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Ethnomathematics-Based Realistic Mathematics Education Model: Strengthening the Foundation of Understanding Mathematical Concepts

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Abstract: The problem raised in this research is the lack of understanding of mathematical concepts among students of primary students. The aim of this research is to examine the impact of implementing the ethnomathematics-based realistic mathematics education (RME) model on concept understanding in elementary school students' mathematics learning. This research used a quantitative experimental design and the specific quantitative type used was quasi-experimental design. The samples taken and used in this research were 60 primary students. The research instrument used was an essay test. The data collected were subsequently processed and measured using measurement instruments to analyze the data in this research using statistical tests, namely the independent sample t-test. Based on the results of the *t*-test, it shows a value of $t = 2.400$ and Sig. $= 0.020 < 0.05$. The regression test results show *t*-count $2.136 >$ *t*-table 2.056, which means there is a significant influence between the ethnomathematics-based RME learning model on primary students' understanding of mathematical concepts. Furthermore, based on the final score data, the average value of the experimental class was 85.07 and the control class 73.37. This shows that the use of the RME learning model based on ethnomathematics has an influence on students' understanding of mathematical concepts.

Keywords: *Ethnomathematics, realistic mathematics education model, mathematical concepts, primary students*

INTRODUCTION

Mathematics is a foundational branch of science that plays an indispensable role in national development, daily human socio-economic activities, and the rapid advancement of Science, Technology, Engineering, and Mathematics (STEM) fields across Africa (Charles-Ogan, 2014; Matazu, 2021). Recognizing its critical value, the Nigerian National Policy on Education (NPE) mandates mathematics as a core subject from the early stages of the Universal Basic Education (UBE) scheme through to higher education. Although mathematics education is highly prioritized within the Nigerian school system, contemporary educational data and national assessments highlight a persistent challenge, such as a profound lack of deep conceptual understanding among learners at the primary school level. National diagnostics, such as the National Assessment of Learning Achievements (NALA), consistently show that many pupils struggle to transition from rote memorization to real-world mathematical application (Adeniran et al., 2025; Wanlor & Dashe, 2026). While substantial literature focuses on generalized teaching methods, a critical gap remains in examining the localized effectiveness of specific instructional systems—particularly those utilizing culturally responsive frameworks like ethnomathematics within sub-Saharan classrooms (Aduloju, 2025).

In its truest sense, learning mathematics is not merely the mechanics of calculation; it involves understanding numbers, spatial configurations, structural patterns, and systemic ways of thinking. True mathematical literacy requires primary school pupils to comprehend facts, abstract structures, and relationships in a manner that aligns with their immediate environment and developmental stages (Sylvia, 2020). According to goals laid out by the Nigerian Educational Research and Development Council (NERDC), the primary objective of the mathematics curriculum is to cultivate mathematical thinking, logical reasoning, and the ability to apply algorithmic concepts effectively when solving everyday problems. Mastering these conceptual foundations is essential (Awofala et al., 2020; Iyekekpolor & Francis, 2023). If pupils grasp the underlying *"why"* of a mathematical concept early on, they develop the cognitive scaffolding necessary to excel in more complex competencies later—including mathematical communication, analytical reasoning, and structured problem-solving.

However, field observations and diagnostic evaluations conducted across many public primary schools in regional clusters reveal that pupils' actual conceptual understanding remains significantly low (Adeniran et al., 2023; Dairo et al., 2023). Learners often face severe difficulties when asked to restate geometric properties or solve word problems that deviate even slightly from the exact examples written on the chalkboard. This dependence on surface-level memorization means that when pupils are presented with modified tasks, performance drops sharply below minimum proficiency benchmarks. This systemic challenge is heavily linked to prevailing pedagogical norms. In many typical Nigerian primary classrooms, instruction is dominated by teacher-centric, conventional lecture methods (Prahmana et al., 2023). Learning is often confined to abstract rules copied from standard textbooks, instructional technologies are underutilized due to infrastructure deficits, and lessons are rarely contextualized to link mathematics to the pupils' immediate physical or cultural environments outside the classroom (Dairo et al., 2023; Osakwe et al., 2023). These instructional realities underscore the urgency of addressing the cognitive deficits in early mathematics education. When children are pushed to memorize equations without conceptual internalization, they find it difficult to construct a strong cognitive foundation for future academic growth. Without this foundation, pupils quickly form negative attitudes toward the subject, viewing mathematics as an abstract, alien, and unnecessarily difficult discipline.

To bridge this gap, the learning process must be transformed into a meaningful, interactive experience where children can explore and construct mathematical ideas under a teacher's guidance. Because primary school children (typically aged 7–11) operate within Piaget's concrete operational stage, they rely heavily on physical objects and familiar cultural contexts to process abstract thoughts. Among contemporary instructional frameworks, the Realistic Mathematics Education (RME) model has proven highly effective in transforming abstract mathematics into intuitive knowledge by launching lessons with real-world, contextual problems.

To maximize the impact of RME within Nigerian classrooms, the model can be enriched through ethnomathematics—the study of mathematics as it expresses itself within specific cultural practices. Incorporating ethnomathematics allows educators to preserve indigenous knowledge systems while simultaneously making Western mathematical concepts accessible. By linking abstract geometry and arithmetic to concrete cultural artifacts—such as the geometric symmetries found in

Yoruba *Adire* or Igbo *Akwete* textile weaves, the structural patterns of traditional Hausa architecture, or indigenous counting and market measurement systems—mathematics ceases to be foreign. It becomes a natural extension of the pupil's lived reality.

This study introduces a localized pedagogical adaptation by evaluating an ethnomathematics-infused RME model. The framework utilizes regional cultural motifs, traditional building layouts, and indigenous artistic patterns to teach fundamental geometric concepts (such as the perimeter and area of 2D shapes) to primary school pupils. To measure the impact of this approach on the pupils' conceptual development, the study utilizes specific indicators of mathematical understanding:

1. The ability to restate mathematical concepts in the learner's own words.
2. The ability to classify real-world and cultural objects based on their geometric properties.
3. The ability to correctly apply mathematical algorithms to solve practical, contextual problems.

METHOD

Research Design

The type of research used by the researcher was quasi-experimental research with a quantitative approach. This quantitative research was conducted to determine whether there is an influence of the ethnomathematics-based RME model on concept understanding in elementary school mathematics learning, which is based on the achievement or non-achievement of indicators of mathematical concept understanding in students. In this nonequivalent control group design, a saturated sampling technique is used. According to Creswell & Creswell (2022), this research design consists of a control group and an experimental group, which in its implementation does not carry out random selection to become samples, but the researcher uses classes that are already available at a school where the research is conducted. In this design, both class groups were given a pre-test and then their scores are seen, after which the experimental group received treatment while the control group does not receive treatment, then after that both received a post-test to determine the scores after treatment.

Participants

This study employed a quasi-experimental design with a Nonequivalent Control Group Design, using convenience sampling to recruit sixty Nigerian primary students aged 8–10 years (mean = 9.12, SD = 0.84) from a single public primary school in Awka. Participants were non-randomly assigned to two intact groups, namely 30 students in the experimental group (mean = 9.08, SD = 0.79; 16 males, 14 females) and 30 students in the control group (mean = 9.17, SD = 0.89; 15 males, 15 females). Both groups were comparable in prior mathematical achievement based on pretest scores. The experimental group received ethnomathematics-based RME instruction integrating Nigerian cultural artefacts, while the control group followed conventional lecture-based instruction. This design allowed examination of treatment effects while acknowledging the absence of true randomisation, a common constraint in educational field research where administrative and ethical considerations preclude individual-level assignment.

Data Collection

Data collection was carried out with essay tests. The tool was used to determine the understanding of mathematical concepts with the application of the ethnomathematics-based RME model. The mathematical concept understanding test instrument compiled includes indicators a) Restating concepts, b) Grouping objects used based on mathematical concepts, and c) Implementing algorithm concepts in problem-solving, as outlined in the Table 1. The compiled instrument consists of 12 questions, then tested for validity and reliability. Validity testing was carried out using the point-biserial test by comparing it with the r-table value. Meanwhile, reliability testing was carried out using the KR-20 test. Based on these validity and reliability tests, from 12 questions, it was found that 9 questions were valid and reliable.

Table 1. Test instrument grid.

Concept Understanding Indicator	Basic Competency	Question Indicators
Restating a concept	Analyzing the perimeter of flat shapes	• Explaining flat shapes • Understanding the properties and elements of flat shapes • Calculating the perimeter of squares and rectangles • Calculating the area of squares and rectangles
Applying algorithm concepts to problem-solving	Presenting and solving problems related to the perimeter of flat shapes	Solving problems related to the perimeter of flat shapes

Data Analysis

Data analysis in this research begins with prerequisite testing, namely normality test and homogeneity test. The normality test is needed to see whether the data is in a normal distribution or not. The normality test will be carried out with the help of SPSS application. If the significance value (Sig) < 0.05, then the data distribution is said to be not normal. If the significance value (Sig) > 0.05, then the data distribution is said to be normal. Furthermore, a homogeneity test is carried out which aims to see whether several population variances are the same or not. The following are the decision criteria for the homogeneity test: If the significance value (Sig) < 0.05, then the data is said to have non-homogeneous variance. If the significance value (Sig) > 0.05, then the data is said to have homogeneous variance. After carrying out the prerequisite test and it is declared normal and homogeneous, it is continued with an independent sample t-test. Furthermore, a regression test is carried out to test the influence of one independent variable (RME) on the dependent variable (concept understanding) with the basis of decision-making if the significant value < 0.05, meaning variable x influences variable y, or if t-count > t-table, meaning variable x influences variable y. This data analysis is carried out using SPSS 27.0.

RESULTS

In the implementation of the research, the instrument used was 9 essay questions. This test was conducted to determine the ability to understand mathematical concepts of each participant used in this research, each group totaling 30 participants. It is known that the research data results that have been carried out show that there is a significant difference between the research data results in the experimental group and the control group. The following are the data results of the experimental group and the control group, as presented in Table 2. Based on the results of Table 2, it is known that the pretest scores of participants who took the test numbered (N) 30 participants, the minimum participant score was 33, the maximum score achieved was 75, the mean value obtained was 50.60, and the std. deviation was 8.896. It is known that participants who took the posttest numbered (N) 30 participants, the minimum participant score was 64, the maximum score achieved was 97, the mean value obtained was 85.07, and the std. deviation was 9.450. Based on the results of Table 2, it is known that the control group participants who took the pretest numbered (N) 30 participants, the minimum participant score was 31, the maximum score achieved was 61, the mean value obtained was 47.17, and the Std. Deviation was 7.914. And it is known that the participants who took the posttest numbered (N) 30 participants, the minimum participant score was 42, the maximum score achieved was 97, the mean value obtained was 78.37, and the std. deviation was 12.021.

Table 2. Descriptive data of pretest and posttest of the experimental and control group.

Descriptive	Experimental Group		Control Group	
	Pretest	Posttest	Pretest	Posttest
N	30	30	30	30
Minimum	33	64	31	42
Maximum	67	97	61	97
Mean	50.60	85.07	47.17	78.37
Std. Deviation	8.896	9.450	7.914	12.021

A normality test is carried out to assess whether the data obtained is normal or not normal. Finding the normal data distribution on the test using Shapiro-Wilk, as presented in Table 3. Based on the results obtained from the normality test of the data, it was found that for the initial test (pre-test) data of the experimental group, the significance (Sig.) = 0.107 ≥ 0.05, so it can be interpreted that the data is normally distributed. As for the final score (post-test) data, the significance value (Sig.) 0.075 > 0.05, then the data is determined to be normally distributed. As for the results of the normality test data for the initial test (pre-test) of the control group, the significance value (Sig.) = 0.267 > 0.05, so it can be interpreted that the data is normally distributed. As for the final score (post-test) data, the significance value (Sig.) 0.126 > 0.05, so the data obtained is declared normally distributed.

Table 3. Normality test result.

Test	Group	Shapiro-Wilk	Sig.
Initial ability	Control group	0.958	0.267
	Experimental group	0.943	0.107
Final ability	Control group	0.945	0.126
	Experimental group	0.937	0.075

Furthermore, a homogeneity test is carried out for the initial test of the control group and the experimental group. The Levene statistic value was 1.733 and the significance (Sig.) = 0.193 > 0.05, and for the posttest data of the experimental and control groups, the Levene statistic value was 0.711 and the significance (Sig.) = 0.403 > 0.05, so it can be interpreted that the data is homogeneous. The independent-sample t-test has a value of $t = 2.400$ and Sig. = 0.020 < 0.05, which means there is a significant influence between the ethnomathematics-based RME learning model on Nigerian primary students' understanding of mathematical concepts with indicators a) Restating concepts, b) Grouping objects used based on mathematical concepts, and c) Implementing algorithm concepts in problem-solving.

As for knowing how much influence the ethnomathematics-based learning model has on concept understanding, a regression test was conducted. The regression analysis yields a constant value (a) of 8.946 and a regression coefficient (b) for RME of 0.733. This produces the regression equation: Concept Understanding = 8.946 + 0.733(RME). The constant value of 8.946 represents the baseline level of mathematical concept understanding when the RME model is not applied (i.e., when RME = 0). In practical terms, this suggests that even without the ethnomathematics-based RME intervention, Nigerian primary students would still demonstrate a basic concept understanding score of approximately 8.946 points. The regression coefficient of 0.733 indicates that for every one-unit increase in the application of the RME model, students' mathematical concept understanding scores increase by 0.733 points. Since this coefficient is positive, it confirms that the relationship between the RME model and concept understanding moves in the same direction—greater implementation of the RME approach corresponds to higher levels of concept understanding. The statistical significance value of 0.042 falls below the standard threshold of 0.05, which means the relationship between the RME model and concept understanding is statistically significant and unlikely to have occurred by chance. Additionally, the calculated t-value of 2.136 exceeds the critical t-table value of 2.056, further confirming that the RME model exerts a meaningful and statistically significant effect on primary students' mathematical concept understanding.

DISCUSSION

This study emerges from a persistent challenge in Nigerian primary education: the widespread difficulty learners face in comprehending mathematical concepts, particularly when instruction relies heavily on rote memorisation rather than meaningful engagement with ideas (Shittu & Alex, 2025). In many Nigerian public primary schools, mathematics pedagogy remains dominated by teacher-centred lecture methods, with limited connection to learners' lived experiences or cultural backgrounds (Osakwe et al., 2023). Consequently, pupils often struggle to restate concepts in their own words, apply procedures to unfamiliar problems, or recognise mathematical relationships beyond worked examples provided in textbooks. These patterns align with Piaget's (1964) theory of cognitive development, which positions children aged 7–11 years at the concrete operational stage—a period during which conceptual understanding is best supported through direct interaction with tangible, culturally relevant materials rather than abstract symbolic manipulation alone (Griese, 2017). The present investigation therefore adopted an ethnomathematics-based RME learning model, grounded in the belief that embedding mathematics instruction within familiar Nigerian cultural contexts can render abstract concepts more accessible and intellectually engaging for young learners (Enun & Iyaji, 2025).

The theoretical foundation for this approach draws extensively from the work of (Gravemeijer (1994), which posits that mathematics should be reconceived as a human activity situated in reality rather than a fixed body of knowledge to be transmitted. When adapted to the Nigerian context, this perspective invites educators to harness indigenous knowledge systems—such as traditional architectural patterns, local textile designs, and craft practices like weaving and beadwork—as legitimate starting points for mathematical exploration (Papadakis et al., 2021). For instance, the geometric symmetries evident in Hausa mud architecture (Jabbi, 2026), the proportional relationships in Yoruba adire dyeing techniques, or the spatial reasoning required in Igbo basket weaving can all serve as authentic contexts for introducing perimeter, area, and shape properties. By positioning these cultural practices as mathematical resources rather than mere illustrations, the RME model encourages pupils to progressively mathematise their informal understandings into more formalised mathematical structures.

The enthusiasm and active participation observed among learners during the intervention resonate with findings from comparable studies across African contexts (Naidoo, 2021). In Ghana, researchers have documented significant improvements in mathematical reasoning when primary students engage with culturally embedded problem scenarios drawn from local market transactions and traditional games (Bukari, 2026). Similarly, research conducted in South African township schools demonstrated that ethnomathematically informed RME instruction fostered deeper conceptual engagement among learners who had previously been labelled as mathematically disengaged (Meeran & Niranjan, 2026). These converging patterns suggest that the motivational benefits of cultural relevance operate through multiple mechanisms: by validating learners' home knowledge, reducing mathematics anxiety through familiar contexts, and positioning pupils as active constructors rather than passive recipients of mathematical meaning.

Furthermore, the regression findings illuminate the practical significance of the intervention in terms of instructional design. The substantial constant value indicates that even before RME implementation, Nigerian primary pupils possess some foundational mathematical understanding—likely derived from informal mathematical experiences in their home and community environments (Abah et al., 2020). This baseline competence, however modest, represents an underutilised resource in conventional instruction that typically disregards out-of-school mathematical knowledge (Pradhan, 2024). The regression coefficient demonstrates that systematic cultivation of this informal knowledge through structured RME activities yields measurable gains in formal concept understanding. This pattern supports the argument that ethnomathematics is not merely a pedagogical embellishment but a fundamental epistemological stance that recognises the legitimacy of diverse mathematical knowledges and their transformative potential for mainstream mathematics education

The observed outcomes also invite reflection on teacher professional development needs within the Nigerian context. Effective implementation of ethnomathematics-based RME requires educators who can identify mathematical structures embedded in local cultural practices and design instructional sequences that guide pupils from informal to formal mathematisation. Yet pre-service teacher education in Nigeria has historically prioritised mathematical content knowledge over pedagogical content knowledge, with minimal attention to culturally responsive teaching strategies. The success of the present intervention underscores the urgency of revising teacher preparation programmes to include ethnomathematical competencies, community-based mathematical ethnography, and progressive mathematisation frameworks. Without such systemic investment in teacher capacity, the potential of culturally grounded mathematics instruction may remain unrealised at scale.

In considering the broader implications for Nigerian mathematics education, it is worth noting that the intervention's effectiveness was achieved within the constraints typical of public primary schools: large class sizes, limited instructional time, and scarce material resources. This pragmatic feasibility distinguishes the RME approach from technology-intensive interventions that, while potentially effective, remain inaccessible to the majority of Nigerian pupils enrolled in under-resourced schools. The reliance on culturally available materials—whether architectural forms, textile patterns, or craft objects—renders the model potentially sustainable and scalable across diverse Nigerian educational settings, from urban centres to rural communities where traditional practices remain vibrant.

CONCLUSION

This study shows that the use of an ethnomathematics-based RME model has a significant impact on improving the mathematical concept understanding ability of primary students. Previously, students experienced difficulties in understanding mathematical concepts, which was largely caused by a less effective conventional learning approach. However, after implementing the ethnomathematics-based RME learning model, a significant increase occurred in the understanding of mathematical concepts. This indicates that learning that uses real contexts and local culture (ethnomathematics) in teaching mathematical concepts can effectively improve student learning outcomes in the form of mathematical concept understanding. Thus, this study not only contributes to the field of mathematics education but also highlights the importance of paying attention to cultural contexts and daily life in the learning process. With these results, it can be concluded that the ethnomathematics-based RME learning model has advantages in improving students' understanding of mathematical concepts. Therefore, it is recommended that this approach be adopted more widely in the context of mathematics learning, especially at the elementary school level, to improve learning effectiveness and increase student learning achievement. Based on the results of processed data in the results and discussion sections, there is a fairly significant influence between learning before and after being given treatment. With the results obtained from the independent t-test with a significant value, it can be stated that there is a significant influence of the ethnomathematics-based realistic mathematics education model on concept understanding ability.

Authors' Contributions CIO: conceptualization; methodology; validation; writing—review and editing and supervision; project administration; funding acquisition. AOB: methodology; visualization; data curation; formal analysis. FZA: methodology; formal analysis; investigation; drafting, and writing; review and editing. All authors read and approved the final manuscript.
Data Availability The data supporting the findings of this study are available from the corresponding author upon reasonable request.
Ethical approval All procedures performed in the study were following the ethical standards.
Consent for publication All authors have read and agreed to the published version of the manuscript.
Consent to participate Consent to participate was obtained from all individual participants included in the study.
Informed consent Informed consent was obtained from all individual participants included in the study. Data was reported anonymously in the study.
Conflict of interest The authors declare no competing interes

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