Cognitive Development Journal
Vol. 1, No. 2 (2024), pp. 80-90| e-ISSN: 3025-8693
Homepage: https://ojs.edutechpublishing.com/index.php/cognitive

Realistic Mathematics Education as a Pedagogical Approach to Improve Geometry Learning in Higher Education

Annisa Prima Exacta[1*], Muhammad Zain Musa[2], Isna Farahsanti[3], Rizqona Maharani[4], Salvadaor V. Briones[5]
[1,3] Universitas Veteran Bangun Nusantara, Indonesia
[2]Musa Asyiah Foundation, Cambodia
[4]Institut Agama Islam Negeri, Indonesia
[5]Partido State University, Philippines

Email: [1*]annisa.p.exacta@gmail.com, [2]mzanbm@gmail.com , [3]isnafarahsanti@gmail.com, [4]rmaharani@iainkudus.ac.id, [5]salvador.briones@parsu.edu.ph
*Corresponding author

Received: November 2, 2024; Accepted: November 29, 2024; Published: November 30, 2024

ABSTRACT

This study investigates the effectiveness of the Realistic Mathematics Education (RME) approach in enhancing undergraduate students' understanding of geometry. Conducted as a classroom action research project in two cycles, the study involved 38 second-semester students in the Mathematics Education Program at Universitas Veteran Bangun Nusantara, Indonesia. Data were collected through observation and written tests, with analysis conducted using descriptive techniques. Results show that the percentage of students achieving the minimum mastery criterion increased from 55.26% (pre-cycle) to 65.79% (Cycle I) and 86.84% (Cycle II). These findings suggest that RME can significantly enhance students' comprehension of geometric concepts.

Keywords: *Realistic Mathematics Education, Geometry, Understanding, Classroom Action Research*

INTRODUCTION

In recent decades, a shift in mathematics education has emphasized learning grounded in real-life contexts, student-generated problem-solving strategies, and classroom interaction (Kwon, 2019). These principles align with Realistic Mathematics Education (RME), which encourages learners to develop mathematical understanding through meaningful experiences.

In Indonesia, the implementation of mathematics education has evolved since the 1970s. However, the focus has often remained on teacher-centered instruction aimed at meeting curriculum outcomes, with limited student engagement in the learning process (Zakaria & Syamaun, 2017). This contradicts constructivist principles, which emphasize that knowledge is constructed by learners through active participation (Azizi et al., 2005).

Allsopp et al. (2007) highlight that teaching grounded in students' experiences and environments improves engagement and comprehension. RME, rooted in Freudenthal's philosophy that mathematics is a human activity, promotes this by presenting real-world or experientially real problems (Van den Heuvel-Panhuizen & Drijvers, 2014). Research by Cobb et al. (2008) confirms the effectiveness of this approach in restructuring students' mathematical reasoning.

In geometry, traditional instruction often relies heavily on theoretical content, making it difficult for students to relate abstract concepts to real-world contexts. Hadi et al. (2002) argue that RME is particularly suitable for addressing these challenges in Indonesian mathematics education.

According to NCTM (1989), conceptual understanding in mathematics is reflected in students' abilities to define, represent, interpret, and relate mathematical ideas. Ruseffendi (2006) further categorizes understanding into translation, interpretation, and extrapolation.

This classroom action research was conducted in two cycles involving 38 students enrolled in the geometry course. Each cycle followed four stages: planning, action, observation, and reflection. Data sources included lecturers and students, and the instruments comprised observation sheets and tests.

Observations focused on student activity and comprehension during lessons. Meanwhile, written tests evaluated students' mastery of geometric concepts before and after RME-based instruction. Data validity was ensured using source triangulation, comparing two independent observers' notes.

Success was measured by the proportion of students reaching or exceeding the minimum mastery criterion (KKM), set at 75. According to Mulyasa (2004), a classroom action is considered successful if at least 75% of students achieve this threshold.

METHODS

This study employed a Classroom Action Research (CAR) design to investigate the effectiveness of the Realistic Mathematics Education (RME) approach in improving undergraduate students' understanding of geometry. CAR was selected for its systematic, reflective, and cyclical nature, which allows educators to iteratively plan, implement, observe, and reflect on instructional interventions (Kemmis & McTaggart, 1988).

Participants and Research Context

The research was conducted at Universitas Veteran Bangun Nusantara Sukoharjo, Indonesia, involving 38 second-semester students enrolled in a Geometry course within the Mathematics Education Program. The course is typically taken in the first year and serves as a foundation for advanced mathematical thinking. The researcher was also the course instructor, assuming the dual role of facilitator and practitioner-researcher.

Research Design and Procedure

The study consisted of two action research cycles, each comprising the four standard phases:

1. Planning: The researcher prepared learning activities based on RME principles. These activities included real-life problem situations, opportunities for guided reinvention, and collaborative group work to stimulate meaningful student engagement. Lesson plans, learning materials, and instruments were validated before implementation.
2. Action: The planned lessons were implemented in the classroom. RME strategies were applied, including presenting contextual problems, encouraging student dialogue, and using visual or spatial representations to bridge abstract and concrete understanding.
3. Observation: Two trained observers used structured observation sheets to monitor classroom dynamics. These observations focused on student engagement, interaction patterns, punctuality, group collaboration, and how students approached problem-solving tasks within the RME framework.

4. Reflection: After each cycle, the researcher analyzed both observational and test data, then identified strengths and weaknesses in the instructional process. Adjustments were made for the subsequent cycle to address challenges such as late attendance and group collaboration issues.

Data Collection Techniques and Instruments

Multiple instruments were used to collect data:

1. Observation Sheets: Used by observers to document student behavior, levels of engagement, and the overall effectiveness of instructional strategies during class activities.
2. Written Tests: Administered before the intervention (pre-cycle), after Cycle I, and after Cycle II to assess students' conceptual understanding of geometry. These tests included tasks related to the interpretation, representation, and application of geometric concepts.
3. Reflective Notes: Maintained by the researcher to record insights, instructional challenges, and student responses throughout the study.

Data Analysis

Data was analyzed using descriptive statistics. The key metric was the percentage of students meeting or exceeding the Minimum Mastery Criterion (KKM), which was set at 75. The analysis focused on comparing student achievement across three points: pre-cycle, Cycle I, and Cycle II.

Validity Measures

Source triangulation was used to ensure the credibility of the qualitative data. Observations were conducted by two independent observers whose notes were cross-checked to confirm consistency. The test instruments were reviewed for content validity by two mathematics education experts.

Instructional Challenges and Adjustments

Initial observations during Cycle I revealed several implementation issues. Many students arrived late due to the early class time (07:30 AM), and group collaboration was weak, with students often completing tasks individually. To address this, the researcher reorganized groups based on student performance and introduced brief pretests to encourage punctuality in Cycle II. These changes led to better group dynamics and learning outcomes.

RESULTS AND DISCUSSION

Before the implementation of the Realistic Mathematics Education (RME) approach, the geometry course was conducted using conventional, teacher-centered instructional methods. The lecturer, who also served as the researcher, relied on traditional pedagogical strategies that focused primarily on explanation and demonstration. This approach provided limited opportunities for students to actively engage in the learning process or to relate mathematical concepts to real-world contexts.

To understand students' baseline knowledge, a pre-cycle test was administered to all participants at the beginning of the study. These students were in their first semester of the Mathematics Education Program at Universitas Veteran Bangun Nusantara Sukoharjo. The test served as an initial diagnostic tool to assess their understanding of fundamental geometric concepts before any intervention was applied.

Observations conducted during this phase revealed several challenges that hindered effective learning. A notable number of students arrived late to class, which caused disruptions and diminished the quality of instruction. Additionally, the learning environment lacked dynamic interaction; students tended to be passive recipients of information rather than active constructors of knowledge. Without the integration of RME principles—such as contextual learning, student autonomy, and collaborative problem-solving—many students struggled to grasp the abstract and theoretical nature of geometry. Their difficulties were particularly evident in their inability to connect mathematical formulas to practical applications or visual representations.

Following the initial instructional session, a formal assessment was conducted to measure students' comprehension before the application of the RME model. The results of this assessment formed the basis for comparison in the subsequent cycles of classroom action research. The following section presents the percentage of students who met the Minimum Mastery Standard (KKM) during the pre-cycle phase, providing a clear picture of the learning challenges that necessitated instructional reform.

Initial observations indicated low engagement and frequent tardiness. The average pre-cycle test score was 73.62, with only 55.26% of students meeting the KKM.

Table 1. Pre-Cycle Achievement Score Distribution

Achievement Indicator	**Number of Students**	**Percentage (%)**
≥ KKM	21	55,26
< KKM	17	44,74
Total	**38**	**100**

Table 1 shows the distribution of students' pre-cycle achievement scores based on the passing grade (KKM). Out of a total of 38 students, 21 students (55.26%) scored at or above the passing grade, while 17 students (44.74%) scored below the passing grade. This indicates that slightly more than half of the students met the minimum competency requirement before the intervention. However, a significant portion of students still did not achieve the expected level of mastery, highlighting the need for instructional improvements in the subsequent learning cycles.

Cycle I

Instruction incorporated RME principles, although students were initially unfamiliar with collaborative group work. Test results showed improvement: 65.79% of students achieved the KKM, up from 55.26% pre-cycle.

During the learning process, two observers conducted continuous assessments and observations to evaluate the students' level of understanding. The observations were performed through direct monitoring using structured observation sheets, which allowed the observers to systematically record the behaviors and interactions of both the students and the lecturer throughout the learning activities employing Realistic Mathematics Education (RME). Additionally, the students completed a cycle test at the end of Cycle I, which served as a formal evaluation to measure their comprehension and mastery of the material covered.

The observations indicated that the implementation of RME in the mathematics class was generally successful. However, several challenges were noted. At the start of the first meeting, a considerable number of students arrived late, likely due to the early class starting at 7:30

AM. This affected the smooth flow of the initial session. During Cycle I, the lecturer organized the students into small groups to facilitate collaborative learning, a key component of RME. Despite this, it was observed that some groups tended to work individually rather than collaboratively, with members completing tasks independently without engaging in meaningful group discussions. This behavior appeared to stem from students' lack of experience and familiarity with cooperative learning methods, which suggests a need for further guidance and support to develop effective teamwork skills.

The results of the Cycle I test, which reflect the students' achievement after the RME-based instruction, are summarized in Table 2. These results provide important insight into the impact of RME on students' understanding and highlight areas that require further attention in subsequent cycles to enhance learning outcomes.

Table 2. Achievement Scores in Cycle I

Indicator	**Number of Students**	**Percentage (%)**
≥ KKM	25	65,79
< KKM	13	34,21
Total	**38**	**100**

Table 2 presents the distribution of students' achievement scores after the implementation of Realistic Mathematics Education (RME) in Cycle I. Out of 38 students, 25 students (65.79%) scored at or above the passing grade (KKM), showing an improvement compared to the pre-cycle results. Meanwhile, 13 students (34.21%) still scored below the passing grade. This increase in the percentage of students meeting the minimum competency indicates that the RME approach positively influenced students' understanding of the material. However, there remains a significant portion of students who have yet to reach the expected level of mastery, suggesting that further instructional refinement and support are necessary in the following cycles to enhance overall learning outcomes.

Cycle II

Adjustments included regrouping students and introducing a pretest to improve punctuality. The final assessment indicated further progress: 86.84% met the KKM, exceeding the success criterion. The average class score also increased by 3.44% from Cycle I to Cycle II. The actions carried out in Cycle II followed a similar approach to those in Cycle I, with the continued application of Realistic Mathematics Education (RME) in the teaching and learning process. However, improvements were made based on reflections and observations from the first cycle to address issues previously encountered. Notably, the lecturer restructured the student groups according to their performance in the Cycle I test to create more balanced and effective learning teams. Additionally, a pretest was introduced at the beginning of the session to motivate punctuality and better prepare students for the learning activities.

Observational data from Cycle II revealed significant positive changes. Unlike in the first cycle, no students arrived late, which can be attributed to clear communication from the lecturer regarding the pretest schedule. This punctuality ensured that the learning session started promptly without interruptions. When students were divided into newly formed groups, they adjusted quickly and cooperated well within their teams. During group discussions, students actively engaged with one another, sharing ideas and collaboratively solving problems, demonstrating improved group dynamics and communication skills compared to Cycle I.

After the learning activities, the lecturer administered the Cycle II final test to assess students' understanding and mastery of the material. The test results, summarized in Table 3, reflect the impact of the refined RME implementation in Cycle II. These outcomes provide valuable insights into the effectiveness of the instructional adjustments and highlight the progress students made because of the more structured and engaging learning environment.

Table 3. Achievement Scores in Cycle II

Indicator	**Number of Students**	**Percentage (%)**
≥ KKM	33	86,84
< KKM	5	13,16
Total	**38**	**100**

Table 3 clearly illustrates the positive impact of the instructional interventions implemented during Cycle II. The proportion of students scoring below the passing grade (KKM) decreased significantly from 34.21% in Cycle I to 13.16% in Cycle II, representing a substantial reduction of 21.05%. This decline indicates that fewer students struggled to meet the minimum competency standards following the refinements made to the learning process, particularly through the continued application of Realistic Mathematics Education (RME).

Conversely, the percentage of students achieving scores at or above the passing grade increased markedly by the same margin, rising from 65.79% in Cycle I to 86.84% in Cycle II. This improvement reflects a notable enhancement in student understanding and mastery of the material after the second cycle of teaching. The data suggests that the changes made, such as reorganizing groups based on prior performance and implementing a pretest to encourage punctuality and preparedness, were effective in fostering a more productive and collaborative learning environment.

Overall, these results demonstrate that the iterative process of reflection and adjustment in Cycle II significantly contributed to improving student learning outcomes. The substantial increase in students meeting or exceeding the expected competency level underscores the value of applying RME in mathematics instruction, alongside strategic modifications tailored to address challenges identified in earlier cycles.

Students' understanding of Geometry was measured through essay tests administered at the end of each cycle. Students who achieved scores at or above the passing grade (KKM) on the final test of a cycle were considered to have understood the material for that cycle. The improvement in students' scores on the Cycle I final test was determined by comparing their Cycle I scores with their scores before the intervention (pre-cycle). The following section presents the score improvements observed in Cycle I.

Table 4. Improvement in Scores from Pre-Cycle to Cycle I

Indicator	**Pre-Cycle**		**Cycle I**		**Difference (%)**
	Number of Students	Percentage (%)	Number of Students	Percentage (%)	
≥ KKM	21	55,26	25	65,79	10,53
< KKM	17	44,74	13	34,21	-10,53
Total	**38**	**100**	**38**	**100**	

Based on the data presented in Table 4, the percentage of students scoring below the passing grade (KKM) after Cycle I decreased to 34.21%. This represents a notable 10.53% reduction from the pre-cycle phase, where 44.74% of students were below the minimum competency level. This decline indicates that the instructional interventions implemented during Cycle I—specifically, the application of Realistic Mathematics Education (RME)—had a positive effect in helping more students reach the expected level of understanding.

On the other hand, the proportion of students achieving scores at or above the passing grade increased from 55.26% before the intervention to 65.79% after Cycle I, showing a 10.53% improvement. This increase reflects a significant improvement in students' academic performance and suggests that the RME-based teaching approach contributed to a better understanding of geometric concepts.

Further analysis of the Cycle I test scores reveals that individual student scores ranged from 35 to 100, with the class average reaching 81.09. This average represents a significant improvement compared to the pre-cycle average score, demonstrating overall progress in students' mastery of the material.

To quantify this improvement, the increase in the average score from the pre-cycle test to the Cycle I final test can be calculated using a standard formula for measuring gain in classroom action research. This quantitative analysis allows for a clear assessment of the effectiveness of the teaching intervention by providing a precise measure of student progress over the cycle.

$$P = \frac{Post\ Rate - Base\ Rate}{Base\ Rate} x100\%$$

$$P = \frac{81{,}09 - 73{,}62}{81{,}09} x100\% = 9{,}21\%$$

The class average score increased by 9.21% after the completion of Cycle I. Based on Table 5, the level of score improvement, which reflects the students' understanding, can be presented visually in the form of a diagram shown in Figure 1.

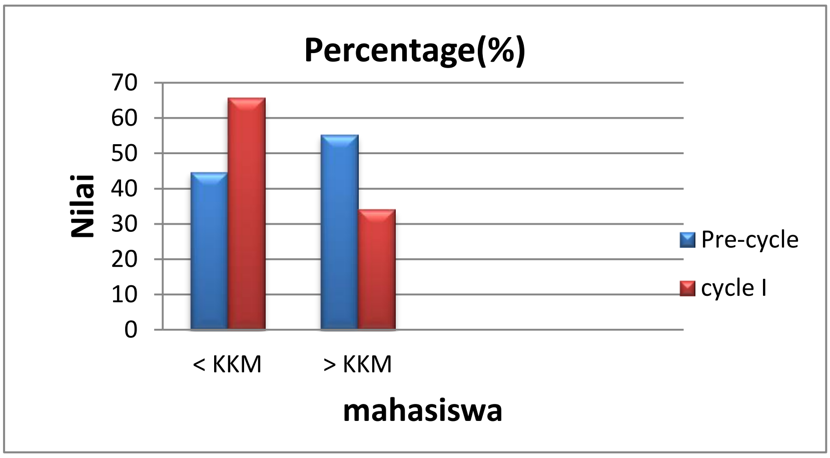

Figure 1: Diagram of Percentage Increase in Level of Understanding from Pre-Cycle to Cycle I

Based on the diagram in Figure 1, it is evident that the percentage of students scoring above the passing grade (KKM) increased in Cycle I. Specifically, 65.79% of the students who took the test achieved scores at or above the KKM. However, this level of mastery had not yet reached the predetermined target, which required at least 75% of students to score above the passing grade.

Following the completion of Cycle I, the intervention continued into Cycle II. Several shortcomings identified during Cycle I were addressed and improved based on reflective analysis. As a result, the issues encountered during the Cycle I learning process were effectively resolved during the actions taken in Cycle II. It is expected that the learning outcomes, particularly student understanding, will show further improvement in Cycle II compared to Cycle I.

Student understanding in Cycle II was also assessed through an essay test administered at the end of the cycle. The improvement in scores on the Cycle II final test was determined by comparing the results with those from Cycle I. The following section presents the score improvements observed in Cycle II.

Table 5. Improvement in Scores from Pre-Cycle to Cycle II

Indicator	**Cycle I**		**Cycle II**		**Difference (%)**
	Number of Students	Percentage (%)	Number of Students	Percentage (%)	
≥ KKM	25	65,79	33	86,84	21,05
< KKM	13	34,21	5	13,16	-21,05
Total	**38**	**100**	**38**	**100**	

Based on Table 5, it is noted that the percentage of students scoring below the passing grade (KKM) in Cycle II was 13.16%. This represents a decrease of 21.05% compared to Cycle I, where 34.21% of students scored below the passing grade. Conversely, the percentage of students scoring above the passing grade in Cycle II increased by 21.05%, reaching 86.84% after the Cycle II intervention.

The increase in the average score from the Cycle I final test to the Cycle II final test can be analyzed using the quantitative data formula commonly applied in classroom action research, which is:

$$P = \frac{Post\ Rate - Base\ Rate}{Base\ Rate} x100\%$$

$$P = \frac{83{,}98 - 81{,}09}{83{,}98} x100\% = 3{,}44\%$$

The class average score increased by 3.44% following the implementation of the intervention in Cycle II. Based on Tables 4 and 5, the progression in test scores reflecting the students' level of understanding during the pre-cycle, Cycle I, and Cycle II phases can be illustrated in the diagram shown in Figure 2

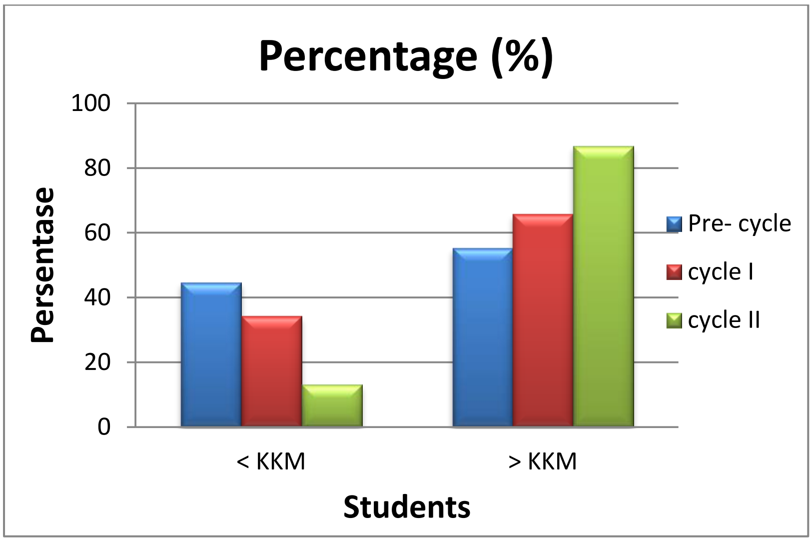

Figure 2: Diagram of Percentage Increase in Level of Understanding in Pre-Cycle, Cycle I, and Cycle II

Based on the diagram presented in Figure 2, a clear upward trend can be seen in the percentage of students achieving mastery-level scores across the pre-cycle, Cycle I, and Cycle II phases. Initially, during the pre-cycle phase, the proportion of students who met or exceeded the passing grade (KKM) was below the desired benchmark. After the first cycle of intervention, this figure improved to 65.79%, reflecting initial gains in student comprehension resulting from the application of Realistic Mathematics Education (RME) strategies.

More notably, after the second cycle of intervention, the percentage of students demonstrating sufficient understanding increased substantially by 21.05%, reaching 86.84%. This significant improvement not only indicates the effectiveness of the instructional modifications made between cycles, such as reorganizing student groups based on performance data and introducing pretests to enhance readiness but also surpasses the predetermined target of 75% mastery. Achieving this target reflects a successful enhancement in students' geometric understanding through the iterative cycle of teaching, reflection, and adjustment.

These findings are consistent with existing literature, which emphasizes that RME promotes deeper mathematical understanding by embedding learning within real-world contexts and fostering active student collaboration and discussion. For instance, studies by Suryana et al. (2023) and Prahmana et al. (2020) have shown that contextualized problem-solving tasks and peer interaction within RME frameworks contribute significantly to improving student engagement and conceptual grasp in mathematics. The current study's results further validate that such an approach, when carefully implemented and refined, can lead to meaningful and measurable improvements in students' academic performance and confidence in mathematical concepts.

CONCLUSION

The implementation of Realistic Mathematics Education (RME) in teaching Geometry significantly improved students' understanding and academic performance throughout two action research cycles. Initially, the pre-cycle assessment showed that only 55.26% of students achieved scores at or above the passing grade (KKM). After the first cycle of intervention, this percentage increased to 65.79%, reflecting initial positive effects of the RME approach on student learning.

Following reflective adjustments and improvements made after Cycle I, such as regrouping students based on their performance and introducing pretests to ensure punctuality and readiness, the results in Cycle II demonstrated further substantial gains. The percentage of students meeting the passing criteria rose to 86.84%, surpassing the targeted mastery level of 75%. This consistent upward trend in scores and mastery percentage indicates that RME, through its contextualized learning tasks and emphasis on peer collaboration, fosters deeper conceptual understanding and engagement in mathematics.

The average class scores also showed steady improvement, increasing by 9.21% after Cycle I and an additional 3.44% following Cycle II, which highlights the cumulative benefits of the iterative cycle of teaching, observing, reflecting, and refining instructional strategies. These findings align with previous research emphasizing the effectiveness of RME in promoting meaningful mathematical learning by situating problems within realistic contexts and encouraging student interaction.

In conclusion, the action research confirms that Realistic Mathematics Education is an effective pedagogical approach for enhancing undergraduate students' comprehension of Geometry. The structured, reflective cycles of intervention and adaptation were essential in addressing initial challenges and optimizing learning outcomes. This study supports the wider application of RME as a valuable teaching strategy in higher education mathematics courses to improve student achievement and understanding.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this article. The research was conducted independently without any financial, commercial, or personal relationships that could be construed as potential conflicts

REFERENCES

Allsopp D.H., Kyger, M.M., Lovin, L.A. (2007). Teaching Mathematics Meaningfully: A solution for reaching struggling learners. London: Paul. H. Brookes Publishing.

Azizi, Y., Noordin, Y., & Zurhanmi, Z. (2005). Psikologi Kognitif, Penerbit Universiti Teknologi Malaysia

Cobb, P., Zhao, Q., and Visnovska, J. (2008). Learning from and Adapting the Theory of Realistic Mathematics Education. Éducation et didactique 2(1)

Fauzan, A., Slettenhaar, D., Plomp, T. (2002). Traditional Mathematics Education vs. Realistic Mathematics Education, In P.Valero & O.Skovsmose. (Eds). Proceedings of the 3rd International Mathematics Education and Society Conference, Copenhagen: Centre for Research in Learning Mathematics, pp1-4.

Hadi, S., Plomp, T., & Suryanto. (2002). Introducing Realistic Mathematics Education to Junior High School Mathematics Teachers in Indonesia. 2nd International Conference on the Teaching of Mathematics, Greece.

Kwon, O. H. 2019. Conceptualizing the Realistic Mathematics Education Approach In The Teaching and Learning of Ordinary Differential Equations. Journal of.

Mulyasa, E. (2004). Implementasi Kurikulum 2004 Panduan Pembelajaran KBK. Bandung: PT

Remaja Rosdakarya

NCTM. (1989). Curriculum and Evaluation Standards for School Mathematics. Reston, VA: NCTM

Prahmana, R. C. I., Zulkardi, & Hartono, Y. (2020). The RME Approach and Its Impact on Mathematical Literacy. Journal of Physics: Conference Series, 1521(2), 022016.

Ruseffendi, E. T. (2006). Pengantar kepada Membantu Guru Mengembangkan Kompetensinya dalam Pengajaran Matematika untuk Meningkatkan CBSA. (Edisi Revisi). Bandung: Tarsito.

Suryana, D., Retnawati, H., & Hanif, M. (2023). The Effect of RME on Student Reasoning in Geometry. International Journal of Instruction, 16(1), 205–220

Van den Heuvel-Panhuizen, M., & Drijvers, P. (2014). Realistic Mathematics Education. In S. Lerman (Ed.), Encyclopedia of Mathematics Education (pp. 1-5). Dordrecht, Heidelberg, New York, London: Springer.

Zakaria, E. & Syamaun, M. (2017). The Effect of Realistic Mathematics Education Approach on Students' Achievement and Attitudes Towards Mathematics. Mathematics Education Trends and Research 2017. No.1 (2017) 32-40