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Level of achievement in problem-solving with Realistic Mathematics in secondary school students

Nivel de logro de la resolución de problemas con Matemática Realista en estudiantes de secundaria

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Abstract

The research aimed to identify the level of achievement in mathematical problem-solving skills, using the Realistic Mathematics Education (RME) approach, among second-year secondary school students. A quantitative, descriptive, and non-experimental design was adopted. The sample consisted of 122 students of both sexes from a public educational institution, who were administered a test comprised of two booklets with mathematical problems contextualized in real-life situations. The results showed that the majority of students did not reach a satisfactory level in the assessed skill. The developing level predominated at 42.6% (52 students), followed by the beginning level at 36.1% (44 students), and finally, the achieved level at 21.3% (26 students). Furthermore, no significant differences were found in mathematical performance according to gender. The study concludes that there are concerning limitations in students' contextualized mathematical skills, highlighting the need to improve teaching practices. It is recommended to implement active methodologies focused on problem-solving, using the Realistic Mathematics Education approach, to foster meaningful and effective learning.

Keywords: mathematical competencies, problem-solving, Realistic Mathematics.

Resumen

La investigación tuvo como objetivo identificar el nivel de logro en la competencia de resolución de problemas matemáticos, bajo el enfoque de la Educación Matemática Realista (EMR), en estudiantes de segundo grado de secundaria. Se adoptó un enfoque cuantitativo, descriptivo y un diseño no experimental. La muestra estuvo constituida por 122 estudiantes de ambos sexos de una institución educativa pública, a quienes se aplicó un test conformado por dos cuadernillos con problemas matemáticos contextualizados en situaciones reales. Los resultados evidenciaron que la mayoría de los escolares no alcanzan un nivel satisfactorio en la competencia evaluada. Predominó el nivel de proceso con un 42.6% (52 estudiantes), seguido del nivel de inicio con un 36.1% (44 estudiantes) y, finalmente, el nivel logrado con un 21.3% (26 estudiantes). Asimismo, no se encontraron diferencias significativas en el desempeño matemático según el género. Se concluye que existen limitaciones preocupantes en las habilidades matemáticas contextualizadas de los estudiantes, lo que resalta la necesidad de mejorar la práctica docente. Se recomienda implementar metodologías activas centradas en la perspectiva de resolución de problemas con el enfoque de la Educación Matemática Realista para favorecer un aprendizaje significativo y efectivo.

Palabras clave: competencias matemáticas, resolución de problemas, Matemática Realista.

Introduction

Learning mathematics involves developing fundamental cognitive competencies in students, such as logical reasoning, conceptualization, interpretation, and, most importantly, problem-solving (Aceves & Vargas, 2024). For this reason, mathematical competence is seen as essential for enhancing reasoning and critical thinking

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skills (Osorio-Álzate et al., 2024). Furthermore, it enables individuals to understand and address problem situations where achieving a goal does not yield immediate or obvious solutions (Paniagua-Esquivel, 2022). In this regard, solving mathematical problems promotes active and creative learning, fostering skills such as decision-making, argumentation, and communication (Leyva et al., 2024; Rodríguez-Nieto et al., 2025). However, Leyva et al. (2024) emphasize that learning autonomy is best supported in meaningful contexts, while Rodríguez-Nieto et al. (2025) underline the importance of establishing cognitive connections within real-life situations, thereby highlighting the relevance of methodologies like Realistic Mathematics Education (RME).

Today's society demands individuals who can succeed both academically and in their daily lives, demonstrating mastery in procedures, skills, and conceptual understanding; in essence, being mathematically competent (Costado, 2023). As a result, the problem-solving perspective stresses the necessity for students to identify, articulate, and resolve everyday challenges to cultivate competent citizens (Rodríguez-Nieto et al., 2025). According to the Peruvian curricular framework (MINEDU, 2016), these situations are categorized into four domains: regularity, equivalence and change; quantity; shape, movement, and location; and data management and uncertainty (More & Cunya, 2025).

Within this context, mathematics education confronts significant challenges in strengthening the ability to solve problems in a meaningful and effective manner (Benítez Pérez et al., 2023). Unfortunately, this competence has not yet reached the desired levels in many students (OECD, 2023). Various studies link low performance in this area to pedagogical factors such as the ongoing use of traditional methods, the lack of contextualization of knowledge, and inadequate teacher training in mathematics education (Yupanqui, 2023; Costado, 2023). These deficiencies hinder the development of a deep and functional understanding aligned with contemporary educational demands (Vélez et al., 2024).

This issue is reflected in international assessments: the PISA report revealed a global decline in mathematical performance from 496 to 480 points between 2018 and 2022, with a decrease in Peru from 400 to 391 points, indicating a concerning downturn in the skills of 15-year-old students (OECD, 2023). Furthermore, the national assessment ENLA 2023 showed that 88.8% of second-grade secondary students did not reach the expected level in problem-solving with quantities (More & Cunya, 2025).

In this scenario, the approach to addressing mathematical problems has been strengthened by Realistic Mathematics Education, which is increasingly recognized in educational research and consolidates itself as a methodology that enhances the development of mathematical skills in secondary school students. This methodological proposal is rooted in the research and contributions of Freudenthal, who not only promotes the assimilation of mathematical ideas but also emphasizes the connection to daily life through collaborative learning and critical thinking, thereby increasing students' interest in mathematics (Dinglasan et al., 2023).

It is crucial to reflect on the ways mathematics is taught and learned. In this respect, RME emerges as a necessary didactic approach that promotes teaching linked to reality and centered on the guided reinvention of mathematical concepts based on meaningful contexts for students (Gallego & Pérez, 2013; Bressan et al., 2016). In this way, mathematization becomes a key process for understanding and organizing the world through mathematics, originating from reality (Jácome et al., 2022).

Moreover, recent research confirms that the current curriculum can be transformed through RME, emphasizing the continuous construction of content and knowledge arising from contextualized and relatable situations for students (Listyaningrum et al., 2025). This aligns with international pedagogical proposals that advocate for project-based mathematics education, problem-based learning (PBL), and gamification—methodologies that enhance the development of mathematical skills applicable to everyday life (Arias-Albuja et al., 2025; Poma et al., 2020).

From this perspective, RME promotes horizontal and vertical mathematization (Cuevas-Vallejo et al., 2023), wherein mathematics is organized and enriched progressively across various levels: situational, referential, general, and formal (Jácome et al., 2022). Furthermore, its theory rests on six interconnected principles: activity, reality, guided reinvention, levels of formalization, interaction, and interconnection (Gallego & Pérez, 2013). These principles guide mathematics education for all, taking into account personal experiences, fostering collaborative work, promoting gradual understanding, and enabling the practical application of mathematical knowledge (González-Polo & Castañeda, 2023).

The comprehensive implementation of Realistic Mathematics Education (RME), alongside digital tools and interactive games, amplifies its impact by fostering a more inclusive, contextualized, and adaptable learning experience in line with current needs (Da, 2023). However, significant challenges remain, including the persistence of traditional, behaviorist teaching methods focused on memorization, the necessity for a relevant curriculum, and ongoing teacher training, which limit the full potential of this approach (Choirudin et al., 2025).

While authors like Dinglasan et al. (2023) and Koerunnisa et al. (2024) recognize the effectiveness of RME in enhancing learner autonomy, others, such as Choirudin et al. (2025), caution against the difficulties arising from persistent behaviorist approaches. This discrepancy underscores the importance of analyzing how these limitations manifest in secondary education in Peru, where the gap between theory and practice is particularly pronounced.

Consequently, there is a consensus among researchers regarding the urgent need to transform pedagogical practices to reverse the concerning results of international and national assessments, advocating for active methodologies centered on learning and grounded in measurable evidence (Díaz & Gastello, 2025). In this light, it has been demonstrated that RME and active methodologies, when integrated into teacher training programs and educational policies, yield significant advancements in mathematical learning and increase motivation, as evidenced in various Latin American and global contexts (Amanda et al., 2023).

Thus, improving mathematical competencies and fostering critical and reflective thinking are direct outcomes of the appropriate application of active methodologies. These methodologies encourage the development of essential skills and capabilities to effectively face the challenges of the 21st century (Abbas et al., 2025). Accordingly, the aim of this study is to determine the level of competence in mathematical problem-solving among second-grade secondary students in a public school, focusing on Realistic Mathematics Education. This study poses the questions: What levels of achievement do students attain in the mathematical competencies outlined by the National Curriculum for Basic Education (CNEB)? Based on this, two main hypotheses are formulated: (H1) Students exhibit significantly different achievement levels across the four mathematical competencies; and (H2) Gender plays a significant role in their mathematical performance.

This investigation is relevant in theoretical, methodological, and social contexts, as it addresses an urgent need within the Peruvian educational system: to understand and strengthen mathematical competencies through a lens that connects school with everyday reality. Evaluating the achievement levels of students from the perspective of RME provides empirical evidence regarding the effectiveness of this approach in promoting meaningful and contextualized learning, particularly in a context where both national and international assessments indicate a downward trend in mathematical performance.

Theoretically, this analysis contributes to the ongoing discourse surrounding mathematics teaching through problem-solving, integrating the principles of RME with the competencies defined in the CNEB. This integration allows for a reinterpretation of learning processes as active experiences that promote new ways of understanding and applying mathematical knowledge in everyday situations.

Methodologically, the study offers a robust empirical reference by employing a contextualized tool aligned with RME principles, enabling precise evaluation of students' actual performance across the four mathematical competencies. The results provide a useful foundation for future comparative or longitudinal studies aimed at assessing the impact of active methodologies on the development of mathematical thinking.

Finally, the social significance of this research lies in its findings, which can guide pedagogical decisions and educational policies toward the design and implementation of contextualized, creative, and realistic didactic strategies. Additionally, the evidence gathered will be crucial for developing teacher training programs that enhance teachers' capacity to promote critical, reflective, and logical thinking in alignment with 21st-century demands. In summary, this research not only diagnoses a concerning situation but also actively contributes to the transformation of mathematics education, fostering a more equitable, meaningful, and real-world-connected learning experience.

Despite advances in the implementation of RME in various international contexts, there remains a lack of empirical evidence demonstrating its impact on achievement levels in problem-solving for secondary students in Peru. Previous studies have primarily focused on early education or descriptive qualitative approaches, failing to provide clear quantitative data regarding specific performance levels within each mathematical competency outlined in the CNEB. Therefore, this study introduces new and valuable evidence at the national level by establishing a diagnostic baseline regarding performance in the four mathematical competencies from the perspective of RME.

Methodology

For the purposes of this study, a quantitative method with a descriptive focus and a non-experimental design was adopted. The aim was to examine and detail student performance in solving mathematical problems from the perspective of Realistic Mathematics Education (RME), without influencing the study's inherent variables (Hernández & Fernández, 2014). This methodological approach facilitates an objective and detailed analysis of students' performance within authentic educational contexts.

The study population comprised second-grade high school students from a public educational institution in Peru, aged between 12 and 14 years, representing both genders. A non-probabilistic, intentional sample was drawn, consisting of 122 students who simultaneously completed the two booklets corresponding to the 2025 Diagnostic Assessment in mathematics. The average age of the sample was 13.5 years (SD = 0.8), with 51.6% female (n = 63) and 48.4% male (n = 59). According to official reports from the Regional Directorate of Education, all participants were graduates of a public institution in Metropolitan Lima, exhibiting prior academic performance in mathematics that was considered average within the institutional context. Selection was based on convenience sampling, with a margin of error of 5% and a confidence level of 95%, taking into account student accessibility during the assessment.

The 2025 Regional Diagnostic Assessment was based on the "Problem-Solving Test with a Realistic Mathematics Focus," developed by the Regional Directorate of Education of Metropolitan Lima (DRELM, 2025). This instrument comprised two booklets, each containing 23 items contextualized in specific situations and aligned with the four mathematical competencies established in the National Basic Education Curriculum. It was validated by a team of experts in mathematics education, achieving an Aiken's V coefficient exceeding 0.85. The instrument's reliability was confirmed using Cronbach's alpha, yielding a result of 0.89, indicating high internal consistency.

The items were organized according to the four specific competencies outlined in the curriculum: problem-solving regarding quantity; regularity, equivalence, and change; shape, movement, and location; and data management and uncertainty. Achievement levels were classified into three categories: beginning, process, and achieved (DRELM, 2025).

Data analysis was conducted using descriptive statistics, employing absolute frequencies and percentages to represent each achievement level by competency. Data were processed using Microsoft Excel 365, and results are presented in five detailed tables, facilitating a clear and systematic interpretation of students' performance.

This methodology, centered on a contextualized and validated instrument, allowed for an accurate assessment of students' actual performance from the RME perspective, providing relevant empirical evidence for improving mathematics instruction at the secondary level.

Results

The descriptive analysis of the data collected in the 2025 Regional Diagnostic Assessment reveals that 42.6% of students were positioned at the process level, while 36.1% fell into the beginning level and only 21.3% achieved the level considered as accomplished. The mean score was 27.4 out of a total of 46 items, with a standard deviation (SD) of 9.8, and a range from a minimum of 8 to a maximum of 43 correct answers, reflecting considerable variability in academic performance among the assessed students. The skewness coefficient was -0.34, indicating a slight concentration of scores towards the higher values, suggesting that although there are few, some students demonstrated significantly superior performance.

To complement the general analysis, a differential breakdown of the results by mathematical competency and other relevant variables is presented below, with the aim of identifying specific performance patterns and areas requiring pedagogical intervention. This differential analysis is essential for guiding targeted educational strategies and designing interventions that address the specific needs identified among the student population.

Table 1

General descriptive statistics of performance

Statistic	Value	Interpretation
N	122	
Mean Correct Answers	27.4/46 (59%)	Process Level
Standard Deviation	9.8	High Variability
Range	8-43	Wide Dispersion
Skewness	-0.34	Slight Negative Skew

The sample consisted of 122 students (n = 122), and performance was expressed as the number of correct answers obtained out of a total of 46 assessed items. A negatively skewed distribution was observed, indicating a slight concentration of scores above the mean. This suggests that a small group of students achieved higher than the overall average.

Table 2
Distribution of achievement levels

Level	Frequency	Percentage	Characteristics
Beginning (<50%)	44	36.1%	Requires Intensive Support
Process (50-79%)	52	42.6%	Needs Targeted Reinforcement
Achieved (≥80%)	26	21.3%	Consolidation of Learning

The distribution of the 122 participants among the achievement levels indicates that the majority (78.7%) fall within the beginning or process levels, suggesting the need for differentiated and focused pedagogical interventions.

Table 3
Performance by mathematical competencies

Competency	% Correct	Level	SD	95% Confidence Interval
Quantity	58.3%	Process	12.4	[56.1; 60.5]
Regularity, Equivalence, and Change	61.1%	Process	11.8	[59.0; 63.2]
Shape, Movement, and Location	55.4%	Process	13.2	[53.0; 57.8]
Data Management and Uncertainty	63.2%	Process	10.9	[61.2; 65.2]

All competencies were classified at the "process" level (with a percentage of correct answers between 50% and 79%). Notably, the "Data Management and Uncertainty" competency achieved the highest percentage at 63.2%. However, the 95% confidence intervals indicate that the observed differences among the competencies are not statistically significant, suggesting homogeneous performance across the various evaluated areas.

Table 4
Percentage distribution of achievement levels by mathematical competency (n=122)

Mathematical Competency	Achieved	Process	Beginning
Solves Problems of Quantity	45.1%	39.3%	15.1%
Solves Problems of Regularity, Equivalence, and Change	31.1%	50.8%	18%
Solves Problems of Shape, Movement, and Location	36.1%	41.8%	22.1%
Solves Problems of Data Management and Uncertainty	28.7%	23%	48.4%

The results show a marked variation in performance across the evaluated competencies. While the "Quantity" competency had the highest percentage of students achieving the level of accomplishment at 45.1%, the "Data Management and Uncertainty" competency revealed that nearly half of the students (48.4%) were at the beginning level. These findings suggest that critical areas require prioritized attention through specific pedagogical interventions.

Using an independent samples t-test, no statistically significant differences were found between the performance of males (M = 26.8, SD = 9.9) and females (M = 27.9, SD = 9.7), t(120) = 0.61, p = 0.542. The effect size calculated using Cohen's d was (d = 0.11), indicating that gender is not a determining factor in mathematical performance within this sample under the Realistic Mathematics Education framework.

Table 5
Comparison by gender (Student's t-Test)

Gender	n	Mean	SD	t	p	Cohen's d
Males	56	26.8	9.9	0.61	0.542	0.11
Females	66	27.9	9.7			

There is no statistically significant difference in mathematical performance between males and females, with a t-value of t(120) = 0.61, p = 0.542, and a small effect size (d = 0.11). This indicates that both genders perform similarly on the assessed competencies, suggesting equity in mathematical learning opportunities in this specific context.

Discussion

The results indicate that in all four evaluated mathematical competencies, 78.7% of students do not reach a satisfactory level. According to Yupanqui (2023) and Osorio-Alzate et al. (2024), this underperformance can be attributed to the continued reliance on traditional teaching methods that emphasize memorization and algorithmic repetition, thereby limiting students' ability to transfer learned concepts to real-life situations. Conversely, the implementation of strategies that promote horizontal mathematization—connecting real problems to mathematical models—is hindered by a lack of teacher training in innovative methodologies such as Realistic Mathematics Education (RME).

Among the evaluated competencies, the one demonstrating the best relative results was "solving problems of quantity," with 45.1% of students achieving the desired level. This can be linked to students' familiarity with arithmetic calculations and operations involving whole and rational numbers in everyday contexts, as these topics are widely covered in primary education, making them more recognizable (More & Cunya, 2025; MINEDU, 2016). However, it is important to note that this performance is still suboptimal, as the majority of students are at basic levels.

From the perspective of RME, the low levels of achievement in competencies such as data management and uncertainty—where 48.4% of students fell within the beginning level—underscore a limited horizontal mathematization, reflecting difficulties in transforming real situations into mathematical models. Additionally, the sparse presence of students at the achieved levels indicates insufficient development in vertical mathematization, which refers to students' progressive structuring and formalization of mathematical concepts (Cuevas-Vallejo et al., 2023; Jácome et al., 2023). RME posits that both processes are essential for meaningful mathematical learning, a reality not currently observed in prevailing teaching practices.

Moreover, the absence of significant gender differences in mathematical performance is a positive and encouraging finding, suggesting equitable learning opportunities for both boys and girls under the RME framework. This result challenges traditional cultural stereotypes that associate inherent differences in mathematical abilities with gender.

Regarding the adoption of active methodologies, Choirudin et al. (2025) note that in contexts dominated by traditional teaching, such strategies face considerable resistance. Nevertheless, Poma et al. (2020) report substantial progress in problem-solving mediated by problem-based learning. Additionally, Dinglasan et al. (2023) highlight the effectiveness of RME in contexts where teachers are adequately trained. Thus, merely implementing active methodologies in isolation is insufficient; a comprehensive pedagogical transformation that systematically adopts the principles of RME is imperative.

Finally, it is important to acknowledge that the non-experimental and cross-sectional design of this study limits the ability to establish causal relationships. Furthermore, the specificity of the context and the non-probabilistic nature of the sampling restrict the generalization of the findings. Future research should explore the relationship of RME with socioemotional and metacognitive variables to deepen the understanding of its impact.

Conclusions

The results indicate that second-grade high school students demonstrate insufficient achievement in problem-solving using a Realistic Mathematics Education (RME) approach. The majority of students are positioned at the process level for the competencies of regularity, equivalence, and change (50.85%), as well as shape, movement, and location (41.8%). While the quantity competency reaches 45.1% of students at the achieved level, the most critical area is data management and uncertainty, where 48.4% of students remain at the beginning level. The lack of gender differences reflects equity in learning opportunities within this pedagogical approach.

From a theoretical perspective, these findings reveal a limited application of the principles of RME, particularly regarding horizontal mathematization—the translation of real situations into mathematical schemes—and vertical mathematization—the gradual formalization of mathematical concepts (Cuevas-Vallejo et al., 2023; Jácome et al., 2022). This gap can be partially attributed to the disconnect between the official curriculum and teaching practices, which still rely on traditional methods.

Consequently, the following actions are recommended:

1. Implement professional training programs for teachers focused on RME and active methodologies such as problem-based learning.
2. Incorporate contextualized pedagogical sequences that promote both vertical and horizontal mathematization, especially in problem-solving related to data management and uncertainty.
3. Review and adapt curriculum materials to ensure alignment with realistic and critical approaches that meet the demands of the 21st century (González-Polo & Castañeda, 2023; Poma et al., 2020).

Finally, future studies should explore how RME influences socioemotional variables, such as motivation and self-efficacy, as well as metacognitive aspects like self-regulation and critical reasoning. This should ideally be done through experimental or longitudinal designs that allow for the determination of causal relationships. Additionally, it is suggested to extend research to other educational contexts in Peru to validate and expand these findings.

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