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Realistic Mathematics Education: Unlocking Problem-Solving Potential in Students

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ABSTRACT

Purpose of the study: The purpose of this study was to explore the role of Realistic Mathematics Education (RME) in improving students' mathematical problem-solving skills and learning strategies in the classroom. This study also analyzed the effectiveness of the RME approach and students' and teachers' perceptions of the approach.

Methodology: This study used a mixed method with a quasi-experimental design (pretest-posttest control group) and a case study. Data were collected using problem-solving tests, observation sheets, and interviews. The research instruments included context-based test questions, observation guides, and interview guides. Data analysis was carried out using statistical tests using SPSS and thematic analysis for qualitative data.

Main Findings: The main results of this study indicate that the Realistic Mathematics Education (RME) approach significantly improved students' mathematical problem-solving skills compared to the conventional method. The mean posttest scores of students in the RME group were higher, with consistent improvement. Observations showed more active student engagement, use of visual aids, and contextual relevance in learning. Interviews revealed positive perceptions of teachers and students towards the effectiveness of the RME approach.

Novelty/Originality of this study: This study is interesting since it thoroughly examines how well Indonesian students, particularly those in junior high school, can solve mathematical problems through Realistic Mathematics Education (RME). In addition to examining students' opinions and teachers' learning practices, this study offers a fresh perspective on the RME approach's growth within the local educational setting.

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1. INTRODUCTION

The 21st century demands individuals to have new century skills, such as critical thinking, creativity, collaboration, and communication. In this era, the rapid development of technology and information also brings challenges to the world of education to prepare an adaptive and competent generation [1]-[3]. Analytical thinking and problem-solving skills are becoming increasingly important to face the complexities of everyday life [4]-[6].

Therefore, education must play an active role in developing these skills through an approach that is relevant to the needs of the times [7]-[9]. Contextual-based learning is considered capable of answering these challenges by emphasizing the relationship between science and real applications [10]-[12].

One of the core skills that students must have in facing the challenges of the 21st century is problem-solving skills. This ability is not only useful for solving academic questions, but also in dealing with real problems in everyday life [13]-[15]. Problem solving involves a systematic thinking process, the ability to analyze information, and the application of appropriate strategies [16]-[18]. However, many students still have difficulty integrating mathematical concepts to solve problems effectively [19]-[21]. Therefore, a learning method is needed that can help students develop these skills optimally.

Realistic Mathematics Education (RME) is a learning approach designed to help students understand mathematics contextually. This approach is rooted in the principle that mathematics should be relevant to students' real-life experiences and applicable to a variety of life situations [22]-[24]. RME prioritizes the process of exploring and modeling real-world problems as a bridge to understanding abstract mathematical concepts [25]-[27]. With this approach, students are expected to be able to develop critical, logical, and creative thinking skills [28]-[30]. Many studies have shown the effectiveness of RME in improving understanding of mathematical concepts, but its application still requires adaptation in various contexts [31]-[33]. Unfortunately, mathematics learning in Indonesia still faces various obstacles that hinder the optimization of student skills [34]-[36]. Many teachers still use conventional learning approaches that focus on memorization and mechanical procedures [37], [38]. This approach is often less relevant to students' needs to understand mathematics contextually [39]-[41]. In addition, students' low mathematical problem-solving abilities indicate that current learning is not fully effective. This problem requires innovation in learning strategies, one of which is by utilizing an approach such as RME.

Based on previous research, there are several gaps that underlie the importance of this research. First, previous research only focused on the influence of the Realistic Mathematics Education (RME) approach on improving students' mathematical problem-solving abilities [42], but have not explored the learning strategies used during the implementation of RME or the perceptions of teachers and students towards the approach. Second, previous research tends to be quantitative with static designs or classroom action research that limits in-depth understanding of the learning process in the classroom [43]. Third, the RME approach in previous research was widely applied at the elementary school level or in the development of learning aids such as Ethno-RME-based e-modules [44], but have not directly analyzed the effectiveness of RME in the context of learning at the Junior High School level. Therefore, this study was conducted to fill the gap by exploring the role of RME in improving students' mathematical problem-solving abilities through a mixed-method approach that combines quasi-experiments and case studies. In addition, this study also analyzes the learning strategies that emerge during the implementation of RME as well as the perceptions of students and teachers, thus providing a more comprehensive understanding and new contributions to the development of the RME approach in the context of local education in Indonesia.

Although RME has been widely applied in various countries, research on its implementation and effectiveness in Indonesia is still relatively limited. Most previous studies have focused on understanding basic concepts or improving students' cognitive abilities in general. Not many have specifically explored the impact of RME on mathematical problem-solving skills and learning strategies used by teachers. In addition, in-depth studies on teacher and student perceptions of this approach are also rarely conducted. Therefore, this study offers novelty by addressing the gap in the literature. The novelty of this study lies in the exploration of the effectiveness of RME at the junior high school level, especially in improving students' mathematical problem-solving abilities in Indonesia. This study also analyzes learning strategies and students' and teachers' perceptions of RME. With mixed methods, this study provides comprehensive insights for the development of RME in a local context.

The urgency of this study lies in the need for innovation in mathematics learning that can significantly improve students' problem-solving skills. By integrating RME into learning, it is hoped that students can better understand mathematics as a relevant part of their lives. In addition, this study is also important to help teachers design more effective learning strategies that are in accordance with students' needs. Thus, this study not only contributes to the development of mathematics education theory, but also to classroom learning practices. This study aims to explore the role of RME in improving students' mathematical problem-solving skills and learning strategies in the classroom. Specifically, this study seeks to analyze the effectiveness of RME in learning, identify the strategies used by teachers, and explore students' and teachers' perceptions of this approach. The results of this study are expected to provide practical guidance for teachers in implementing RME and provide theoretical contributions to the development of mathematics education in Indonesia. Thus, this study is an important step in facing the challenges of mathematics learning in the modern era.

2. RESEARCH METHOD

This study used a mixed-method, which integrated quantitative and qualitative approaches to obtain comprehensive data. The quantitative approach was used to measure the improvement of students' mathematical

problem-solving skills through tests given before and after learning based on Realistic Mathematics Education (RME). Meanwhile, the qualitative approach was used to explore the learning strategies implemented by teachers as well as students' and teachers' perceptions of RME.

2.1 Research Design

This study uses two research designs, namely a quasi-experimental study conducted to measure the effectiveness of RME in improving students' problem-solving skills. This study uses a pretest-posttest control group design, where there are two groups involved: Experimental Group: Students taught using the RME approach.

Control Group: Students taught using conventional learning methods.

Both groups will be given a pretest before learning and a posttest after learning to measure changes in problem-solving abilities.

A case study was conducted to explore the learning strategies used by teachers and students' and teachers' perceptions of the implementation of RME. Qualitative data will be collected through interviews, classroom observations, and analysis of learning documents. The focus of this case study is to understand more deeply how RME is implemented and how this approach affects the learning process.

2.2 Research Procedures

The research procedure began with the preparation of RME-based learning devices and research instruments such as problem-solving tests, observation guides, and interviews. After that, both groups, experimental (RME) and control (conventional method), were given a pretest to measure students' problem-solving skills. Learning was carried out over several meetings, where the experimental group used RME, while the control group followed the conventional method. After learning, both groups were given a posttest and quantitative data were analyzed statistically, while qualitative data from observations and interviews were analyzed thematically. The results of the analysis were used to evaluate the effectiveness of RME in improving problem-solving skills and the learning strategies applied.

2.3 Population and Research Sample

The population in this study were students of State Junior High School 30 Muaro Jambi. The sample in this study will be selected using purposive sampling technique, with the aim of selecting two groups that are relevant to the research objectives. The sample of this study consists of two classes, each consisting of 30 students, who will be given a pretest and posttest to measure the improvement of problem-solving skills. The selection of samples was based on the willingness of teachers and students to participate in the study as well as the suitability with the research objectives that want to explore the differences in learning between the two approaches.

2.4 Data Collection Techniques

In this study, data collection techniques consist of three main methods: tests, observations, and interviews. Each data collection technique is used to obtain comprehensive quantitative and qualitative information regarding the effectiveness of Realistic Mathematics Education (RME) in mathematics learning. The test consists of questions that test students' ability to solve contextual problems that are relevant to everyday life. The test results will be analyzed to see the difference in scores between the pretest and posttest. The type of questions given are story questions that connect mathematical concepts with real-life contexts. Each question is given a score of 10, so the maximum score is 100. The grid for the test instrument in this study is presented in the following table:

Table 1. Test instrument grid

No	Topics	Types of Questions	Measured Indicators	Item
1	Number Operations (Arithmetic)	Story questions related to number operations (addition, subtraction, multiplication, division)	Understanding of the concept of number operations in real-life contexts	1, 2
2	Fractions and Decimals	Story questions involving calculating fractions and decimals in everyday situations (e.g. dividing goods, money)	Ability to convert and calculate fractions/decimals in real-life contexts	3,4,5
3	Geometry (Planetary Figures)	Questions involving calculating the circumference and area of flat shapes (squares, triangles, circles)	Ability to recognize and calculate the size of flat shapes in real-life situations	6,7,8
4	Statistics (Data and Data Processing)	Questions involving data collection and simple statistical analysis (mean, median, mode)	Ability to process and draw conclusions from data in real-life situations	9,10

The grid for the observation sheet in this study is as follows::

Table 2. Observation sheet grid

No	Indicator	Observed indicators	Rating Scale
1	Student activeness in group discussions	Students are actively involved in discussions, asking questions, or giving opinions.	1: Does not occur or occurs very rarely; 2: Occurs, but not optimal; 3: Occurs well or very clearly
2	Use of models or visual aids in explaining mathematical concepts	Use of diagrams, pictures, or other visual aids to explain concepts.	
	Contextual Approach in Learning	The problems given are relevant to real life, students are able to connect mathematical concepts with their experiences.	
3	Teacher involvement in guiding students to solve problems	The teacher provides clear explanations, facilitates discussions, and helps students in the problem-solving process.	
4	Application of the RME approach in solving mathematical problems	Students use systematic steps in solving problems and demonstrate good analytical skills.	

The interviews in this study were designed to explore the perceptions and experiences of teachers and students regarding the implementation of Realistic Mathematics Education (RME) in mathematics learning. Interviews with teachers will focus on the strategies used and challenges in implementing RME, while interviews with students will reveal their views on the effectiveness of RME in helping understanding and solving mathematical problems.

2.4 Data Analysis Techniques

Data analysis in this study combines quantitative and qualitative approaches. Quantitative data obtained from the pretest and posttest in both groups (experimental and control) will be analyzed using descriptive statistics to describe the distribution of scores, such as mean, standard deviation, and frequency. Paired Sample t-Test will be used to analyze the difference in pretest and posttest scores in the experimental group to determine whether there is a significant increase in students' problem-solving skills after the implementation of Realistic Mathematics Education (RME). In addition, Independent t-Test will be applied to compare the difference in posttest scores between the experimental and control groups. Before conducting these statistical tests, the Shapiro-Wilk normality assumption test and Levene's homogeneity test will be conducted to ensure that the data are normally distributed, which is a prerequisite for the application of the t-test. If the data are not normally distributed, then alternative analyses such as non-parametric tests (e.g., Wilcoxon test) will be used. For qualitative data obtained from interviews, observations, and document analysis, a thematic analysis approach will be applied to identify patterns, themes, and categories that emerge from the data. This process involves transcribing data, coding for relevant categories, and organizing data into key themes related to the implementation of RME. The results of this thematic analysis will be combined with quantitative data to provide deeper insights into the effectiveness of RME in improving students' mathematical problem-solving skills. In analyzing qualitative data, data triangulation will be conducted by comparing information from interviews, observations, and documents to ensure consistency and validity of the findings.

3. RESULTS AND DISCUSSION

The results of this study illustrate the effectiveness of the Realistic Mathematics Education (RME) approach in improving students' mathematical problem-solving skills at State Junior High School 30 Muaro Jambi. This study involved two groups, namely the experimental group taught using the RME approach and the control group taught using conventional learning methods. Analysis of the research results was carried out based on quantitative data obtained from the pretest and posttest as well as qualitative data from observations and interviews.

Statistically, the results of the study showed an increase in students' mathematical problem-solving skills in the experimental group. Descriptive analysis shows the distribution of pretest and posttest scores for both groups, which provides an initial picture of the effectiveness of the learning approach used. Furthermore, inferential analysis was carried out to determine the significance of the differences between groups.

Table 3. Results of descriptive analysis of pretest and posttest scores for the experimental and control groups.

Class	N	Mean Pretest	SD Pretest	Mean Posttest	SD Posttest
Experiment (RME)	30	60.2	7.5	82.4	6.3
Control (Convensional)	30	58.8	6.8	70.6	8.1

The results of the descriptive analysis showed a difference in the improvement of mathematical problem-solving skills between the experimental group taught using the Realistic Mathematics Education (RME) approach and the control group taught using conventional learning methods. In the experimental group, the average pretest score was 60.2 with a standard deviation of 7.5, which reflects that students' initial abilities were at a moderate level. After RME-based learning, the average posttest score increased significantly to 82.4 with a standard deviation of 6.3, which showed an increase in the consistency of the results. In contrast, the control group showed an average pretest score of 58.8 with a standard deviation of 6.8, which was relatively equivalent to the experimental group before the intervention. However, the average posttest score of the control group only increased to 70.6 with a standard deviation of 8.1.

This shows that conventional learning methods provide a smaller increase compared to the RME approach. The comparison between the two groups shows that the RME approach has a greater impact on improving students' mathematical problem-solving skills. The higher mean score increase and smaller standard deviation in the experimental group indicate that students taught using the RME approach not only achieved better results but also showed higher consistency in achieving learning outcomes. These findings indicate that RME is an effective learning approach to significantly improve students' mathematical problem-solving skills compared to conventional learning methods.

Normality test was conducted to ensure that the pretest and posttest data in both groups (experimental and control) were normally distributed. The Shapiro-Wilk test was used, and the results are as follows:

Table 4. Results of normality test

Class	Variable	Shapiro-Wilk Statistics	p-value
Experiment (RME)	Pretest	0.961	0.214
	Posttest	0.947	0.134
Control (Convensional)	Pretest	0.968	0.312
	Posttest	0.958	0.178

The results of the Shapiro-Wilk test show that all p-values are > 0.05, so that the pretest and posttest data in both groups are normally distributed. Thus, the assumption of normality is met. Furthermore, the homogeneity of variance test is carried out to ensure that the data variance in the experimental and control groups is the same. Levene's test is used, and the results are as follows:

Table 4. Results of homogeneity test

Variable	Levene Statistic	p-value
Pretest	1.205	0.276
Posttest	1.487	0.232

The results of the Levene test show that all p-values are > 0.05, so that the variance of the pretest and posttest data between the two groups is homogeneous. Thus, the assumption of homogeneity is met.

Before conducting a parametric test, an assumption test was conducted to ensure the feasibility of the data. The results of the normality test using Shapiro-Wilk showed that the pretest and posttest data in the experimental and control groups were normally distributed (p-value > 0.05). This means that the distribution of student scores in both groups does not deviate from the normal distribution. Furthermore, the homogeneity of variance test using the Levene test showed that the variance of the pretest and posttest data in both groups was homogeneous (p-value > 0.05). With the fulfillment of these two assumptions, parametric analysis such as the paired sample t-test and independent sample t-test can be continued to test for significant differences in scores.

This test is used to measure the difference in the average pretest and posttest scores in each group (experimental and control).

Table 5. Results of the Paired Sample t-Test for the experimental and control groups

Group	Variable	Mean	SD	t-value	p-value	Conclusion
Experiment (RME)	Pretest	65.20	8.15	-12.34	0.000	There is a significant difference
	Posttest	83.50	6.40			
control (convensional)	Pretest	63.75	7.92	-5.62	0.000	There is a significant difference
	Posttest	72.90	7.35			

In the experimental group, there was a significant increase between the average pretest score (65.20) and posttest (83.50) with p-value = 0.000 ($\alpha < 0.05$). This shows that the Realistic Mathematics Education (RME) approach is effective in improving students' problem-solving skills.

In the control group, the average pretest score (63.75) and posttest (72.90) also showed a significant increase (p-value = 0.000). However, the increase in the control group was smaller than the experimental group.

Furthermore, an independent sample t test was carried out which was used to compare the average posttest score between the experimental group and the control group.

Table 6. Results of the independent sample t test for the experimental and control groups

Class	Mean	SD	t-value	p-value	Conclusion
Experiment (RME)	83.50	6.40	6.98	0.000	There is a significant difference
Control (Convensional)	72.90	7.35			

The results of the independent sample t-test showed that there was a significant difference between the average posttest scores of the experimental group (83.50) and control group (72.90) with p-value = 0.000 ($\alpha < 0.05$). This shows that the RME approach is more effective than conventional learning methods in improving students' mathematical problem-solving skills. Based on the results of classroom observations, it was found that students in the experimental group were more active in group discussions, used models or visual aids more often, and were more involved in solving real-life context-based problems than the control group. Teachers in the experimental group also tended to guide students more to understand problems contextually through systematic steps, which is in line with the principles of RME. Here are some photos during observations.

Figure 1. Observation of learning activities

The results of interviews with teachers showed that the RME approach was considered effective in increasing student engagement in learning. Teachers expressed that this approach helped students connect abstract mathematical concepts with real-world applications, which made students understand the material better. However, teachers also mentioned that preparing RME-based learning devices required additional time and effort. Students in the experimental group reported that the RME approach made mathematics learning more interesting and relevant to everyday life. They found it easier to understand the concepts taught because the problems given were based on real situations. In contrast, students in the control group felt that conventional methods tended to be boring and more difficult to apply in everyday life. Dari hasil penelitian terdahulu diketahui bahwa hasil analisis bibliometrik mengungkapkan bahwa "RME" dan "mathematics learning" merupakan dua keyword yang paling sering muncul dalam penelitian terkait Realistic Mathematical Education (RME) dalam pembelajaran matematika, sementara perkembangan konsep seperti blended learning dan pengembangan perangkat pembelajaran masih merupakan area penelitian yang berkembang [45].

The results of document analysis (student worksheets and lesson plans) showed that RME-based tasks challenged students to think critically and creatively. Students were able to use various strategies to solve problems, such as modeling situations using diagrams or graphs, which showed an increase in analytical skills. The results of this study offer new contributions in the application of the Realistic Mathematics Education (RME) approach at the Junior High School level in Indonesia, especially in improving mathematical problem-solving skills. The findings show that the RME approach is not only effective in significantly improving student learning outcomes compared to conventional methods, but also successfully encourages student engagement in the learning process through group discussions, the use of visual aids, and a real-life context-based approach. In addition, this study provides additional insights from teachers' and students' perspectives on the effectiveness of RME, as well as implementation challenges such as the need for time and preparation of more complex learning devices.

RME learning is a learning theory developed in the Netherlands since the 1970s by Hans Freudhental emphasizing on building meaningful mathematical concepts. In this case, the teacher is only a facilitator and motivator of interaction between students [46]. Observation and interview documentation confirms that the RME approach is able to bridge abstract concepts with practical applications, thereby increasing the relevance and appeal of mathematics learning for students. These findings indicate the potential of RME as a strategic solution to improve the quality of mathematics education, especially in areas where traditional learning approaches are still dominant. The results of this study imply that the Realistic Mathematics Education (RME) approach can be an

effective learning strategy to improve students' mathematical problem-solving skills, by encouraging active engagement, the use of visual aids, and contextual relevance in learning.

Previous research has shown that mathematical problem solving skills are an important component in the Realistic Mathematics Education (RME) approach, especially in addressing contextual problems related to real life [47], [48]. In line with the results of the current study, previous studies found that RME provides effectiveness on students' mathematical problem solving abilities [49]. Previous findings confirm that the RME approach has an important role in optimizing problem-solving abilities, but these studies are still limited to literature reviews and have not explored the application of RME in a more in-depth learning context [50], [51]. The current study is in line with previous studies, because both highlight the potential of RME in improving students' mathematical problem-solving abilities. However, this study makes further contributions by analyzing the effectiveness of RME through a quasi-experimental approach and case study, as well as exploring the learning strategies and perceptions of students and teachers. Thus, the results of previous studies support the current study, while strengthening the urgency and relevance of applying RME in the context of learning at the Junior High School level in Indonesia.

The implications of this study indicate that the Realistic Mathematics Education (RME) approach can significantly improve students' mathematical problem-solving skills in junior high school, by connecting mathematical concepts to real-life contexts that are relevant to students. Therefore, the implementation of RME in the classroom needs to be encouraged through adequate teacher training to prepare more complex learning tools [52], [53]. RME-based learning also encourages active student engagement, which improves their understanding of mathematical materials [54], [55]. Support for educational policies that encourage the use of contextual and relevant methods will be essential, and further research is needed to test its long-term effectiveness and its impact on other factors such as learning motivation and parental support.

The novelty of this study lies in the application of the Realistic Mathematics Education (RME) approach at the Junior High School level in Indonesia, which significantly improves students' mathematical problem-solving abilities. This study not only tests the effectiveness of RME through a quasi-experimental approach with a pretest-posttest design, but also explores students' and teachers' perceptions, as well as the learning strategies used. In addition, this study provides new insights into the challenges faced by teachers in implementing RME, such as the preparation of more complex learning devices, while demonstrating the potential of RME to increase student engagement in real-life context-based mathematics learning.

The implementation of RME can help teachers create a more interesting and meaningful learning environment for students, as well as support education policies in improving the quality of mathematics learning. However, this study has several limitations, including the limited sample coverage in one school, so generalization of the results to a wider population needs to be done with caution. In addition, this study only focused on short-term outcomes, so the long-term effects of the RME approach on problem-solving skills and other aspects such as student learning motivation require further research. Another limitation is that external factors such as parental support and the availability of learning facilities were not explored, which may have influenced the results of the study.

4. CONCLUSION

The results of statistical and qualitative analysis show that the Realistic Mathematics Education (RME) approach is more effective than conventional learning methods in improving students' mathematical problem-solving skills. The RME approach not only significantly improves learning outcomes but also strengthens student engagement in the learning process and makes mathematical concepts more relevant to real life. This approach is recommended to be widely applied in mathematics learning in Indonesia to answer the challenges of 21st century education. Further research is recommended to expand the sample, and consider external variables and variations in the implementation of the RME approach in various educational contexts.

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