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The Effectiveness of Banten Culture-Based Ethnomathematics Teaching Materials for Learning the Pythagorean Theorem

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ABSTRACT

Mathematics learning requires instructional approaches that enable students to understand abstract concepts through meaningful experiences. Ethnomathematics offers opportunities to connect mathematical ideas with cultural contexts; however, previous studies have largely focused on identifying mathematical concepts in cultural objects, while empirical evidence on the effectiveness of culture-based instructional materials remains limited. This study aimed to examine the effectiveness of Banten culture-based ethnomathematics video instructional materials in learning the Pythagorean Theorem. This study employed a posttest-only quasi-experimental design involving 60 eighth-grade students from a junior high school in Banten, Indonesia. The participants were divided into an experimental group ($n = 30$) and a control group ($n = 30$), with initial equivalence examined using Mid-Semester Test scores. Data were collected through a validated essay test and analysed using descriptive statistics, assumption tests, and an independent samples t-test. The experimental group achieved a higher mean posttest score (66.98) than the control group (46.11). The difference was statistically significant, $t(58) = 3.678, p < .001$, with a large effect size (Cohen's d = 0.95). The findings indicate that the developed instructional materials significantly improved students' learning outcomes compared with conventional textbook-based instruction. However, the study was limited to one school and a relatively small sample. Future studies should involve broader contexts and additional learning variables.

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1. INTRODUCTION

Mathematics is a fundamental field of knowledge in education that plays an important role in developing students' logical, critical, systematic, and creative thinking skills [1]. In addition to serving as a foundation for the development of science and technology, mathematics also helps students analyse problems, make decisions, and apply learned concepts in various real-life situations [2], [3]. Therefore, mathematics learning should not only focus on mastering procedures and formulas but also provide meaningful learning experiences that enable students to develop a deeper understanding of mathematical concepts. Meaningful mathematics learning requires learning materials and instructional approaches that connect abstract mathematical concepts to real-life contexts close to students' experiences [4], [5], [6], [7].

In practice, mathematics learning still faces various challenges, particularly students' difficulties in understanding and applying mathematical concepts. International assessment results indicate that Indonesian students' mathematical abilities continue to face challenges, particularly in conceptual understanding, reasoning, and problem-solving skills. Based on the results of the Programme for International Student Assessment (PISA) 2022, Indonesian students achieved an average mathematics score of 366, indicating that mathematics competency remains an area requiring improvement [8]. These challenges are also identified in local contexts. A preliminary needs analysis was conducted involving 100 ninth-grade junior high school students and 5 mathematics teachers from five schools in Serang City, namely SMP Negeri 2 Kota Serang, SMP Negeri 3 Kota Serang, SMP Negeri 7 Kota Serang, SMP IT Al Izzah Serang, and SMP Negeri 5 Kota Serang. Data were collected through student needs questionnaires and interviews with teachers and students. The needs analysis involved ninth-grade students because the Pythagorean Theorem had been studied in eighth grade. The results showed that 84% of students perceived mathematics as a difficult subject, while 45.4% identified the Pythagorean Theorem as one of the mathematical topics that was difficult to understand. These difficulties were related to students' ability to understand right triangles, determine relationships among triangle sides, apply the Pythagorean formula, and solve mathematical problems involving the concept [9], [10], [11], [12].

Students' difficulties in understanding the Pythagorean Theorem are related not only to the topic's abstract nature but also to the learning resources used during instruction. Teaching materials play an important role in supporting students' conceptual understanding systematically and facilitating effective learning processes [13], [14]. Based on the preliminary needs analysis, 87.1% of students stated that textbooks were still the main learning resources used in schools. Furthermore, 52.9% of students stated that the existing teaching materials did not explain the material in sufficient detail to support their understanding of difficult topics, while 55.1% stated that the teaching materials did not provide examples of mathematical problems in everyday contexts. These findings indicate that existing teaching materials still have limitations in presenting mathematical concepts in context and connecting mathematical ideas to students' experiences. Therefore, teaching materials are needed that can present mathematical concepts in a meaningful, systematic, and contextually relevant manner [15], [16].

One approach that can support contextual mathematics learning is ethnomathematics. Ethnomathematics views mathematics as knowledge that is not only developed within academic settings but also exists in cultural activities, social practices, and various cultural artefacts used by communities [17], [18]. Through this approach, students can understand mathematical concepts by connecting them with their own experiences and cultural backgrounds, thereby creating more meaningful learning experiences [19]. Previous studies have demonstrated that ethnomathematics-based learning has the potential to support mathematics education. Research findings indicate that integrating cultural contexts into mathematics learning can enhance conceptual understanding, motivation to learn, student engagement, and students' ability to connect mathematical concepts to real-life situations [20], [21], [22], [23]. However, most previous studies have focused on implementing ethnomathematics approaches or exploring cultural elements that contain mathematical concepts, while the development of ethnomathematics-based teaching materials and the empirical evaluation of their effectiveness remain relatively limited.

In the context of local culture, several studies have explored the relationship between Banten culture and mathematical concepts. Previous studies have identified mathematical concepts embedded in various elements of Banten culture, such as Banten batik motifs and other cultural artefacts [24], [25]. Furthermore, research exploring the Pythagorean Theorem within Banten cultural contexts has demonstrated that local cultural elements have potential as contexts for mathematics learning [26]. Nevertheless, these studies have primarily focused on identifying mathematical concepts within cultural contexts. Research on developing Banten culture-based ethnomathematics teaching materials and empirically examining their effectiveness in formal classroom learning remains limited. Therefore, further studies are needed not only to explore mathematical ideas within local culture but also to develop learning resources that can be implemented directly in mathematics classrooms and evaluated for effectiveness.

Based on the previous discussion, this study offers novelty by developing and testing the effectiveness of Banten culture-based ethnomathematics teaching materials specifically designed to teach the Pythagorean Theorem. Unlike previous studies that mainly focused on cultural exploration or the implementation of ethnomathematics approaches, this study develops an instructional product that integrates Banten cultural contexts into mathematics learning and provides empirical evidence regarding its effectiveness through a quasi-experimental approach. In this study, teaching materials refer specifically to video-based instructional materials developed using an ethnomathematics approach. The use of video-based instructional materials is expected to provide a more contextual and meaningful learning experience by presenting mathematical concepts through visual representations and cultural contexts familiar to students.

This study aims to analyse the effectiveness of Banten Culture-Based Ethnomathematics Teaching Materials in learning the Pythagorean Theorem among eighth-grade junior high school students. The research question addressed in this study is: Do students who learn using Banten culture-based ethnomathematics teaching materials achieve better learning outcomes in the Pythagorean Theorem compared with students who learn using conventional teaching materials?

This study contributes to mathematics education by providing empirical evidence regarding the effectiveness of culturally contextualised instructional materials in mathematics learning. In practice, the findings of this study can serve as an alternative resource for mathematics teachers seeking to integrate local culture into classroom instruction, creating more contextual and meaningful learning experiences.

2. METHOD

2.1 Research Design

This study employed a Research and Development (R&D) approach combined with a quasi-experimental method to develop and examine the effectiveness of Banten culture-based ethnomathematics video instructional materials for learning the Pythagorean Theorem. The R&D approach was used to produce instructional materials through a systematic development process, while the quasi-experimental method was applied to evaluate the effectiveness of the developed product [27], [28].

The development process followed the ADDIE model, which consists of five stages: *analysis, design, development, implementation,* and *evaluation* [29], [30], [31]. After the product was developed and validated by experts, the effectiveness of the instructional materials was examined using a nonequivalent posttest-only control group design [32], [33].

This design was selected because the study involved pre-existing classroom groups, making individual random assignment impossible. Therefore, participant selection and assignment were conducted at the class level rather than at the individual student level [34], [35], [36]. The experimental group received mathematics instruction using Banten culture-based ethnomathematics video instructional materials, whereas the control group received conventional mathematics instruction using the learning resources commonly used at the school. A specific pretest on the Pythagorean Theorem was not administered because the topic had not been taught to students before the intervention. To ensure initial equivalence between groups, the researchers used students' Mid-Semester Test (MST) scores as an indicator of initial academic ability. The equivalence between groups was examined through normality, homogeneity, and mean comparison tests.

2.2 Development of Banten Culture-Based Ethnomathematics Video Instructional Materials

The developed product was a video-based instructional material that integrated Banten cultural contexts with ethnomathematical concepts for learning the Pythagorean Theorem. In this study, the term *teaching materials* specifically refers to video-based instructional materials developed using an ethnomathematics approach.

The development process followed the ADDIE model [29]. In the analysis stage, a needs analysis was conducted to identify students' learning difficulties, teachers' needs, and the need to develop more contextual mathematics learning materials. The needs analysis was conducted in five schools in Serang City, namely SMP Negeri 2 Kota Serang, SMP Negeri 3 Kota Serang, SMP Negeri 7 Kota Serang, SMP IT Al Izzah Serang, and SMP Negeri 5 Kota Serang. The analysis involved 100 students and five mathematics teachers.

The design stage involved selecting content on the Pythagorean Theorem, identifying relevant Banten cultural elements, developing learning scenarios, and designing the instructional video's structure. The video presented the Pythagorean Theorem through Banten cultural contexts, using local cultural objects as examples to help students understand the relationship between mathematical concepts and their cultural environment.

The development stage involved video production, expert validation, and product revision. The validation process involved eight experts: four material experts and four media experts. The material experts were mathematics education lecturers from different universities, while the media experts were lecturers with expertise in instructional media.

The validation assessed several aspects, including content quality, material presentation, language clarity, visual design, usability, and accessibility. Revisions were made to improve the accuracy of the mathematical content, the organisation of the material presentation, the language clarity, and the visual components of the instructional video, based on expert recommendations. The validation scores were calculated from expert ratings and interpreted against predetermined feasibility criteria.

2.3 Research Location, Participants, and Sampling Technique

The study was conducted at SMP Negeri 5 Kota Serang, Banten Province, Indonesia, during the implementation phase of the developed instructional materials.

The participants involved in the effectiveness testing were eighth-grade students at SMP Negeri 5 Kota Serang. The research sample consisted of 60 students, divided into an experimental group of 30 and a control group of 30.

The sample selection employed cluster random sampling, in which participants were selected based on existing classroom groups rather than individual students [34]. Two classes with relatively similar initial academic abilities, as indicated by Mid-Semester Test (MST) scores, were assigned to the experimental and control groups.

2.4 Research Procedure and Treatment

The learning treatment was conducted over four instructional meetings on the Pythagorean Theorem.

In the experimental group, students learned using Banten culture-based ethnomathematics video instructional materials as the primary learning resource. The teacher facilitated learning activities by guiding students to observe cultural contexts presented in the video, identify mathematical concepts, understand the Pythagorean Theorem, solve contextual problems, and evaluate their understanding.

The instructional video served as an interactive learning resource that connected abstract mathematical concepts to local cultural contexts. This approach allowed students to relate mathematical knowledge to familiar cultural objects and real-life situations.

In the control group, students received conventional mathematics instruction using the school's standard textbook. The learning activities consisted of teacher explanations, presentation of mathematical procedures, examples of problem-solving processes, classroom discussions, and exercises without the use of the developed video instructional materials.

2.5 Data Sources and Research Instruments

The research data consisted of product development data and effectiveness data. Product development data were obtained from needs-analysis activities, expert validation sheets, and product-revision records. Effectiveness data were obtained from students' learning achievement scores after the instructional treatment.

The effectiveness instrument consisted of five essay questions on the Pythagorean Theorem. Each item was developed based on learning indicators, including understanding the concept of the Pythagorean Theorem, determining the relationship between sides of right triangles, applying the Pythagorean formula, and solving contextual problems. Students' responses were assessed using a scoring rubric that considered conceptual accuracy, mathematical procedures, calculation processes, and correctness of the final answer.

Before being used in the effectiveness test, the instrument was validated by two mathematics education experts to establish content validity. The validation focused on the suitability of items with learning indicators, the appropriateness of cognitive levels, clarity of instructions, language quality, and the avoidance of ambiguous interpretations.

2.6 Variables and Data Analysis Technique

The independent variable in this study was the use of Banten culture-based ethnomathematics video instructional materials, while the dependent variable was students' learning achievement in the Pythagorean Theorem, measured by posttest scores.

The collected data were analysed using descriptive and inferential statistics. Descriptive statistics were used to describe students' learning achievement in the experimental and control groups. Before hypothesis testing, normality and homogeneity tests were conducted to ensure that the data met the assumptions for parametric analysis [37].

The effectiveness of the developed instructional materials was analyzed using an independent-samples t-test to determine whether there was a significant difference in learning achievement between the experimental and control groups [38].

The hypotheses were formulated as follows:

$H_0: \mu_E \leq \mu_C$

$H_1: \mu_E > \mu_C$

where:

μ_E: mean learning achievement score of the experimental group.

μ_C: mean learning achievement score of the control group.

2.7 Ethical Consideration

This study was conducted after obtaining permission from the participating school. Students participated in the research activities in accordance with school procedures. Students' identities were kept confidential, and all collected data were used solely for academic research purposes.

3. RESULTS AND DISCUSSION

3.1. Results

3.1.1 Expert Validation Results of the Developed Instructional Materials

Before the effectiveness testing, the developed Banten culture-based ethnomathematics video instructional materials were evaluated by material and media experts to determine their feasibility for classroom implementation.

The validation process involved eight experts: four material experts and four media experts. The material experts were mathematics education lecturers from different universities, while the media experts were lecturers with expertise in instructional media.

The validation assessed several aspects, including content quality, material presentation, language clarity, visual design, usability, and accessibility of the instructional materials.

The validation results indicated that the developed instructional materials met the feasibility criteria for implementation. The material expert validation obtained an average score of 92.5%, categorised as very valid, while the media expert validation obtained an average score of 88.9%, categorised as very valid. Based on these results, the instructional materials were deemed feasible and subsequently implemented during the effectiveness testing stage.

Table 1. Expert Validation Results of the Developed Instructional Materials

Validator	Percentage Score	Category
Material Experts	92.5%	Very Valid
Media Experts	88.9%	Very Valid

3.1.2 Descriptive Statistics of Students' Learning Achievement

The effectiveness testing involved 60 eighth-grade students, divided into two groups. The experimental group consisted of 30 students who received mathematics instruction using Banten culture-based ethnomathematics video instructional materials, while the control group consisted of 30 students who received conventional mathematics instruction using the learning resources commonly applied at the school.

The descriptive statistics of students' posttest scores are presented in Table 2. The results showed that the experimental group had a higher mean score than the control group.

The experimental group achieved a mean posttest score of 66.98 (SD = 21.40), whereas the control group obtained a mean score of 46.11 (SD = 22.53). The mean difference between the two groups was 20.86 points.

Based on the minimum mastery criterion (MMC) established by the school (60 points), the mean score of the experimental group exceeded the mastery standard, while the mean score of the control group remained below the criterion.

Table 2. Descriptive Statistics of Students' Posttest Scores

Group	n	Mean	SD	Minimum	Maximum	SE	95% CI
Experimental Group	30	66.98	21.40	18.52	98.15	3.91	58.99–74.96
Control Group	30	46.11	22.53	7.41	79.63	4.11	37.70–54.52

3.1.3 Assumption Test Results

Before hypothesis testing, prerequisite analyses were conducted to determine whether the data fulfilled the assumptions required for parametric analysis. The assumption tests included normality and homogeneity tests.

The Shapiro-Wilk normality test indicated that the posttest scores in both groups were normally distributed. The experimental group obtained a significance value of 0.144, while the control group obtained a significance value of 0.100. Both values were greater than 0.05, indicating that the data met the normality assumption.

Furthermore, Levene's Test yielded a p-value of 0.617, indicating that the variances of the experimental and control groups were homogeneous.

Therefore, the data met the assumptions required for an independent-samples t-test.

Table 3. Normality and Homogeneity Test Results

Test	Group	$p-value$	Interpretation
Shapiro-Wilk Test	Experimental Group	0.144	Normally distributed
Shapiro-Wilk Test	Control Group	0.100	Normally distributed
Levene's Test	Experimental and Control Groups	0.617	Homogeneous variance

3.1.4 Hypothesis Testing and Effect Size Analysis

An independent samples t-test was conducted to examine whether there was a statistically significant difference in students' learning achievement between the experimental and control groups.

The results showed a statistically significant difference between the two groups, $t(58) = 3.678$, $p < 0.001$. The mean difference between the experimental and control groups was 20.86 points.

Therefore, the null hypothesis (H_0) was rejected, indicating that students who learned using Banten culture-based ethnomathematics video instructional materials achieved significantly different learning outcomes compared with students who received conventional instruction.

Table 4. Independent Samples $t-Test$ Results

Comparison	Mean Difference	t	df	$p-value$
Experimental vs Control	20.86	3.678	58	< 0.001

In addition to statistical significance, Cohen's d was calculated to determine the practical magnitude of the difference between the experimental and control groups [39].

The analysis yielded a Cohen's d of 0.95, indicating a large effect size. This finding suggests that the difference between the two groups was not only statistically significant but also practically meaningful in the context of mathematics learning.

Table 5. Effect Size Analysis

Comparison	Mean Difference	Cohen's d	Interpretation
Experimental vs Control	20.86	0.95	Large Effect

3.1.5 Summary of Key Findings

Overall, the findings indicate that the developed Banten culture-based ethnomathematics video instructional materials met the feasibility criteria as determined by expert validation. In the effectiveness testing stage, students who learned using the developed instructional materials achieved higher posttest scores than students who received conventional instruction.

The difference between the two groups was statistically significant and supported by a large effect size. These findings indicate a significant difference in learning achievement between students who used the developed instructional materials and those who received conventional instruction.

3.2. Discussion

3.2.1 Main Findings and Interpretation

This study investigated the effectiveness of Banten culture-based ethnomathematics video instructional materials in learning the Pythagorean Theorem. The findings demonstrated that students who learned with the developed instructional materials achieved significantly higher learning outcomes than those who received conventional instruction. The statistical analysis showed a significant difference between the two groups, supported by a large effect size.

These findings indicate that integrating local cultural contexts into mathematics instruction can provide students with more meaningful learning experiences. Instead of introducing the Pythagorean Theorem solely through abstract formulas and procedural exercises, the developed instructional materials connected mathematical concepts to cultural contexts familiar to students.

This approach is consistent with previous studies showing that ethnomathematics-based learning can improve students' conceptual understanding, motivation to learn, and engagement in mathematics [40], [41]. However, this study extends previous findings by transforming cultural exploration into structured video-based instructional material and empirically examining its effectiveness through a quasi-experimental design.

3.2.2 The Role of Banten Cultural Context in Understanding the Pythagorean Theorem

The effectiveness of the developed instructional materials can be explained through the role of Banten cultural contexts as a bridge between abstract mathematical concepts and students' everyday experiences. The Pythagorean Theorem is often considered challenging because students need to understand the relationship between the sides of right triangles and apply mathematical reasoning rather than simply memorise formulas.

In this study, Banten cultural elements were not used merely as visual illustrations but were integrated into learning contexts to support understanding of mathematical concepts. Through the developed videos, students were guided to identify geometric characteristics, analyse shapes, and connect cultural objects with mathematical representations involving right triangles and the Pythagorean relationship.

For example, cultural patterns and structures presented in the instructional materials provided opportunities for students to recognise geometric forms and understand the relationship between the two perpendicular sides and the hypotenuse. Through this process, students could move from concrete representations toward formal mathematical concepts, including the relationship expressed as:

$$a^2 + b^2 = c^2 \tag{1}$$

This finding supports the concept of ethnomathematics introduced by D'Ambrosio, which explains that mathematics is closely related to human activities, cultural practices, and social environments [17]. Mathematics learning becomes more meaningful when students can connect formal mathematical knowledge to their cultural experience [42].

Furthermore, contextual learning theory emphasises that students construct knowledge more effectively when new information is connected with their prior experiences and real-world environments [43], [44]. Therefore, integrating Banten cultural contexts may have helped students develop a deeper understanding of the Pythagorean Theorem.

3.2.3 Comparison with Previous Studies and Research Contribution

Previous studies related to Banten ethnomathematics have mainly focused on identifying mathematical concepts embedded in local cultural elements, including Banten batik motifs, traditional buildings, and cultural artefacts [18], [24], [26]. These studies demonstrated that Banten culture contains mathematical concepts that have potential value for mathematics education.

However, most previous studies remained at the exploratory stage, describing mathematical ideas found in cultural objects. The present study extends these studies by transforming cultural knowledge into a structured instructional product and testing its effectiveness through classroom implementation.

The novelty of this research lies in the development of video-based instructional materials that integrate Banten cultural contexts, mathematical explanations, and learning activities specifically designed for the Pythagorean Theorem. Therefore, this study contributes beyond previous ethnomathematics studies by providing empirical evidence regarding how local cultural elements can be transformed into effective mathematics learning resources [40], [45], [46].

3.2.4 Alternative Explanations of the Findings

Although the experimental group demonstrated higher learning achievement, several alternative explanations should also be considered.

First, the use of video-based instructional materials may have contributed to increased student attention and engagement. Multimedia learning provides opportunities for students to receive information through visual and auditory representations, which may support comprehension of abstract concepts [47], [48]. Therefore, the improvement in learning outcomes may be attributed not only to the ethnomathematics approach but also to the characteristics of video-based learning media.

Second, teacher-related factors may have influenced the findings. Teacher explanations, classroom management, and interaction patterns during implementation may affect students' learning experiences. Although the instructional procedures were designed consistently, teacher effects cannot be entirely ruled out.

Third, the novelty effect should also be considered. Since students were introduced to a different type of learning material compared with their usual classroom resources, increased enthusiasm and participation may have contributed to improved outcomes.

Furthermore, although the experimental group achieved a higher average score and exceeded the school's minimum mastery criterion, a mean score of 66.98 indicates that some students still experienced difficulties understanding the Pythagorean Theorem. This finding suggests that ethnomathematics-based instructional materials should be supported by appropriate teacher guidance, continuous practice, and additional learning strategies.

3.2.5 Theoretical and Practical Implications

Theoretically, this study provides empirical support for the application of ethnomathematics and constructivist perspectives in mathematics education. From a constructivist perspective, students actively construct knowledge by connecting new information with previous experiences and existing cognitive structures [49], [50].

The integration of Banten cultural contexts allows students to develop mathematical understanding through meaningful connections between formal concepts and their cultural environment. Thus, this study strengthens the argument that culturally relevant learning environments can support students' mathematical construction processes.

Practically speaking, this study has implications for mathematics teachers and instructional material developers. Teachers may utilise local cultural elements as meaningful learning resources rather than presenting mathematics solely through abstract explanations. The findings suggest that cultural contexts can support students' understanding of mathematical concepts, particularly geometric concepts such as the Pythagorean Theorem.

For instructional material developers, this study demonstrates that local cultural knowledge can be transformed into structured digital learning resources that are relevant to students' characteristics and learning environments [40], [45].

3.2.6 Limitations and Future Research

This study has several limitations. First, the effectiveness testing was conducted in only one junior high school with a limited number of participants. Therefore, the findings should be generalised cautiously to other educational contexts.

Second, this study employed a posttest-only quasi-experimental design. Although this design was appropriate for comparing learning outcomes between groups, it did not measure students' learning development before and after the intervention.

Third, the study focused primarily on learning achievement outcomes. Other factors that may influence the effectiveness of ethnomathematics-based learning, such as students' motivation, engagement, mathematical reasoning ability, and perceptions of culturally based learning, were not investigated.

Future research may involve larger samples, multiple educational contexts, and longitudinal or mixed-method approaches to examine the broader impact of ethnomathematics-based instructional materials on students' mathematical understanding, motivation, and cultural awareness.

4. CONCLUSION

This study aimed to develop and examine the effectiveness of Banten culture-based ethnomathematics video instructional materials for learning the Pythagorean Theorem at the junior high school level.

The findings indicate that the developed instructional materials met the feasibility criteria, as evidenced by expert validation results. Furthermore, the effectiveness testing showed that students who learned using Banten culture-based ethnomathematics video instructional materials achieved higher learning outcomes compared with students who received conventional instruction. These findings suggest that integrating local cultural contexts into mathematics instructional materials can support more meaningful learning experiences, particularly for the Pythagorean Theorem.

Theoretically, this study contributes to ethnomathematics research by demonstrating that local cultural elements can be transformed from objects of cultural exploration into structured instructional materials that are empirically evaluated in classroom settings. The findings strengthen the understanding that the relationship between culture and mathematics can provide a meaningful foundation for contextual mathematics learning.

Practically, this study provides implications for mathematics teachers and instructional material developers by demonstrating that local cultural contexts can be utilised as learning resources to help students connect abstract mathematical concepts with their real-life experiences. However, the implementation of ethnomathematics-based instructional materials should take into account students' characteristics, learning objectives, and educational contexts.

This study has several limitations. The effectiveness testing involved only 60 students from one junior high school and focused specifically on the Pythagorean Theorem. Therefore, the findings should not be generalised to all mathematics topics or educational levels. In addition, the posttest-only quasi-experimental design did not examine students' learning development before and after the intervention.

Future research should involve larger samples, multiple schools with diverse characteristics, and pretest-posttest or mixed-method research designs. Further studies may also investigate the effects of ethnomathematics-based instructional materials on other learning outcomes, including conceptual understanding, motivation to learn, mathematical reasoning, and students' cultural awareness.

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