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Reseacrh Article

The Effect of the Realistic Mathematics Education (RME) Learning Model Assisted by Stick Media on Understanding the Concept of Multiplication

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Abstract: This study is grounded in the need to enhance students' conceptual understanding of multiplication, which often remains procedural and lacks meaningful comprehension at the elementary level. The research aimed to examine the effect of the Realistic Mathematics Education (RME) model assisted by stick media on students' understanding of multiplication concepts. A quantitative approach with a quasi-experimental design was employed, involving 64 elementary school students divided into an experimental group and a control group. Data were collected using a validated post-test instrument measuring conceptual understanding. Data analysis techniques included descriptive statistics, Pearson correlation, and simple linear regression to determine the strength and significance of the relationship and predictive contribution of the independent variable. The findings indicate that students taught using the RME model assisted by stick media achieved higher post-test scores compared to those receiving conventional instruction. The regression analysis demonstrates a strong and significant positive effect of the RME model on conceptual understanding, with a substantial proportion of variance explained by the model. These results confirm that contextual learning integrated with concrete manipulatives enhances students' ability to construct mathematical meaning. The study contributes empirically to the development of mathematics learning strategies by demonstrating the effectiveness of combining RME principles with simple, low-cost media. Its added value lies in providing a practical and theoretically grounded instructional alternative that can be readily implemented to strengthen conceptual learning in elementary mathematics.

Keywords: realistic mathematic education, mathematic education, understanding concept, multiplication, contextual learning

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INTRODUCTION

Understanding the concept of multiplication constitutes an essential foundation in elementary mathematics education, as it underpins the mastery of more advanced operations such as division, fractions, and algebra (Doyan et al., 2021). Empirical evidence indicates that the teaching of multiplication remains largely dominated by procedural approaches and rote memorization of numerical facts. As a result, students are often able to perform calculations without comprehending the underlying conceptual structure (Rangkuti et al., 2024). An excessive emphasis on algorithms contributes to students' limited ability to represent multiplication as repeated addition, equal grouping, or area models. Weaknesses at this conceptual stage may lead to cumulative misconceptions that hinder the acquisition of mathematical knowledge at subsequent educational levels.

The Realistic Mathematics Education (RME) model offers a theoretical framework that positions mathematics as a human activity constructed through contextual experiences (Putri et al., 2025). The principles of using realistic problems, engaging in mathematization processes, developing models as bridges between context and formal symbols, and fostering social interaction through classroom discussion enable students to gradually construct mathematical meaning. The implementation of RME in teaching multiplication can be facilitated through situations closely related to students' daily lives, allowing concepts to be understood not merely as abstract symbols but as representations of real experiences. The integration of stick media as a concrete manipulative tool further strengthens this process by helping students directly visualize grouping and number structures (Matondang, 2026). This approach aligns with the cognitive developmental characteristics of elementary school students, who still require concrete representations to build abstract understanding.

Several previous studies have reported that RME contributes positively to improving mathematics learning outcomes and problem-solving skills (Meidianti et al., 2022). However, these studies generally emphasize achievement scores or overall performance, while the dimension of conceptual understanding as a deep cognitive construction has not been extensively explored, particularly in the context of multiplication operations (Monika & Ramadan, 2022). Research integrating the RME approach with simple manipulative media based on locally available materials also remains limited, especially in examining how the combination of realistic contexts and concrete tools can reinforce the construction of mathematical meaning. This gap indicates the need for a more in-depth investigation into the effectiveness of integrating RME and simple concrete media in fostering sustainable conceptual understanding (Nurjanah et al., 2025).

The urgency of this study lies in the importance of strengthening the conceptual foundations of mathematics from the elementary level to prevent the accumulation of misconceptions in later stages of learning. This research aims to enrich the literature on the implementation of RME in teaching basic arithmetic operations supported by accessible and economical concrete media. The findings are expected to provide practical implications for teachers in designing multiplication instruction that is more contextual, meaningful, and oriented toward the construction of conceptual understanding.

THEORETICAL FRAMEWORK

The theoretical framework of this study is grounded in two major foundations in educational psychology: cognitive constructivism developed by Jean Piaget and the theory of representation proposed by Jerome Bruner. Both provide epistemological and pedagogical bases for explaining how elementary school students construct an understanding of multiplication concepts gradually, meaningfully, and systematically (Anuntiata et al., 2024). From Piaget's constructivist perspective, knowledge is the result of individuals' active construction through interaction with their physical and social environments. This process operates through the mechanisms of assimilation and accommodation, which continuously move toward cognitive equilibrium (equilibration) (Arafah et al., 2022).

In classroom practice, these mechanisms become visible when students engage directly with concrete materials. For example, students are given 12 sticks and asked to arrange them into equal groups. Initially, many students interpret multiplication as repeated counting (e.g., counting each stick one by one). When they arrange the sticks into 3 groups of 4, they assimilate the new experience into their existing counting schema. However, when the teacher challenges them to represent 4 groups of 3 using the same 12 sticks and asks whether the total remains equal, students begin to reorganize their understanding. This moment of cognitive conflict encourages accommodation, as students realize that multiplication involves structural relationships between the number of groups and the number of elements in each group, rather than merely sequential counting (Thampinathan, 2022).

At the concrete operational stage, students are capable of logical reasoning but remain dependent on tangible objects. Therefore, multiplication cannot be introduced effectively as an abstract algorithm alone. Through manipulating sticks to form equal groups, rectangular arrays, or repeated addition models, students construct meaning from observable quantity relationships. When students physically rearrange 12 sticks into 3×4 and 4×3 configurations, they experience the commutative property concretely before encountering symbolic notation. Such activities activate prior numerical experiences (assimilation) while simultaneously restructuring conceptual schemas (accommodation), leading to more stable cognitive organization (Jendriadi et al., 2025).

The Realistic Mathematics Education (RME) approach strengthens this constructivist process by positioning contextual problems as the starting point of learning (Resti et al., 2025). For instance, the lesson may begin with a realistic scenario: "There are 4 baskets, and each basket contains 3 mangoes. How many mangoes are there in total?" Students are then provided with sticks to model the situation physically by forming four equal groups. This stage represents horizontal mathematization, where contextual situations are translated into informal mathematical representations. Through guided discussion, students compare different grouping strategies, reflect on similarities, and gradually formulate generalized relationships. Vertical mathematization occurs when they express the situation symbolically as $4 \times 3 = 12$ and relate it to repeated addition ($3 + 3 + 3 + 3$) (Fransisca et al., 2021). Social interaction during group work and class discussion accelerates cognitive restructuring, as students articulate reasoning, confront alternative representations, and refine their conceptual understanding.

Bruner's theory of representation further explains the systematic transition from concrete manipulation to abstract reasoning. Bruner identifies three complementary modes of representation: enactive, iconic, and symbolic (Hayun & Hutami, 2024). In multiplication learning, the enactive stage occurs when students physically manipulate sticks to construct equal groups. The iconic stage follows when students draw diagrams of grouped sticks, rectangular arrays, or area models to represent the same structure visually. Finally, the symbolic stage emerges when students express the relationship using multiplication notation and formal algorithms. For example, after constructing 3 groups of 5 sticks, students sketch three rows of five dots and then write 3 × 5 = 15. This representational progression ensures continuity between action, visualization, and abstraction, preventing premature symbolic instruction that may lead to procedural understanding without conceptual grounding.

The integration of Piaget's constructivism and Bruner's representational theory thus becomes operational within the RME framework. RME provides meaningful contexts and problem-based situations; stick media function as concrete epistemic tools; and guided discussion facilitates reflection and abstraction. Conceptual understanding in this study is therefore defined not merely as the ability to compute multiplication results, but as students' capacity to (1) model contextual situations using concrete objects, (2) translate these models into visual representations, (3) express them symbolically, and (4) explain the structural relationships between quantities consistently and logically (Hayati & Nuraina, 2025; Yuliana et al., 2022).

METHODS

Research Design

This study employed a quantitative approach using a quasi-experimental design of the post-test only control group type to examine the effect of the Realistic Mathematics Education (RME) model assisted by stick media on students' understanding of multiplication concepts. The sample was selected using cluster sampling from two intact classes at the same grade level in one elementary school, as random assignment at the individual level was not feasible. To reduce selection bias, prior mathematics achievement records were analyzed to ensure that both groups had comparable baseline academic abilities. Both classes were taught by the same teacher, used the same curriculum content, followed identical instructional time allocations, and were assessed using the same post-test instrument to control instructional variability. The experimental group received RME-based instruction supported by stick media emphasizing contextual problem solving and representational transitions, while the control group received conventional teacher-centered instruction focused on procedural explanations and routine exercises. These control procedures were implemented to strengthen internal validity while maintaining the natural classroom setting**.**

Table 1. Posttest-only control group design

Group	Treatment	Post-test
Experiment	X	O_1
Control	-	O_2

Sample

The research subjects consisted of 64 third-grade elementary school students, divided into two groups 32 students in the experimental group and 32 students in the control group. The sampling technique employed was cluster sampling based on naturally formed classroom groups within the school, thereby maintaining the existing class structure as the unit of analysis. All students were within the concrete operational stage of development and followed the same curriculum, resulting in relatively homogeneous academic characteristics. The number of participants in both groups was intentionally balanced to support the accuracy of comparative analysis and to minimize potential distribution bias.

Data Collection

Data were collected through a multiplication conceptual understanding test developed based on four indicator aspects: (1) the ability to restate a concept in one's own words; (2) the ability to represent the concept in concrete, visual, and symbolic forms; (3) the ability to select and apply appropriate procedures according to problem structure; and (4) the ability to apply concepts in contextual problem solving. The instrument consisted of open ended questions and representational tasks designed to capture students' reasoning processes rather than merely procedural accuracy. Content validity was established through expert judgment by two mathematics education specialists and one elementary education practitioner, who evaluated the alignment between items, indicators, and learning objectives. Construct validity was examined through item analysis to ensure that each question reflected the targeted dimensions of conceptual understanding. The reliability of the instrument was tested using internal consistency analysis, yielding a satisfactory reliability coefficient that indicated stable measurement. Scoring was conducted using an analytic rubric assessing conceptual accuracy, representational consistency, and logical coherence, thereby ensuring a comprehensive and accurate evaluation of students' conceptual construction.

Table 2. Scoring guidelines

Score	Understanding the Problem	Problem Solving Process	Answering the Question
0	No attempt to understand the problem	No attempt at solution	No answer, or an incorrect answer resulting from inappropriate solution procedures
1	Misinterpretation of the problem	The solution plan is inappropriate	Incorrect computation, no concluding statement, or incorrect labeling
2	Misinterpretation in most parts of the problem	Some procedures are correct, but errors are still present	Correct solution
3	Misinterpretation in a small part of the problem	Substantially correct procedures, but minor errors remain	
4	Complete and correct interpretation of the problem	Appropriate solution procedures without arithmetic errors	
	Maximal Score = 4	Maximal Score = 4	Maximal Score = 4

Data Analysis

Data analysis was conducted using both descriptive and inferential statistics. Descriptive statistics were employed to describe the learning outcome profiles of each group, including the mean, standard deviation, minimum and maximum scores, as well as score distribution. Correlation analysis was used to identify the strength of the relationship between the implementation of the instructional model and students' level of conceptual understanding. Regression analysis was applied to examine the magnitude of the contribution of the RME model assisted by stick media to the variance in students' understanding of multiplication concepts. Statistical testing was performed at a predetermined level of significance to ensure that the interpretation of the results was objective, measurable, and scientifically accountable.

RESULT

Descriptive statistical analysis was carried out to provide a comprehensive overview of the distribution of post-test scores on students' multiplication conceptual understanding after the implementation of the instructional treatments. Information concerning the number of participants, minimum and maximum scores, mean, and standard deviation is presented systematically to depict the quantitative characteristics and central tendencies of the data in both the experimental and control groups. This description functions as a preliminary foundation for identifying differences in conceptual understanding outcomes between students who received the Realistic Mathematics Education (RME) model assisted by stick media and those who experienced conventional instruction, prior to conducting further inferential analyses. A summary of the descriptive statistical findings is presented in Table 3.

Table 3. Descriptive statistics analysis

Group	N	Minimum	Maximum	Mean	Std. Deviation
Experiment	32	76.00	94.00	82.25	23.226
Control	32	58.00	76.00	67.21	22.822

The descriptive statistics table shows that the sample size in both the experimental and control classes consisted of 32 students each. The experimental class obtained a minimum score of 76.00 and a maximum score of 94.00, with a mean of 82.25 and a standard deviation of 23.226. The control class had a minimum score of 58.00 and a maximum score of 76.00, with a mean of 67.21 and a standard deviation of 22.822. The mean score of the experimental class was higher than that of the control class, with a difference of 15.04 points. The score range in the experimental class was positioned at a higher interval compared to the control class, indicating a tendency toward better learning outcomes in the experimental group. The standard deviation values in both groups were relatively large and nearly equivalent, suggesting a considerable variation in students' abilities within each class. These descriptive findings provide preliminary evidence that the implementation of the instructional model in the experimental class is associated with improved conceptual understanding compared to conventional instruction in the control class. These findings were further supported by regression analysis summarized in Table 4.

Table 4. Model summary of regression analysis

Model	R	R^2	Adjusted R^2	SD Error of the Estimate
1	.886	.785	.781	4.79830

The regression model summary indicates a very strong relationship, with an R value of 0.886 and a coefficient of determination of 0.785. This value suggests that 78.5% of the variance in students' understanding of multiplication concepts can be explained by the implementation of the Realistic Mathematics Education (RME) model assisted by stick media as the predictor variable. The Adjusted R^2 value of 0.781 demonstrates that, after controlling for sample size and model complexity, the proportion of explained variance remains in the high category, indicating that the model is stable and possesses strong explanatory power.

The standard error of the estimate of 4.79830 indicates a relatively small level of prediction error, suggesting that the model's estimation of conceptual understanding scores can be considered accurate. These findings confirm that the regression model provides a substantial contribution to explaining data variation before further analysis through the regression coefficient parameters. A detailed explanation of the direction of influence, the magnitude of the coefficients, and the significance level of each predictor variable is presented in Table 5.

Table 5. Coefficients[a] of regression analysis

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	87.219	.848		79.246	.000
	Realistic Mathematic Education	18.031	1.200	.886	15.031	.000

The regression coefficients table shows that the constant value is 87.219 with a standard error of 0.848. The t-value of 79.246 and a significance level of 0.000 indicate that the constant is statistically significant. This value represents the multiplication conceptual understanding score when the Realistic Mathematics Education (RME) model assisted by stick media does not change or remains at the baseline condition in the model. The Realistic Mathematics Education (RME) model assisted by stick media has an unstandardized coefficient (B) of 18.031 with a standard error of 1.200. This coefficient indicates that each one-unit increase in the implementation of the RME model is associated with an increase of 18.031 points in students' multiplication conceptual understanding scores. The standardized beta coefficient of 0.886 reflects a very strong effect. The t-value of 15.031 with a significance level of 0.000 (< 0.05) demonstrates that the effect is statistically significant. These results confirm that the implementation of the RME model assisted by stick media makes a positive and significant contribution to the improvement of students' understanding of multiplication concepts.

Table 6. Correlation analysis

		Post-test scores	Realistic Mathematic Education
Post-test scores	Pearson Correlation	1	.886
	Sig. (2-tailed)		.000
	N	64	64
Realistic Mathematic Education	Pearson Correlation	.886	1
	Sig. (2-tailed)	.000	
	N	64	64

The correlation table indicates that the relationship between the implementation of Realistic Mathematics Education (RME) assisted by stick media and the post-test scores of multiplication conceptual understanding has a Pearson correlation value of 0.886. This value falls within the category of a very strong and positive correlation, meaning that the more optimal the implementation of the RME model, the higher the post-test scores achieved by students. This positive relationship demonstrates a consistent increase in learning outcomes in line with the intensity or quality of the instructional model's implementation. The significance value (Sig. 2-tailed) of 0.000 (< 0.05) indicates that the correlation is statistically significant. The total sample size (N) of 64 students strengthens the validity of the findings, as the analysis was conducted on all research participants. These results suggest that there is a strong and meaningful relationship between the implementation of the RME model assisted by stick media and the improvement of students' understanding of multiplication concepts at the post-test stage.

DISCUSSION

The results indicate that the implementation of the Realistic Mathematics Education (RME) model assisted by stick media has a positive and statistically significant effect on students' understanding of multiplication concepts (Zakiyah et al., 2025). The higher mean post-test scores in the experimental group confirm that learning grounded in contextual problems and concrete manipulation is more effective than conventional procedural instruction. These findings are consistent with previous studies reporting that RME enhances conceptual understanding by situating mathematics within meaningful real-life contexts and promoting active student engagement (Dewantara, 2024; Pasaribu et al., 2022). This study contributes further empirical support by demonstrating that the addition of simple manipulative media, such as sticks, strengthens the enactive dimension of learning and produces measurable improvements in conceptual indicators, particularly in representational flexibility and contextual application. While earlier research has emphasized contextualization, the present findings highlight that the quality of students' physical interaction with learning materials significantly amplifies the mathematization process (Pathuddin & Nawawi, 2021; Putri et al., 2025).

The regression results, showing a strong coefficient of determination and a substantial standardized beta value, indicate that the instructional model is not merely associated with Improvement but serves as a dominant predictor of conceptual understanding outcomes.
The significant role of stick media can be explained through both cognitive and pedagogical mechanisms. Physically arranging sticks into equal groups enables students to visualize multiplicative structures, compare alternative configurations (e.g., 3 × 4 and 4 × 3), and observe invariant total quantities despite structural rearrangement. This activity supports schema reorganization, reduces abstraction gaps, and minimizes misconceptions particularly the tendency to interpret multiplication solely as linear repeated addition rather than as a relationship between two coordinated quantities. Compared to purely visual diagrams, tangible manipulation provides kinesthetic reinforcement that strengthens memory retention and conceptual coherence. From a practical standpoint, mathematics teachers can structure lessons in four stages: introducing contextual problems, facilitating hands-on group modeling with sticks, guiding reflective discussion across different representations, and formalizing symbolic notation. Teachers may also incorporate comparative tasks, such as asking students to construct two different stick models that produce the same product, to stimulate relational reasoning (Eka Sulistyawati et al., 2025).

These concrete strategies demonstrate that effective multiplication learning requires deliberate orchestration of context, manipulation, dialogue, and abstraction (Dwi Kurono & Cahyaningsih, 2021). Future research could investigate how moderating variables such as prior mathematical ability, metacognitive awareness, or collaborative interaction patterns influence the magnitude of the intervention's impact, thereby providing a more nuanced understanding of the mechanisms underlying conceptual change (Husna & Bentri, 2025).

CONCLUSION

This study demonstrates that the implementation of the Realistic Mathematics Education (RME) model assisted by stick media significantly improves elementary school students' understanding of multiplication concepts. Learning that begins with contextual problems and is supported by concrete manipulation enables students to construct structural meaning more effectively than conventional procedural instruction. The findings emphasize that mathematics teaching should prioritize hands-on modeling, guided discussion, and gradual transitions from concrete representations to symbolic notation. Practically, teachers are encouraged to incorporate simple manipulative tools such as sticks to model equal grouping, compare different multiplicative structures, and prompt students to explain relationships between quantities before introducing formal algorithms. These strategies support deeper conceptual comprehension rather than rote memorization of multiplication facts. Future research should investigate the long-term sustainability of these learning gains and explore the application of this approach to other mathematical topics while considering mediating variables such as prior knowledge and learning motivation.

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