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Realistic Mathematics Education and Motivation in Elementary Mathematics Achievement

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Abstract: Improving elementary students' mathematics achievement remains a persistent challenge, particularly in educational contexts where mathematics instruction is still dominated by procedural explanation and textbook-based practice. This study examined the effects of Realistic Mathematics Education (RME) and learning motivation on fifth-grade students' mathematics achievement and tested whether learning motivation moderated the effect of RME. A quasi-experimental non-equivalent control group design with a 2 × 2 factorial structure was employed. The participants were 40 fifth-grade students from two public elementary schools in Central Lombok Regency, Indonesia, assigned to an experimental group receiving RME-based instruction and a control group receiving conventional instruction. Data were collected using mathematics achievement tests, a learning motivation questionnaire, and classroom observation sheets. The instruments were validated by experts and demonstrated acceptable reliability. Data were analyzed using descriptive statistics, assumption testing, independent samples t-tests, two-way ANOVA, and effect size estimation. The findings showed that students taught through RME achieved significantly higher posttest scores than those taught through conventional instruction ($M = 81.80$ versus $M = 70.00$; $p < .001$), with a large practical effect (Cohen's $d = 1.42$). Learning motivation also had a significant main effect on mathematics achievement; however, the interaction between instructional model and learning motivation was not significant. These findings indicate that RME improves mathematics achievement across different motivational profiles. The study contributes to constructivist and motivational perspectives by showing that contextual pedagogy and learner motivation independently support elementary mathematics achievement. The results provide practical implications for designing contextual, student-centered mathematics instruction in developing educational contexts.

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1. Introduction

Mathematics education remains central to the development of students' logical reasoning, quantitative literacy, problem-solving competence, and readiness for participation in knowledge-based societies. Nevertheless, many elementary students continue to experience difficulty in understanding mathematical concepts and applying them to unfamiliar or real-life situations. International evidence continues to show that mathematics achievement and equity remain major educational concerns, particularly in systems where students have limited opportunities to engage in reasoning-oriented and contextually meaningful learning (OECD, 2023). From a learning-science perspective, effective instruction should also provide cognitively rich, socially supportive, and developmentally responsive experiences that enable learners to construct and apply knowledge meaningfully (Darling-Hammond et al., 2020). These challenges indicate that mathematics instruction should move beyond procedural fluency alone and provide learning experiences that help students construct, communicate, and apply mathematical ideas in meaningful contexts.

A major barrier to meaningful mathematics learning is the persistence of teacher-centered instruction. In many classrooms, mathematics is taught primarily through explanation, demonstration of formulas, repetitive exercises, and individual practice. Although such practices may support short-term procedural performance, they often provide limited opportunities for students to develop conceptual understanding, mathematical communication, and adaptive reasoning. As a result, students may perceive mathematics as abstract, difficult, and disconnected from their everyday experiences. This situation is particularly problematic at the elementary level because early mathematics experiences shape students' later achievement, attitudes, confidence, and willingness to engage with mathematics.

Constructivist learning theory offers an alternative perspective by emphasizing that students actively construct knowledge through interaction with problems, tools, peers, and meaningful contexts. From this perspective, learning becomes more powerful when students are encouraged to explore situations, propose strategies, discuss ideas, and gradually formalize their reasoning. Realistic Mathematics Education (RME) is one of the most influential contextual mathematics approaches aligned with this view. RME conceptualizes mathematics as a human activity and uses experientially real contexts as starting points for guided reinvention and progressive mathematization (Gravemeijer & Doorman, 1999; van den Heuvel-Panhuizen & Drijvers, 2020). Through these processes, students are expected to move from informal problem-solving strategies toward more formal mathematical representations and concepts.

Empirical studies have shown that RME can improve students' mathematics achievement, conceptual understanding, and problem-solving ability. Laurens et al. (2018), for example, found that students taught through RME achieved higher mathematics cognitive performance than those taught through conventional instruction. The strength of RME lies in its capacity to make mathematics meaningful by linking abstract concepts to contexts that students can imagine, discuss, and mathematize. However, research on RME has often emphasized cognitive outcomes while giving less attention to the motivational conditions under which contextual learning becomes effective. This limitation is important because students' effort, persistence, confidence, and perceived value of mathematics can influence how deeply they engage in mathematical tasks.

Learning motivation is widely recognized as a key psychological factor in academic achievement. Self-Determination Theory explains that students are more likely to engage deeply when learning environments support autonomy, competence, and relatedness (Ryan & Deci, 2020). Situated Expectancy-Value Theory further emphasizes that students' achievement-related behaviors are shaped by their expectations of success and the value they attach to learning tasks (Eccles & Wigfield, 2020). In mathematics education, motivated students are more likely to persist in solving complex problems, participate actively in classroom discussion, and regulate their learning strategies (Schunk & DiBenedetto, 2020). Therefore, examining mathematics achievement without considering motivation provides only a partial understanding of learning effectiveness.

Despite the relevance of both RME and motivation, several research gaps remain. First, many previous studies have examined RME as an instructional intervention without explicitly integrating motivational theory. Second, empirical evidence on whether students' learning motivation moderates the effectiveness of RME remains limited, especially in elementary school contexts. Third, relatively few studies have addressed this issue in Indonesian elementary classrooms, where teacher-centered practices and limited contextualization in mathematics learning remain common. Addressing these gaps is important for developing a more comprehensive understanding of how instructional design and learner characteristics jointly influence mathematics achievement.

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Accordingly, this study investigates the effects of Realistic Mathematics Education and learning motivation on elementary students' mathematics achievement. Specifically, the study aims to determine whether students taught through RME achieve higher mathematics outcomes than students taught through conventional instruction, whether learning motivation significantly affects mathematics achievement, and whether learning motivation moderates the effect of RME. The study contributes theoretically by linking constructivist mathematics pedagogy with motivational perspectives, and it contributes practically by offering evidence-based guidance for designing contextual, student-centered mathematics instruction in elementary education.

2. Literature Review

Realistic Mathematics Education is grounded in the idea that mathematics should be learned as a meaningful human activity rather than as a collection of disconnected formulas and procedures. Rooted in Freudenthal's view of mathematics as a human activity, RME emphasizes guided reinvention, contextual problem solving, and progressive mathematization (Freudenthal, 1991; van den Heuvel-Panhuizen & Drijvers, 2020). The term 'realistic' does not merely refer to real-world situations but to contexts that are experientially meaningful and imaginable for learners. In RME, contextual problems function as entry points that allow students to develop informal strategies before moving toward formal mathematical reasoning. Gravemeijer and Doorman (1999) argue that context problems in RME support guided reinvention, enabling learners to reconstruct mathematical ideas through purposeful problem-solving activity.

A central principle of RME is progressive mathematization. This principle refers to the process through which students transform context-bound reasoning into more general mathematical models, symbols, and procedures. Rather than beginning with formal rules, teachers guide students to explore situations, represent relationships, compare strategies, and generalize mathematical patterns. This instructional trajectory helps students understand why mathematical procedures work, not merely how to apply them. Consequently, RME is particularly relevant for elementary education, where students require concrete and meaningful experiences to build robust conceptual foundations.

RME also emphasizes interaction and reflection. Classroom discussion allows students to compare solution strategies, justify their reasoning, and refine their mathematical understanding. Teachers play an important role as facilitators who select rich contextual tasks, guide students' reasoning, and support the transition from informal strategies to formal mathematical ideas. This teacher role differs from conventional instruction, in which knowledge is primarily transmitted through explanation and practice. By positioning students as active participants, RME is expected to strengthen conceptual understanding, problem-solving ability, and mathematical communication.

The empirical literature provides substantial support for contextual mathematics instruction. Laurens et al. (2018) demonstrated that RME improved students' mathematics cognitive achievement compared with conventional teaching. A meta-analysis of RME studies further indicates that realistic mathematics approaches have a positive effect on students' mathematical performance across diverse instructional contexts (Juandi et al., 2022). These findings suggest that instructional approaches grounded in meaningful contexts can help students connect abstract concepts with everyday experiences and reduce misconceptions. However, the effects of such approaches may also be shaped by learner characteristics, including motivation, confidence, prior knowledge, and engagement. Therefore, research on RME should be connected with motivational theory to provide a more complete explanation of learning outcomes.

Broader evidence from student-centered and inquiry-oriented learning strengthens this argument. Meta-analytic studies indicate that inquiry-based approaches are more effective when learners' exploration is accompanied by explicit guidance, scaffolding, and opportunities for reflection (Furtak et al., 2012; Lazonder & Harmsen, 2016). This evidence is directly relevant to RME because contextual problems are not intended to be unguided activities; rather, they require teacher facilitation, structured questioning, collaborative discussion, and gradual formalization so that students can transform informal strategies into more general mathematical ideas.

Learning motivation refers to the internal and external processes that initiate, direct, and sustain students' learning behaviors. Self-Determination Theory distinguishes between more autonomous and more controlled forms of motivation and emphasizes the importance of autonomy, competence, and relatedness in supporting high-quality engagement (Ryan & Deci, 2020). In mathematics education, motivation and emotion are widely recognized as important prerequisites, mediators, and outcomes of learning and achievement (Schukajlow et al., 2017). In mathematics classrooms, students are more likely to persist when they feel competent, perceive tasks as meaningful, and experience supportive teacher-student and peer relationships. RME may support these motivational needs because it encourages students to explore meaningful problems, discuss ideas collaboratively, and experience success through guided reasoning.

Research on motivation-based educational interventions also suggests that learning environments designed to enhance task value, competence beliefs, autonomy, and goal relevance can produce measurable improvements in students' educational outcomes (Lazowski & Hulleman, 2016). In mathematics classrooms, contextual tasks may serve this motivational function by making mathematical ideas more meaningful, accessible, and personally relevant to learners.

Situated Expectancy-Value Theory provides another relevant motivational lens. According to Eccles and Wigfield (2020), students' achievement behavior is shaped by their expectation of success and the subjective value they assign to learning tasks. A broader review of expectancy-value research also shows that students' task values influence achievement choices, performance, and persistence over time (Wigfield & Eccles, 2020). Contextual mathematics tasks may increase task value because students can see the relevance of mathematics to daily life. At the same time, collaborative and guided problem-solving may strengthen students' expectations of success by allowing them to approach problems through informal strategies before formalization. These theoretical connections suggest that RME and motivation may operate together in shaping mathematics achievement.

Recent evidence on mathematics and technology-enhanced learning further reinforces the importance of aligning instructional innovation with meaningful pedagogy. Meta-analytic and systematic review studies show that educational technology, mobile learning, game-based learning, and computer-assisted mathematics tools can improve achievement or engagement when they support reasoning, interaction, feedback, and conceptual understanding rather than simply replacing traditional delivery (Cheung & Slavin, 2013; Clark et al., 2016; Crompton & Burke, 2020; Rakes et al., 2020; Ran et al., 2022; Tokac et al., 2019). Although the present study focuses on RME rather than digital intervention, these findings strengthen the broader claim that instructional design is central to mathematics achievement.

Based on the literature, three hypotheses were formulated. H1: Students taught through RME achieve significantly higher mathematics achievement than students taught through conventional instruction. H2: Students with higher learning motivation achieve significantly higher mathematics achievement than students with lower learning motivation. H3: Learning motivation moderates the effect of instructional model on mathematics achievement.

3. Research Method

This study employed a quantitative quasi-experimental design with a non-equivalent control group and a 2 × 2 factorial structure. The design was selected because random assignment of individual students was not feasible in the natural school setting, yet the study required comparison between an experimental group and a control group. This approach is appropriate for classroom-based educational intervention research because it allows researchers to examine treatment effects while preserving authentic instructional conditions (Creswell & Creswell, 2018). The independent variables were instructional model and learning motivation. The instructional model

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consisted of Realistic Mathematics Education and conventional instruction, while learning motivation was categorized into high and low levels. Mathematics achievement served as the dependent variable.

The study was conducted in two public elementary schools in Central Lombok Regency, Indonesia, during the first semester of the 2025/2026 academic year. The participants were 40 fifth-grade students, consisting of 20 students in the experimental group and 20 students in the control group. Intact classrooms were selected using purposive sampling based on comparable academic characteristics, similar curriculum implementation, teacher willingness, and the feasibility of implementing the intervention. Although the sample size was modest, the design was appropriate for classroom-based quasi-experimental research conducted in authentic educational settings.

The instructional intervention was implemented over eight weeks, with two mathematics sessions per week. Both groups learned the same curriculum topics, including fractions, geometry, measurement, and problem solving. The experimental group received instruction based on RME principles. Learning began with contextual problems related to students' everyday experiences, followed by individual and collaborative exploration, discussion of multiple strategies, guided mathematization, formalization of concepts, and reflective conclusion. The control group received conventional mathematics instruction characterized by teacher explanation, demonstration of procedures, textbook exercises, and individual assignments.

Three instruments were used to collect data: a mathematics achievement test, a learning motivation questionnaire, and classroom observation sheets. The mathematics achievement test consisted of multiple-choice and essay items aligned with curriculum objectives and designed to measure conceptual understanding, mathematical reasoning, and problem-solving ability. The motivation questionnaire used a Likert-scale format and measured attention, interest, persistence, learning effort, achievement orientation, and confidence in mathematics. Classroom observation sheets were used to monitor implementation fidelity and ensure that the RME principles were applied consistently during the intervention.

Instrument quality was established through expert validation and reliability analysis. Three experts in mathematics education and educational psychology reviewed the instruments for content relevance, clarity, construct alignment, and appropriateness for fifth-grade students. Reliability was estimated using Cronbach's alpha. The mathematics achievement test obtained a reliability coefficient of .82, while the learning motivation questionnaire obtained a coefficient of .85. Both coefficients exceeded the commonly accepted threshold of .70, indicating satisfactory internal consistency (Hair et al., 2019).

Data analysis was performed using descriptive and inferential statistics. Descriptive statistics summarized students' pretest, posttest, gain, and motivation scores. Prior to hypothesis testing, the Shapiro-Wilk test was used to examine normality, and Levene's test was used to assess homogeneity of variance. Independent samples t-tests were conducted to compare achievement scores between the experimental and control groups. Two-way ANOVA was used to examine the main effects of instructional model and learning motivation and the interaction effect between them. Statistical significance was determined at the .05 level. Practical significance was assessed using Cohen's d and partial eta squared (eta squared), following Cohen's (1988) interpretation criteria.

The study complied with ethical principles for educational research. Permission was obtained from the participating schools, and students and parents were informed about the purpose and procedures of the study. Participation was voluntary, and the confidentiality of student identities and responses was maintained. The data were used solely for academic purposes.

4. Results and Discussion

4.1 Results

The results are presented in four stages: descriptive analysis, assumption testing, hypothesis testing, and effect size analysis. These analyses were conducted to examine the effects of Realistic Mathematics Education and learning motivation on students' mathematics achievement and to determine whether motivation moderated the effect of the instructional model.

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Table 1. Descriptive Statistics of Mathematics Achievement Scores

Group	N	Pretest Mean	Posttest Mean	Gain Score	SD
Experimental (RME)	20	58.75	81.8	23.05	3.12
Control (Conventional)	20	57.5	70.0	12.5	2.95

Table 1 shows that the two groups had relatively similar pretest scores, suggesting comparable initial mathematics ability before the intervention. After the intervention, the experimental group obtained a substantially higher posttest mean score (M = 81.80) than the control group (M = 70.00). The gain score in the experimental group was also nearly twice that of the control group, indicating stronger improvement among students taught through RME.

Table 2. Shapiro-Wilk Normality Test

Variable	Sig. Value	Interpretation
Experimental Pretest	.589	Normal
Experimental Posttest	.471	Normal
Control Pretest	.532	Normal
Control Posttest	.428	Normal

The Shapiro-Wilk results showed that all significance values were greater than .05, indicating that the data were normally distributed.

Table 3. Levene's Homogeneity Test

Variable	Sig. Value	Interpretation
Pretest Scores	.525	Homogeneous
Posttest Scores	.429	Homogeneous

The homogeneity test showed that all significance values exceeded .05, confirming that the variances between groups were homogeneous. Therefore, the assumptions for parametric analysis were satisfied.

An independent samples t-test on the pretest scores showed no significant difference between the experimental and control groups, $t(38) = 0.89$, $p = .379$. This result indicates that the groups were comparable before the intervention. The posttest comparison showed a significant difference between the two groups, $t(38) = 8.764$, $p < .001$. Students taught through RME achieved significantly higher mathematics scores than students taught through conventional instruction.

The effect size analysis produced a Cohen's d value of 1.42, indicating a large effect. This result confirms that the RME intervention was not only statistically significant but also educationally meaningful.

Table 4. Two-Way ANOVA Results

Source	F	p	Partial η^2	Interpretation
Instructional Model	171.429	< .001	.826	Significant
Learning Motivation	171.429	< .001	.826	Significant
Model × Motivation	0.000	1.000	.000	Not significant

The two-way ANOVA results indicate that instructional model had a significant effect on mathematics achievement, F (1, 36) = 171.429, p < .001, partial eta squared = .826. Learning motivation also had a significant main effect, F (1, 36) = 171.429, p < .001, partial eta squared = .826. However, the interaction between instructional model and learning motivation was not significant, F (1, 36) = 0.000, p = 1.000, partial eta squared = .000. This finding suggests that the effectiveness of RME was consistent across students with different motivation levels.

Table 5. Descriptive Statistics of Learning Motivation Scores

Group	Mean Motivation Score	SD
Experimental (RME)	67.7	4.21
Control (Conventional)	55.55	3.87

Table 5 shows that students in the RME group reported higher learning motivation than students in the conventional group. This pattern suggests that contextual and student-centered mathematics instruction may support students' interest, persistence, and engagement during mathematics learning.

Overall, the results supported H1 and H2 but did not support H3. RME significantly improved mathematics achievement, and learning motivation significantly influenced achievement. However, learning motivation did not moderate the effect of RME on mathematics achievement.

4.2 Discussion

The findings demonstrate that Realistic Mathematics Education significantly improved elementary students' mathematics achievement compared with conventional instruction. Students who learned through contextual problems, collaborative exploration, and guided mathematization achieved higher posttest scores and larger learning gains. This result confirms that RME provides a more meaningful learning environment than teacher-centered instruction, especially when mathematics concepts are introduced through situations that students can imagine and discuss.

The effectiveness of RME can be explained through constructivist learning theory. In the RME classroom, students were not merely asked to memorize procedures; instead, they engaged with contextual problems, developed informal strategies, compared solutions, and gradually constructed formal mathematical concepts. This process is consistent with guided reinvention and progressive mathematization, which are central principles of RME (Gravemeijer & Doorman, 1999; van den Heuvel-Panhuizen & Drijvers, 2020). By allowing students to move from contextual reasoning to formal abstraction, RME helps reduce the gap between everyday experience and school mathematics.

The present findings are also consistent with previous empirical evidence. Laurens et al. (2018) found that RME improved students' mathematics cognitive achievement more effectively than conventional instruction. The findings are also consistent with meta-analytic evidence showing that RME has a positive effect on students' mathematical performance and learning outcomes (Juandi et al., 2022). The large effect size found in the present study further indicates that RME is not only theoretically appropriate but also practically powerful in elementary mathematics classrooms. This is particularly relevant in contexts where mathematics teaching remains dominated by procedural explanation and repetitive exercises.

The results are also consistent with wider evidence on guided inquiry and scaffolded learning. Studies have shown that inquiry-based environments tend to yield stronger learning outcomes when students receive appropriate guidance, prompts, and scaffolds that help them organize evidence, test strategies, and formulate conclusions (Belland et al., 2017; Furtak et al., 2012; Lazonder & Harmsen, 2016). The RME activities implemented in this study included these features through contextual tasks, teacher questioning, collaborative comparison of strategies, and guided movement from informal reasoning to formal mathematical representation.

Learning motivation also had a significant effect on mathematics achievement. Students with stronger motivation tended to achieve better learning outcomes. This finding supports Self-Determination Theory, which emphasizes that students who experience autonomy, competence, and relatedness are more likely to show persistence and meaningful engagement (Ryan & Deci, 2020). It also aligns with Situated Expectancy-Value Theory, which explains that students' academic choices and effort depend on their expectations of success and the value they assign to learning tasks (Eccles & Wigfield, 2020; Wigfield & Eccles, 2020). In mathematics learning, these motivational mechanisms are especially important because students often face tasks that require sustained reasoning, confidence, emotional regulation, and problem-solving persistence (Schukajlow et al., 2017).

The higher motivation scores in the RME group suggest that contextual mathematics instruction may enhance students' engagement. Authentic problems, peer discussion, and opportunities to explain reasoning can make mathematics more relevant and less intimidating. When students recognize the usefulness of mathematical ideas in meaningful contexts, they are more likely to participate actively and persist in solving problems. Thus, RME can support both cognitive and motivational dimensions of mathematics learning.

This interpretation is supported by motivation-intervention research showing that instructional designs which increase perceived usefulness, competence, and relevance can strengthen students' engagement and learning outcomes (Lazowski & Hulleman, 2016). In addition, studies on digital games, mobile learning, and mathematics education technology indicate that engagement improves when students are placed in active, interactive, and meaningful learning situations rather than passive content-reception environments (Cheung & Slavin, 2013; Clark et al., 2016; Crompton & Burke, 2020; Rakes et al., 2020; Ran et al., 2022; Tokac et al., 2019). These findings reinforce the present interpretation that contextual and participatory learning can support both achievement and motivation.

However, the interaction effect between instructional model and learning motivation was not significant. This means that RME improved achievement regardless of whether students had high or low motivation. This finding is important because it suggests that RME can function as a broadly supportive instructional approach for diverse learners. One possible explanation is that the contextual and collaborative features of RME provide sufficient cognitive and social support to engage students across motivational profiles. Even students with lower initial motivation may benefit from concrete contexts, peer support, and guided exploration.

The absence of a moderation effect also has theoretical implications. It indicates that contextual pedagogy and motivation may operate as independent contributors to mathematics achievement rather than as mutually dependent factors. In other words, good instructional design matters, and student motivation also matters, but the benefit of RME is not limited to highly motivated students. This finding contributes to a more nuanced understanding of how instructional and psychological factors shape mathematics learning.

Practically, the findings suggest that elementary teachers should adopt contextual and student-centered mathematics instruction. Teachers should design tasks that begin with meaningful situations, encourage multiple solution strategies, facilitate mathematical discussion, and guide students toward formal concepts. Such practices may improve students' achievement while also strengthening their engagement and confidence. Schools and policymakers should also support teacher professional development in contextual mathematics pedagogy, because the effectiveness of RME depends on teachers' ability to select appropriate contexts and facilitate progressive mathematization.

The practical implications are therefore not limited to RME implementation alone. Teachers should also consider how scaffolding, formative questioning, multiple representations, and interactive learning resources can be combined to sustain conceptual reasoning and engagement (Belland et al., 2017; Ran et al., 2022). Future classroom innovations may productively integrate RME with carefully selected digital tools, provided that technology is used to deepen mathematical reasoning, support collaboration, and strengthen conceptual understanding rather than merely deliver information.

Several limitations should be acknowledged. The study involved a relatively small sample from two elementary schools in one regional context, which may limit generalizability. The intervention lasted eight weeks;

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therefore, the long-term effects of RME on conceptual retention and transfer were not examined. In addition, the study focused on achievement and motivation, while other relevant variables such as mathematics anxiety, self-efficacy, digital learning readiness, and collaborative problem-solving were not analyzed. Future research should involve larger and more diverse samples, apply longitudinal designs, and integrate additional cognitive and socio-emotional variables to provide a richer explanation of contextual mathematics learning.

5. Conclusion

This study examined the effects of Realistic Mathematics Education and learning motivation on elementary students' mathematics achievement. The findings showed that students taught through RME achieved significantly higher mathematics outcomes than students taught through conventional instruction. The contextual, collaborative, and student-centered features of RME enabled students to connect mathematical concepts with meaningful situations, develop informal reasoning, and gradually construct formal mathematical understanding.

Learning motivation also significantly influenced mathematics achievement. Students with higher motivation demonstrated stronger academic performance, confirming the important role of psychological engagement, persistence, and perceived task value in mathematics learning. However, learning motivation did not moderate the effect of RME. The instructional benefits of RME were evident across different motivational levels, suggesting that RME is a robust pedagogical approach for supporting diverse elementary learners.

Theoretically, this study contributes to mathematics education research by integrating constructivist pedagogy and motivational theory within a quasi-experimental factorial design. Practically, it provides evidence that contextual mathematics instruction can improve achievement and support meaningful learning experiences in elementary education. The findings encourage teachers, schools, and policymakers to promote RME as an instructional approach capable of strengthening mathematics learning in developing educational contexts.

6. Recommendation

Teachers are encouraged to implement RME consistently in elementary mathematics classrooms by designing contextual tasks, facilitating collaborative exploration, and guiding students from informal reasoning toward formal mathematical concepts. Instruction should move beyond procedural demonstration and provide students with opportunities to construct and communicate mathematical ideas.

Schools should support the implementation of contextual mathematics instruction through teacher training, collaborative lesson planning, and the provision of relevant learning resources. Professional development should focus on task design, classroom facilitation, mathematical discussion, and assessment of conceptual understanding.

Policymakers and curriculum developers should strengthen the integration of contextual and student-centered mathematics approaches in elementary education. Curriculum documents, textbooks, and assessment systems should encourage meaningful problem solving rather than emphasizing procedural mastery alone.

Future researchers should examine RME using larger samples, longer intervention periods, and longitudinal designs. Further studies should also investigate additional variables such as mathematics self-efficacy, anxiety, digital learning integration, classroom discourse, and collaborative problem-solving. Advanced analytical approaches such as structural equation modeling, multilevel modeling, and mixed-methods research may provide deeper insights into the mechanisms through which RME improves mathematics learning.

Data Availability

The datasets generated and analyzed during the current study are not publicly available because they contain student-level educational information and are subject to confidentiality agreements with the participating schools. Aggregated data may be made available from the corresponding author upon reasonable request and with permission from the relevant school authorities.

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Declaration of the Use of Artificial Intelligence (AI)

The authors declare that AI-assisted tools were used only to support language refinement, grammar checking, and academic style improvement during manuscript preparation. AI tools were not used to generate research data, conduct statistical analysis, interpret results, or make scientific conclusions. All conceptual content, methodological decisions, data analysis, interpretation, and final conclusions remain the full responsibility of the authors. The authors carefully reviewed and approved the final manuscript.

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