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From context to reasoning: realistic mathematics education and students' problem-solving skills in ratios

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ABSTRACT

Purpose: to examine the effect of the realistic mathematics education (RME) approach on seventh-grade students' mathematical problem-solving abilities in learning ratios, based on Polya's four problem-solving indicators.
Method: this study used a quasi-experimental design with 62 seventh-grade students divided into experimental and control groups. Data were collected through pretests and posttests and analyzed using an Independent Samples t-test.
Findings: students taught using RME achieved significantly higher problem-solving scores than those receiving conventional instruction (54.11 vs. 34.31; $p < 0.001$). RME also showed better performance across all four of Polya's problem-solving indicators, although devising a plan remained the most challenging stage.
Implications: the findings suggest that RME can serve as an effective alternative for mathematics instruction by connecting real-life contexts with mathematical concepts to strengthen students' problem-solving abilities, particularly in ratio learning.
Originality: lies in integrating the RME approach with Polya's four problem-solving indicators to examine students' problem-solving abilities specifically in ratio learning at the junior high school level in Jember, Indonesia.

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Introduction

Mathematical problem-solving is a fundamental competency students need to develop in mathematics education because it enables them to understand mathematical concepts, formulate strategies, and apply mathematical knowledge to solve problems in real-life situations (Nilimaa, 2023; Zaini & Marsigit, 2014). Beyond mastering computational procedures, students are expected to interpret problems, identify relevant information, select appropriate strategies, execute solutions, and evaluate the

accuracy of their results (Astuti et al., 2025; Woo & Falloon, 2022). These competencies are particularly important in learning ratios, as ratio concepts are closely associated with everyday situations, including comparisons of quantities, scale, proportions, and rates (Joutsenlahti & Perkkilä, 2024; Schulz, 2024). Nevertheless, developing students' problem-solving abilities remains a significant challenge in mathematics education, particularly at the junior secondary school level (Gunawan et al., 2023; Nilimaa, 2023), where students are required to move beyond procedural knowledge toward meaningful mathematical reasoning and application (Dorner & Ableitinger, 2022).

This challenge is also reflected in the context of mathematics education in Jember regency, Indonesia. Previous studies have identified several weaknesses in students' mathematical problem-solving abilities, particularly in developing appropriate solution strategies. Wahab A. et al. (2024), for instance, reported difficulties among junior high school students in solving problems involving integers and fractions based on Polya's problem-solving framework. Similarly, Febrima & Mahmudi (2026) found that students' mathematical problem-solving abilities, when analyzed using the Solo taxonomy, remained at relatively basic levels. These findings indicate that students may struggle not only to understand mathematical problems but also to connect available information with appropriate mathematical procedures and develop systematic solution plans. Such conditions suggest that conventional mathematics instruction needs to be complemented by learning approaches that provide meaningful contexts and opportunities for students to construct, communicate, and evaluate their own problem-solving strategies.

In response to these challenges, realistic mathematics education (RME) has received considerable attention as an alternative approach to improving mathematics learning and students' mathematical competencies. Previous studies have shown that RME can produce more favorable mathematics learning outcomes than conventional instructional approaches (Catrining & Widana, 2018; Zaini & Marsigit, 2014). More recent research has further explored its contribution to mathematical problem-solving and related competencies. Da (2023) examined the effect of RME on high school students' problem-solving competency in calculus, while Tumangger et al. (2024) reported the potential of RME-based student worksheets to improve mathematical problem-solving skills. Khasanah et al. (2025) also highlighted RME's effectiveness in improving elementary school students' problem-solving abilities through a literature review. Furthermore, Ventistas et al. (2025) investigated the impact of RME on secondary school students' problem-solving skills through a comparative evaluation study. Research on ratio learning has also identified persistent challenges in students' mathematical literacy processes when solving ratio and proportion problems (Wardani et al., 2024), while Maharani et al. (2024) demonstrated the relevance of instructional innovation for improving students' problem-solving skills in ratio through problem-based learning. Collectively, these studies establish a strong rationale for investigating contextual and student-centered approaches in mathematics instruction.

Despite the growing body of literature, several aspects still warrant further investigation. Previous RME studies have examined different mathematical topics, educational levels, and learning outcomes, including calculus problem-solving competency (Da, 2023), elementary school students' problem-solving skills (Khasanah et al., 2025), and secondary school students' problem-solving performance (Ventistas et al., 2025). Meanwhile, studies focusing specifically on ratio learning have explored students' difficulties in ratio and proportion problems (Wardani et al., 2024) and the implementation of problem-based learning to improve ratio problem-solving skills

(Maharani et al., 2024). Research by Reinke et al. (2023) further emphasizes the importance of contextualization in developing students' understanding of ratios. However, the relationship between RME implementation and students' problem-solving abilities in ratio learning at the junior high school level, particularly in the educational context of Jember Regency, remains an important area for further empirical examination. In addition, Purnama et al. (2023) emphasized the need to optimize RME implementation by developing more effective learning materials. Therefore, this study offers a contextual, subject-specific investigation by examining the effect of RME on junior high school students' problem-solving abilities in ratio learning at SMPN 12 Jember. Its novelty lies in integrating the RME approach, the ratio topic, and Polya's problem-solving framework within a specific local educational setting.

This study examines the effect of the realistic mathematics education approach on junior high school students' mathematical problem-solving abilities when learning ratios at SMPN 12 Jember. This investigation matters because ratios are not merely an abstract mathematical topic but also a concept students encounter in everyday situations, such as comparing quantities, interpreting maps and scales, determining unit prices, and understanding rates. Consequently, students' difficulties in solving ratio problems may limit their ability to apply mathematical knowledge meaningfully beyond the classroom. Implementing RME in this topic is expected to provide learning experiences that connect mathematical concepts with familiar situations, encourage students to construct their own solution strategies, and strengthen their ability to translate contextual problems into mathematical representations. Thus, this study is significant not only for evaluating an alternative instructional approach but also for addressing the practical need to improve students' mathematical problem-solving competencies through meaningful and context-based learning.

This study is grounded in realistic mathematics education, an approach to mathematics instruction rooted in the idea that mathematics should be experienced as a meaningful human activity rather than presented solely as a collection of abstract rules and procedures (Gravemeijer, 1994). RME emphasizes progressive mathematization, through which students develop mathematical understanding by starting with meaningful contextual situations and gradually moving toward more formal mathematical representations. Gravemeijer (1994) identifies five fundamental characteristics of RME: (1) phenomenological exploration, which involves using meaningful contextual problems as starting points for learning; (2) the use of models and progressive mathematization, in which students develop informal representations that function as bridges toward formal mathematical concepts; (3) student contributions, which encourage students to construct and present their own ideas and strategies; (4) interactivity, which promotes mathematical communication, discussion, and collaboration; and (5) intertwining, which connects mathematical concepts and topics to develop integrated understanding. Through these characteristics, RME positions students as active participants in constructing mathematical knowledge while allowing teachers to facilitate the transition from informal reasoning to formal mathematical understanding.

Furthermore, RME's characteristics align closely with Polya's (1945) four-stage framework for mathematical problem-solving: understanding the problem, devising a plan, carrying out the plan, and looking back. The contextual exploration characteristic of RME supports students in understanding problems by helping them identify relevant information and interpret relationships in real-life situations. Models and progressive mathematization give students opportunities to devise plans by developing

representations, recognizing mathematical relationships, and selecting appropriate strategies. Student contributions and interactivity facilitate the implementation and communication of solution procedures, while the intertwining of mathematical concepts encourages students to examine relationships among different mathematical ideas. Finally, through discussion, reflection, and mathematical verification, students can evaluate their solutions and revisit the strategies they have used. This theoretical alignment suggests that RME has the potential to support the development of problem-solving abilities across all four stages of Polya's framework, particularly the devising-a-plan stage, which has been identified as a challenge in previous research in Jember (Rahmawati et al., 2026).

Based on these considerations, this study is expected to provide empirical evidence on the effectiveness of RME in improving junior high school students' mathematical problem-solving abilities in ratio learning. Theoretically, this study is expected to enrich the literature on the relationship between contextual mathematics instruction and students' problem-solving development, particularly by connecting the characteristics of RME with Polya's problem-solving framework. Practically, the findings may provide mathematics teachers with insights into designing contextual learning activities that encourage students to construct mathematical models, develop solution strategies, communicate their reasoning, and evaluate their answers. For schools and educational stakeholders, the results may serve as a reference for improving the quality of mathematics instruction through student-centered and context-based learning approaches. Ultimately, this study is expected to contribute to the development of more meaningful mathematics learning experiences that strengthen students' ability to apply ratio concepts and solve mathematical problems systematically and effectively.

The realistic mathematics education (RME) approach is expected to improve students' mathematical problem-solving abilities by engaging them in meaningful learning experiences through contextual problems, mathematical modeling, student contributions, interaction, and connections among mathematical concepts (Gravemeijer, 1994). These characteristics give students opportunities to develop their understanding, formulate appropriate solution strategies, execute mathematical procedures, and evaluate their solutions in accordance with Polya's (1945) four stages of problem-solving. Previous studies have shown RME's positive contribution to students' mathematical learning outcomes and problem-solving abilities (Da, 2023; Tumangger et al., 2024; Ventistas et al., 2025; Zaini & Marsigit, 2014). Furthermore, contextualization is particularly relevant to ratio learning because ratio concepts are closely connected to everyday situations (Reinke et al., 2023). Therefore, RME is expected to provide more effective learning experiences than conventional instruction in developing students' mathematical problem-solving abilities. Based on this theoretical and empirical foundation, the research hypothesis is formulated as follows: H1: Students who receive mathematics instruction through the RME approach demonstrate significantly higher mathematical problem-solving abilities in ratio learning than students who receive conventional instruction.

Method

This study used a quasi-experimental, nonequivalent control group design to examine the effect of the realistic mathematics education (RME) approach on students' mathematical problem-solving abilities in learning ratios. This design involved two groups: an experimental group that received mathematics instruction using the RME approach and a control group that received conventional instruction. Both groups were

administered a pretest before the intervention and a posttest after the intervention to measure changes in students' mathematical problem-solving abilities. The study population consisted of all seventh-grade students at SMP Negeri 12 Jember, Indonesia. The researchers selected two classes as the research sample through purposive sampling, based on the equivalence of students' initial mathematical abilities. This selection was intended to ensure that the experimental and control groups had relatively comparable initial characteristics before the instructional treatment was implemented.

The primary instrument in this study was a mathematical problem-solving ability test consisting of open-ended essay questions on ratios. The test was developed based on Polya's four-stage problem-solving framework: understanding the problem, devising a plan, carrying out the plan, and looking back. Each question was designed to assess students' ability to identify relevant information, formulate appropriate solution strategies, execute mathematical procedures, and evaluate the solutions obtained. The instrument was administered twice: as a pretest before the instructional intervention to identify students' initial problem-solving abilities and as a posttest after the intervention to assess their final abilities. The test items and scoring guidelines are provided in the appendix.

The research was conducted in three main stages: preparation, implementation, and final analysis. The preparation stage involved identifying the research problem, developing the research instruments, and preparing the instructional materials for both groups. The problem-solving test was subsequently subjected to expert validation to examine its content relevance and alignment with the indicators of Polya's problem-solving framework. Following expert validation, an empirical pilot test was conducted to evaluate the validity and reliability of the test items. After the instrument met the established criteria, two classes were selected as the research sample through purposive sampling.

The implementation stage began with administering the pretest to both the experimental and control groups to determine their initial mathematical problem-solving abilities. After the pretest, the experimental group received mathematics instruction using the RME approach, while the control group received conventional mathematics instruction. The experimental group's instructional activities emphasized contextual problem exploration, developing mathematical models, student-generated strategies, mathematical interaction, and connections among mathematical concepts. These activities were intended to help students transition from informal mathematical reasoning to more formal representations of ratio concepts. After the instructional intervention was completed, both groups were administered the posttest using the problem-solving ability instrument to measure their achievement following the respective instructional approaches.

The final stage involved organizing, processing, and analyzing the collected data to address the research hypothesis. The posttest scores from both groups were first examined through prerequisite statistical tests, including normality and homogeneity tests. Based on the results of these tests, an appropriate statistical procedure was selected to compare students' mathematical problem-solving abilities between the experimental and control groups. Figure 1 illustrates the overall sequence of research activities, from preparation and implementation to data analysis.

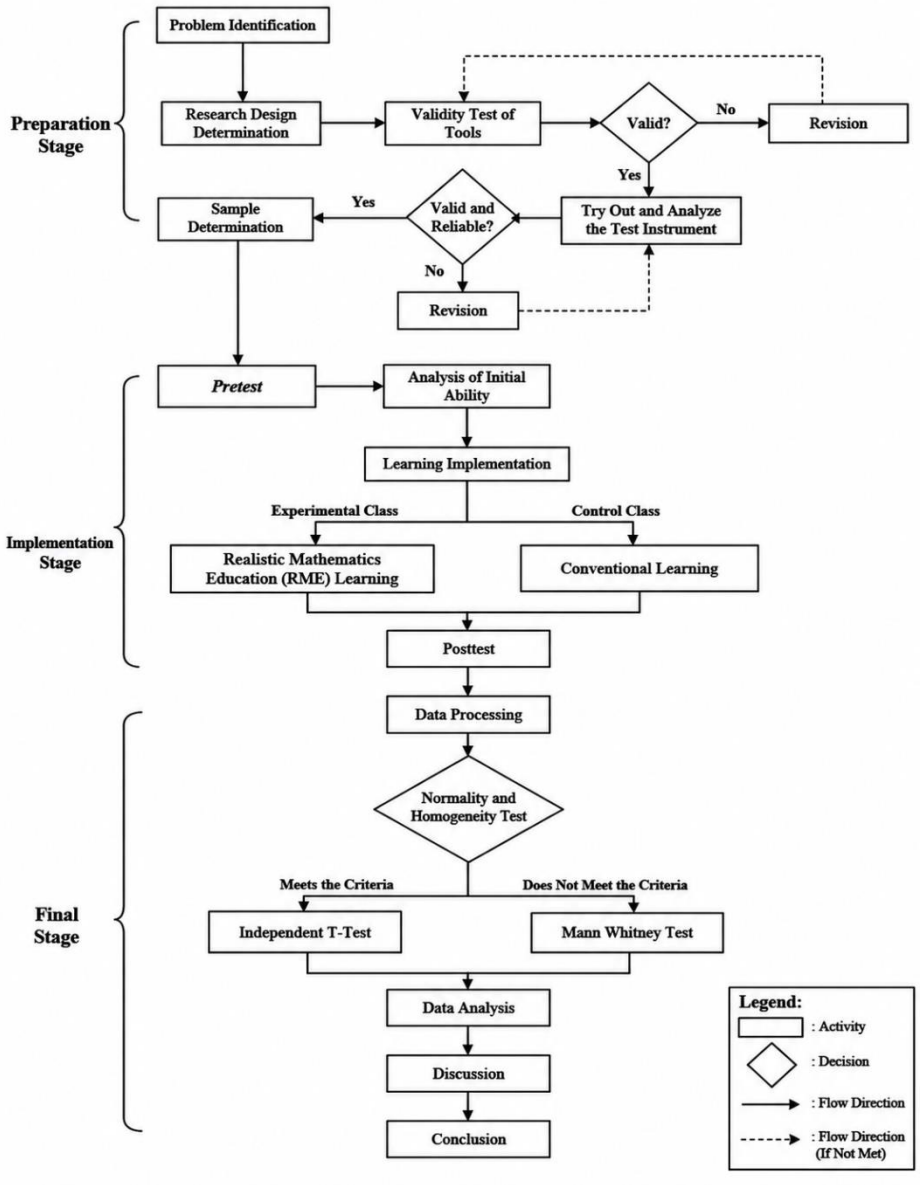


Figure 1 research procedure chart

The research instrument's validity and reliability were examined through expert judgment and empirical testing. Expert validation was conducted to evaluate the relevance, clarity, and suitability of the test items in measuring students' mathematical problem-solving abilities based on Polya's framework. Subsequently, empirical item validity and instrument reliability were analyzed using data obtained from the pilot test. All statistical analyses were performed using PSPP software. Item validity was assessed using the Pearson Product-Moment correlation technique. Each item's validity was determined by examining the significance value of its correlation coefficient. An item was considered valid if its significance value was less than 0.05. Items that did not meet this criterion were revised or excluded, whereas valid items were retained for the main data collection. Instrument reliability was evaluated using Cronbach's Alpha coefficient to determine the internal consistency of the test items. The instrument was considered to have acceptable reliability when its coefficient met the established criteria. The reliability coefficient was interpreted using the classification proposed by Putri et al. (2023), as shown in Table 1.

Table 1 reliability coefficient criteria

Reliability coefficient	Criteria
$0.80 < r_{11} \leq 1.00$	Very high
$0.60 \leq r_{11} \leq 0.80$	High
$0.40 \leq r_{11} \leq 0.60$	Moderate
$0.20 \leq r_{11} \leq 0.40$	Low
$0.00 \leq r_{11} \leq 0.20$	Very low

The collected data were analyzed using PSPP statistical software to determine whether mathematical problem-solving abilities differed significantly between students who received RME-based instruction and those who received conventional instruction. Before conducting hypothesis testing, prerequisite analyses were performed on the posttest scores of both groups. The Shapiro-Wilk test examined normality, while Levene's test assessed homogeneity of variance. The significance level for the statistical analyses was set at 0.05. The selection of the hypothesis-testing procedure was determined by the results of the prerequisite tests. If the posttest data were normally distributed and showed homogeneous variances, an Independent-Samples t-test was used to compare the mean scores of the experimental and control groups. If the normality assumption was not satisfied, the Mann-Whitney U test was used as a non-parametric alternative. The decision regarding the research hypothesis was based on the significance value obtained from the selected statistical test. A significance value below 0.05 indicated a statistically significant difference between the two groups, whereas a significance value greater than or equal to 0.05 indicated no statistically significant difference.

Results and discussion

This study involved 62 seventh-grade students at SMP Negeri 12 Jember: 31 in the experimental group and 31 in the control group. The experimental group received mathematics instruction using the realistic mathematics education (RME) approach, whereas the control group received conventional instruction. Students' mathematical problem-solving abilities were assessed through pretests and posttests based on Polya's four problem-solving indicators. The descriptive statistics of students' performance in both groups are presented in Table 2.

Table 2 descriptive statistics of students' mathematical problem-solving ability

Statistical indicators	Experimental group (Pretest)	Experimental group (Posttest)	Control group (Pretest)	Control group (Posttest)
Number of students	31	31	31	31
Minimum score	10.00	26.25	8.25	10.00
Maximum score	51.25	75.00	61.25	65.00
Mean	31.49	54.11	28.38	34.31
Standard deviation	12.35	14.06*	13.22	10.40

Source: primary data, processed.

As presented in Table 2, both groups demonstrated relatively low initial mathematical problem-solving performance, with comparable pretest mean scores. After the instructional intervention, both groups improved their average scores, although the magnitude of improvement differed considerably. The experimental group increased by 22.62 points, from 31.49 to 54.11, whereas the control group improved by 5.93 points, from 28.38 to 34.31. Thus, the experimental group increased by 16.69 points, compared with the control group. These findings provide an initial indication

that mathematics instruction through the RME approach was associated with more substantial improvements in students' mathematical problem-solving abilities than conventional instruction.

To examine whether differences in students' initial abilities were statistically significant, an Independent-Samples t-test was conducted on the pretest scores. The analysis produced a significance value of 0.343 ($p > 0.05$), indicating no statistically significant difference between the two groups before the instructional intervention. This result provides preliminary support for the comparability of their initial mathematical problem-solving performance. Nevertheless, the absence of a statistically significant difference does not, by itself, establish complete equivalence between the groups.

Before hypothesis testing, prerequisite statistical analyses were conducted to determine the appropriate statistical procedure. The Shapiro-Wilk normality test indicated that the posttest scores of both groups were normally distributed ($p > 0.05$). Furthermore, Levene's test produced a significance value of 0.060, which exceeded the 0.05 significance level. Therefore, the assumption of homogeneity of variances was met, allowing the use of the Independent-Samples t-test with equal variances assumed. The results of the hypothesis testing are presented in Table 3.

Table 3 independent samples t-test results for posttest scores

Statistical indicators	Results
Experimental group mean	54.11
Control group mean	34.31
Mean difference	19.80
Levene's test (F)	3.66
Levene's test (Sig.)	0.060
t-value	6.42
Degrees of freedom (df)	60
Sig. (2-tailed)	0.000*
Standard error difference	3.08
95% confidence interval (lower)	13.63
95% confidence interval (upper)	25.97

Source: primary data, processed.

As shown in Table 3, the Independent Samples t-test yielded a t-value of 6.42 with 60 degrees of freedom and a significance value below 0.001. This value was lower than the predetermined significance level of 0.05. The positive mean difference of 19.80 points, with a 95% confidence interval from 13.63 to 25.97, further indicates that the experimental group achieved significantly higher posttest scores than the control group (H1 support). These findings provide statistical evidence of a significant difference in students' mathematical problem-solving abilities between the two instructional groups, favoring the RME approach.

To better understand students' mathematical problem-solving performance, we conducted a comparative analysis based on the four indicators of Polya's framework: understanding the problem, devising a plan, carrying out the plan, and looking back. The comparison of the average scores for each indicator in the experimental and control groups is illustrated in Figure 3.

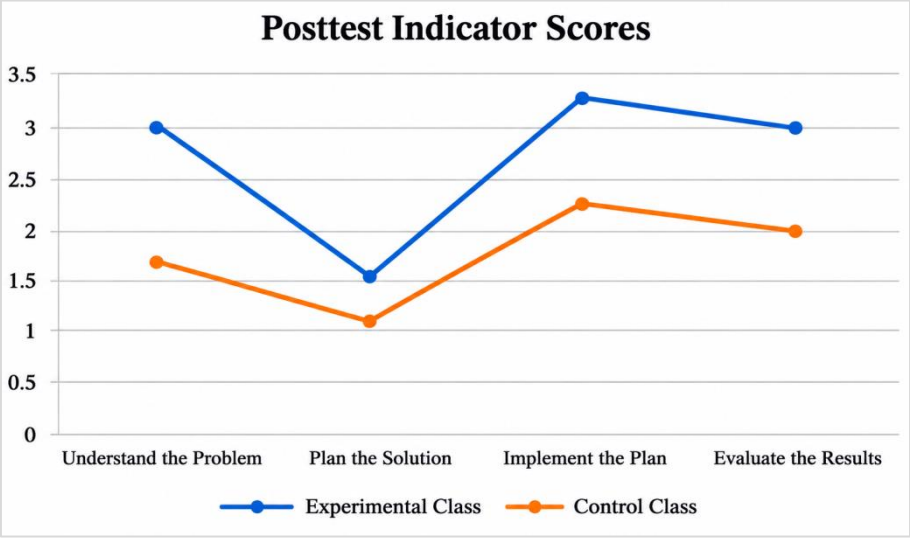


Figure 3 comparison of average scores for polya's problem-solving indicators
Source: primary data, processed.

Figure 3 illustrates that the experimental group achieved higher average scores than the control group across all four indicators of mathematical problem-solving. In both groups, the highest performance was in the carrying-out-the-plan indicator, while devising a plan was the lowest-performing indicator. The experimental group performed best in carrying out the plan, with an average score of approximately 3.25, followed by understanding the problem and looking back, both at approximately 3.00. Meanwhile, the devising-a-plan indicator showed a comparatively lower average of approximately 1.50. A similar pattern appeared in the control group, although its average scores were consistently lower across all indicators. These findings suggest that the RME group's advantage was evident throughout the problem-solving process, although students continued to face greater challenges in formulating appropriate solution strategies.

The findings indicate that implementing realistic mathematics education offers a promising instructional alternative for developing students' mathematical problem-solving abilities, particularly in learning ratios. The substantially greater improvement in the experimental group suggests that contextual, student-centered mathematics instruction may offer learning experiences more conducive to mathematical understanding and problem-solving development than conventional instruction. This finding can be understood through the fundamental principle of RME, which views mathematics as a meaningful human activity rather than a set of abstract procedures that students must memorize. According to Gravemeijer (1994), mathematical understanding develops through progressive mathematization, in which students begin with meaningful contextual situations and gradually construct more formal mathematical representations. In ratio learning, students can explore mathematical relationships through familiar situations, such as comparing quantities, determining proportions, interpreting scales, and calculating rates (Giberti et al., 2023). Such experiences provide meaningful starting points for students to recognize the mathematical structures underlying everyday situations. Consequently, students are not merely exposed to mathematical formulas but are encouraged to understand how and why particular mathematical procedures can be used to solve problems.

The greater improvement in the experimental group can also be explained by the opportunities RME provides for students to construct their own mathematical knowledge. Through contextual exploration, students are encouraged to interpret

situations, identify relevant information, and establish relationships between quantities before applying formal mathematical procedures (Mbhiza & Zondo, 2025). This learning process matters because ratio problems often require students to distinguish between quantities, recognize multiplicative relationships, and choose appropriate comparison strategies. Reinke et al. (2023) emphasized the importance of teachers' contextualization practices in grounding students' mathematical understanding of ratio. This perspective supports the relevance of contextual problems in RME, as they enable students to connect abstract ratio concepts with situations that are meaningful to them. Similarly, Wardani et al. (2024) identified obstacles students face when solving ratio and proportion problems, particularly related to mathematical literacy processes. These findings suggest that difficulties in ratio learning are not necessarily limited to computational errors but may also involve interpreting situations and translating contextual information into mathematical representations. Therefore, implementing RME may help address these difficulties by giving students structured opportunities to develop contextual understanding before moving toward formal mathematical reasoning.

The findings also support previous research demonstrating the positive potential of RME in mathematics education. Zaini & Marsigit (2014) reported differences in the effectiveness of realistic mathematics and conventional approaches in developing students' mathematical reasoning and communication abilities. Catrining & Widana (2018) likewise showed RME's contribution to students' mathematical learning outcomes and interest in learning. More specifically, Da (2023) investigated the effect of RME on high school students' problem-solving competency in calculus, while Tumangger et al. (2024) highlighted the potential of RME-based student worksheets to improve mathematical problem-solving abilities. Ventistas et al. (2025) further examined the impact of RME on secondary school students' problem-solving skills through a comparative evaluation study. The present findings extend this body of research by providing empirical evidence from junior high school ratio instruction in an Indonesian educational context. Unlike studies focusing on other mathematical topics or educational levels, this study specifically examines how RME relates to students' performance across the four stages of Polya's problem-solving framework when addressing ratio problems. Thus, the findings strengthen the argument that RME benefits can apply to different mathematical topics, particularly those with strong connections to everyday experiences.

A particularly important finding concerns the consistent advantage of the experimental group across all four indicators of Polya's problem-solving framework. This pattern suggests that the potential contribution of RME is not restricted to a single stage of problem-solving but extends to several interconnected cognitive processes. The theoretical relationship between RME and Polya's framework can be understood through the five characteristics of RME proposed by Gravemeijer (1994). Contextual exploration supports students in understanding problems because they encounter situations that require interpretation and identification of relevant information. The development of models and progressive mathematization facilitates the transition from contextual understanding toward the formulation of mathematical strategies. Student contributions and interactivity create opportunities for students to explain, compare, and refine their reasoning, while intertwining encourages them to recognize relationships among mathematical concepts. These characteristics collectively establish a learning environment in which students can engage in the different stages of mathematical problem-solving described by Polya (1945). Accordingly, the higher

performance of the experimental group across the four indicators is theoretically consistent with the underlying principles of RME.

Despite the experimental group's overall advantage, devising a plan remained the most challenging indicator for students in both groups. This finding deserves particular attention because planning requires more than recognizing mathematical information or performing calculations. Students must identify relationships among known and unknown quantities, select appropriate representations, determine relevant mathematical operations, and organize a sequence of steps that leads to a solution (Kim, 2025). In ratio problems, for example, students may understand the quantities presented but still struggle to determine whether the situation requires direct comparison, equivalent ratios, proportional reasoning, or another mathematical strategy. This difficulty aligns with Suratman et al. (2026), who identified weaknesses in students' problem-solving processes based on Polya's framework in Jember. Xu & Qi (2022) also reported that students' mathematical problem-solving abilities remained at relatively basic levels. These findings suggest that devising a plan represents an important area for instructional improvement. Although the RME approach gives students opportunities to develop mathematical strategies through contextual exploration and modeling, the relatively low performance on this indicator suggests that these opportunities may not automatically guarantee mastery of strategic planning. Students may still require explicit guidance, structured questioning, opportunities to compare different solution methods, and sufficient practice in translating contextual situations into mathematical models.

Furthermore, the comparatively stronger performance in carrying out the plan indicates that students were more successful in executing mathematical procedures once a solution strategy had been established. This pattern suggests a distinction between students' procedural performance and their ability to formulate mathematical strategies independently. In the RME learning environment, students can develop representations such as drawings, tables, diagrams, or other informal models to organize information and support their calculations. These representations bridge students' informal reasoning and formal mathematical procedures, as emphasized in the RME framework (Gravemeijer, 1994). Once students have identified an appropriate mathematical relationship, these representations may help them perform calculations more systematically. However, the lower performance in devising a plan indicates that procedural execution should not be interpreted as evidence of complete problem-solving mastery. Effective problem-solving requires students to coordinate conceptual understanding, strategic planning, mathematical execution, and evaluation (Naz & Qayyum, 2025). Therefore, mathematics instruction should balance procedural fluency and strategic reasoning.

The performance observed in the looking-back indicator also provides an important perspective on students' problem-solving development. This stage requires students to examine the reasonableness of their answers, verify calculations, and reflect on the strategies used. Within RME, teachers can encourage these activities through classroom discussions, collaborative evaluation, and comparisons of different student-generated solutions. Interactivity, a central characteristic of RME, enables students to communicate their reasoning and examine alternative approaches. Through these interactions, students may recognize errors, reconsider mathematical assumptions, and better understand the relationship between their answers and the original contextual situations. This interpretation is consistent with Polya's (1945) framework, which emphasizes looking back as an essential stage of problem-solving rather than treating

the final answer as the endpoint of mathematical activity. The experimental group's relatively higher performance on this indicator suggests that opportunities for mathematical discussion and reflection may contribute to students' ability to evaluate their solutions (Fitrah et al., 2025). Nevertheless, the continued difference between the groups should be interpreted as evidence of relative performance rather than proof that all students in the experimental group have fully mastered mathematical reflection.

Taken together, these findings provide both theoretical and practical implications for mathematics education. Theoretically, they support the relevance of connecting the RME approach with Polya's problem-solving framework, particularly in teaching ratio concepts that involve contextual interpretation and proportional reasoning. The results also extend previous investigations into RME by highlighting the importance of examining problem-solving performance at the level of individual indicators rather than relying exclusively on overall achievement scores. This perspective aligns with the broader emphasis on improving mathematical competencies through meaningful, contextualized instruction, as reflected in the studies of Purnama et al. (2023); Tumangger et al. (2024); and Khasanah et al. (2025). Practically, the findings suggest that mathematics teachers should incorporate familiar contextual problems, encourage students to construct their own mathematical representations, facilitate discussions of alternative strategies, and provide opportunities for students to evaluate their solutions. Particular attention should be given to the devising-a-plan stage through scaffolding activities that guide students to identify mathematical relationships and select appropriate strategies (Mardhiyatirrahmah & Rosikhoh, 2026). Although the results indicate a significant advantage for the RME group, the quasi-experimental design and the use of purposively selected classes mean that the findings should be interpreted within the context of the participating students and instructional setting. Further research in different schools, with larger samples and longer instructional periods, would help establish the broader applicability of RME in developing students' mathematical problem-solving abilities.

Conclusions

This study shows that implementing the realistic mathematics education (RME) approach significantly improves seventh-grade students' mathematical problem-solving abilities when learning ratios at SMP Negeri 12 Jember. The experimental group achieved a higher posttest mean score (54.11) than the control group (34.31), with a statistically significant difference between the two groups ($t(60) = 6.42$, $p < 0.001$). Furthermore, the analysis based on Polya's four problem-solving indicators revealed that students in the experimental group outperformed those in the control group in understanding the problem, devising a plan, carrying out the plan, and looking back. Nevertheless, devising a plan remained the most challenging indicator in both groups, suggesting that developing appropriate mathematical strategies remains an important aspect of students' problem-solving development. These findings provide empirical support for RME as an effective approach to facilitating meaningful, contextualized mathematics learning, particularly in ratio instruction.

The findings have theoretical and practical implications for mathematics education. Theoretically, this study contributes to the literature by showing the value of integrating RME characteristics with Polya's problem-solving framework, particularly in developing students' ability to solve contextual ratio problems. Practically, the findings suggest that mathematics teachers can incorporate real-life contexts, mathematical modeling, student-generated strategies, collaborative discussions, and reflective

activities to facilitate students' problem-solving processes. However, this study has several limitations. First, the research was conducted in only one junior high school involving two purposively selected classes, which limits the generalizability of the findings to other educational contexts. Second, the intervention focused exclusively on ratio-related material, so the findings may not necessarily represent students' problem-solving abilities across other mathematical topics. Third, the study focused primarily on quantitative achievement scores and did not explore in depth the cognitive processes underlying students' problem-solving strategies during RME instruction.

Future research should address these limitations by including larger samples from multiple schools with diverse educational backgrounds to strengthen the findings' generalizability. Further studies could also investigate the implementation of RME across different mathematical topics, particularly those involving proportional reasoning, algebra, geometry, and other real-world applications. In addition, mixed-methods or qualitative approaches are recommended to explore how students construct mathematical models, develop solution strategies, and evaluate their answers throughout the four stages of Polya's framework. Particular attention should be given to the devising-a-plan stage through instructional scaffolding, contextual learning materials, and structured problem-solving activities. Such investigations may provide a more comprehensive understanding of how RME can be optimized to foster students' mathematical problem-solving abilities.

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