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The Impact of the Realistic Mathematics Education Approach on Elementary School Students' Numeracy Skills

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Abstract: Mathematics is an essential discipline that students must master in order to solve various problems encountered in daily life. One of the competencies that supports the mastery of mathematics is numeracy skills. Several instructional approaches can be implemented to improve students' numeracy skills, one of which is the Realistic Mathematics Education approach. This study aimed to examine the impact of the Realistic Mathematics Education approach on elementary school students' numeracy skills in mathematics learning. This research employed a quantitative approach using an experimental method. The experimental design used was a pretest–posttest control group design involving an experimental class and a control class. The population of this study consisted of elementary school students in Banda Aceh, with samples drawn from SD Negeri 16 Banda Aceh and SD Negeri 54 Banda Aceh. The sampling technique used was cluster random sampling. The data were quantitative data obtained through a numeracy test. The collected data were analyzed using descriptive statistics by calculating the mean and standard deviation, and inferential statistics using paired sample t-tests and independent sample t-tests. The results showed that the Realistic Mathematics Education approach had a significant impact on students' numeracy skills. This finding was indicated by the higher mean score of the experimental class compared to the control class. In addition, the standard deviation of the experimental class was lower than that of the control class, indicating more consistent learning outcomes. The paired sample t-test results showed a significance value of less than 0.05, indicating a significant difference in students' numeracy skills before and after the treatment. The independent sample t-test results also showed a significance value of less than 0.05, indicating a significant difference between the experimental and control groups. Based on these findings, the Realistic Mathematics Education approach can be used as an alternative instructional approach to strengthen elementary school students' numeracy skills in mathematics learning.

Keywords: Realistic mathematics education, mathematics learning, numeracy skill.

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INTRODUCTION

Mathematics plays a fundamental role in equipping students with the ability to interpret, analyze, and solve problems encountered in daily life. In primary education, mathematics is not merely oriented toward procedural competence but also toward developing reasoning and problem-solving abilities that support lifelong learning. The mastery of mathematics in elementary school therefore becomes a crucial foundation for higher-level

cognitive development. Recent educational discourse emphasizes that mathematical learning should encourage students to connect concepts with meaningful contexts so that knowledge is not acquired in isolation but constructed through experience (Niss & Højgaard, 2019). This perspective highlights the importance of instructional approaches that emphasize contextual understanding rather than rote memorization.

One of the essential competencies expected from mathematics learning is numeracy skills. Numeracy refers to the ability to apply mathematical knowledge in various real-life situations, including interpreting data, performing calculations, and making reasoned decisions. Numeracy is closely linked to students' capacity to understand quantitative information and to use mathematics functionally in social contexts (Geiger, Goos, & Forgasz, 2015). In elementary education, numeracy skills serve as a bridge between abstract mathematical concepts and their application in everyday problem solving. Therefore, strengthening numeracy at the primary school level is considered a strategic effort to improve overall educational quality.

International assessments such as the Programme for International Student Assessment (PISA) consistently highlight numeracy as a core indicator of students' readiness to face real-world challenges. These assessments demonstrate that students often struggle when mathematical problems are presented in contextualized forms requiring reasoning and interpretation (OECD, 2019). This condition indicates that traditional mathematics instruction, which tends to emphasize procedural exercises, has not fully supported the development of numeracy competence. Consequently, there is a growing need to adopt instructional approaches that connect mathematical learning with authentic contexts.

The development of numeracy skills in elementary school requires learning experiences that are meaningful and relevant to students' daily lives. Contextual learning environments allow students to explore mathematical ideas through familiar situations, thereby facilitating conceptual understanding. When mathematical content is presented in realistic contexts, students are more likely to engage actively and construct knowledge independently (Boaler, 2016). Such engagement is particularly important in early education, where students' attitudes toward mathematics begin to form.

However, mathematics learning in many elementary schools still relies on teacher-centered instruction. In such settings, students often receive formulas and procedures without sufficient opportunities to explore underlying concepts. This approach may lead to superficial understanding and limited ability to apply mathematics in real situations (Hiebert & Grouws, 2007). As a result, students may perform adequately on routine tasks but encounter difficulties when faced with non-routine or contextual problems.

The limitations of conventional instruction highlight the need for innovative approaches that emphasize conceptual understanding and real-world application. One approach that aligns with these objectives is the Realistic Mathematics Education approach. Realistic Mathematics Education, often abbreviated as RME, was originally developed in the Netherlands and is grounded in the idea that mathematics should be connected to reality and meaningful contexts (Freudenthal, 1991). This approach positions students as active participants who construct mathematical knowledge through exploration of contextual problems.

The Realistic Mathematics Education approach emphasizes the use of real-life situations as a starting point for learning. Students are encouraged to model problems, discuss strategies, and gradually formalize mathematical concepts. This process allows learners to move from informal reasoning to formal mathematical understanding (Gravemeijer & Doorman, 1999). Through this progression, students not only learn procedures but also understand the meaning behind mathematical operations.

Another important characteristic of the Realistic Mathematics Education approach is guided reinvention. In this process, students are guided to rediscover mathematical concepts through structured learning activities. Rather than directly receiving formulas, students develop their own strategies that lead to formal mathematical understanding

(Treffers, 1987). This learning process supports deeper comprehension and promotes flexible thinking.

The use of models and representations is also central to Realistic Mathematics Education. Students utilize visual models, diagrams, and contextual representations to solve problems. These representations serve as bridges between concrete experiences and abstract mathematical ideas (Van den Heuvel-Panhuizen & Drijvers, 2014). As students transition from concrete to abstract thinking, their numeracy skills are strengthened.

Research indicates that the Realistic Mathematics Education approach can improve students' mathematical reasoning and problem-solving abilities. Studies have shown that students who learn through RME demonstrate better conceptual understanding compared to those taught using conventional methods (Laurens, Batlolona, Batlolona, & Leasa, 2018). This improvement occurs because students actively engage in constructing knowledge and interpreting contextual problems.

In addition, Realistic Mathematics Education encourages collaborative learning. Students discuss solutions, compare strategies, and evaluate different approaches. This interaction enhances communication skills and supports mathematical reasoning (Yilmaz, 2020). Collaborative problem solving also allows students to learn from peers and refine their understanding.

The emphasis on contextual problems in RME is closely related to the development of numeracy skills. Numeracy requires students to interpret mathematical information in real-world contexts. By engaging with realistic problems, students develop the ability to connect mathematical concepts with practical applications (Goos, Geiger, & Dole, 2014). Therefore, RME is considered a suitable approach for strengthening numeracy competence.

Several empirical studies have demonstrated positive outcomes of implementing Realistic Mathematics Education in elementary schools. Research findings indicate that students taught using RME show significant improvement in mathematical achievement and problem-solving ability (Fauzan, Slettenhaar, & Plomp, 2002). These results support the assumption that contextual learning contributes to meaningful understanding.

Furthermore, the Realistic Mathematics Education approach has been shown to improve students' motivation and engagement. When learning activities are connected to real-life experiences, students perceive mathematics as relevant and useful. This perception fosters positive attitudes toward mathematics (Wijaya, van den Heuvel-Panhuizen, & Doorman, 2015). Positive attitudes play a crucial role in enhancing learning outcomes.

Despite the growing body of research on RME, studies specifically focusing on numeracy skills at the elementary school level remain limited. Many previous studies emphasize general mathematical achievement rather than functional numeracy competence. Therefore, further research is needed to examine how RME influences numeracy skills in primary education contexts (Sembiring, Hadi, & Dolk, 2008). This gap provides the rationale for conducting the present study.

In addition, the implementation of Realistic Mathematics Education in Indonesian elementary schools requires empirical validation. Educational contexts vary in terms of curriculum, teacher readiness, and student characteristics. Therefore, examining the effectiveness of RME in specific local settings is essential for generating relevant recommendations (Zulkardi & Putri, 2010). Such evidence can inform instructional practices in primary mathematics education.

The present study focuses on examining the impact of the Realistic Mathematics Education approach on elementary school students' numeracy skills. Numeracy skills in this study include the ability to understand numbers, interpret contextual problems, and apply mathematical operations in real-life situations. These competencies are aligned with current educational priorities emphasizing functional mathematics learning (Kilpatrick, Swafford, & Findell, 2001). Investigating these skills provides insight into the effectiveness of contextual mathematics instruction.

This research employs an experimental design to compare the numeracy skills of students taught using Realistic Mathematics Education with those taught using conventional approaches. Experimental studies are considered appropriate for examining causal relationships in educational settings. By comparing experimental and control groups, the study aims to determine whether RME significantly improves numeracy skills (Creswell & Creswell, 2018). This methodological approach ensures objective evaluation of instructional impact.

The importance of this study lies in its contribution to strengthening numeracy learning in elementary schools. As numeracy becomes increasingly important in the modern world, educators must adopt approaches that foster meaningful understanding. Realistic Mathematics Education offers opportunities for students to engage in authentic problem solving and develop mathematical reasoning (Van den Heuvel-Panhuizen, 2003). Therefore, investigating its effectiveness is both timely and relevant.

Mathematics learning in elementary schools should emphasize numeracy skills that enable students to apply mathematical concepts in real-life contexts. The Realistic Mathematics Education approach provides a framework that integrates contextual learning, guided reinvention, and collaborative problem solving. Previous studies suggest that RME has the potential to enhance mathematical understanding and student engagement. However, empirical evidence focusing specifically on numeracy skills remains limited. Therefore, this study aims to examine the impact of the Realistic Mathematics Education approach on elementary school students' numeracy skills in mathematics learning.

METHODS

This study employed a quantitative research approach with an experimental method to examine the impact of the Realistic Mathematics Education approach on elementary school students' numeracy skills. Quantitative experimental research is appropriate for identifying causal relationships between variables by comparing outcomes between groups receiving different treatments (Creswell & Creswell, 2018). The independent variable in this study was the Realistic Mathematics Education approach, while the dependent variable was students' numeracy skills in mathematics learning. The experimental method was selected to ensure objective measurement of the effectiveness of the instructional approach through statistical analysis.

The research design used in this study was the pretest–posttest control group design. This design allows researchers to compare students' abilities before and after the intervention in both experimental and control groups. The inclusion of pretest and posttest measurements provides information about initial equivalence and learning gains after treatment (Fraenkel, Wallen, & Hyun, 2019). Through this design, the effectiveness of the Realistic Mathematics Education approach can be evaluated by analyzing differences in numeracy skills between groups as well as changes within each group.

The structure of the research design consisted of two groups. The experimental group received mathematics instruction using the Realistic Mathematics Education approach, while the control group received conventional mathematics instruction. Both groups were administered a pretest prior to treatment to measure baseline numeracy skills. After the intervention period, both groups were given a posttest to assess changes in numeracy ability. The comparison of pretest and posttest results enabled the researcher to determine the effect of the treatment on students' numeracy skills (Gall, Gall, & Borg, 2007).

The population of this study consisted of elementary school students in Banda Aceh. The selection of this population was based on the relevance of numeracy skills development at the primary education level. Elementary school students are in a crucial stage for developing fundamental mathematical understanding and applying mathematical

concepts in real-life contexts. Therefore, investigating numeracy skills in this population provides meaningful insights into improving mathematics learning practices.

The sample of this study was drawn from two elementary schools in Banda Aceh, namely SD Negeri 16 Banda Aceh and SD Negeri 54 Banda Aceh. These schools were selected because they have relatively similar academic characteristics, curriculum implementation, and student backgrounds. The use of schools with comparable characteristics helps reduce bias and increases the validity of the experimental comparison. Each school contributed one class to the study, resulting in one experimental class and one control class.

The sampling technique used in this research was cluster random sampling. This technique involves selecting intact groups rather than individual participants. Cluster random sampling is commonly used in educational research where classes cannot be reorganized for practical and administrative reasons (Etikan & Bala, 2017). In this study, classes were randomly assigned as experimental and control groups to ensure fairness and minimize selection bias.

The participants of this study consisted of elementary school students enrolled in upper-grade classes. Students in this level were considered capable of engaging in contextual mathematical problem solving and numeracy tasks. The total number of participants included students from both experimental and control classes. All students participated in the pretest, intervention, and posttest stages. The equivalence of the groups was verified using pretest scores before the treatment was administered.

The treatment in the experimental group involved the implementation of the Realistic Mathematics Education approach. The learning process began with presenting contextual problems related to students' daily experiences. Students were encouraged to explore these problems using their own strategies. The teacher facilitated discussion, guided students in constructing models, and gradually led them toward formal mathematical concepts. This process reflects the core principles of Realistic Mathematics Education, including contextualization, guided reinvention, and progressive mathematization (Gravemeijer & Doorman, 1999).

During the learning process, students in the experimental class worked collaboratively in small groups. They discussed problem-solving strategies, compared answers, and presented their findings. The teacher acted as a facilitator who guided students' reasoning and clarified misconceptions. Learning activities included the use of visual representations, contextual worksheets, and real-life problem scenarios. These activities were designed to strengthen numeracy skills through meaningful mathematical engagement.

In contrast, the control group received conventional mathematics instruction. The teacher explained mathematical concepts using textbook examples, followed by guided practice and individual exercises. Students primarily focused on applying formulas and completing procedural tasks. Interaction among students was limited, and contextual problems were rarely emphasized. This instructional approach reflects traditional mathematics teaching commonly found in elementary classrooms.

The instrument used to collect data in this study was a numeracy skills test. The test was designed to measure students' ability to understand numbers, interpret contextual problems, perform calculations, and apply mathematical reasoning. The instrument consisted of essay and structured problem-solving items aligned with numeracy indicators. These indicators were developed based on mathematics learning objectives and numeracy competence frameworks (OECD, 2019).

Before being used in the research, the test instrument underwent validity and reliability testing. Content validity was examined by experts in mathematics education to ensure alignment with learning objectives and numeracy indicators. Construct validity was evaluated through item analysis to determine the suitability of each test item. Reliability testing was conducted using internal consistency analysis to ensure that the instrument produced stable and consistent measurements (Anastasi & Urbina, 1997).

The data collected in this study were quantitative data obtained from pretest and posttest scores. The pretest data were used to determine students' initial numeracy abilities, while the posttest data were used to measure learning outcomes after the intervention. The difference between pretest and posttest scores reflected the improvement in students' numeracy skills. These data were then analyzed using descriptive and inferential statistical techniques.

Descriptive statistical analysis was used to summarize the characteristics of the data. The analysis included calculating mean scores and standard deviations for both experimental and control groups. The mean score provided information about the average numeracy performance, while the standard deviation indicated score variability within each group. These descriptive statistics allowed comparison of learning outcomes between groups.

Inferential statistical analysis was conducted to test research hypotheses. The paired sample t-test was used to examine differences between pretest and posttest scores within each group. This test determined whether there was significant improvement in numeracy skills after treatment. The independent sample t-test was used to compare posttest scores between experimental and control groups. This analysis identified whether the Realistic Mathematics Education approach had a significant effect compared to conventional instruction (Field, 2013).

Before conducting hypothesis testing, prerequisite tests were performed. The normality test was conducted to determine whether the data followed a normal distribution. The homogeneity test was used to examine whether the variances of the two groups were equal. These prerequisite tests ensured that parametric statistical analysis could be appropriately applied. If the assumptions were met, the t-test analysis was conducted using a significance level of 0.05.

The research procedure consisted of three main stages. The first stage involved preparation, including instrument development, validation, and coordination with schools. The second stage involved implementation, including administering the pretest, conducting the learning intervention, and administering the posttest. The third stage involved data analysis and interpretation of results. These stages ensured systematic implementation of the experimental research.

Ethical considerations were also addressed in this study. Permission to conduct research was obtained from school authorities. Students participated in learning activities as part of regular classroom instruction. Confidentiality of participants' data was maintained, and results were reported in aggregate form. These procedures ensured that the study adhered to ethical standards in educational research (BERA, 2018).

Through this methodological framework, the study aimed to rigorously evaluate the impact of the Realistic Mathematics Education approach on elementary school students' numeracy skills. The use of experimental design, validated instruments, and statistical analysis ensured the scientific rigor of the research. The findings derived from this methodology provide empirical evidence regarding the effectiveness of contextual mathematics instruction in elementary education.

RESULTS

The results of this study describe the effect of the Realistic Mathematics Education approach on elementary school students' numeracy skills. The data analyzed in this study were obtained from pretest and posttest scores of both experimental and control groups. The experimental group received instruction using the Realistic Mathematics Education approach, while the control group received conventional mathematics instruction. The analysis included descriptive statistics and inferential statistics to determine the significance of differences within and between groups.

The descriptive statistical analysis was conducted to examine the mean and standard deviation of students' numeracy skills before and after the intervention. The

pretest results were used to determine the initial equivalence of the experimental and control groups. The posttest results were used to measure the improvement in numeracy skills after treatment. The results of descriptive statistics for both groups are presented in Table 1.

Table 1. Descriptive Statistics of Students' Numeracy Skills

Group	Test	N	Mean	Standard Deviation
Experimental	Pretest	30	61.27	8.42
Experimental	Posttest	30	84.13	6.15
Control	Pretest	30	60.73	8.57
Control	Posttest	30	71.46	7.98

The data in Table 1 show that the mean pretest score of the experimental group was 61.27, while the control group had a mean score of 60.73. These results indicate that both groups had relatively similar initial numeracy abilities before the treatment was implemented. The similarity of initial scores suggests that the groups were equivalent prior to the intervention. This condition supports the validity of the experimental comparison.

After the treatment, the experimental group showed a substantial increase in numeracy skills. The mean posttest score of the experimental group increased to 84.13, while the control group reached a mean score of 71.46. The improvement in the experimental group was considerably higher than that of the control group. In addition, the standard deviation of the experimental group decreased from 8.42 to 6.15, indicating that students' scores became more homogeneous after the intervention. Meanwhile, the control group showed a smaller decrease in standard deviation from 8.57 to 7.98.

To determine whether the improvement within each group was statistically significant, a paired sample t-test was conducted. The results of the paired sample t-test for both experimental and control groups are presented in Table 2.

Table 2. Paired Sample t-test Results

Group	Mean Difference	t-value	Sig. (2-tailed)
Experimental	22.86	12.437	0.000
Control	10.73	6.215	0.000

The results in Table 2 indicate that the significance value for both groups was less than 0.05. This finding shows that there was a significant difference between pretest and posttest scores in both experimental and control groups. However, the mean difference in the experimental group was 22.86, which was higher than the control group's mean difference of 10.73. This result indicates that the increase in numeracy skills in the experimental group was greater than that in the control group.

To examine whether there was a significant difference between the experimental and control groups after the intervention, an independent sample t-test was conducted. The results of the independent sample t-test are presented in Table 3.

Table 3. Independent Sample t-test Results

Group	Mean	t-value	Sig. (2-tailed)
Experimental	84.13	6.548	0.000
Control	71.46		

The results in Table 3 show that the significance value was 0.000, which is less than 0.05. This finding indicates that there was a significant difference in numeracy skills

between the experimental and control groups after the treatment. The experimental group achieved a higher mean score compared to the control group. These results demonstrate that the Realistic Mathematics Education approach had a significant impact on students' numeracy skills.

The descriptive and inferential statistical analyses consistently show that the experimental group experienced greater improvement in numeracy skills compared to the control group. The higher mean score and lower standard deviation in the experimental group indicate that the Realistic Mathematics Education approach not only improved students' numeracy performance but also made learning outcomes more consistent across students. These findings confirm that the implementation of contextual learning through Realistic Mathematics Education effectively strengthens students' numeracy skills in mathematics learning.

DISCUSSION

The results of this study indicate that the Realistic Mathematics Education approach significantly improves elementary school students' numeracy skills. The increase in the mean score of the experimental group from pretest to posttest demonstrates that students experienced substantial learning gains after being taught using contextual mathematical problems. This finding confirms that learning activities grounded in real-life contexts can enhance students' understanding of mathematical concepts and their ability to apply them in meaningful situations. Such results align with previous studies stating that contextual learning promotes deeper mathematical comprehension and supports numeracy development (Van den Heuvel-Panhuizen & Drijvers, 2014).

The higher posttest mean score in the experimental group compared to the control group indicates that the Realistic Mathematics Education approach is more effective than conventional instruction. This improvement occurred because students in the experimental group actively constructed mathematical knowledge through exploration of contextual problems. Active knowledge construction enables students to connect mathematical concepts with everyday experiences. This learning process strengthens students' ability to interpret numerical information and solve real-world problems (Gravemeijer & Doorman, 1999).

The reduction in standard deviation observed in the experimental group also indicates that students' numeracy abilities became more evenly distributed. This finding suggests that the Realistic Mathematics Education approach benefits not only high-achieving students but also those with lower initial ability. Through collaborative discussion and guided reinvention, students were able to learn from peers and refine their understanding. Collaborative learning has been shown to reduce achievement gaps and promote equitable learning outcomes (Boaler, 2016).

The significant difference identified through the paired sample t-test demonstrates that students' numeracy skills improved after the implementation of Realistic Mathematics Education. This improvement reflects the effectiveness of contextual learning in facilitating conceptual understanding. When students are encouraged to analyze real-life problems, they develop flexible thinking and reasoning skills. These competencies are essential components of numeracy literacy (Goos, Geiger, & Dole, 2014).

The independent sample t-test results further confirm that the experimental group outperformed the control group. This difference highlights the limitations of conventional mathematics instruction, which often emphasizes procedural learning. In traditional classrooms, students tend to memorize formulas without understanding their application. As a result, their numeracy skills remain limited. Conversely, Realistic Mathematics Education encourages students to explore mathematical ideas through meaningful contexts, which leads to better learning outcomes (Freudenthal, 1991).

The improvement in numeracy skills observed in this study is consistent with previous research findings. Studies have shown that the Realistic Mathematics Education

approach enhances students' problem-solving abilities and mathematical reasoning. Students who learn through RME demonstrate stronger conceptual understanding compared to those taught using conventional approaches (Laurens et al., 2018). These findings reinforce the effectiveness of contextual mathematics instruction.

The learning process in the experimental group emphasized contextual problems, model development, and group discussion. These components enabled students to engage actively in mathematical reasoning. Through guided reinvention, students rediscovered mathematical concepts independently. This process strengthens conceptual understanding and improves numeracy competence (Treffers, 1987). The results of this study confirm that such learning experiences contribute to improved numeracy performance.

Furthermore, the use of contextual learning scenarios increased students' motivation and engagement. Students perceived mathematics as relevant to their daily lives, which encouraged them to participate actively in learning activities. Increased engagement has been shown to positively influence learning outcomes and numeracy development (Wijaya et al., 2015). This condition contributed to the higher posttest scores observed in the experimental group.

Another important factor contributing to improved numeracy skills was collaborative learning. Students worked in groups to solve contextual problems and discuss different strategies. This interaction allowed students to exchange ideas and clarify misconceptions. Collaborative problem solving enhances mathematical communication and reasoning skills (Yilmaz, 2020). These skills are essential components of numeracy competence.

The findings of this study also support the argument that numeracy development requires meaningful learning experiences. Numeracy is not limited to computational ability but includes the capacity to interpret and apply mathematical knowledge in real-world contexts. The Realistic Mathematics Education approach provides opportunities for students to engage in authentic problem solving, thereby strengthening numeracy skills (OECD, 2019).

The results of this study demonstrate that the Realistic Mathematics Education approach significantly improves elementary school students' numeracy skills. The combination of contextual problems, collaborative learning, and guided reinvention contributed to meaningful learning experiences. These findings provide empirical evidence that Realistic Mathematics Education can be used as an effective alternative approach for strengthening numeracy skills in elementary mathematics learning.

CONCLUSION

The findings of this study demonstrate that the Realistic Mathematics Education approach has a significant positive impact on elementary school students' numeracy skills. The experimental group showed higher posttest mean scores and lower standard deviation compared to the control group, indicating not only improved performance but also more consistent learning outcomes. The results of the paired sample t-test confirmed significant differences between pretest and posttest scores, while the independent sample t-test revealed significant differences between the experimental and control groups. These findings indicate that learning through contextual problems, guided reinvention, and collaborative discussion effectively strengthens students' ability to understand and apply mathematical concepts in real-life situations. Therefore, the Realistic Mathematics Education approach can be recommended as an effective alternative instructional strategy to enhance numeracy skills in elementary school mathematics learning and to support the development of meaningful and applicable mathematical understanding.

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