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The Effect of Realistic Mathematics Education (RME) on Mathematical Reasoning Ability and Critical Thinking of Elementary School Students in Plane Figures Material

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A B S T R A C T

This study investigated the effect of Realistic Mathematics Education (RME) on mathematical reasoning and critical thinking abilities of second-grade elementary students in plane figures material. The low performance in base on initial observations and preliminary observations showing only 27.27% of students solving contextual problems successfully motivated this research. A quasi-experimental design with one-group pretest-posttest involving 30 second-grade students at UPTD SD Negeri 12 Makmur was employed. Data were collected using validated written tests measuring mathematical reasoning and critical thinking abilities. The Shapiro-Wilk test confirmed normal data distribution, and paired sample t-test analyzed the intervention effects. Results showed significant improvements in both abilities. Mathematical reasoning increased from a mean of 59.33 to 79.67 (gain = 20.34, $t = -30.113$, $p < 0.001$), while critical thinking improved from 57.00 to 73.83 (gain = 16.83, $t = -16.793$, $p < 0.001$). These findings demonstrate that RME significantly enhances students' mathematical reasoning and critical thinking by engaging them in contextual problem-solving, guided reinvention, collaborative discussions, and progressive mathematization from concrete to abstract thinking. The study provides empirical evidence supporting RME implementation in elementary mathematics education to develop higher-order thinking skills through meaningful, real-world learning experiences.

1. Introduction

Education plays a fundamental role in developing superior and competent human resources. Through education, individuals can maximize their potential to support future life challenges (Kurniawati, 2020). In the Indonesian educational context, mathematics constitutes one of the core competencies that must be mastered by

students at all levels, particularly in elementary schools. Mathematics plays a crucial role in daily life by helping students think logically, systematically, and critically. Mathematical learning can develop critical thinking toward problem-solving, enabling students to apply theoretical knowledge and experience to situations that need resolution (Padmakrisya & Meiliasari, 2023).

Mathematical reasoning and critical thinking represent two essential abilities that need development in mathematics learning. Mathematical reasoning encompasses the ability to understand relationships between concepts, make generalizations, and solve problems logically. The process of mathematical reasoning involves generalization and combinatorial thinking in solving open problems, allowing students to develop deep understanding of mathematical concepts and apply them in various contexts (Medová et al., 2020). Meanwhile, critical thinking involves the ability to analyze, evaluate, and construct rational arguments. Critical thinking ability in mathematics involves the capacity to analyze, evaluate, and interpret mathematical information carefully and rationally, which must be mastered especially to face the industrial revolution 4.0 era (Zahro, 2024).

Despite its importance, several studies indicate that elementary school students' mathematical reasoning and critical thinking abilities remain low. Research by Rizki and Priatna (2019) found that more than 60% of fifth-grade students in Bandung experienced difficulties in solving high-level mathematical reasoning problems. Similarly, Widyastuti et al. (2021) reported that only approximately 35% of elementary students could solve geometry reasoning-based problems effectively. The primary factor is the lack of relevant learning approaches and minimal use of real-world contexts. Moreover, conventional approaches tend to be teacher-centered, providing no opportunities for students to analyze problems deeply, evaluate alternative solutions, or express logical arguments (Lestari & Kurniawan, 2022).

International survey results from the Programme for International Student Assessment (PISA) 2018 by the Organisation for Economic Co-operation and Development (OECD) and Trends in International Mathematics and Science Study (TIMSS) 2019 by the International Association for the Evaluation of Educational Achievement (IEA) show that Indonesian students' mathematical abilities remain relatively low compared to other countries (Mullis et al., 2020). One contributing factor is ineffective learning approaches, such as mechanistic direct instruction methods that insufficiently promote reasoning and critical thinking. Preliminary observations conducted in second-grade classes at UPTD SD Negeri 12 Makmur for the 2024-2025 academic year revealed that conventional teaching methods dominated instruction, with students passively working through textbook exercises. When story problems related to real-life contexts requiring mathematical reasoning and critical thinking were administered during daily tests, only 6 students (27.27%) could solve them correctly, while 18 students (81.82%) could not.

The Realistic Mathematics Education (RME) approach offers an innovative solution by connecting mathematical concepts with real-world situations. This approach, developed by Freudenthal, emphasizes that mathematics should be

viewed as a human activity, not merely a collection of rules and formulas (Ramadhani et al., 2020). Gravemeijer defines RME as a mathematical learning approach emphasizing the importance of using real-world contexts to introduce and develop mathematical concepts (Ma'arif & Sutarni, 2023). Students not only memorize concepts but build understanding by discovering patterns or rules through solving real problems. Recent research by Fitriani et al. (2021) demonstrates that RME can enhance students' critical thinking abilities in geometry material. This aligns with research by Aprilianto and Sutarni (2023) stating that using contextual problems in RME helps students think more deeply and critically in solving mathematical problems.

RME possesses several main characteristics: (1) using real contexts as learning starting points, (2) the mathematization process, which connects concrete experiences with abstract mathematical concepts, and (3) interactivity, actively involving students in the learning process through discussion and exploration (Parapean & Langi, 2025). The approach also aims to help students develop deep mathematical understanding through exploration and reflection on taught concepts. Research by Hasibuan and Hasibuan (2023) states that RME positively impacts students' mathematical communication abilities because this approach involves active discussion and interaction processes in class.

Similar to augmented reality-based learning media development that enhances student engagement and understanding (Khusnunnisa & Andriani, 2025; Septiani et al., 2025; Muti'ah et al., 2024), RME creates conducive environments for developing critical thinking abilities through activities emphasizing problem exploration, group discussion, and individual reflection. Interactive module development research also shows that contextual approaches significantly improve learning outcomes (Putri et al., 2025; Suarmita et al., 2025). In mathematics learning specifically, Oktama et al. (2026) demonstrated that interactive media development using innovative applications can improve student learning outcomes in elementary school mathematics, while Muti'ah et al. (2024) found that augmented reality-based media development successfully improved students' numeracy skills in fraction material. These findings support the importance of contextual and innovative approaches in mathematics education.

The application of various learning models has also shown positive effects on student learning outcomes. Research by Gunawan et al. (2026) revealed that implementing the Problem-Based Learning model improved fourth-grade students' learning outcomes, while Rizqi et al. (2025) found that the Team Games Tournament learning model assisted by engaging media enhanced elementary students' numeracy skills and learning motivation. Furthermore, Nuraini et al. (2025) demonstrated that the guided inquiry learning model influenced students' critical thinking skills. These studies collectively emphasize that active, contextual, and student-centered learning approaches are essential for developing higher-order thinking skills in elementary mathematics education.

In the context of plane figures learning, RME implementation enables students to understand concepts through active exploration, group discussions, and contextual

problem-solving. However, RME implementation in Indonesia remains suboptimal, requiring further research to test its effectiveness. Previous studies demonstrate that RME positively influences student learning outcomes, including reasoning and critical thinking abilities. Research by Arhalifi et al. (2024) shows that RME can enhance students' abilities in understanding mathematical concepts more deeply. Additionally, research by Amalia (2019) proves this approach effectively improves students' understanding of mathematics material, particularly in geometry. Research by Cindyana et al. (2024) shows significant effects of differentiated learning assisted by RME-based geometry teaching materials on students' mathematical reasoning abilities. Similarly, Fendrik (2021) found significant differences in mathematical reasoning ability improvement between students receiving RME-based mathematics learning and those receiving conventional learning.

This research aims to analyze the effect of the Realistic Mathematics Education (RME) approach on mathematical reasoning and critical thinking abilities of second-grade elementary school students in plane figures material at UPTD SD Negeri 12 Makmur. Specifically, this study examines: (1) students' mathematical reasoning and critical thinking abilities before RME implementation, (2) students' mathematical reasoning and critical thinking abilities after RME implementation, and (3) the magnitude of RME's effect on improving students' mathematical reasoning and critical thinking abilities.

Based on theoretical frameworks and relevant previous research, this study hypothesizes that the Realistic Mathematics Education (RME) approach significantly affects the improvement of mathematical reasoning and critical thinking abilities of second-grade students on plane figures material at UPTD SD Negeri 12 Makmur. This research contributes to developing more effective and contextual mathematics learning approaches in elementary schools, particularly in developing students' mathematical reasoning and critical thinking abilities through real-world context-based learning.

2. Methodology

This study employed a quantitative research approach using a quasi-experimental design with a one-group pretest-posttest design. This design was selected because the research was conducted on a single group without a control group, with measurements taken through pretest (before treatment) and posttest (after treatment) in one learning session. The treatment effect was determined by the average difference between pretest and posttest scores, reflecting the improvement in students' abilities after participating in learning activities with the Realistic Mathematics Education (RME) approach.

The research was conducted at UPTD SD Negeri 12 Makmur, located in Sukarame Village, Makmur District, Bireuen Regency, during the odd semester of the 2025-2026 academic year. The study duration was one month, encompassing preparation, implementation, and data analysis stages. The population consisted of all second-

grade elementary school students in Makmur District across 13 schools studying plane figures material. The sample was selected using simple random sampling technique, consisting of 30 students from UPTD SD Negeri 12 Makmur who attended completely during the treatment process and possessed heterogeneous ability levels.

Instrument

The research instrument was a written test designed to measure students' mathematical reasoning and critical thinking abilities. The test consisted of 10 essay questions based on plane figures material, administered in both pretest and posttest formats. The instrument was developed based on mathematical reasoning indicators: (1) identifying relevant information (C1), (2) formulating mathematical questions (C3), (3) constructing hypotheses based on patterns or data (C3), (4) finding relationships among elements in problems (C4), and (5) drawing conclusions based on arguments (C5). Critical thinking indicators included: (1) understanding and stating problems clearly (C2), (2) using correct information (C3), (3) selecting information appropriate to the problem faced (C4), (4) drawing reasonable conclusions (C5), and (5) evaluating arguments (C5).

The instrument underwent validation by experts and limited trials at UPTD SD Negeri 8 Makmur involving 15 respondents. Validity testing was conducted using Pearson Product Moment correlation analysis with IBM SPSS Statistics 27, with validity criteria adapted from Nurmalita and Wardani (2021): very high (0.81-1.00), high (0.61-0.80), moderate (0.41-0.60), low (0.21-0.40), and very low (0.00-0.20). The decision basis was: if Sig. (2-tailed) < 0.05, the item was declared valid. All 10 items showed r-values ranging from 0.545 to 0.707 (r-table = 0.514), indicating all items were valid. Reliability testing used Cronbach's Alpha coefficient with criteria: very reliable (0.81-1.00), reliable (0.61-0.80), moderately reliable (0.41-0.60), somewhat reliable (0.21-0.40), and less reliable (<0.20). The instrument demonstrated Cronbach's Alpha value of 0.808, categorized as high reliability, confirming the instrument's suitability for research use.

Data Collection

Data collection was conducted through three stages: (1) Preparation stage, including coordination with the school, instrument preparation, and learning device validation; (2) Implementation stage, consisting of pretest administration to measure students' initial abilities, implementation of RME approach-based learning on plane figures material, and posttest administration to evaluate treatment effects; and (3) Data analysis stage, involving statistical data processing to test research hypotheses. The learning implementation followed RME principles, emphasizing real-world contexts as learning starting points, horizontal mathematization (transforming real-world problems into mathematical models), vertical mathematization (simplifying mathematical models into abstract solutions), and reflection and generalization processes. Students engaged in active exploration, group discussions, and contextual problem-solving activities related to plane figures in their daily lives.

Data Analysis

Data analysis employed several statistical tests using IBM SPSS Statistics 27. First, normality testing was conducted using the Shapiro-Wilk test, appropriate for samples < 50 (Andra Ningsih et al., 2019). The hypotheses were: H_0 = pretest and posttest data represent the population (normal distribution), and H_a = pretest and posttest data do not represent the population (non-normal distribution). The decision criterion was: if significance value > 0.05, the sample was normally distributed and parametric statistics were used; if significance value < 0.05, the sample was not normally distributed and non-parametric statistics were employed.

Second, hypothesis testing was conducted using Paired Sample T-Test to examine significant differences between paired values (pretest and posttest scores) from the same group. The hypotheses were: H_0 = the Realistic Mathematics Education (RME) approach has no significant effect on mathematical reasoning and critical thinking abilities, and H_a = the Realistic Mathematics Education (RME) approach has a significant effect on mathematical reasoning and critical thinking abilities. The decision criteria were: if p-value < 0.05, reject H_0 (significant difference exists between pretest and posttest, indicating the approach is effective); if p-value ≥ 0.05, fail to reject H_0 (no significant difference exists, indicating the approach is not effective). The treatment effect magnitude was calculated from the average difference between pretest and posttest scores, reflecting the improvement in students' mathematical reasoning and critical thinking abilities after RME implementation.

3. Results and Discussion

Students' Mathematical Reasoning and Critical Thinking Abilities Before RME Implementation

The research was conducted from September 15-20, 2025, at UPTD SD Negeri 12 Makmur, Sukarame Village, Makmur District, Bireuen Regency, involving all second-grade students as research subjects. Prior to implementing the treatment, validity and reliability tests were conducted with 15 students as the pilot sample. The research examined the effect of the Realistic Mathematics Education (RME) approach on students' mathematical reasoning and critical thinking abilities in plane figures material through a pretest-posttest design.

Table 1 presents descriptive statistics of students' pretest and posttest scores for both mathematical reasoning and critical thinking abilities. The pretest results revealed that students' initial abilities were in the low to moderate category. The mean pretest score for mathematical reasoning was 59.33 (SD = 8.380), with scores ranging from 40 to 75, indicating that most students obtained relatively low scores. Similarly, the mean pretest score for critical thinking was 57.00 (SD = 7.144), with scores ranging from 45 to 70. These findings indicate that students' abilities to explain reasoning, connect plane figure concepts with contextual situations, and solve problems

requiring more than mere memorization remained underdeveloped before the intervention.

Table 1. Descriptive Statistics of Pretest and Posttest Scores

Variable	Test	N	Mean	SD	Min	Max
Mathematical Reasoning	Pretest	30	59.33	8.380	40	75
	Posttest	30	79.67	7.980	65	95
Critical Thinking	Pretest	30	57.00	7.144	45	70
	Posttest	30	73.83	8.579	60	90

The low pretest scores reflect that prior mathematics instruction remained predominantly procedural and focused on memorization rather than developing reasoning abilities. Students demonstrated limited capability in analyzing problems, evaluating alternative solutions, or expressing logical arguments when confronted with contextual problems requiring deeper thinking. The normal distribution of pretest data was confirmed by Shapiro-Wilk test results showing significance values of 0.296 for mathematical reasoning and 0.091 for critical thinking (both > 0.05), indicating that students' initial abilities were relatively homogeneous across the sample, providing a solid foundation for measuring the intervention's effects.

Students' Mathematical Reasoning and Critical Thinking Abilities After RME Implementation

Following the implementation of the RME approach, posttest results demonstrated substantial improvements in both mathematical reasoning and critical thinking abilities. The mean posttest score for mathematical reasoning increased to 79.67 (SD = 7.980), with scores ranging from 65 to 95, representing an average gain of 20.34 points. Similarly, the mean posttest score for critical thinking reached 73.83 (SD = 8.579), with scores ranging from 60 to 90, showing an average improvement of 16.83 points. These improvements indicate that students achieved moderate to high competency levels in both abilities after experiencing RME-based instruction.

The enhanced mathematical reasoning abilities manifested in students' improved capacity to understand plane figure concepts meaningfully, provide simple justifications for their chosen answers, and connect mathematical concepts with real-life situations presented in learning activities. Students no longer merely memorized plane figure shapes but began comprehending their properties and characteristics through contextual activities and discussions facilitated by the RME approach. The RME emphasis on using daily life contexts helped students construct conceptual understanding progressively, moving from concrete experiences to abstract mathematical formulations through horizontal and vertical mathematization processes.

Regarding critical thinking abilities, students showed marked improvement in analyzing simple problems related to plane figures, comparing different plane figure shapes based on their properties, and drawing simple conclusions from given problems. The RME-based learning activities including contextual problem-solving, group discussions, and student work presentations provided opportunities for students to think actively and develop critical thinking skills, particularly in

understanding problems and determining solution strategies. Figure 1 illustrates the distribution of pretest and posttest scores for mathematical reasoning, while Figure 2 shows the distribution for critical thinking abilities.

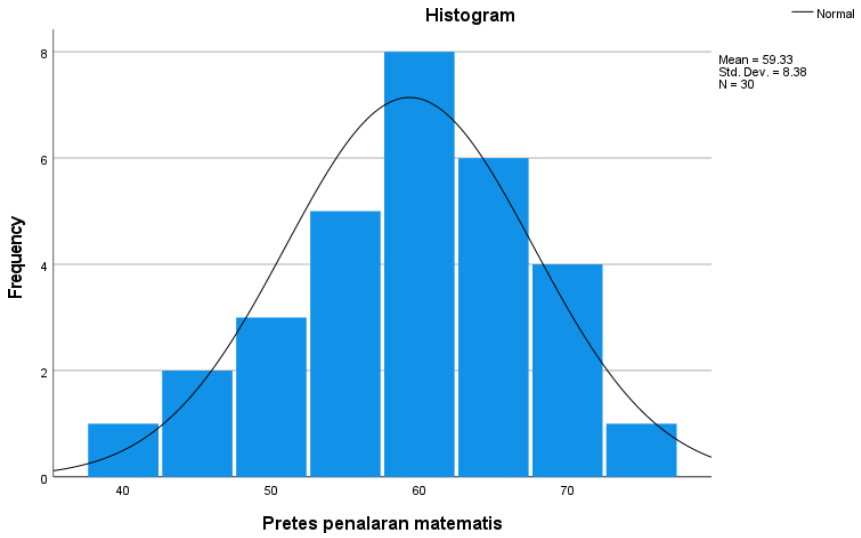

Figure 1. Distribution of Mathematical Reasoning Scores

Histogram showing pretest (Mean = 59.33, SD = 8.380) and posttest (Mean = 79.67, SD = 7.980) distributions

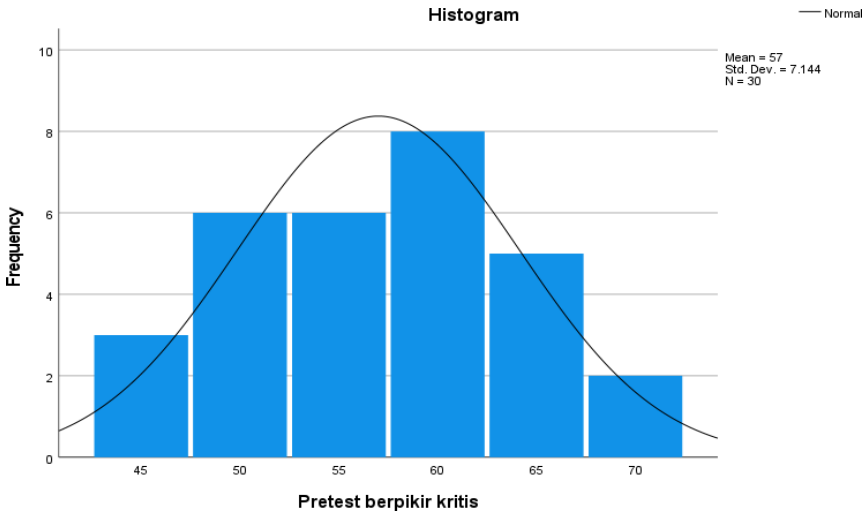

Figure 2. Distribution of Critical Thinking Scores

Histogram showing pretest (Mean = 57.00, SD = 7.144) and posttest (Mean = 73.83, SD = 8.579) distributions

The histograms reveal that both pretest distributions approximated normal curves centered around their respective means, with most scores clustering near the average and fewer scores at the extremes. The posttest distributions similarly demonstrated normal patterns but with higher means and maintained relatively consistent standard deviations, indicating that improvements occurred across the

ability spectrum rather than benefiting only certain student groups. The normality of all distributions was confirmed by Shapiro-Wilk test results, with posttest significance values of 0.121 for mathematical reasoning and 0.183 for critical thinking (both > 0.05), validating the appropriateness of parametric statistical analyses for hypothesis testing.

The Effect of RME Approach on Improving Mathematical Reasoning and Critical Thinking Abilities

Table 2 presents the results of the paired sample t-test conducted to examine the differences between students' pretest and posttest scores in mathematical reasoning and critical thinking abilities after the implementation of the Realistic Mathematics Education (RME) approach. The paired sample t-test was selected because the same group of students was measured twice, before and after the intervention, and the data were confirmed to be normally distributed. This analysis aimed to determine whether the observed improvements were statistically significant and not caused by random variation. The comparison between pretest and posttest scores provides empirical evidence regarding the effectiveness of RME in enhancing higher-order thinking skills. By examining mean differences, standard deviations, t-values, and significance levels, this analysis offers a comprehensive evaluation of learning gains. The statistical results summarized in Table 2 serve as the primary basis for decision-making in hypothesis testing. These results are interpreted using a significance level of 0.05, which is commonly applied in educational research.

Table 2. Paired Sample T-Test Results

Variable	Mean Difference	SD	t	df	Sig. (2-tailed)	95% CI
Mathematical Reasoning	-20.333	3.698	-30.113	29	.000	[-21.714, -18.952]
Critical Thinking	-16.833	5.490	-16.793	29	.000	[-18.883, -14.783]

Based on the results shown in Table 2, the paired sample t-test for mathematical reasoning revealed a mean difference of -20.333 with a standard deviation of 3.698, indicating that posttest scores were substantially higher than pretest scores. The negative sign of the mean difference confirms that students' mathematical reasoning abilities improved after the RME intervention. The obtained t-value of -30.113 with 29 degrees of freedom and a significance value of $p < 0.001$ indicates a very strong statistical effect. Since the Sig. (2-tailed) value is far below the 0.05 threshold and the 95% confidence interval does not include zero, the null hypothesis (H_0) is rejected and the alternative hypothesis (H_a) is accepted. This result provides strong evidence that the RME approach significantly improved students' mathematical reasoning abilities in plane figures material. The large t-value also suggests that the observed improvement was consistent across most students.

Similarly, the paired sample t-test results for critical thinking abilities showed a mean difference of -16.833 with a standard deviation of 5.490, again indicating higher posttest scores compared to pretest scores. The statistical analysis produced a t-value of -16.793 with 29 degrees of freedom and a significance value of $p <$

0.001. As with mathematical reasoning, the Sig. (2-tailed) value is below 0.05 and the confidence interval entirely excludes zero, leading to the rejection of the null hypothesis and acceptance of the alternative hypothesis. These findings confirm that the RME approach significantly enhanced students' critical thinking abilities. The relatively larger standard deviation compared to mathematical reasoning suggests greater variability in students' critical thinking gains; however, the overall improvement remained substantial for nearly all participants. This result indicates that RME is effective not only in improving conceptual reasoning but also in fostering evaluative and analytical thinking skills.

Instrument Validity Decision Basis

Before conducting the main data analysis, the validity of the research instrument was examined to ensure that each test item accurately measured students' mathematical reasoning and critical thinking abilities. The validity test was conducted using the Pearson Product Moment correlation technique based on data obtained from a pilot test involving 15 students. The decision criteria for item validity were established using two indicators: the significance value and the comparison between the calculated correlation coefficient (r-count) and the critical value in the r-table. An item was declared valid if the Sig. (2-tailed) value was less than 0.05 and the r-count value exceeded the r-table value. At a significance level of 0.05 with n = 15 respondents, the r-table value was determined to be 0.514. These criteria were applied consistently to all test items to ensure methodological rigor.

The results of the validity analysis showed that all 10 test items met the established validity criteria. The correlation coefficients (r-count) for the items ranged from 0.545 to 0.707, all of which were greater than the r-table value of 0.514. In addition, all items produced Sig. (2-tailed) values below 0.05, indicating statistically significant correlations between each item score and the total test score. These findings confirm that each item was capable of measuring the intended constructs effectively. Therefore, based on both the significance level and the r-count versus r-table comparison, all items were declared valid and suitable for use in the main study. The confirmed validity of the instrument strengthens the credibility of the research findings and ensures that the reported improvements in mathematical reasoning and critical thinking abilities can be attributed reliably to the implementation of the RME approach.

Implementation of Realistic Mathematics Education (RME) in Plane Figures Learning

The significant improvement in students' mathematical reasoning and critical thinking abilities after the implementation of the Realistic Mathematics Education (RME) approach is closely related to how each core stage of RME was systematically applied during classroom instruction. In this study, RME was not merely treated as a theoretical framework, but was operationalized through concrete classroom practices that guided students from real-life experiences toward abstract mathematical understanding. The learning process emphasized the use of meaningful contexts, progressive mathematization, interactive discussion, and

reflection, all of which contributed to students' active engagement in learning plane figures. These stages functioned as an integrated process rather than isolated activities, enabling students to gradually develop reasoning and critical thinking skills. The following discussion elaborates how each RME stage was implemented in detail and how it supported the observed learning outcomes. This explanation is intended to strengthen the linkage between instructional processes and quantitative findings, as well as to enhance the replicability of the study for future researchers and practitioners.

The learning process began with the use of real-life contexts that were familiar and meaningful to second-grade elementary students. At this initial stage, students were introduced to plane figures through objects commonly found in their daily environment, such as the classroom blackboard, windows, doors, wall clocks, books, and floor tiles. The teacher encouraged students to observe these objects directly and relate them to geometric shapes, thereby activating students' prior knowledge and experiences. For example, students were asked to identify the shape of the blackboard or explain why the classroom floor appeared as a collection of small squares. Through this contextual approach, mathematics learning became more concrete and relevant, reducing students' anxiety toward abstract concepts. This stage played a crucial role in building initial conceptual understanding and motivating students to participate actively in subsequent learning activities. The use of real-life contexts aligns with the RME principle that mathematics should be experienced as a human activity rooted in reality rather than as a set of isolated rules.

After students were able to recognize plane figures within real-life contexts, the learning process continued with horizontal mathematization. During this stage, students were guided to transform contextual situations into informal mathematical representations using their own language, drawings, and symbols. Students worked collaboratively in small groups to redraw the shapes of real objects they had identified and to describe their characteristics, such as the number of sides or corners. For instance, students drew the shape of a window and described it as having four sides with two longer sides. These informal representations indicated that students were beginning to model real situations mathematically without relying on formal definitions. The teacher's role during this process was to facilitate and scaffold students' thinking by posing guiding questions rather than providing direct explanations. This approach supported students' reasoning processes and encouraged them to construct meaning independently. Horizontal mathematization thus served as a bridge between concrete experiences and emerging mathematical concepts.

The next stage involved vertical mathematization, where students gradually transitioned from informal representations toward more formal and abstract mathematical concepts. At this stage, the teacher helped students generalize the characteristics they had identified and introduced formal mathematical terminology related to plane figures, such as square, rectangle, triangle, and circle. For example, after students described a shape as having four equal sides, the teacher guided them to recognize and name the shape as a square. This process enabled students to

reinvent mathematical concepts through guided instruction rather than memorizing definitions. Vertical mathematization strengthened students' conceptual understanding by helping them connect informal knowledge with formal mathematical structures. As a result, students were better able to apply their understanding to solve abstract problems involving plane figures. This stage contributed significantly to improvements in mathematical reasoning, particularly in drawing conclusions and identifying relationships among geometric properties.

Interactive discussion was integrated throughout the learning process and played a central role in fostering students' critical thinking abilities. Students were encouraged to share their ideas, present group findings, and respond to their peers' explanations during both small-group and whole-class discussions. The teacher facilitated these interactions by asking reflective and open-ended questions, such as whether all shapes with four sides are the same or how a square differs from a rectangle. Through discussion, students were required to justify their answers and consider alternative viewpoints, which promoted deeper thinking and reasoning. Reflection activities were conducted at the end of each lesson, where students were asked to summarize what they had learned using their own words. This reflective process allowed students to consolidate their understanding and evaluate their learning experiences. The combination of discussion and reflection helped students move beyond procedural knowledge toward analytical and evaluative thinking.

Overall, the results of this study indicate that the successful implementation of RME lies in the coherent integration of its stages rather than in isolated instructional techniques. The use of real-life contexts provided a meaningful foundation for learning, horizontal mathematization supported students in developing informal mathematical models, vertical mathematization facilitated the transition to abstract understanding, and interactive discussion and reflection strengthened higher-order thinking skills. These interconnected processes explain the significant increases observed in students' mathematical reasoning and critical thinking scores. The detailed description of RME implementation in this study clarifies how learning activities contributed to the outcomes and enhances the potential for replication in similar educational settings. Consequently, this study provides strong empirical and practical support for the use of RME in elementary mathematics instruction, particularly for developing reasoning and critical thinking skills in plane figures learning.

4. Conclusion

This study investigated the effect of the Realistic Mathematics Education (RME) approach on mathematical reasoning and critical thinking abilities of second-grade elementary students in plane figures material at UPTD SD Negeri 12 Makmur. The findings demonstrate that RME implementation significantly improved both abilities. Before the intervention, students' mathematical reasoning and critical thinking abilities were at moderate levels, with mean pretest scores of 59.33 and 57.00 respectively, indicating limited capacity to connect plane figure concepts with real-world contexts. Following RME implementation, substantial

improvements were observed, with mean posttest scores reaching 79.67 for mathematical reasoning and 73.83 for critical thinking, representing average gains of 20.34 and 16.83 points respectively. Statistical analysis confirmed these improvements were highly significant, demonstrating that RME effectively helps students understand mathematical concepts through real-life contexts, thereby enhancing reasoning and critical thinking abilities.

The success of this approach can be attributed to RME's emphasis on contextual problems, guided reinvention processes, collaborative learning through group discussions, and progressive mathematization from concrete experiences to abstract mathematical formulations. These findings provide empirical evidence supporting RME's effectiveness in developing higher-order thinking skills in elementary mathematics education. Future research should employ true experimental designs with control groups, larger sample sizes, extended implementation periods, and comprehensive assessment of multiple learning outcomes including motivation and attitudes to provide more robust evidence. Additionally, investigating RME application across different mathematical topics and grade levels would further establish its effectiveness and generalizability in elementary education contexts.

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