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Enhancing Eighth-Grade Students' Plane Geometry Problem-Solving Skills through Realistic Mathematics Education

A Case Study at São José Operário Balide, Timor-Leste

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ABSTRACT

This study examines the influence of the Realistic Mathematics Education (RME) approach on eighth-grade students' ability to solve plane geometry problems at Ensino Básico 3° Ciclo São José Operário Balide during the 2025 academic year. The research followed a quantitative pre-experimental design using a one-group pre-test and post-test structure. Prior to data collection, a try-out test consisting of 15 items was administered to 10 non-sample students to determine the validity and reliability of the research instrument. The results indicated that 10 items met the validity criteria, while 5 items were invalid. All 10 valid items demonstrated acceptable reliability, allowing their use as the main instrument for measuring students' problem-solving ability. After administering the pre-test and post-test to the sample class, normality testing using the Lilliefors method showed that both pre-test (Lmax = 0.3707 > Ltabel = 0.14) and post-test data (Lmax = 0.4562 > Ltabel = 0.14) were normally distributed. Linearity testing further revealed that Fcount < Ftable (−28.18 < 2.78), indicating a linear relationship between the two sets of scores. Given the conditions of normality and linearity, the paired-sample t-test was conducted to determine the effect of the RME approach. The results showed a significant difference between the pre-test and post-test mean scores, demonstrating that RME positively influenced students' geometry problem-solving abilities. These findings support the view that RME, grounded in constructivist principles, effectively encourages active student participation and

enhances conceptual understanding in mathematics learning.

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Keywords
Geometry of the Plane
Mathematics Learning
Paired Sample t-Test
Problem-Solving Ability
Realistic Mathematics Education

Introduction

Education is a conscious and well-planned effort to create learning environments and processes that enable students to actively develop their potential, as stated by Purwaningsih [1]. As a fundamental need within community, national, and state life, education plays a critical role in forming intelligent individuals with noble character, strong personality, skills, and creativity that benefit themselves, society, and the nation [2], [3]. The advancement and development of a nation are often measured by the quality of its education system [4], [5]. For Timor-Leste, strengthening the education sector becomes essential for enabling the nation to compete in science and technology alongside developed countries. Therefore, the Government of Timor-Leste, through the Ministry of Education, continues to enhance the quality of education through curriculum development, teacher capacity building, improved learning strategies, and the provision of adequate facilities and infrastructure at all levels of education.

The importance of education is also legally reinforced in the Constitution of the Democratic Republic of Timor-Leste (DRTL), Article 59, which guarantees the right of every citizen to access education and culture. This includes ensuring universal basic education, equal opportunities for schooling and professional training, regulation and supervision of private and cooperative schools, and provisions for higher scientific research. Article 29 of the Basic Education Law further emphasizes inclusive education aimed at promoting social and educational integration, equal opportunities, and professional preparation. In this sense, education becomes a transformative force in shaping national character and supporting meaningful teaching and learning processes.

Teaching and learning activities constitute a process through which teachers and students interact to transfer and transform knowledge [6], [7]. This reciprocal interaction is essential for achieving learning objectives. The ultimate goal of education is not merely to provide information but to assist students in developing capacities, attitudes, and values necessary for meaningful living. Among the disciplines contributing significantly to cognitive

development is mathematics, which plays a vital role in enhancing thinking abilities and fostering logical reasoning [8].

Mathematics is a method of using information and skills to perform calculations and find solutions to problems [9]. However, misconceptions still arise, particularly when mathematics is viewed merely as formulas and numbers. Mastery of mathematics requires not only an understanding of concepts but also the capability to solve problems through logical steps. Students must be able to describe and apply these steps appropriately. As stated by Abdillah [10], the goal of mathematics learning extends beyond conceptual mastery to include building students' character by strengthening critical and creative thinking skills. In everyday life and scientific study, students need mathematics to analyze situations, reason effectively, and solve problems [9].

Despite its importance, mathematics learning often encounters challenges. These challenges occur due to teaching methods, instructional approaches, and other contextual factors. At Escola 3° Ciclo São José Operário Balide, students—especially in Grade 8—still face significant difficulties in solving plane geometry problems. Many students learn solely from theoretical explanations in textbooks without connecting lessons to real-life contexts. Consequently, they struggle to understand and apply mathematical concepts in daily situations. This issue was also observed in classroom practices, where teachers primarily used conventional methods, focused on textbook content, and provided limited opportunities for students to explore alternative solutions [11]. When confronted with problems presented in unfamiliar forms, students became confused, demonstrating low critical thinking abilities.

To address these challenges, the selection of an appropriate learning model becomes crucial. A learning model serves as a structured guide for implementing learning approaches, methods, strategies, and techniques [12]. An effective model can help students better understand the material, increase motivation, and enhance engagement in the learning process [13]. One promising approach is the Realistic Mathematics Education (RME) approach. RME emphasizes connecting mathematical concepts to real-life contexts, enabling students to construct their own understanding through guided reinvention. This approach aligns with Freudenthal's view that mathematics is a human activity closely linked to daily life [14]. In RME, teachers act as facilitators who guide students in exploring, reasoning, and constructing meaning through realistic situations [15].

Based on preliminary observations at Escola 3° Ciclo São José Operário Balide, many students still demonstrate low problem-solving abilities and limited critical thinking skills in geometry. They rely heavily on teacher explanations and struggle when questions are modified or presented in contextual forms. This highlights a significant learning gap, indicating the need

for an approach that connects mathematical ideas to meaningful contexts. Therefore, applying the Realistic Mathematics Education approach is expected to enhance students' understanding and improve their ability to solve plane geometry problems.

The novelty of this research lies in the application of the Realistic Mathematics Education (RME) approach specifically to enhance Grade 8 students' abilities to solve plane geometry problems within the unique educational context of Timor-Leste. While RME has been widely explored in various international settings, empirical studies examining its effectiveness in Timor-Leste (particularly in geometry learning) remain scarce. Most mathematics instruction in local schools continues to rely on traditional, teacher-centered methods, resulting in limited opportunities for students to actively construct conceptual understanding through real-life contexts. This condition creates a significant research gap, as few studies have systematically evaluated how RME can influence students' problem-solving performance, especially in geometric reasoning, which is known to require strong visualization and contextual interpretation skills. Therefore, this study addresses this gap by implementing RME in the topic of Plane Geometry and analyzing its impact on students' cognitive outcomes. The objective of this research is to determine whether the RME approach significantly improves Grade 8 students' ability to solve plane geometry problems at Escola 3° Ciclo São José Operário Balide during the 2025 academic year. By doing so, this study contributes localized evidence that supports the integration of innovative, student-centered pedagogies into mathematics teaching practices in Timor-Leste.

Material and Methods

A. Research Setting and Duration

This study was conducted at Ensino Báziku 3° Ciclo São José Operário de Balide, Dili, during the 2025 academic year, focusing on Grade 8 learning within the topic *Geometry of the Plane*. The research activities were carried out from 19 August to 30 August 2025, covering the implementation of RME-based learning, classroom observations, student assessments, and documentation. The school was selected because preliminary observations indicated difficulties among Grade 8 students in solving geometry problems, making it a relevant setting for evaluating the effectiveness of the Realistic Mathematics Education approach.

B. Population and Sample

The population in this study consisted of all Grade 8 students enrolled at Ensino Báziku 3° Ciclo São José Operário, totaling 185 students distributed across five classes (A–E). Referring to definitions, this population represents the entire group possessing the characteristics relevant to the research objectives [15], [16], [17]. From this population, 37 students from Grade 8 Turma D were selected as the sample using a cluster sampling technique. The selection process involved randomly drawing one class from the five existing clusters. Turma D was

obtained as the chosen class and was considered to have characteristics representative of the whole population. The sample consisted of 18 male and 19 female students, and this class was used consistently throughout the data collection process.

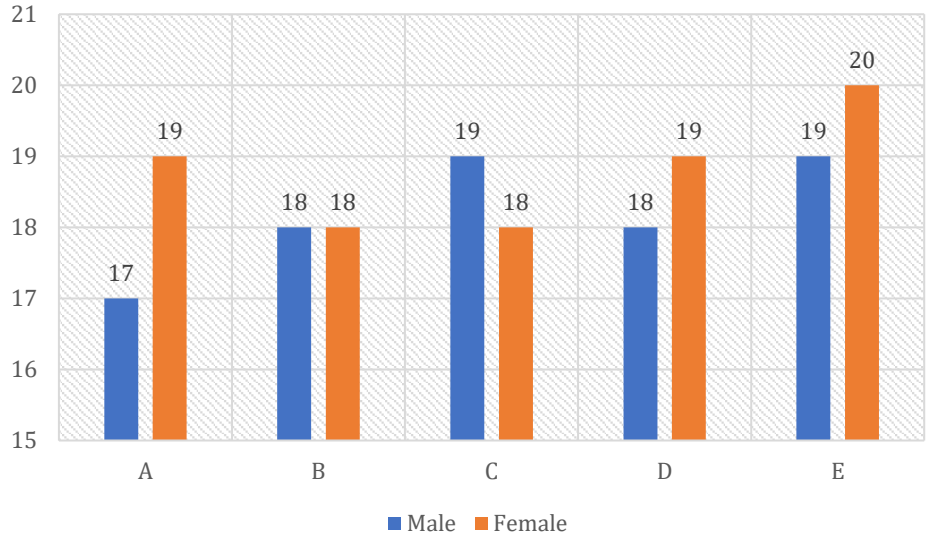


Fig. 1. Population of Grade 8 Students

C. Research Variables

This study used two variables: the independent variable (X) and the dependent variable (Y). The independent variable was the Realistic Mathematics Education (RME) approach, defined operationally as students' engagement and participation during lessons facilitated through realistic contexts. The indicator for this variable was the extent of student participation, measured using the Guttman scale. The dependent variable was the students' problem-solving ability in Plane Geometry, operationally defined as the improvement in their ability to address questions within the geometry topic for Trimester II. The indicator for this variable was the students' mathematics achievement score, also measured using the Guttman scale, allowing for dichotomous categorization of correct and incorrect responses.

D. Data Collection Techniques

Data were collected using three main techniques: observation, testing, and documentation [15]. Observation was conducted directly in the classroom to capture students' behaviors, engagement levels, and interactions during RME-based learning. This allowed the researcher to gain naturalistic insights into how students responded to contextual mathematics tasks. The second technique involved administering pre-tests and post-tests to measure students' problem-solving abilities before and after the intervention. These tests were designed specifically to assess conceptual understanding and application of Plane Geometry. The third technique was documentation, which included gathering school records, attendance lists,

students' written work, lesson plans, and photographs of classroom activities. Documentation served as supporting data to strengthen analysis and interpretation.

Table 1. Summary of Data Collection Techniques

Technique	Purpose	Instruments Used
Observation	Measure engagement & participation	Observation sheet
Test	Measure problem-solving ability	Pre-test & Post-test
Documentation	Validate and support findings	School and field documentation

E. Instruments and Data Analysis Techniques

The measurement of variables used the Guttman scale, which assigns a value of 1 for correct answers and 0 for incorrect answers [18]. Before data analysis, the test instruments were validated using the Product Moment correlation formula to determine item validity. Items with correlation values greater than the critical value at α = 0.05 were considered valid. Reliability testing was conducted using the formula $r_{11} = \frac{2r_b}{1+r_b}$, where items exceeding the reliability threshold were regarded as reliable. After establishing validity and reliability, data were analyzed through several statistical procedures. A normality test using the Lilliefors method was performed to confirm whether the data followed a normal distribution. This was followed by a linearity test to ensure the relationship between the independent and dependent variables met linear regression assumptions. Finally, hypothesis testing was conducted using a paired sample t-test, comparing pre-test and post-test mean scores. Results were interpreted using the decision rule that the treatment is significant if the calculated t-value exceeds the table value at α = 0.05.

Table 2. Criteria for Validity and Reliability

Criterion	Threshold	Interpretation
Validity	r_calculated > r_table	Item is valid
Reliability	r_{11} > r_table	Instrument is reliable
Significance Level	α = 0.05	Standard criterion

Results

A. School Profile of Colégio de São José Operário

The profile of Colégio de São José Operário reflects its long historical development and strong Catholic educational tradition. The school originated from the merger of Ensino Pré-Secundário São José Operário and the former Ensino-Primário Santa Madalena de Canossa during the 2002 academic year under the Diocese of Dili. Early teaching staff included committed educators such as Anacleto da Costa, Emilia Tilman de Andrade, Luís dos Reis Cota, and Margarida Gusmão Goulart, who were assigned to Imaculada Conceição Balide. By 2007, its first cohort completed Grade 6 under the coordination of Reverend Pe. Mateus Afonso,

establishing the foundation for the eventual formation of the current Colégio de São José Operário. The subsequent expansion included new classroom buildings constructed between 2008 and 2012, enabling the school to accommodate increasing student numbers. Supported by continuous accreditation from the Ministry of Education, the school now operates as a fully integrated basic and secondary education institution serving the Balide, Dili community.

B. Vision and Mission of the School

The school's vision emphasizes excellence in science, knowledge, technology, faith, and moral character grounded in Christian values. This vision guides all academic and extracurricular programs in the institution. The mission highlights six major commitments: (1) producing students with strong character and intelligence based on Christian values; (2) preparing students to contribute meaningfully to families and society; (3) supporting student talent development; (4) improving educational quality through activities and extracurricular programs; (5) cultivating discipline, sportsmanship, and achievement motivation; and (6) preserving the Catholic school tradition that emphasizes holistic formation. These mission elements form the philosophical basis for the instructional, developmental, and pastoral approaches applied in the school environment.

C. Respondent Characteristics

Respondent characteristics were analyzed to understand the demographic composition of students participating in the study. A total of 37 students from Ensino Básico 3.º Ciclo participated, consisting of 18 male respondents (49%) and 19 female respondents (51%). This distribution indicates a relatively balanced gender composition, although female students slightly outnumber male students. The demographic structure supports a representative sample from the student population and ensures that the subsequent analysis of learning outcomes and instrument performance applies across genders.

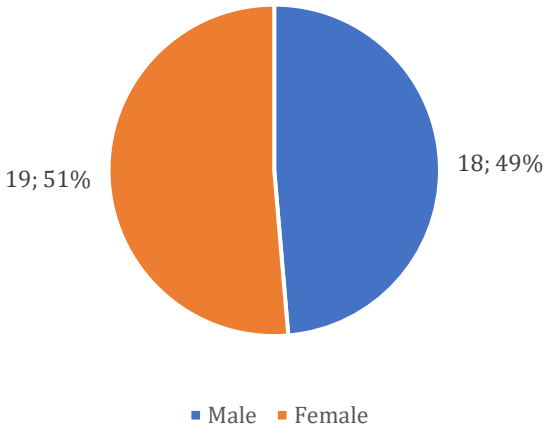


Fig. 2. Gender Distribution of Respondents

D. Instrument Validity and Reliability Test

The validity test was conducted on 15 questionnaire items using Pearson Product Moment correlation, with ten try-out respondents. The calculated values were compared with the critical t-table value at $\alpha = 0.05$ and df = 8 (t-table = 1.86). Results show that items 2, 3, 4, 6, 7, 8, 9, 10, 14, and 15 were valid because their t-count exceeded the t-table value, while items 1, 5, 11, 12, and 13 were invalid. Reliability analysis using the r11 formula confirmed that all valid items were reliable, with r11 values ranging between 0.78 and 0.88, exceeding the reliability threshold (0.666). These results confirm that the instrument is both valid and reliable for further data collection.

E. Pre-Test and Post-Test Results

The comparison between pre-test and post-test results for 37 students was conducted to measure the improvement in learning outcomes. Pre-test scores ranged from 4 to 8 with a total score of 213, whereas post-test scores increased to a range of 6 to 9 with a total of 291. This noticeable rise indicates that the learning intervention contributed positively to student achievement. The gain score reflects substantial progress in students' understanding and problem-solving abilities following the implementation of the instructional approach. These initial results highlight meaningful learning development, which provides a strong basis for conducting further statistical analyses to verify the significance of the improvement through tests such as normality, linearity, and the paired sample t-test.

Table 3. Summary of Pre-Test and Post-Test Scores

Test Type	Total Respondents	Total Score	Mean Score
Pre-test	37	213	7
Post-test	37	291	9

F. ANOVA Test for Linearity

The ANOVA test was conducted to determine whether the relationship between the independent variable (Realistic Mathematics Education approach) and the dependent variable (students' problem-solving ability in plane geometry) follows a linear pattern. Linearity testing is essential because parametric tests such as the paired sample t-test require data to show both normal distribution and linearity. The results of the ANOVA calculation are presented in Table 4.16. The comparison between F_calculated and F_table shows that F_calculated < F_table, or −28.18 < 2.78, indicating that the regression relationship meets the assumption of linearity. This means the learning outcomes follow a consistent linear trend across the measured scores. Because the data are normally distributed and meet linearity requirements, further analysis using the t-test can be performed to examine the significance of differences between pre-test and post-test scores.

Table 4. Summary of ANOVA for Linearity

Source of Variation	df	Sum of Squares	MS	F_calculated	F_table
Total	N = 37	$\sum Y^2$	–	−28.18	2.78
Regression (A)	1	2288.67	2288.67	< F_table	Linear
Regression A/B	1	60.02	60.02	–	–
Residual	35	−31.69	−0.90	–	–
Lack of Fit	2	−54.12	−18.04	–	–
Error	35	22.43	0.60	–	–

Decision rule:

- If F_calculated ≤ F_table, data follow a linear pattern.
- If F_calculated > F_table, data do not follow a linear pattern.

Based on the table: −28.18 < 2.78, therefore the data meet the linearity assumption.

G. Paired Sample T-Test

The paired sample t-test was used to determine whether there is a significant difference between students' pre-test and post-test scores after applying the Realistic Mathematics Education approach. This test compares the means of two related measurements from the same participants at different times. Fig. 1 presents the raw data used for the calculation.

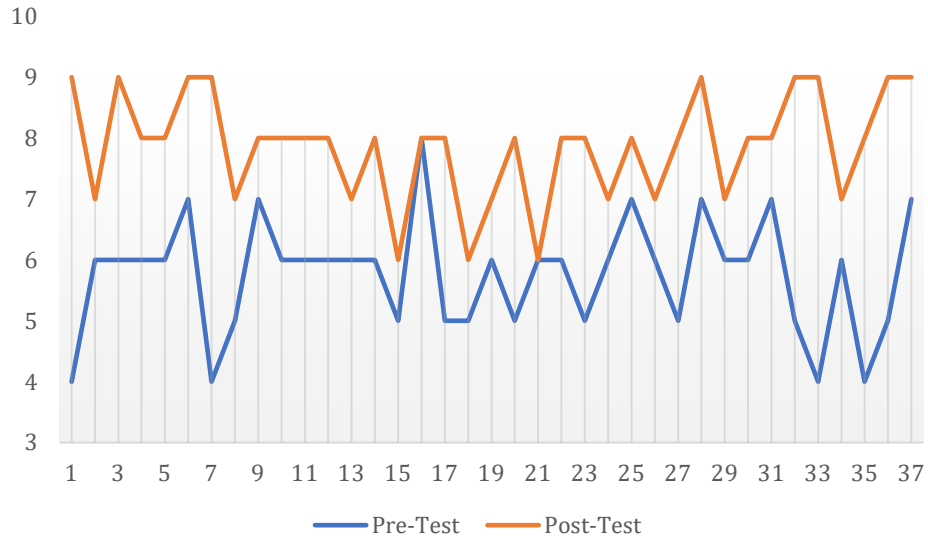


Fig. 3. Pre-Test and Post-Test Scores of 37 Students

To calculate the t-value, the score difference between each student's post-test and pre-test results was determined. These individual differences were then used to compute the mean difference, standard deviation, and variance required for the paired sample t-test analysis. The complete statistical process, including the computation of deviation scores and squared deviations, is presented in Table 7. This table provides the essential values used to obtain the final t-value for hypothesis testing.

Table 5. Statistical Calculation for Paired Sample t-Test

No.	Pretest	Postest	Posttest-Pretest	D	(Pre-Post)-D	((Post-Pre)-D)^2
1	4	9	5		2.89	8.35
2	6	7	1		-1.11	1.23
3	6	9	3		0.89	0.79
4	6	8	2		-0.11	0.01
5	6	8	2		-0.11	0.01
6	7	9	2		-0.11	0.01
7	4	9	5		2.89	8.35
8	5	7	2		-0.11	0.01
9	7	8	1		-1.11	1.23
10	6	8	2		-0.11	0.01
11	6	8	2		-0.11	0.01
12	6	8	2		-0.11	0.01
13	6	7	1		-1.11	1.23
14	6	8	2		-0.11	0.01
15	5	6	1		-1.11	1.23
16	8	8	0		-2.11	4.45
17	5	8	3		0.89	0.79
18	5	6	1	2.11	-1.11	1.23
19	6	7	1		-1.11	1.23
20	5	8	3		0.89	0.79
21	6	6	0		-2.11	4.45
22	6	8	2		-0.11	0.01
23	5	8	3		0.89	0.79
24	6	7	1		-1.11	1.23
25	7	8	1		-1.11	1.23

With t_calculated = 9.72 and t_table = 1.688 ($\alpha = 0.05$); thus, H_0 is rejected and H_1 is accepted, meaning: The Realistic Mathematics Education approach has a significant influence on students' ability to solve plane geometry problems.

Discussion

The findings of this study provide important evidence regarding the influence of the Realistic Mathematics Education (RME) approach on Grade 8 students' ability to solve problems in Plane Geometry at Ensino Básico 3.º Ciclo São José Operário Balide. The discussion integrates results from the instrument validation process, normality testing, linearity testing, and the paired sample t-test, all of which together confirm the effectiveness of the RME approach in enhancing students' mathematical problem-solving ability.

The first stage of the analysis involved determining the quality of the research instrument through try-out testing. The instrument consisted of 15 test items administered to 10 students outside the sample class. Based on the validity test, 10 items were found to be valid while 5 items were invalid. Only the valid items were retained for the final test. Following this process, a reliability test was conducted on the 10 valid items, and the results showed that all items were reliable and appropriate for use as the main research instrument. This outcome indicates that the instrument was capable of consistently measuring students' abilities in

solving mathematical problems in the topic of Plane Geometry. Therefore, the prepared test instrument was considered adequate for data collection during the second trimester of Grade 8.

After the data were collected, the next stage was to analyze students' abilities by conducting several statistical tests. The normality test using the Lilliefors method revealed that both pre-test and post-test scores followed a normal distribution. The pre-test obtained a value of Lmax = 0.3707, which was greater than Ltabel = 0.14, and similarly, the post-test obtained Lmax = 0.4562 > Ltabel = 0.14. These results indicate that the distribution of students' scores met the assumptions of normality. As a result, the dataset fulfilled one of the key prerequisites for performing parametric statistical testing.

Because the data were normally distributed, the analysis proceeded with a linearity test to determine whether a linear relationship existed between pre-test and post-test scores. The ANOVA-based linearity test produced Fkontagen = −28.18, which was smaller than Ftabela = 2.78. According to the decision rule, if Fkontagen ≤ Ftabela, the data meet the assumption of linearity. Therefore, the results confirmed that there was a linear relationship between the pre-test and post-test scores. This implied that the difference between pre-test and post-test scores could reliably be analyzed using a paired sample t-test. The linearity and normality assumptions allowed for a robust hypothesis test regarding the effect of the RME approach.

The paired sample t-test results indicated a significant difference in students' mean scores between the pre-test and post-test. The mean difference ($\bar{D}$) was calculated as 2.11, with a standard deviation of 1.32. Using these values, tcount was calculated to be 9.72, while ttable at $\alpha = 0.05$ and $n - 1 = 36$ was 1.688. Since tcount > ttable, the null hypothesis (H0), which stated that the RME approach had no significant influence on students' problem-solving abilities, was rejected. Consequently, the alternative hypothesis (H1) was accepted, confirming that the RME approach had a significant positive influence on students' ability to solve Plane Geometry problems.

This finding aligns with theoretical perspectives that emphasize the student-centered nature of RME. RME is grounded in constructivist principles, requiring learners to actively participate in constructing mathematical knowledge through meaningful real-world contexts [9]. This active engagement not only stimulates students' cognitive processes but also encourages deeper understanding of mathematical concepts through contextual problem solving [9], [12]. The results of this study support these claims, as students demonstrated improved performance after being taught through activities grounded in real-life situations .

Furthermore, RME promotes innovation in the mathematics classroom because it shifts the focus from teacher-centered instruction to student-centered learning [9]. This creates

opportunities for students to explore, reason, and discover mathematics independently or collaboratively. The significant improvement observed in post-test results in this study reinforces the relevance of RME, especially in enhancing learners' reasoning and problem-solving skills in geometry.

Overall, the study provides strong empirical evidence that Realistic Mathematics Education offers an effective approach to improving students' mathematical problem-solving abilities [19]. The findings affirm that when students are actively involved in constructing mathematical meaning through real contexts, they achieve better learning outcomes [10]. Thus, the use of RME is highly recommended for teaching geometry and other mathematical topics at the junior secondary level.

Conclusion

The findings of this study demonstrate that the application of the Realistic Mathematics Education (RME) approach has a significant influence on students' ability to solve plane geometry problems in Grade 8 at Ensino Básico 3° Ciclo São José Operário Balide during the 2025 academic year. The instrument development process began with a try-out of 15 items, from which 10 were validated and confirmed reliable, ensuring that the data collected reflected students' true problem-solving abilities. The results of the normality test using the Lilliefors method indicated that both pre-test and post-test data were normally distributed, while the linearity test showed a linear relationship between the two variables, permitting further inferential analysis. The paired sample t-test revealed a substantial improvement in students' post-test scores compared to their pre-test results, confirming the effectiveness of the RME approach. This improvement aligns with the principles of constructivist learning, where students actively construct knowledge through meaningful problem contexts. The results affirm that RME promotes active engagement, deeper conceptual understanding, and improved mathematical reasoning. Therefore, RME is recommended as an effective instructional approach for enhancing students' geometry problem-solving skills in similar educational settings.

Conflict of Interest

The authors declare that there is no conflict of interest.

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