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Enhancing Mathematical Reasoning through the Integration of Realistic Geometry with Interactive Multimedia Learning Application

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Abstract: Enhancing Mathematics Reasoning: Integrating Realistic Geometry with Interactive Multimedia. Objectives: This study is motivated by the importance of students' mathematical reasoning abilities. The aim of this research is to compare the mathematical reasoning skills of students who receive instruction through the Realistic Geometry model supported by interactive multimedia with those who undergo conventional teaching. **Methods:** The research method employed is a quasi-experimental design using the Static Group Pretest-Posttest Design. The population for this study consists of students from SD 37 Pekanbaru, with the sample including 30 students from class IVa as the experimental group and 30 students from class IVd as the control group. **Findings:** The results indicate that students who engaged in the Realistic Geometry instruction with interactive multimedia demonstrated superior mathematical reasoning abilities compared to those who experienced conventional learning. The quality of improvement in both approaches is interpreted as moderate. **Conclusion:** Overall, the integration of realistic geometry with interactive multimedia Learning Application can enhance students's abilities in mathematical reasoning.

Keywords: geometry realistic, interactive multimedia, mathematics reasoning.

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INTRODUCTION

Geometry is a fundamental component of the mathematics curriculum in elementary schools (Juana et al., 2022; Marande & Diana, 2023; SILVA et al., 2015). Learning geometry enables students to analyze and interpret the world around them, equipping them with tools that can be applied in other areas of mathematics (Biber et al., 2013; Wahyuni et al., 2020; Yulita & Ain, 2021). The subject of geometry is rich with content that can motivate, engage, and inspire students when presented with visualization (Abadi & Amir, 2022; Fauzan et al., 2013; Milovanovic et al., 2013; Nadzeri et al., 2022). Visualization can help students build geometric concepts and facilitate their understanding of geometric objects (Arcavi, 2003; David & Tomaz, 2012; Milovanoviæ et al., 2013).

Learning geometry is not easy, and many students struggle to understand geometric concepts, theorems, and the ability to solve geometric story problems (Alim et al., 2020; Andini et al., 2018; Syarmadi & Izzati, 2020). Several underlying factors contribute to this issue. One significant factor is that instruction is often dominated by memorizing facts and concepts, focusing on computational aspects, and applying formulas (Fauzan et al., 2013). This occurs

because the teaching methods designed by educators do not take into account students' abilities, the content being taught, students' thinking processes, and the learning methods and resources used (Zuya, 2014).

Teaching geometry to students certainly presents its own challenges for teachers. Learning geometry requires strong visual skills, especially to understand three-dimensional objects (Ng et al., 2020). Each student has different abilities in spatial abilities (Helsa, 2024). Students also often feel overwhelmed with the logic necessary to understand the relationships between forms or in solving problems related to geometry (Aziz et al., 2020). Learning geometry requires logical and analytical thinking skills, especially when students have to understand the properties of shapes and apply geometric theorems (Fachrudin & Juniati, 2023). Students often memorize formulas without understanding the underlying concepts, so they tend to make mistakes when applying formulas to different problems. This is especially the case in calculating the area, circumference, or volume of various geometric shapes (Samsudin & Nugraha, 2024).

Teaching methods that are less interactive or lack of use of learning media such as teaching aids and technology can exacerbate students' learning difficulties. In addition, facilities such as interactive whiteboards or visual applications are often not available in elementary schools, which can be helpful in understanding geometry concepts (Herawati et al., 2023; Herza et al., 2024). Then the problem is also encountered in students' basic understanding of geometry concepts. Students still find it difficult to understand the basic concepts of geometry such as points, lines, angles, and geometric shapes themselves. This can be caused by various factors, one of which is the lack of a concrete explanation that connects the concept to daily life during learning (Juman et al., 2022; T.R., 2017).

To address the challenges in geometry, the role of the teacher is crucial in the learning process. Teacher performance significantly affects student learning outcomes (Mis Endang Sutin et al., 2022; Palupi, 2018; Rianti et al., 2020) as the quality of education is partly determined by the teacher (Bertram & Pascal, 2016). As educators, teachers must be able to develop and enhance effective learning in the early years of schooling because high-quality teaching and classroom practices positively contribute to students' academic achievement, behavior, and motivation to learn (Anthony & Walshaw, 2016; Oktaviani et al., 2024; Suryatin & Sugiman, 2019).

Monotonous learning will make mathematics learning less fun, so students will easily feel bored and result in a lack of student participation in learning (Ariffah & Rusnilawati, 2023). Therefore, it is necessary for teachers to make efforts to create fun learning for students. Such as integrating multimedia interactive in the learning process (Putri et al., 2022). Interactive multimedia can be presented through attractive visual displays, according to the age of elementary school students, they tend to like colorful things (Swandi et al., 2020).

Then teachers also integrate realistic mathematics learning in improving students' mathematical reasoning skills. Mathematical reasoning can be interpreted as the ability to think logically in analyzing and interpreting mathematical problems. One model that can be used for geometry material is the realistic model. RME (Realistic Mathematics Education) is an approach in which mathematics education is understood as a human activity (Alim et al., 2020; Freudenthal, 1991; Laurens et al., 2017; Lulut Solehhudin & Dewi Wulandari, 2023). The human activities referred to include problem-finding, organizing relevant material, creating mathematical models, problem-solving, and

organizing new ideas and understandings that are contextually appropriate.

Previous research conducted by Runisah et al., (2021) revealed that through the application of daily problem-based learning integrated in interactive media, it can improve students' mathematical reasoning skills. This interactive multimedia can present learning about the basics and concepts through simple ways and interesting visualizations for students. Other research was also conducted by Ariffah & Rusnilawati (2023) namely the application of Realistic Mathematics Education which is integrated in interactive multimedia to increase students' reasoning and confidence. The results of this study show that there is a significant influence of the Realistic Mathematics Education approach assisted by interactive multimedia articulate storyline on students' reasoning ability and confident attitude. Based on previous research, this research was carried out by integrating RME through multimedia interaction with learning applications in improving students' reasoning skills. This learning application not only presents storylines but also visualizations of the material taught equipped with color images and several features that can be operated by students.

Research in several countries shows that mathematics learning with a realistic approach makes the subject more engaging, relevant, and meaningful. However, in realistic mathematics learning, students sometimes require a significant amount of time to grasp concepts before they can solve mathematical problems (Febriani & Sidik, 2020; Lestari & Surya, 2017; Taufina et al., 2019; Van den Heuvel-Panhuizen, 2020). With the advancement of knowledge in this era of globalization, technology has become a vital medium for transferring knowledge. One such educational technology is interactive multimedia. This is supported by research indicating that interactive multimedia can provide an effective learning environment for various types of learners (Alim et al., 2020; Alim, Fauzan, Arwana, et al., 2020a; Jalinus & Alim, 2018, 2019). Demonstrate that interactive learning environments can lead to effective teaching and learning systems. Thus, utilizing the surrounding environment can comprehensively develop students' potential, aligning with the objectives of the realistic geometry learning model supported by interactive multimedia, ultimately enhancing students' reasoning skills.

METHOD

Participants

The subjects of this study are 60 fourth-grade students from SDN 37 Pekanbaru. 30 students for control class and 30 students for experiment class. Participants were selected using random sampling. The students who participated in this study were fourth-grade elementary school students, who, according to Piaget, are in the concrete operational stage between the ages of 7-11, where they begin to think logically but can only apply it to real objects (Yanti et al., 2024). In this study, a Realistic Mathematics Education (RME) approach will be implemented, which is expected to help students view learning concretely through real-life situations, thereby assisting them in their mathematical reasoning.

Research Design

This research follows a quantitative experimental approach using a quasi-experimental design, with a control class and an experimental class. The experimental class will receive treatment through the application of interactive multimedia in the form of a learning application based on Realistic Mathematics Education. The control class will learn using traditional methods without the use of interactive multimedia based on Realistic Mathematics Education.

The meetings will be conducted three times each. In the control class, during the first meeting, students will be given a pretest. In the second meeting, students will be taught about the geometry of plane shapes using the traditional lecture method. In the third meeting, students will be given a posttest. For the experimental class, in the first meeting, students will be given a pretest. In the second meeting, students will be taught using interactive multimedia in the form of a learning application based on Realistic Mathematics Education. Finally, in the third meeting, students will be given a posttest.

Instrument

In this study, the instrument used is a pretest and posttest on mathematical reasoning abilities. The test consists of 10 essay-type questions. The question indicators used in the study were developed from the research by Alim et al., (2020). The indicators of the test questions can be seen in Table 1.

Table 1. Reasing ability indicator

No.	Reasing Ability Indicator	Reasing Ability Aspect
1	Observing patterns or regularities to make generalizations.	Students are able to identify and observe patterns to draw conclusions.
2	Providing explanations about facts and their properties.	Students are able to provide explanations about facts and properties of plane shapes.
3	Providing explanations using concepts and their properties.	Students are able to provide explanations about plane shapes using concepts and their properties.
4	Constructing or evaluating mathematical arguments.	Students are able to construct or evaluate mathematical arguments.
5	Describing logical conclusions about ideas and their relationships.	Students can draw conclusions on statements

Data Analysis

Subsequently, an effectiveness analysis was performed to assess the impact of implementing Realistic Geometry with Interactive Multimedia on enhancing students' mathematical reasoning. The calculation of student test results uses the following formula:

$$P: \frac{Skor\ Perolehan}{Total\ Skor\ Keseluruhan} x\ 100\%$$

Next, the technique used to analyze the data is the paired samples t-test. Before the test questions were used, they had to meet the normality and homogeneity tests first. This statistical method is employed to examine the significance of the effectiveness of implementing Realistic Geometry with Interactive Multimedia in enhancing students' mathematical reasoning. The indenpendent samples t-test compares the pre-test and post-test scores of the different group of students, allowing us to determine whether the differences in scores are statistically significant. The analysis of the difference in data to see the improvement in students' average results in this study is also conducted using the N Gain (g) test to determine the improvement between the pretest and posttest. The students' mathematical reasoning ability is considered to have improved if the N-Gain result is g < 0.70, which is categorized as moderate, and is categorized as high if the gain value is e" 0.70.

Conversely, students' mathematical reasoning ability is considered not to have improved if the gain value is < 0.30 (Meltzer, 2002).

■ RESULT AND DISCUSSION

The learning outcomes using the Realistic Geometry model supported by Interactive Multimedia are evaluated based on students' mathematical reasoning ability test results. This mathematical reasoning ability can be observed through students' capacity to provide opinions with different answers or strategies. Students' learning progresses from informal mathematics to formal mathematics. The variety of answers and opinions expressed by the students indicates that their reasoning skills have improved compared to previous learning experiences. Mathematics is one of the fundamental sciences that plays a crucial role in the development of knowledge and technology (Algan, 2022; Faqtoids, 2024). The primary aim of mathematics education is to solve everyday problems, particularly concerning the use of numbers and mathematical symbols (Yuhasriati et al., 2022). The application of this concept, grounded in everyday life, aligns with the context of Realistic Mathematics Education (RME). The RME approach is a mathematics learning process that begins in the real world to develop concepts and ideas in mathematics, integrating mathematics into daily life. As a result, learning through this approach becomes more meaningful and memorable for students (Adel, 2020; Lestari & Surya, 2017; Nuraina et al., 2021).

The learning outcomes with the Interactive Multimedia-supported PRG model for geometry instruction focus on mathematical reasoning. Students' mathematical reasoning abilities are assessed after they have participated in lessons using the Interactive Multimedia-supported PRG model. The average improvement in mathematical reasoning ability is presented in picture1.

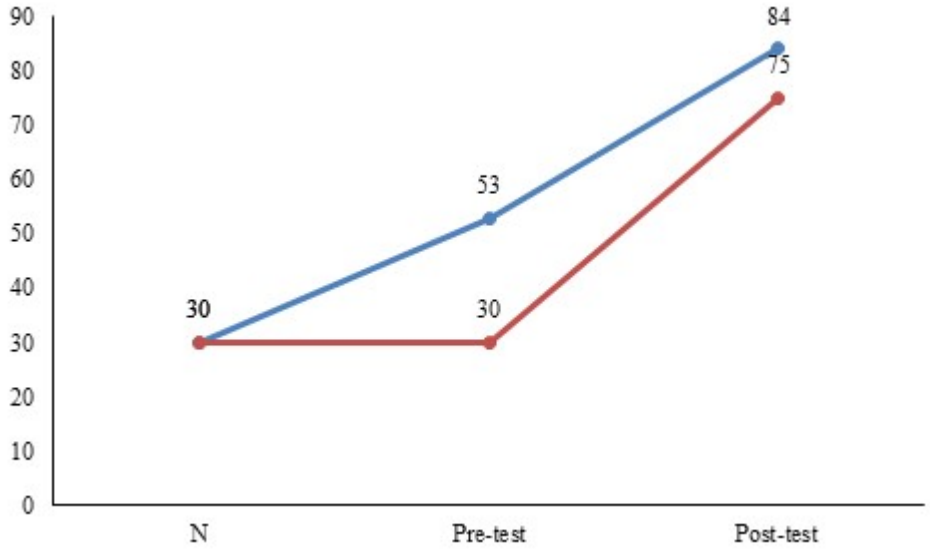

Figure 1. The result of mathematical reasoning ability of students pretest-postest

The results of the pretests-postests showed that there were differences in students' mathematical reasoning skills between the control group and the experimental group. The reasoning ability of the experimental group that used RME-based multimedia interactive was higher compared to the control group that only used the usual lecture method. The implementation of

Realistic Mathematics Education (RME) is also enjoyable and can capture students' attention. When students are interested in learning, they take an active role in the learning process (Alim et al., 2023; Napitupulu et al., 2021; Oktaviani et al., 2024). Through RME, students develop logical, creative, and critical thinking skills (Alim et al., 2020; Laurens et al., 2017). RME provides contextual learning experiences, making education interactive and engaging (Alim et al., 2021, 2022; Hozaima & Subaidi, 2023). It enables teachers to offer real-world experiences, which help students better understand the concepts being taught. Thus, through the application of RME, students' mathematical reasoning abilities are enhanced. Then to see the effectiveness of improving students' mathematical reasoning skills between the control class and the experimental class, an N-Gain test was carried out. The N-Gain results can be seen in figure 2.

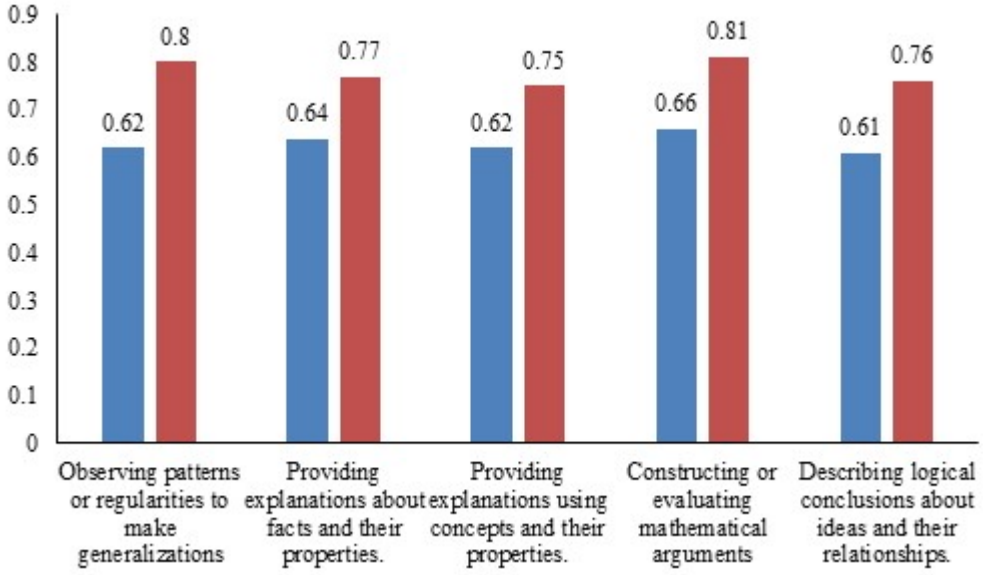

Figure 2. The N-gain result

The average n-gain of the experimental class was obtained 0.78 and control class average n-gain was obtained 0.63. The improvement in students' mathematical reasoning ability using the Interactive Multimedia-supported PRG model is higher than that achieved with the conventional teaching methods typically used by teachers. Mathematical reasoning begins with the ability to observe patterns or regularities in mathematical situations. In the experimental class, where PMRI-based interactive multimedia is used, students are given the opportunity to observe various types of flat shapes through visualizations presented in the app. This allows students to clearly see the properties of flat shapes, such as the number of sides, angles, and types of the shapes themselves. Through this observation, students can identify patterns in the shape and properties of flat shapes, as well as relate them to the area concepts of each shape. In the control class, which uses conventional methods, students rely solely on verbal explanations and static images from textbooks. This limits students' ability to observe deeper patterns or regularities and reduces their ability to make generalizations about the types and properties of flat shapes.

Mathematical reasoning also involves the ability to explain the facts and properties of a mathematical object. In the experimental class, students are able to provide deeper explanations

about the properties of flat shapes, such as symmetry, side lengths, and angle measures, as the PMRI-based application provides visualizations that help them understand how each shape has specific properties. The app also provides practice exercises that guide students to link these concepts to area calculations for flat shapes. Conversely, in the control class, while students receive explanations about the properties of flat shapes, the information is presented only verbally and through static images, which limits depth. The focus on memorizing properties and area formulas restricts students' understanding of the relationships between the types and properties of flat shapes.

Learning with PMRI-based interactive multimedia allows students to more easily link concepts related to the types of flat shapes, their properties, and how to calculate their area. The app presents visualizations of various flat shapes, such as squares, triangles, and circles, and shows how area is calculated based on the properties of each shape. Students can see the differences in how area is calculated for each type of flat shape and understand the relationship between the shape's properties and the area formula. In the control class, students often only learn area formulas without understanding how the properties of flat shapes are connected to those formulas. The explanation is limited to theory without providing visual context to help students understand the deeper relationship between the concepts and properties of flat shapes.

Constructing and evaluating mathematical arguments is a crucial aspect of mathematical reasoning. In the experimental class, students are encouraged to build arguments based on the facts and properties of flat shapes. The PMRI-based app provides exercises that require students to explain why a particular area formula for a flat shape is valid, linking the shape's properties. In the control class, students are rarely given the opportunity to build or evaluate their own arguments, as they are more focused on receiving information from the teacher and memorizing formulas. This reduces the chances for students to develop critical thinking skills in understanding mathematical concepts. In the experimental class, students are able to describe logical conclusions about the relationships between types of flat shapes, their properties, and how to calculate their area. In contrast, in the control class, students find it more difficult to describe logical conclusions about the relationships between various mathematical ideas due to the limitations of the media used. Without the opportunity to see clear relationships through visualization, students rely solely on teacher explanations or textbook images, which reduces their ability to describe logical conclusions.

The integration of Realistic Mathematics Education (RME) with interactive multimedia can serve as a strategy for teachers to implement interactive learning. As educators, teachers must continually train and innovate to create engaging mathematics education for students. Consequently, they are challenged to design learning experiences that captivate their students (Setiyani et al., 2020). By integrating interactive multimedia-based realistic geometry, it is expected that students' mathematical reasoning abilities will improve. The results indicate that the application of this instructional model not only contributes to enhanced learning outcomes but also significantly develops students' critical and creative thinking skills. The implementation of realistic mathematics can indeed boost students' critical thinking abilities (Suastrawan et al., 2021; Thornhill-miller et al., 2023; Yuhasriati et al., 2022).

Following this, prerequisite analysis testing was conducted. The prerequisite analysis included normality testing using the Mann-Whitney and Shapiro-Wilk tests. Based on the normality test in the experimental class, the normality value was obtained of $0.535 > 0.05$ and the normality test

of the control class was obtained with a normality result of 0.620 >0.05. Overall, it was concluded that the data of the experimental class and the control class were normally distributed. Similarly, the criteria for normally distributed data is when the significance is greater than á. The data analysis using the Kolmogorov-Smirnov test showed a significance of 0.227 for the experimental class (which is greater than 0.05) and 0.324 for the control class (also greater than 0.05).

Next, the results of the homogeneity variance test. The criterion for homogenous variance is when the significance is greater than á. The data analysis shows that for class IVa, the significance value obtained is 0.070 (which is greater than 0.05), while for class IVd, the significance value is 0.033 (also greater than 0.05). This indicates that the variance of the data regarding the improvement in students' mathematical reasoning ability is homogeneously distributed. Therefore, it can be concluded that the data is homogenous.

Furthermore, a significance test will be carried out from the improvement of students' mathematical reasoning results. The results of improving students' mathematical reasoning are seen based on the n-gain of each indicator. Then, a t-test is carried out to draw conclusions. The results can be seen in table 2.

Table 2. Results of the efectivness interactive multimedia for improvement in mathematical reasoning ability of students at SD 37 Pekanbaru

School	Class	N	N-Gain	Mean	Std.Error Mean	Std. Deviation	
SD 37	Eksperimen Class IV a	30	0.78	51.8000	1.76583	9.67186	**0.001**
	Kontrol ClassIVd	30	0.63	46.3000	.73367	4.01849	

The criterion for rejecting the null hypothesis (Ho) is when the significance (2-tailed) is less than á. The analysis results in Table 7 show that the significance (2-tailed) is less than 0.05, indicating that Ho is rejected. This means that the improvement in students' mathematical reasoning abilities in the classes taught using the Realistic Geometry model supported by Interactive Multimedia is better than that in the classes not using this model. This demonstrates that the Realistic Geometry model with Interactive Multimedia is effective in enhancing students' mathematical reasoning skills.

One crucial aspect of the realistic geometry approach is its capacity to connect mathematical concepts with real-world contexts (Ariffah & Rusnilawati, 2023; Marande & Diana, 2023). This is particularly relevant, as many students often struggle to understand abstract mathematical concepts that seem disconnected from their daily lives. By presenting geometric material within more tangible and applicable contexts, students can more easily comprehend and internalize the concepts being taught. The use of interactive multimedia plays a significant role in enhancing student engagement. Through visual and interactive elements, students become not only passive recipients of information but also active participants in the learning process (Alim, Fauzan, Arwana, et al., 2020b; Oroh et al., 2023). Activities such as simulations, animations, and data visualizations help students develop a deeper understanding and reinforce their memory of the concepts being taught (Kim, 2021; Siregar et

al., 2023; Utomo, 2018; Wijaya et al., 2021). By incorporating these multimedia elements, teachers can create a more dynamic and engaging learning environment, allowing students to explore mathematical concepts in a way that feels relevant and practical. This not only aids in comprehension but also fosters a more positive attitude toward mathematics, as students find the learning process more enjoyable and relatable.

This study found that students engaged in interactive multimedia-based learning demonstrated a greater improvement in their mathematical reasoning abilities compared to those who participated in conventional learning. This aligns with constructivist learning theory, which emphasizes the importance of active experience in the learning process. By encouraging students to directly engage in exploration and discovery, they can develop a more solid understanding and apply that knowledge in new situations. The findings of this study are consistent with research by Oroh et al., (2023) which revealed that the implementation of interactive multimedia can enhance students' mathematical reasoning, leading to better learning outcomes. Similar research conducted by Muhaimin and Juandi (2023) also indicated that multimedia can make the knowledge transfer process more effective. Additionally, a study by Angraini and Fitri (2023) found that interactive multimedia can improve students' problem-solving abilities. Overall, these pieces of evidence suggest that the integration of interactive multimedia in education not only enhances mathematical reasoning but also enriches students' learning experiences, making the learning process more effective and enjoyable.

■ CONCLUSION

The conclusion of this study indicates that the integration of interactive multimedia-based realistic geometry significantly enhances students' mathematical reasoning abilities. Learning with this approach not only improves academic outcomes but also encourages students to be more active in critical and creative thinking. Recommendations for future implementation include enabling teachers to better integrate technology into mathematics instruction, particularly in geometry, to create a more interactive and engaging learning environment. Additionally, training for teachers in using this instructional model is necessary to increase their confidence and competence in its classroom implementation. Further research is also recommended to explore the impact of this instructional model in the context of other mathematical subjects and at various educational levels.

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