

# Realistic Mathematics Education Approach

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Mathematics is widely recognized as a cornerstone of quality education, particularly in fostering problem-solving skills and preparing learners to compete in a global context. The World Economic Forum (2020) identified problem-solving as one of the most in-demand competencies for the coming decade. In alignment with this, the Philippine Department of Education designed a curriculum that underscores the twin goals of mathematics: the development of problem-solving abilities and critical thinking skills. This initiative reflects the broader objective of equipping Filipino students with the competencies necessary to navigate the demands of the twenty-first century.

However, despite these curricular innovations, mathematics remains one of the most challenging subjects for students, particularly in the area of problem-solving (Nurjamaludin et al., 2021). The Philippines' performance in the Program for International Student Assessment (PISA) 2018 illustrates this concern, with the country ranking last among 79 participating nations in mathematics (OECD, 2019). The Philippines recorded a mean score of 353, far below the OECD average of 489. Similarly, Roman (2019)

emphasized that results from national assessments and local research conducted over the past 15 years consistently point to poor mathematical performance, evident across all levels of education. This is further supported by Imam (2016), who observed that the adoption of the K–12 curriculum has yet to yield significant improvements in mathematics outcomes.

A range of factors contribute to this persistent challenge, among which ineffective teaching practices and limited learning strategies are particularly influential (Laurens et al., 2018). To address such gaps, innovative pedagogical approaches have been explored internationally. Notably, in the 1970s, the Freudenthal Institute in the Netherlands introduced the Realistic Mathematics Education (RME) approach. Grounded in contextual and experiential learning, RME has been shown to enhance students' cognitive development and mathematical achievement in multiple international studies (Laurens et al., 2018; Zakaria & Syamaun, 2017). Despite its demonstrated effectiveness, this approach remains underutilized in the Philippines, where traditional lecture-based instruction continues to dominate mathematics classrooms. A review of related literature reveals a lack of empirical research in the Philippine context investigating the potential of RME as a strategy for strengthening mathematical competencies.

### **The Realistic Mathematics Education Approach**

The Realistic Mathematics Education (RME) approach, introduced in the 1970s by the Freudenthal Institute in the Netherlands, is grounded in Hans Freudenthal's principle that mathematics should be meaningfully connected to real-life situations (Dickinson & Hough, 2012; Freudenthal,

1991). As a constructivist-oriented pedagogy, RME encourages learners to actively explore, collaborate, and apply mathematical concepts to authentic contexts. Learning begins with students' everyday experiences, which serve as a foundation for developing deeper conceptual understanding and practical application of mathematics (Kosim & Tirta, 2020). Central to RME are three heuristic principles identified by Gravemeijer (1994) and Freudenthal (1991): guided reinvention, where students rediscover mathematical ideas through structured problem-solving; didactical phenomenology, which highlights the importance of linking instruction to meaningful phenomena; and emergent modeling, wherein learners construct models that progressively evolve into formal mathematical representations.

*Guided reinvention* emphasizes structuring learning experiences in ways that parallel the historical development of mathematical concepts, enabling students to “reinvent” these ideas through their own reasoning and problem-solving (Anwar et al., 2012). In this process, learners' outputs and responses become the focal point of classroom interaction, while teachers assume the role of facilitators who guide, probe, and scaffold understanding rather than directly transmitting knowledge.

*Didactical phenomenology* highlights introducing mathematical concepts through contexts that are authentic, meaningful, and accessible to learners. This process adapts to classroom realities, considering students' backgrounds, prior knowledge, and levels of thinking, thereby underscoring the importance of contextualization and indigenization in mathematics education (Dickinson & Hough, 2012; Stephan et al., 2014). When learning activities are personally relevant and situated in students' lived experiences, they are more likely to engage actively in discussions and develop deeper conceptual understanding.

*Emergent modeling* facilitates the transition from informal strategies

to more formal mathematical reasoning. In this process, educators introduce or refine models often building on representations generated by students themselves to scaffold understanding and structure abstract ideas (Stephan et al., 2014; Anwar et al., 2012). By embedding modeling activities into instruction, learners gradually shift from concrete, context-based problem solving to more generalized and formalized mathematical thinking. Research further affirms that incorporating modeling into mathematics learning significantly strengthens students' analytical and problem-solving skills (Erbaş et al., 2014).

Developing problem-solving skills is a key goal of 21st-century education, as these skills prepare learners to meet the demands of modern life (Khoiriyah & Husamah, 2018). However, challenges in problem-solving remain. According to Krawec et al. (2013), understanding the problem is one of the most difficult aspects of mathematics, requiring not only calculation but also the interpretation and integration of information, mental visualization, and strategic planning. Polya's problem-solving framework, as discussed by Ersoy and Güner (2014), emphasizes four stages:

*Understand the problem.* involves comprehending the given information, forming a mental representation, and identifying what needs to be solved (Krawec et al., 2013).

*Devise a plan.* requires selecting appropriate strategies, such as drawing diagrams or exploring special cases, to transfer mathematical reasoning and enhance critical thinking skills (Hoon et al., 2013; Ersoy & Güner, 2014).

*Carry out the plan.* entails implementing the chosen strategies, which may include creative approaches like acting out scenarios or working backward, to find and verify solutions (Hoon et al., 2013).

*Look back.* looking back emphasizes reflection on the solution process, which strengthens long-term memory and builds meaningful connections for future problem-solving (Liljedahl et al., 2016).

Dewey underscored that ideas and processes are best learned when rooted in personally meaningful experiences, a perspective that aligns with the RME approach's focus on real-life contexts. Guided by these principles, the present study explored the potential of adapting RME to enhance learners' problem-solving skills in the Philippine educational setting.

### **Effectiveness of Realistic Mathematics Education Approach on the Problem-Solving Skills of the Students: A Case Study**

This study aimed to assess students' problem-solving skills in mathematics through the application of the RME approach. Specifically, it sought to determine the pre-test performance of students in problem-solving skills in terms of understanding the problem, devising a plan, carrying out the plan, and looking back; to evaluate their post-test performance after the use of the RME approach in the same areas; and to examine whether there is a significant difference between their pre-test and post-test performance in problem-solving skills.

#### *Methodology*

The study employed a pre-experimental research design, specifically a one-group pre-test and post-test design. The RME approach served as the intervention, with students' problem-solving skills understanding, strategizing, applying, and reflecting carefully assessed. The study population comprised junior high school students enrolled in a school in Batangas, Philippines, during the academic year 2021–2022. A clustered

sampling technique was applied, and from the two Grade 9 sections, random sampling was conducted to select the respondents, yielding a total of 35 Grade 9 students.

Descriptive and inferential statistics were utilized to analyze the data collected. Frequency counts and percentages were used to describe students' pre-test and post-test performance in problem-solving skills, while paired t-tests were conducted to determine the effectiveness of the RME approach in enhancing students' mathematical problem-solving skills.

### *Findings*

Table 1 presents the respondents' pre-test scores in mathematical problem-solving skills prior to exposure to the RME approach. In the area of understanding the problem, the majority of students (15 respondents) were classified at the developing level. While they were able to comprehend the terminology and phrases used in the problems, their responses often contained missing or incorrect values, typically involving more than two errors. This suggests that many of the respondents lacked sufficient familiarity with the topic, which hindered their ability to identify and apply key concepts in solving the problems. This result is consistent with the findings of Vula and Kurshumlia (2015), who emphasized that students with prior knowledge of the terms used in word problems are better equipped to grasp mathematical concepts and improve their understanding.

With regard to devising a plan, more than half of the students (51.43%) were classified at the developing level. This indicates that many of them struggled to formulate effective strategies, such as representing possible scenarios and selecting appropriate methods to arrive at the correct solution. This finding is consistent with Phonapichat et al. (2014), who noted that students often demonstrate disorganization in their problem-

solving processes, particularly in writing formulas and following sequential steps.

**Table 1**

*Pre-test performance of the students in problem-solving skill*

Score	Understand the problem		Devise a plan		Carry out the plan		Look back		Interpretation
	f	%	f	%	f	%	f	%	
25-32	7	20.00	-	-	-	-	-	-	Exemplary
17-24	13	37.14	1	2.86	-	-	-	-	Proficient
9-16	15	42.86	18	51.43	10	28.57	1	2.86	Developing
0-8	-	-	16	45.71	25	71.43	34	97.14	Emerging
							4		
<b>Total</b>	<b>35</b>	<b>100</b>	<b>35</b>	<b>100</b>	<b>35</b>	<b>100</b>	<b>35</b>	<b>100</b>	

**Legend:** 25-32: Exemplary; 17-24: Proficient; 9-16: Developing; 0-8: Emerging

In terms of carrying out the plan, the majority of respondents (25 students, or 71.43%) were at the emerging level. This suggests that most students encountered difficulties in applying the strategies necessary to solve the problems. Their responses often lacked elaboration of processes and outcomes, and their reasoning was generally weak in executing their plans. Dhlamini et al. (2016) similarly observed that students with limited proficiency in trigonometry frequently left items unanswered or applied incorrect procedures, leading to mathematically inaccurate solutions.

Finally, in the area of looking back, nearly all respondents (97.14%) were classified at the emerging level. This reveals that students either made minimal attempts or entirely failed to check and reflect on their answers, highlighting difficulties in evaluating the accuracy of their solutions. Such weaknesses also suggest shortcomings in the earlier stages of the problem-solving process. Annizar et al. (2020) likewise reported that many learners

made errors during planning and execution but rarely engaged in the process of reflection, indicating that looking back remains an underdeveloped practice among students.

**Table 2**

*Post-test performance of the students in problem-solving skills*

Score	Understand the problem		Devise a plan		Carry out the plan		Look back		Interpretation
	f	%	f	%	f	%	f	%	
25-32	32	91.43	24	68.57	7	20.0	10	28.57	Exemplary
17-24	3	8.57	9	25.71	15	42.86	10	28.57	Proficient
9-16	-	-	2	5.72	9	25.71	6	17.15	Developing
0-8	-	-	-	-	4	11.43	9	25.71	Emerging
<b>Total</b>	<b>35</b>	<b>100</b>	<b>35</b>	<b>100</b>	<b>35</b>	<b>100</b>	<b>35</b>	<b>100</b>	

**Legend:** 25-32: Exemplary; 17-24: Proficient; 9-16: Developing; 0-8: Emerging

In the first phase of mathematical problem-solving, understanding the problem, 32 out of 35 respondents (91.43%) demonstrated exemplary performance. This indicates that most students developed a clear and thorough understanding of the problems, carefully analyzing each question and accurately identifying all given values and variables.

In devising a plan, 24 students (68.57%) achieved an exemplary level of skill. This suggests that the RME approach enhanced students' capacity to generate concrete strategies for solving problems. High-performing students effectively constructed diagrams, identified appropriate methods, and selected suitable techniques to arrive at the correct solutions. Many were also able to apply comprehensive mathematical concepts, approach problems from multiple perspectives, and connect their illustrations to relevant formulas. This aligns with In'am (2014), who emphasized that effective problem-solving strategies often emerge from

students' prior experiences, allowing them to make analogies with similar problems encountered in the past.

With regard to carrying out the plan, the largest proportion of students (15 respondents, or 42.86%) performed at the proficient level. This demonstrates that students were generally adept at executing the strategies they had developed in the previous step. Proficient students recognized multiple ways of implementing their plans and applied sound reasoning skills. While some solutions contained simplified or omitted steps, most still led to accurate answers. For example, in trigonometry problems, students not only recalled the six trigonometric ratios but also applied them correctly to determine missing values.

Finally, in the looking back phase, student performance reflected a balance between exemplary (10 students, 28.57%) and proficient (10 students, 28.57%) levels. This indicates that many students were able to review, interpret, and evaluate their final answers in a logical, systematic manner. Reflective practice enabled them to detect and correct errors from earlier steps, which improved the accuracy of their final solutions. This finding corroborates the work of Thomson et al. (2021), who observed that students actively compare formulas and diagrams in solving word problems involving right triangles, often generating alternative strategies through the use of trigonometric ratios.

Table 3 presents the significant differences between the respondents' mean pre-test and post-test performance. The results reveal that students' mathematical problem-solving skills improved significantly across all four phases, with a computed p-value of 0.000 for each phase. This demonstrates that after exposure to the RME approach, students exhibited enhanced academic performance in problem-solving. This result supports the findings of Taufina et al. (2019), who reported that students

taught using conventional methods performed significantly lower in problem-solving compared with those exposed to RME.

**Table 3**

*Test of difference between the mean pre-test and post-test performance*

Mathematical Problem-solving Skills	Pre-test		Post-test		t	df	Sig. (2- tailed)
	Mean	SD	Mean	SD			
Understanding the problem	20.89	6.09	30.23	3.19	8.350	34	.000
Devising a plan	8.74	4.01	26.31	5.52	16.433	34	.000
Carrying out the plan	5.40	5.00	18.66	7.89	9.186	34	.000
Looking back	2.03	2.91	17.57	8.93	10.402	34	.000

*Legend: p-value (Sig.) < 0.05 – significant, p-value (Sig.) >0.05 – Not significant.*

In understanding the problem, there was a highly significant difference (p-value = 0.000) between pre-test and post-test performance. The mean score increased from 20.89 (developing level) to 30.23 (exemplary level). Initially, many students struggled with the terminology in the problems, which hindered their ability to identify key concepts. Through the RME approach, lessons became more collaborative and interactive, fostering greater self-confidence and active participation. This engagement enabled students to master trigonometric concepts such as trigonometric ratios, special right triangles, angles of elevation and depression, and oblique triangles. These findings are consistent with Nurjamaludin et al. (2021), who argued that RME enhances students' confidence and, consequently, their problem-solving performance.

Additionally, students' reading comprehension improved through self-exploration facilitated by RME. Investigating unfamiliar mathematical

terms and concepts before class discussions enabled students to construct their own understanding, underscoring the effectiveness of RME in the initial step of problem-solving. This is aligned with Afthina and Pramudya (2017), who highlighted that RME fosters engagement and deeper understanding in geometry instruction.

In devising a plan, the mean pre-test score of 8.74 (emerging level) rose to 26.31 (exemplary level) in the post-test, with a p-value of 0.000, indicating a highly significant improvement. This demonstrates that RME strengthened students' ability to strategize. Students drew from prior experiences and made analogies with similar problems, which facilitated effective planning, as emphasized by In'am (2014). Contextualized problems encouraged active engagement, making it easier for students to develop appropriate strategies.

The RME approach further promoted creativity and critical thinking by encouraging students to explore problems from multiple perspectives, design alternative plans, and connect illustrations with appropriate formulas (Szabo et al., 2020). Teachers functioned as facilitators, while student ideas drove the discussion. The principle of emergent modeling also required students to visualize problem situations and identify suitable formulas, enhancing their strategizing skills through repeated practice (Julie et al., 2013).

In carrying out the plan, students demonstrated another highly significant improvement (p-value = 0.000), with mean scores increasing from 5.40 (emerging level) to 18.66 (exemplary level). The principle of guided reinvention fostered student-centered discussions, allowing students to articulate their reasoning, critique peer solutions, and collaborate in solving problems. This process enhanced both computational proficiency and communication skills, confirming Palinussa et al.'s (2021) finding that

RME strengthens mathematical reasoning and communication.

Didactical phenomenology also contributed to progress in this phase. Experience-based activities encouraged students to rely on prior knowledge, fostering deeper involvement and improving their ability to implement problem-solving strategies (Liljedahl et al., 2016; Stephan et al., 2014). Likewise, emergent modeling bridged informal and formal reasoning, further supporting accurate and effective solution processes (Vroom, 2020; Anwar et al., 2012).

In looking back, students initially scored the lowest in the pre-test (mean = 2.03, below emerging level) but showed dramatic improvement in the post-test (mean = 17.57, proficient to exemplary), with a p-value of 0.000. Many students initially neglected this step due to unfamiliarity with reviewing solutions (Thomson et al., 2021; Simpol et al., 2017; In'am, 2014). After exposure to RME, however, reflection became a routine practice. Students applied critical thinking to verify their solutions and evaluate alternative strategies. This outcome supports Wulandari (2020), who found that RME strengthens reflective thinking and problem-solving ability.

The process of looking back also reinforced reflective thinking, enabling students to assess the accuracy, completeness, and applicability of their solutions. The self-emergent modeling principle further bridged informal and formal knowledge, leading to improved performance in this phase (Junaedi & Wahyudin, 2020). Mastery of the first three steps also contributed significantly to success in reflection, consistent with Nurkaeti (2018), who emphasized that difficulties in reviewing solutions diminish when earlier steps are properly executed.

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