in learning models, teaching materials, and content. Improved learning outcomes can be fostered by creating a joyful learning environment (Suwarsih, 2018). Therefore, it is necessary to design learning activities that capture students' attention, one of which is by promoting the implementation of enjoyable learning approaches, specifically the Joyful Learning model, to enhance students' mathematical reasoning ability. Catur states that the application of Joyful Learning strategies can accelerate students' understanding of learning materials and make learning time more efficient (Sufiani & Marzuki, 2021). Joyful Learning is a learning strategy that creates a pleasant atmosphere in which students can fully focus without feeling forced or pressured. The Joyful Learning model is an instructional approach that stimulates students' curiosity and encourages them to be active, innovative, and creative in the classroom, allowing students to gain knowledge and experience meaningful learning in a more engaging and enjoyable environment (Nurfalaq et al., 2022). The stages of the Joyful Learning model, as described in instructional strategy literature, consist of four phases: preparation, presentation, practice, and closure (Nurhasanah et al., 2019).

The implementation of enjoyable learning models can be supported by the use of instructional media to facilitate teachers in delivering learning materials. Instructional media are tools used to convey information, knowledge, skills, or attitudes from teachers to students, thereby enabling learning objectives to be achieved more effectively and efficiently. One instructional medium that can be used to enhance students' active participation during the learning process is GeoGebra. Japa et al. (2017) state that GeoGebra is a highly suitable alternative for presenting various mathematical objects. GeoGebra is software commonly used in mathematics education and is considered an effective tool in the educational process (Mokotjo & Mokhele, 2021). This application is designed to support students, teachers, and professionals in understanding and teaching mathematical concepts through interactive and visual representations. GeoGebra also serves as an instructional aid to clarify students' understanding of solid geometry with flat surfaces (Fitriani et al., 2019).

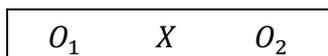
Previous studies have examined the implementation of the Joyful Learning model to improve students' mathematics learning outcomes and reduce mathematics learning anxiety (Sari & Prihatnani, 2017). That study focused on the application of the Joyful Learning model in improving learning outcomes and reducing students' mathematics anxiety in the topic of the Pythagorean Theorem, with eighth-grade students as the research subjects. In addition, other research has investigated Joyful Learning combined with Puzzle Games to increase students' learning interest (Praharsini & Ahsani, 2023). The findings indicated that the experimental implementation of Joyful Learning with Puzzle Games in science learning, which was conducted through introductory, core, and closing activities, significantly enhanced students' learning interest. Furthermore, a study by Istiqomah (2019) on number patterns demonstrated an increase in students' average learning outcomes across instructional cycles.

The novelty of this study lies in the use of the Joyful Learning model assisted by the GeoGebra application to enhance students' mathematical reasoning ability. Akhmad (2014) states that the achievement of learning objectives can be evaluated by considering students' learning mastery. A class is regarded as having successfully achieved learning objectives when 75% or more of the students attain individual mastery in knowledge and skills. Based on the background presented above, these considerations provide the rationale for conducting this study on the implementation of the Joyful Learning model assisted by GeoGebra to improve students' mathematical reasoning ability.

## Method

### Research Design

The research employed an experimental method using a Pre-Experimental Design, specifically the One Group Pretest–Posttest Design. In this design, observations or measurements were conducted on a single group without the presence of a control group for comparison. The research design used in this study follows [Sugiyono \(2019\)](#), as illustrated below:



**Figure 1.** One Group Pretest–Posttest Research Design

Keterangan:

$O_1$  = Pretest administered before the treatment

$O_2$  = Posttest administered after the treatment

$X$  = Treatment using the Joyful Learning model assisted by GeoGebra

### Population and Sample

The population of this study consisted of all seventh-grade students of SMP 3 Al-Muhajirin Purwakarta, comprising 11 classes. The sample was selected using a probability sampling technique, specifically simple random sampling. Simple random sampling is a sampling technique in which each member of the population has an equal chance of being selected, regardless of any existing strata within the population ([Sugiyono, 2019](#)). The sample was determined by writing the names of all population members on pieces of paper, placing them into a container, and conducting a single draw. As a result, Class VII E was selected as the experimental group, consisting of 29 students.

### Research Instruments and Data Collection

The research instrument used in this study was a mathematical reasoning ability test. The test consisted of four essay items designed to measure students' mathematical reasoning ability, with assessed aspects including calculations of surface area and volume of cubes, rectangular prisms, prisms, and pyramids. Data were collected through the administration of the mathematical reasoning ability test conducted twice, namely before the treatment (pretest) and after the treatment (posttest).

### Data Analysis

Data analysis involved prerequisite testing and quantitative statistical analysis. The prerequisite test applied in this study was a normality test, which was conducted to determine whether the sampled data originated from a population with a normal distribution or not ([Silalahi, 2018](#)). The normality test was performed using the Kolmogorov–Smirnov test with a significance level of 5%. The hypotheses for the normality test were formulated as follows:

$H_0$  : The sample originates from a normally distributed population.

$H_1$  : The sample originates from a non-normally distributed population.

The decision criteria were as follows:

If  $\text{sig} < 0,05$ , the data were considered not normally distributed

If  $\text{sig} \geq 0,05$ , the data were considered normally distributed

If the data were normally distributed, hypothesis testing was conducted using parametric statistical tests. However, if the data were not normally distributed, the analysis proceeded using the Wilcoxon signed-rank test. The decision rules were as follows:

- If the Sig. (2-tailed) value was less than 0.05, a significant difference in learning outcomes was identified and the hypothesis was accepted.
- If the Asymp. Sig. value was greater than 0.05, no significant difference in learning outcomes was identified and the hypothesis was rejected.

Furthermore, a paired-sample t-test was conducted to examine whether there was an improvement in students' mathematical reasoning test scores before and after the implementation of the Joyful Learning model assisted by GeoGebra. The testing criteria were defined as follows:

- If  $-t_{table} \leq t_{value} \leq t_{table}$ , there is a difference between the results before and after the study.
- If  $-t_{table} \leq t_{value} \leq t_{table}$ , this indicates that there is no difference between the results before and after the study.
- Based on the significance value, a result of less than 0.05 indicates a difference, whereas a value greater than 0.05 indicates no difference.

## Research Findings

The study was conducted at SMP 3 Al-Muhajirin Purwakarta involving one class, namely Class VII E, which served as the experimental group. The learning intervention was implemented over five instructional meetings, followed by two sessions for administering the mathematical reasoning ability tests. The results of students' mathematical reasoning tests were obtained during the first meeting (pretest) and the seventh meeting (posttest). A total of 29 students participated in the administration of the mathematical reasoning ability tests. The calculation of the percentage of students' mathematical reasoning test results was used as an initial step to determine the mean pretest and posttest scores.

It was found that the mean pretest score was 6.8, while the mean posttest score was 11.6. The Criterion for Learning Objective Achievement (KKTP) for seventh-grade mathematics at SMP 3 Al-Muhajirin is set at 75. To determine the achievement of the KKTP in the experimental class, the following formula was applied:  $\frac{KKTP}{100} \times \text{Ideal Maximum Score}$ . The ideal maximum score for the mathematical reasoning ability test was 16; therefore, the KKTP threshold was calculated as  $\frac{75}{100} \times 16 = 12$ . The results of students' mathematical reasoning ability test scores in relation to the KKTP for Grade VII E at SMP 3 Al-Muhajirin are presented in the following Table 1.

**Table 1.** Students' Mathematical Reasoning Test Scores in Relation to the KKTP

Mathematical Reasoning Test Score	Pretest	F(%)	Posttest	F(%)
$\geq KKTP$	5	17,3%	22	75,9%
$< KKTP$	24	82,7%	7	24,1%

Prior to conducting the t-test, a prerequisite test in the form of a normality test was performed to determine whether the sampled data originated from a population with a normal distribution. If the data were normally distributed, hypothesis testing was conducted using

parametric tests; however, if the data were not normally distributed, the analysis proceeded using the Wilcoxon test. The results of the normality test using the Shapiro–Wilk method are presented in [Table 2](#).

**Table 2. Normality Test Results Using the Shapiro–Wilk Test**

	Kolmogorov-Smirnov <sup>a</sup>			Shapiro-Wilk		
	Statistic	Df	Sig.	Statistic	Df	Sig.
Pretest	.169	29	.034	.944	29	.131
Posttest	.290	29	.000	.893	29	.007

a. Lilliefors Significance Correction

Based on [Table 2](#), the significance value of the pretest was 0.131, while the significance value of the posttest was 0.007. Since the pretest significance value was greater than or equal to 0.05 whereas the posttest significance value was not, the null hypothesis ( $H_0$ ) was rejected. Therefore, it can be concluded that the data were not normally distributed. Consequently, the analysis was continued using the Wilcoxon signed-rank test. The results of the Wilcoxon test are presented in [Table 3](#).

**Table 3. Wilcoxon Signed-Rank Test Results**

Test Statistics <sup>a</sup>	
Posttest of Mathematical Reasoning Ability - Pretest of Mathematical Reasoning Ability	
Z	-4.469 <sup>b</sup>
Asymp. Sig. (2-tailed)	.000

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

Based on [Table 3](#), the Asymp. Sig. (2-tailed) value was 0.000, which is less than 0.05. Therefore, it can be concluded that there is a statistically significant difference in learning outcomes before and after the implementation of the Joyful Learning model assisted by GeoGebra. Subsequently, the analysis was continued using a paired-sample t-test. The results of the paired-sample t-test are presented in [Table 4](#).

**Table 4. Paired Samples Test**

	Paired Differences						T	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error	95% Confidence Interval of the Difference					
	Mean	Std. Deviation	Mean	Lower	Upper				
Pair 1 Pretest of Mathematical Reasoning Ability - Posttest of Mathematical Reasoning Ability	-4.931	2.890	.537	-6.030	-3.832	-9.188	28	.000	

Based on Table 4, the Sig. (2-tailed) value was 0.000. Since the Sig. (2-tailed) value was less than 0.05 ( $0.000 < 0.05$ ), the null hypothesis ( $H_0$ ) was rejected and the alternative hypothesis ( $H_1$ ) was accepted. Thus, it can be concluded that there is a statistically significant difference between the pretest and posttest results.

**Table 5. Paired Samples Statistics**

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pretest of Mathematical Reasoning Ability	6.83	29	3.296	.612
	Posttest of Mathematical Reasoning Ability	11.76	29	3.043	.565

Based on the paired samples statistics, the mean score before the intervention was 6.83 with a sample size of 29, a standard deviation of 3.296, and a standard error mean of 0.612. In contrast, the post-intervention data showed a mean score of 11.76 with the same sample size of 29, a standard deviation of 3.043, and a standard error mean of 0.565. These results indicate an improvement in students' mathematical reasoning ability from before to after the intervention.

**Table 6. Paired Samples Correlations**

		N	Correlation	Sig.
Pair 1	Pretest of Mathematical Reasoning Ability & Posttest of Mathematical Reasoning Ability	29	.587	.001

Based on the paired samples correlation results, the correlation coefficient was 0.587 with a significance value of 0.001. This indicates a relationship between the data obtained before and after the intervention. Based on Table 6 regarding the paired samples test, the analysis results were as follows: (1) The calculated  $t_{value}$  was  $-9,188$  with a significance value of 0.001; (2) The critical t-value  $t_{table}$  was obtained from  $0,05: 2 = 0,025$  (two-tailed test) with degrees of freedom ( $df$ )  $n - 1 = 29 - 1 = 28$ , resulting in a  $t_{table}$  value of 2,048; and (3) Since the value of  $-t_{table} \leq t_{value} \leq t_{table}$  ( $-2,048 \leq -9,188 \leq 2,048$ ) and the significance value was  $< 0,05$  ( $0,000 < 0,001$ ), it can be concluded that there was a difference in test results before and after the intervention. Based on the output of the paired samples statistics, paired samples correlations, and paired samples test, the results indicate a difference between pre-intervention and post-intervention scores. The test scores before the intervention were lower than those obtained after the intervention. Therefore, it can be concluded that students' mathematical reasoning ability improved after the implementation of the Joyful Learning model assisted by GeoGebra.

## Discussion

This study was conducted in Class VII E, where students participated in learning activities using the Joyful Learning model assisted by GeoGebra. During the implementation, the learning process was engaging due to the integration of technology-based instructional media, which increased students' motivation. One factor contributing to the improvement of students'

mathematical reasoning ability through the Joyful Learning model assisted by GeoGebra was that several stages of the learning process were designed to train specific aspects of mathematical reasoning. In the first and second meetings, students were trained to propose conjectures during the practice phase. In the third meeting, students began to develop the ability to identify patterns or characteristics of mathematical phenomena to form generalizations. In the fourth meeting, students practiced mathematical reasoning related to the indicator of applying mathematical manipulation. In the final meeting, students were trained to draw conclusions, collect evidence, and provide justification or proof for the correctness of solutions. Students' achievement on the conjecture indicator reached 75% or higher, while achievement on the indicators of identifying patterns or characteristics to form generalizations, applying mathematical manipulation, and drawing conclusions with justification was below 75%.

During the learning process, several challenges were encountered by the researcher. One of the main difficulties was that some students experienced confusion when working on word problems. There were students who did not fully understand the given problems and therefore were unable to solve them. To address this issue, the researcher provided guidance to students who had difficulties completing the practice tasks. Another challenge was the limited instructional time, as each learning session lasted only two class hours while the Joyful Learning model involves multiple stages. To overcome this constraint, the researcher optimized time management so that classroom learning could remain meaningful and enjoyable.

Overall, students' mathematical reasoning ability when taught using the Joyful Learning model can be categorized as good. The findings are consistent with those of [Sari & Prihatnani \(2017\)](#), who reported that the implementation of the Joyful Learning method was effective in improving students' mathematics learning outcomes. In addition, the use of GeoGebra contributed positively to classroom learning. During the presentation stage, students were able to analyze their answers using GeoGebra, which facilitated their understanding of the given problems and supported an enjoyable learning atmosphere. This result is in line with the study by [Maf'ulah et al. \(2021\)](#), which found a significant difference in students' learning outcomes before and after the implementation of GeoGebra as an instructional medium.

Based on the data analysis, students' mathematical reasoning ability after the implementation of the Joyful Learning model assisted by GeoGebra was better than before the learning intervention. Although the results of the mathematical reasoning ability test indicated that not all students met the KKTP criterion, as some students were still below the required threshold, this outcome may be influenced by several factors during the learning process, such as the learning environment and individual differences in students' mastery of the material. However, in accordance with [Akhmad \(2014\)](#), the achievement of learning objectives can be evaluated by examining students' learning mastery. A class is considered to have successfully achieved learning objectives when 75% or more of the students attain individual mastery in knowledge and skills. Based on the results and discussion presented, it can be concluded that the Joyful Learning model assisted by GeoGebra is effective in improving students' mathematical reasoning ability.

## Conclusion

Based on the results of the study, data processing, and analysis, it can be concluded that there was an improvement in students' mathematical reasoning ability through the implementation of the Joyful Learning model assisted by GeoGebra. Furthermore, this improvement contributed to enhanced learning outcomes and increased students' learning interest in the classroom, while also minimizing students' errors in solving mathematical

problems. Based on these findings, it is recommended that efforts to develop students' mathematical reasoning ability be supported by the construction of assessment tasks aligned with the indicators of mathematical reasoning. In addition, innovation in selecting instructional models and the use of innovative learning media are necessary to create engaging and enjoyable learning experiences. Finally, this study recommends the application of the Joyful Learning model to other instructional media and mathematics topics as a follow-up to the present research.

### Conflict of Interest

The authors declare that this article was prepared as part of fulfilling the requirements for the completion of a student's final project. Aside from this purpose, there are no other conflicts of interest that influenced the planning, implementation, analysis, or writing of the research results.

### Authors' Contributions

S.R. actively participated in the implementation, data collection, preparation of instruments, article narrative, discussion of results, and editing of the manuscript for the final version. I.M. and S.R.M. contributed to understanding the main research ideas, theoretical development, methodology, data organization and analysis, discussion of results, and approval of the final version of the manuscript. All authors confirm that they have read and approved the final version of this paper. The total percentage of contribution to conceptualization, writing, and manuscript revision is as follows: S.R.: 40%, I.M.: 30%, and S.R.M.: 30%.

### Data Availability Statement

The authors declare that data sharing is not applicable, as no new data were created or analyzed in this study.

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### Author Biographies

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