Realistic Mathematics Education: Investigating the Argumentation Dialogue in Problem-Solving Activity

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ABSTRACT

This study delves into how contextualized learning, a key element of the Realistic Mathematics Education (RME) approach, shapes how Grade 9 students develop their problem-solving skills. Set in a laboratory school within a Philippine state university, the research captured fundamental classroom dynamics through observations, interviews, and content analysis. By anchoring lessons in relatable, real-life problems and guiding students through thoughtful questioning, the study found that learners became more engaged, reflective, and confident in approaching mathematical tasks. Using argumentation, dialogues revealed how students gradually transitioned from everyday reasoning to more formal mathematical thinking. Insights from learners and pre-service teachers underscored the value of this approach in making mathematics more meaningful and the practical challenges of its classroom implementation. Ultimately, the study highlights the promise of RME in fostering a richer, more connected learning experience.

Keywords: Realistic Mathematics Education (RME), Problem-solving, Mathematization, Mathematics Education, High School

INTRODUCTION

Mathematics is more than just numbers. It is a field that helps students think critically and solve problems that relate to the real world (Anwar L. et al., 2012). In the Philippines, the Mathematics Framework for Basic Education recognizes this by highlighting the subject's role in building practical reasoning skills, encouraging collaboration, and contributing to national progress, especially in science and technology (Gillesania, K. D., 2011). Collaborative problem-solving (CPS) combines individual problem-solving abilities with the social dynamics of learners working together. In today's 21st-century context, CPS stands out as an essential skill that is highly valued in both educational settings and professional environments (Buan et al., 2019). However, in many classrooms, math is still taught through memorizing formulas and procedures, leaving students with little understanding of how math applies to everyday life (Wahyu, 2017). Realistic Mathematics Education (RME), developed by Hans Freudenthal, offers a more student-centered approach. By rooting mathematics in real-world problems and encouraging exploration through didactical phenomenology, RME enables students to draw mathematical ideas from meaningful, everyday experiences. Despite these promising outcomes worldwide, the implementation of RME in the Philippine context is still at an early stage (Dinglasan et al., 2023).

While RME has demonstrated remarkable success on the international stage, supporting students in making sense of mathematics through real-world applications, its adoption in the Philippine education system remains limited. In addition to these international successes, recent results from national and global assessments, such as the NAT and PISA, underscore the persistent challenges faced by Filipino learners in applying mathematical concepts to authentic situations (PISA, 2018). Consequently, these difficulties are often attributed to the continued reliance on traditional teaching methods and a scarcity of instructional materials that connect mathematics to students' everyday experiences. Although the Philippine K-12 curriculum now advocates for more contextualized

learning, innovative approaches like RME are still not widely implemented in most public schools (DepEd, 2020). Furthermore, since much of the research on RME originates from Western contexts, questions remain about how these strategies can be effectively translated to the Filipino classroom, where cultural norms, language diversity, and resource limitations play a significant role (Nurjamaludin et al., 2021).

This study looks closer at one of RME's most vital principles, 'contextualized learning,' and how it can help improve problem-solving skills among Grade 9 students. It explores how this approach is applied in real classrooms, what challenges teachers face, and how students respond. With limited training and tailored teaching materials, many educators find it difficult to fully embrace this strategy (Sirojuddin, A., Kurniawati, N., & Ismanto, I., 2023). Addressing these gaps is essential. By investigating a classroom with RME in practice and analyzing its effects on student learning, this research aims to offer practical insights for making math more relevant and engaging. Ultimately, the study seeks to bridge the gap between theory and practice and support a more meaningful, accessible, and effective way of learning mathematics in the Philippines.

The primary objective of this study is to investigate the argumentation dialogue in mathematics lessons as contextualized learning, a core principle of the RME approach, and detail how it develops the learners' problem-solving skills.

METHODOLOGY

Research Design

This study adopted a descriptive case study design to explore how contextualized learning within the Realistic Mathematics Education (RME) framework influences learners' problem-solving skills.

Research Setting and Participants

The research was conducted in a developmental school at a state university, chosen purposively for its advanced curriculum and mathematics teachers' usage of the RME approach. The observation covered a Grade 9 class with 31 students, four Grade 9 learners, and two pre-service teachers selected for follow-up interviews. These participants were purposively chosen to ensure rich, relevant insights into classroom behavior and the application of RME strategies.

Research Instrument

The study employed three instruments to gather data: observation notes, an expert-validated structured interview guide for teachers, and an expert-validated structured interview guide for learners. These tools are designed to capture interactions during lessons, examine how real-life scenarios are integrated into teaching, and understand how learners engage with and solve contextual mathematical problems.

Data Gathering Procedure

Classroom observations, using recorders, documented teacher-student interactions and learners' problem-solving behaviors. At the same time, interviews further illuminated how educators and students understand and practice contextualized learning in the classroom.

Data Analysis

For data analysis, the researcher adopted the Argumentation Dialogue from the analysis used by Ayalon & Even (2016) and Gunes Uzon A. (2024) in their studies.

Table I Types of Argumentation Dialogues

Type	Explanation
Individual (I)	A dialogue between the teacher and only one student.

Qualified Individual (QI)	Dialogue between the teacher and only one student in which the student justifies his/her claim.
Collective (C)	Teacher-student dialogue with multiple students involves discussion, idea-sharing, and co-constructing knowledge.
Qualified Collective (QC)	Dialogue between the teacher and more than one student involves a whole-class discussion, evaluation of others' ideas, elaboration on them, and/or co-construction of knowledge, and justification of the claims.
Monologue (M)	Dialogue involving the teacher alone.

Content analysis was applied to identify recurring phrases and categories in observations and interview transcripts. Ethical considerations are paramount throughout the research process, ensuring informed consent, voluntary participation, confidentiality, and data protection. All collected data was securely stored, anonymized, and used solely for academic purposes, with participants retaining the right to withdraw at any point.

RESULTS AND DISCUSSION

Argumentation Dialogue in Ms. TZ's Class

Ms. TZ's class in one of the Grade 9 classes under her is one hour (60 minutes), which is analyzed through students' and pre-service teachers' utterances and dialogues categorized according to the types discussed in Table 1. Table 2 below shows the Argumentation Dialogue used by Ayalon & Even (2016) and Gunes Uzon A. (2024) in their studies.

Table 2 Summary of the Argumentation Dialogues observed in Ms.TZ's class

Type of Argumentation: Dialogue	**Description**	**Example of Utterances**	**Frequency**
Individual	A single student makes a claim or reasoning without peer validation.	Student: Rectangular.	10
Qualified Individual	A student makes a reasoned claim with teacher guidance or correction	Student: Because one side is along the wall.	7
Collective	Multiple students contribute ideas, possibly building on each other	Teacher: Who has the same answer?	6
Qualified Collective	Multiple students collaboratively reason and reach a shared understanding	Group discussion on dimensions and area by Groups 4 and 8	5
Monologue	The teacher explains or elaborates without student interaction	Teacher: So, what would the resulting area be?	8

Table 3 Percentage of the argumentation dialogues observed in Ms. TZ's class

Category	**Argumentation Dialogues**	
	Numbers	**Percentage (%)**
Individual (I)	10	27.80 %

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Qualified Individual (QI)	7	19.40 %
Collective (C)	6	16.70 %
Qualified Collective (QC)	5	13.90 %
Monologue (M)	8	22.20 %
Total	**36**	**100 %**
Category	**Argumentation Dialogues**	
	Numbers	**Percentage (%)**
IBD (Individual Based Dialogue)	17	47.20 %
CBD (Collective Based Dialogue)	11	30.60 %
Monologue	8	22.20 %
Total	**36**	**100 %**

Table 3 presents the findings from the analysis of classroom dialogue classifications. The code "IBD" represents the total number of dialogues between the teacher and a single student, indicating one-on-one interactions initiated by the teacher. Meanwhile, "CBD" refers to the overall number of group or collective dialogues.

Looking at the types of dialogue in the classroom, most were one-on-one exchanges between the teacher and a student, called Individual-Based Dialogues (IBD), making up around 47% of the talk. Collective-Based Dialogues (CBD), where students worked and reasoned together, came next, followed by monologues. Even though IBDs were more frequent, the presence of CBDs in nearly a third of the classroom interactions is noteworthy. These group discussion moments allowed students to co-construct their understanding and transition from informal to more structured, formal math concepts. They connected everyday scenarios to mathematical thinking, a central idea of contextualized learning. The prevalence of IBD and CBD discourse in the transcript demonstrates that students were not only sharing ideas but collaboratively refining them with support from peers and the teacher. This collaborative process reflects the constructivist essence of didactical phenomenology, where knowledge is co-constructed. (Ferreira, S., and Bisognin, V., 2020).

Throughout the lesson, the teacher acted as a facilitator, prompting critical thinking with purposeful questions rather than simply providing answers. This approach, central to Realistic Mathematics Education, positioned students as active reasoners and discoverers, reinforcing mathematics as a process of inquiry rather than rote computation (Palinussa, A., 2020). The dialogue showed clear evidence of vertical mathematization: students progressed from informal estimations to formal algebraic representations, such as transforming trial dimensions into equations like "Y = 100 – 2X." This progression, guided by structured yet adaptable questioning, exemplified how meaningful experiences can anchor the development of formal mathematical knowledge.

Finally, comparing group solutions and critiquing different methods helped students cultivate metacognitive skills, fostering independence and more profound learning, key outcomes that traditional classrooms often overlook (Hayun, M., & Hutami, Y., 2024).

While earlier studies such as those by Ayalon & Even (2016) and Gunes Uzon (2024) have noted challenges in sustaining meaningful argumentation and establishing collective reasoning in traditional classrooms, this study found that a strategic combination of Individual-Based Dialogue (IBD) and Collective-Based Dialogue (CBD) within an RME framework not only boosts student involvement but also fosters a nurturing atmosphere for mathematization and reflective thought. The findings demonstrate how this combination of dialogue allows

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students to move from individual concepts to joint validation and critique, successfully linking everyday reasoning with formal mathematical comprehension (Anwar, L. et al., 2012).

What stood out in Ms. TZ's class was how naturally the lesson followed the principles of RME. The teacher introduced the problem using a familiar, real-life situation of fencing a garden, which immediately grounded the math in something relatable. Students began by recognizing the shape of the garden, gradually moving from these simple ideas toward the formulation of equations and general mathematical rules. Instead of giving them answers, the teacher guided them with thoughtful questions, nudging them to think deeper and compare different strategies. This created an environment where students were not just solving problems but discovering how math works (Nurjamaludin, M., Gunawan, D., Adireja, R., & Alani, N., 2021; Widodo, S., Santia, I., & Katminingsih, Y., 2023). Through this approach, the classroom became a space for exploration and reflection, showing how RME can transform students' engagement with and understanding of mathematics (Treffers, 1987; Gravemeijer, 1994 as cited in the study of Anwar, L. et al., 2012).

Table 4 Content Analysis on Perception of Pre-service Teachers in RME

Category	Code	Statement
Contextualized Learning	Understanding the concept	**TZ: "***The next consideration is relatedness and relevance to the students."* **TJ:** *"My first answer is relevance. Since this is an introduction to the concept…"*
Challenges of the Lesson	Answers and Questioning	**TZ:** "*…when you anticipate the possible answers of the students."* **TJ:** "*Additionally, I learned to anticipate possible misconceptions."*
Developing Problem-Solving Skills	Improved Thinking	**TJ: "***This encourages them to become critical thinkers and to think outside the box."* **TZ: "***From that moment, they begin thinking critically."*

Table 4 Continuation Content Analysis on Perception of Pre-service Teachers in RME

Mastery of the Teacher in Questioning	Guide Questions	**TZ:** *"The main answer lies in using guide questions (the art of questioning)."* **TJ:** "*…a teaching strategy highlighting the importance of questioning."*
Assessment of Learning	Reflections in Problem Solving	**TZ:** *"Reflection plays a key role—both personal and collaborative. During PLD (Post Lesson Discussions)"* **TJ:** "*Reflection as a teacher is beneficial for personal growth and contributing to student learning."*

Pre-service teachers genuinely see the importance of using the RME approach in helping students become more engaged and better problem solvers. To make lessons more meaningful, they use more straightforward language, real-life situations, and supportive techniques like scaffolding, group work, and thoughtful questioning (Cobb et al., 2003).

The pre-service teachers thought carefully about the open approach contextualized questions to have a smooth flow of the lesson, so they came up with the problem of gardening, since most secondary schools in the Philippines have gardens that they cultivate as part of one of the subjects. These methods show teachers moving away from traditional lectures and embracing more flexible, student-centered teaching (Vygotsky, 1978).

However, while they believe in the approach, many also find it challenging to create and carry out lessons that connect real-world problems to more profound math ideas. They often struggle to help students move from everyday thinking to more abstract mathematical reasoning (Van den Heuvel-Panhuizen & Drijvers, 2021). Because of this, many practice teachers emphasize the need for more training and support to improve their skills in choosing the proper contexts, understanding student needs, and managing these lessons effectively within the time and curriculum constraints they face (Alexander R., 2008).

Table 5 Content Analysis on Perception of Learners in RME

Category	Code	Statement
Contextualized Lessons	Solving Real-Life Problems	**L1:** *"It is okay because if it is related to real life, it is easier to understand how to solve it."* **L3:** *"What I thought of was imagining that this real-life situation happened."*
Mathematization	Connect real-world problems to Math.	**L3:** *"For me, since it talks about area — like a garden's fencing — I would first think about the concept of area and start from there."* **L1:** *"I realized it connects to the formula in math."*
Learning Motivation	Engagement and Interest	**L2:** *"... like, it is helpful because it can answer my question, 'where can I connect this math?"* **L4:** *"It is more of a brain teaser.", "Math is always present."*
Reflection on Learning	Development of Problem-Solving Skills	**L3:** *"...wherever I go, I now think about calculations. I can use it more."* **L2:** "*Maybe it helps me — like I have realized that is the problem-solving process."*

The table shows that Realistic Mathematics Education (RME) affects how students understand and solve math problems. By relating math lessons to real-life situations, students can see the relevance of their learning, making it easier for them to move from simple, everyday thinking to more abstract and formal mathematical ideas (Sutarni, S., & Aryuana, A., 2023). Many students shared that they found the lessons more enjoyable and easier to connect with, which helped build their confidence and motivation in tackling math problems (Hayun, M., & Hutami, Y., 2024). RME does not just help them learn math better; it creates a more meaningful and supportive learning environment where students feel empowered to think critically, explore different strategies, and grow both intellectually and emotionally (Van den Heuvel-Panhuizen, M., & Drijvers, P., 2020).

CONCLUSION

The findings of this study reveal a meaningful transformation in how students approach mathematical problem-solving after experiencing Realistic Mathematics Education (RME), mainly when guided by contextualized learning. Students became more engaged and showed a deeper understanding of the concepts due to lessons grounded in real-life situations they could relate to. By starting with familiar and relevant problems, the learners were motivated to active exploration, especially in mathematization. Students were not just following procedures but building their strategies, making sense of the math, and gaining confidence.

Hence, in contextualized learning, the teacher played a crucial role in helping students make sense of the math behind real-world problems. Rather than jumping straight into abstract formulas, students were encouraged to work through situations they already understood, gradually moving toward more formal mathematical ideas. This journey from real-world reasoning to structured problem-solving helped them grasp the content better and develop qualities like creativity, persistence, and teamwork. These are all essential skills beyond just solving equations; they are about learning how to think about solving problems.

This study converges with global studies like those by Ayalon & Even (2016) and Gunes Uzon (2024), emphasizing the importance of structured argumentation and individual and group dialogues in enhancing students' mathematical reasoning within the RME framework. However, it contrasts with earlier findings by illustrating that, in the Philippines, a balanced approach to Individual-Based Dialogue (IBD) and Collective-Based Dialogue (CBD) can be effectively utilized to promote engagement and cultivate a supportive atmosphere for mathematization and reflective thinking, even when RME is not yet fully embedded. A novel contribution of this study is its exploration of how contextualized, real-life challenges and culturally relevant activities, such as the garden fencing task, help Filipino students shift from informal to formal mathematical reasoning. Additionally, it offers empirical evidence that the RME approach, when adapted with care, can connect everyday experiences with formal mathematics while empowering teachers to take on the role of facilitators rather than simply transmitters of knowledge.

RECOMMENDATION

The investigation of RME's contextualized learning showed that it was theoretically and validly promising in helping learners develop their problem-solving skills. Hence, the following are recommended:

1) Apply Didactical Phenomenology in Education: Mathematics educators ought to incorporate real-world situations and everyday experiences to assist students in uncovering mathematical ideas, enriching their comprehension and engagement through the concepts of the RME framework.

2) Improve Teacher Professional Development: Continuous training, workshops, and professional learning communities must be offered to prepare teachers with the skills necessary for creating and executing RME-focused lessons and encouraging argumentation-rich discussions in the classroom.

3) Encourage the Implementation of RME in Schools: School leaders ought to endorse and formalize the application of RME by establishing transparent standards for evaluating classroom techniques and consistently promoting creative, context-responsive teaching methods.

4) Promote Additional Qualitative Research: Subsequent studies should investigate the application of RME and Didactical Phenomenology at various educational stages and in different areas of mathematics, yielding insights that can guide curriculum creation and educational policy.

5) Explore the Role of Cultural and Linguistic Elements: Future research should thoroughly investigate how cultural norms and language variations in the Philippines affect the execution and effectiveness of the Realistic Mathematics Education (RME) approach and argumentation dialogues. Such investigations can offer more profound insights into challenges specific to the context and strategies for optimizing RME's advantages in varied educational environments.

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