

Enhancing Students' Conceptual Understanding in Mathematics through the Realistic Mathematics Education Model

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ABSTRACT (10 PT)

This study investigates the effect of the Realistic Mathematics Education (RME) model on students' conceptual understanding in mathematics within the framework of the *Merdeka Curriculum*. Despite curriculum reforms emphasizing student-centered learning, many classrooms remain teacher-centered, resulting in low levels of student engagement and poor conceptual understanding. This quasi-experimental study employed a one-group pretest-posttest design with a quantitative approach. The research involved students from class VIII.6 at MTsN 2 Pesisir Selatan, selected through purposive sampling. A total of four essay-type items were used in both pretest and posttest assessments, targeting three key indicators of conceptual understanding: restating concepts, applying problem-solving algorithms, and representing mathematical ideas in various forms. Data analysis involved normality and homogeneity tests, followed by a paired sample t-test to determine statistical significance. The results showed that students' posttest scores improved significantly compared to their pretest scores, with a t-value of 18.63 exceeding the critical value at a 5% significance level. Qualitative analysis further supported the quantitative findings, as students demonstrated notable improvement across all indicators. These results suggest that the RME model effectively enhances students' conceptual understanding by fostering contextual learning, active participation, and collaborative problem-solving. The study concludes that RME is a promising instructional model that aligns well with the goals of the *Merdeka Curriculum* and recommends its broader implementation in mathematics education to improve learning outcomes.

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INTRODUCTION

Curriculum serves as a guiding framework for educators in designing learning programs to help students prepare for real-life challenges in their environment (Ramadoni & Cesaria, 2023). The current educational framework implemented in Indonesia is the *Merdeka Curriculum*, which grants teachers the flexibility to develop quality learning experiences tailored to students' individual needs and contexts. This curriculum emphasizes the importance of learner development and achievement, placing expectations on teachers to create engaging and active learning environments, particularly in mathematics education (Riani, 2023).

Mathematics is a universally applicable discipline that significantly contributes to the development of logical thinking and technological advancement, especially in communication and information fields (Elwijaya et al., 2021). To foster active, creative, and independent learning in mathematics, teachers must employ appropriate strategies, approaches, and media that involve students cognitively, physically, and socially (Astuti, 2016).

As an abstract yet applicable subject, mathematics becomes meaningful when connected to real-life situations. Effective mathematics learning requires good communication between teachers and students to build students' confidence and conceptual understanding (Chairani, 2015). The goals of mathematics instruction include preparing students to adapt to dynamic real-world situations, applying mathematical reasoning in daily life, and supporting the learning of other disciplines (Rina, 2023). These objectives underscore that mathematics education should not focus solely on computation but also develop students' ability to solve complex problems across various domains.

A key aspect of mathematics learning is conceptual understanding, which encompasses the ability to explain, interpret, and apply mathematical ideas through meaningful representations and examples (Mawaddah & Maryanti, 2016; Panjaitan & Sinambela, 2023). Strong conceptual understanding enables students to enhance their procedural knowledge and perform better academically (Novitasari, 2016; Aledya, 2019).

However, preliminary observations at MTsN 2 Pesisir Selatan revealed that despite the adoption of the *Merdeka Curriculum*, mathematics instruction remains predominantly teacher-centered. Students are generally passive, struggle with solving word problems, and demonstrate limited conceptual understanding. Interviews with an eighth-grade mathematics teacher revealed that while instructional strategies aligned with the curriculum are in place, many students perceive mathematics as difficult and are unable to grasp problem contexts, resulting in low assessment scores below the school's minimum completeness criteria (KKTP = 78).

To address these challenges, the Realistic Mathematics Education (RME) approach presents a promising alternative. RME encourages students to connect their prior knowledge with real-world contexts, thereby fostering active participation and deeper conceptual understanding. This model also promotes group collaboration, critical thinking, and mathematical communication (Istiana, Satianingsih, & Yustitia, 2020). The core principles of RME—such as contextual learning, student-centered instruction, and guided reinvention—are designed to optimize conceptual development and improve learning outcomes.

The novelty of this study lies in its implementation of the RME model within the structure of the *Merdeka Curriculum* at the secondary education level, particularly in the context of MTsN 2 Pesisir Selatan, where teacher-centered practices still dominate. This research seeks to empirically investigate the effectiveness of RME in enhancing students' mathematical conceptual understanding in this specific educational setting.

METHOD

Research design

This study employed a quasi-experimental design with a quantitative approach. The specific design used was a pre-experimental one-group pretest-posttest design, in which a single class was given both a pretest and a posttest to measure the effect of the treatment. This design enables comparison of student performance before and after the intervention, allowing for the identification of changes attributable to the instructional model (Ima et al., 2024).

The research design is illustrated as follows:

Group	Pre-test	Treatment	Post-test
Experimental	O_1	X	O_2

O_1 : Pre-test administered before the treatment

X: Treatment using the Realistic Mathematics Education (RME) model

O_2 : Post-test administered after the treatment

This design allows researchers to assess the effectiveness of RME by comparing the pretest and posttest results within the same group of students.

Participants

The population of the study comprised all eighth-grade students at MTsN 2 Pesisir Selatan during the academic year 2023/2024. The sample was selected using purposive sampling, focusing on class VIII.6 (Phase D), which was considered representative in terms of instructional challenges and learning conditions relevant to the study. The selection was based on initial observation and consultation with the mathematics teacher, who identified this class as experiencing difficulties in conceptual understanding.

Instruments

The primary research instruments were pretest and posttest assessments designed to evaluate students' mathematical conceptual understanding. Each test consisted of four open-ended essay items, aligned with learning indicators focused on: Restating a concept, applying a concept or problem-solving algorithm, and representing a concept in various mathematical forms.

Instrument validity was established through expert judgment. Two validators—one university mathematics education lecturer and one school mathematics teacher—reviewed the test items for content, construct, and language. The validation scores are summarized in Table 1.

Table 1. Validation scores of instrument

Aspect Evaluated	Validator 1	Validator 2
Content	20	20
Construct	20	19
Language	8	6
Total Score	48	45
Average Score	4.00	3.75
Final Validation Score	3.88	

According to the validation criteria by Zulfaneti et al. (2016), a score between 3.40 and 4.00 indicates that the instrument is highly valid, confirming its appropriateness for use in this study.

Data Analysis

The data analysis in this study was conducted using both descriptive and inferential statistical techniques to evaluate the effectiveness of the Realistic Mathematics Education (RME) model on students' conceptual understanding. Initially, a normality test was performed using the Liliefors method to determine whether the distribution of students' scores on the pretest and posttest conformed to a normal distribution. This step was essential to justify the use of parametric statistical tests in subsequent analyses. Following the normality test, a homogeneity test using the F-test was applied to assess whether the data sets exhibited equal variances, which is another important assumption for the chosen inferential analysis. To examine the impact of the RME model, a paired sample t-test was employed to compare the mean scores between the pretest and posttest. This test was carried out at a significance level of 5% ($\alpha = 0.05$) to determine whether the observed differences were statistically significant. The combination of these analyses enabled the researchers to draw valid conclusions about the influence of RME on students' mathematical conceptual understanding.

RESULTS AND DISCUSSION

RESULT

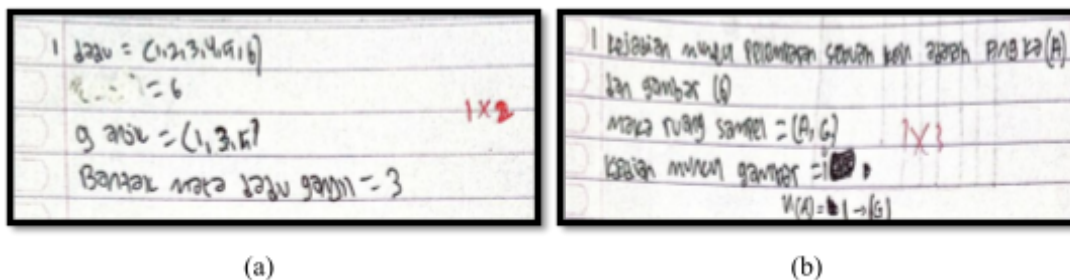
The study investigated the impact of the Realistic Mathematics Education (RME) model on students' mathematical conceptual understanding in class VIII.6 at MTsN 2 Pesisir Selatan. The intervention was implemented over three sessions, using tailored student worksheets (LKPD) based on different academic abilities. The learning process followed five stages of RME: understanding contextual problems, explaining the problems, solving them, comparing and discussing answers, and drawing conclusions.

To measure the effectiveness of the RME model, students were given a pretest before the intervention and a posttest afterward. Both tests consisted of four open-ended essay questions assessing three indicators of conceptual understanding: (1) restating a concept, (2) applying a concept or problem-solving algorithm, and (3) representing the concept in various mathematical forms.

Analysis of student responses revealed substantial improvement across the indicators. For the first indicator, restating a concept, students' pretest answers showed incomplete understanding. For example, when asked to identify the sample space from rolling a die, a student failed to list the correct outcomes, demonstrating a lack of clarity regarding the concept of probability (Figure 1a). However, in the posttest, the same student was able to construct the correct sample space for a coin toss and accurately identify the number of favorable outcomes (Figure 1b), indicating an enhanced conceptual grasp.

Figure 1 Sample of student's response on (a) Pre-test and (b) Post-test for indicator 1

For the second indicator, applying concepts or algorithms to problem-solving, the pretest response showed that a student failed to calculate the probability of selecting a green ball and only noted the known information from the problem without developing a solution (Figure 2a). In contrast, in the posttest, the



student correctly identified the number of favorable and total outcomes and successfully computed the desired probability (Figure 2b). For the third indicator, representing concepts, the pretest response partially demonstrated the ability to construct a table showing the outcomes of rolling two dice but left several cells incomplete and failed to calculate the probability of specific events (Figure 3). These deficiencies were no longer observed in the posttest, where students could present the full outcome set and determine probabilities accurately, reflecting improved representational understanding.

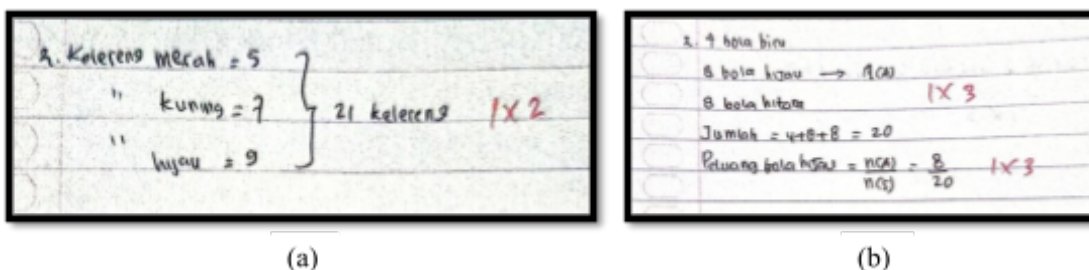


Figure 2 Sample of student's responses on (a) Pre-test and (b) Post-test for indicator 2

	1	2	3	4	5	6
1	1,1	1,2	1,3	1,4	1,5	1,6
2	2,1	2,2	2,3	2,4	2,5	2,6
3	3,1	3,2	3,3	3,4	3,5	3,6
4	4,1	4,2	4,3	4,4		
5	5,1	5,2				

2x2

Figure 3 Sample of student’s responses on pre-test for indicator 3

A normality test using the Liliefors method was conducted to determine the distribution of the pretest and posttest data. The results showed that the pretest scores had an L-value of 0.143 and the posttest scores had an L-value of 0.120, both of which were lower than the critical L-table value of 0.173. These results indicated that the data were normally distributed. A homogeneity test using the F-test was also conducted, yielding an F-value of 1.12, which was below the F-table value of 1.85, indicating that the data had homogeneous variance.

To determine whether there was a statistically significant difference between students’ pretest and posttest scores, a paired sample t-test was applied. The analysis resulted in a t-count value of 18.63, which exceeded the t-table value of 1.70 at a significance level of 5% ($\alpha = 0.05$). This finding confirmed that the difference between the pretest and posttest scores was statistically significant, demonstrating the effectiveness of the RME model in improving students’ conceptual understanding.

In addition to the quantitative results, qualitative analysis of student work also showed improvement across all three indicators. For the first indicator (restating a concept), students’ pretest answers revealed confusion, such as failing to identify the complete sample space when rolling a die. In contrast, posttest responses demonstrated improved understanding, with accurate identification of outcomes and event probabilities.

For the second indicator (applying a concept), pretest responses often lacked complete solutions or failed to apply the appropriate problem-solving algorithm. For example, many students did not compute the probability of selecting a green ball from a set. However, posttest results showed that students were able to apply the correct procedures and complete the calculations successfully.

For the third indicator (representing concepts), students’ pretest responses were incomplete or showed limited ability to present information in structured formats like tables. After the intervention, posttest responses demonstrated improved representation skills, such as constructing two-dice outcome tables and determining specific event probabilities accurately.

These results collectively indicate an overall improvement in students’ conceptual understanding of mathematics following the implementation of the RME model.

Discussion

The findings of this study indicate a significant improvement in students’ conceptual understanding of mathematics following the implementation of the Realistic Mathematics Education (RME) model. The increase in posttest scores, along with qualitative evidence from student work, confirms that the RME model effectively supports students in constructing meaningful mathematical understanding.

This improvement can be attributed to the core principles of the RME approach, which encourages students to actively engage with contextual problems, connect mathematical concepts to real-life situations, and collaboratively construct knowledge (Istiana, Satianingsih, & Yustitia, 2020). As observed in the classroom implementation, students were not only involved in solving problems but were also guided to reflect, discuss, and draw conclusions—activities that are aligned with the phases of guided reinvention and horizontal mathematization described in RME theory.

The results are consistent with previous studies that have highlighted the effectiveness of RME in promoting students’ mathematical literacy and conceptual comprehension. For example, Chairani (2015) emphasized the importance of meaningful learning through scaffolding and communication between teachers and students. Similarly, Elwijaya et al. (2021) noted that RME supports cognitive development by situating

learning within familiar and engaging contexts, allowing students to relate abstract mathematical ideas to real-world experiences.

The significant gain in students' ability to restate, apply, and represent mathematical concepts confirms that the RME model addresses key dimensions of conceptual understanding. As Mawaddah and Maryanti (2016) noted, conceptual understanding involves more than just knowing procedures; it encompasses the ability to explain, justify, and link mathematical ideas. The structured yet flexible nature of RME fosters this level of thinking by offering students opportunities to engage in explorative dialogue and group collaboration, particularly evident in this study's group-based learning activities.

Additionally, the use of differentiated LKPD (student worksheets) tailored to students' readiness levels appears to have supported equitable learning outcomes. This aligns with Panjaitan and Sinambela (2023), who emphasized that adapting instruction to students' varying cognitive abilities can significantly improve learning outcomes in mathematics. Moreover, the observation that high-ability students were more engaged from the beginning while lower-ability students gradually became more active suggests that the RME model supports inclusive engagement over time.

Despite the overall positive outcomes, initial implementation challenges were noted. These included students' confusion with LKPD instructions and group formation conflicts. Such challenges underscore the importance of effective classroom management and the teacher's role in scaffolding students' transition from passive to active learners. As Rina (2023) asserted, teachers play a critical role in guiding students to interpret contextual problems and encouraging participation through supportive feedback and structured problem-solving steps.

Furthermore, the success of the RME model in this context adds to the growing body of evidence supporting its application within the framework of the *Merdeka Curriculum*. Although the curriculum encourages student-centered and contextualized learning, its practical implementation often remains teacher-centered, as noted during preliminary observations in this study. This research demonstrates how the RME model can bridge the gap between curriculum goals and classroom realities, providing a model for effective implementation of *Merdeka* principles in mathematics education.

In summary, the results confirm that RME significantly enhances students' conceptual understanding by fostering active engagement, contextual learning, and collaborative problem-solving. These findings reinforce earlier studies (e.g., Novitasari, 2016; Aledya, 2019) and contribute new insights by demonstrating how RME can be effectively integrated into Indonesia's evolving educational landscape.

CONCLUSION

This study aimed to investigate the effect of the Realistic Mathematics Education (RME) model on students' conceptual understanding in mathematics. The findings demonstrate a significant improvement in students' ability to restate, apply, and represent mathematical concepts following the implementation of the RME model in class VIII.6 at MTSN 2 Pesisir Selatan. The statistical analysis confirmed a meaningful difference between pretest and posttest scores, supported by qualitative evidence showing enhanced student performance across multiple indicators of conceptual understanding.

The success of the RME approach in this study can be attributed to its emphasis on contextual learning, student-centered activities, and collaborative problem-solving, all of which contributed to a more engaging and meaningful mathematics learning experience. Additionally, the integration of differentiated student worksheets supported inclusive learning, enabling students with varying abilities to participate and progress.

These results highlight the potential of RME as an effective instructional model, particularly within the framework of the *Merdeka Curriculum*, where student autonomy and meaningful learning are emphasized. The study suggests that implementing RME can help shift classroom dynamics from teacher-centered instruction to a more interactive and reflective learning environment, ultimately improving students' conceptual understanding in mathematics.

Future research may consider extending this approach across different mathematical topics or educational levels to further explore its impact. Moreover, professional development for teachers in applying RME principles effectively will be essential to support wider adoption of this model in Indonesian classrooms.

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