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Comparative Study of Elementary School Students' Understanding of Geometry Concepts through Ethnomathematics and Conventional Approaches

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ABSTRACT

This study aims to investigate and compare differences in elementary school students' understanding of geometric concepts between those who experienced ethnomathematics-based learning and those who received conventional instruction. This study employed an ex post facto comparative design involving 54 fifth-grade students divided into two groups. Data were collected using a geometry concept understanding test that met validity (0.92) and reliability (Cronbach's Alpha = 0.86) criteria. The data were analyzed using descriptive and inferential statistics. The results showed that the mean score of the ethnomathematics group ($M = 83.96$; $SD = 4.74$) was higher than that of the conventional group ($M = 71.15$; $SD = 2.58$). Welch's t-test indicated a statistically significant difference between the two groups ($t = 12.33$; $df = 40.17$; $p < 0.001$). These findings indicate that ethnomathematics-based learning is associated with higher levels of students' understanding of geometric concepts compared to conventional instruction. However, due to the ex post facto design, the findings should be interpreted as associative rather than causal.

Keywords: conceptual understanding; elementary school; ethnomathematics; geometry

INTRODUCTION

Mathematics learning in elementary school plays an important role in developing students' logical, analytical, and problem-solving abilities. One of the fundamental topics in elementary mathematics is geometry because it supports the development of spatial reasoning, visualization skills, and students' understanding of shapes and their properties in everyday life (Radiusman, 2020; Höft & Bernholt, 2019; Masitoh & Prabawanto, 2016). Geometry learning also contributes to students' conceptual development because geometric ideas are closely related to visual and contextual experiences encountered by students in their environment (Nurani et al., 2021; Yaniawati et al., 2020).

Despite its importance, many elementary school students still experience difficulties in understanding geometric concepts. Previous studies reported that students often struggle to identify geometric relationships, understand properties of shapes, and apply geometric concepts in problem-solving situations (Hidayati & Prahmana, 2022; Repriani & Jupri, 2025; Fauzi & Arisetyawan, 2020). In addition, students' understanding frequently remains procedural, where students tend to memorize formulas without comprehending the underlying concepts (Irmayanti & Danial, 2019; Ramadhani et al., 2023; Sunzuma et al., 2021). This condition indicates that students' conceptual understanding of geometry still requires improvement.

One factor contributing to these difficulties is the dominance of conventional learning approaches in mathematics classrooms. Conventional instruction often emphasizes procedural exercises and teacher-centered explanations rather than meaningful conceptual exploration. As a result, students may succeed in performing calculations but experience difficulty connecting mathematical ideas with real-life contexts (Radiusman, 2020; Masitoh & Prabawanto, 2016). This condition is inconsistent with the theory of conceptual and procedural knowledge proposed by Hiebert and Lefevre (2013), which explains that meaningful mathematical understanding occurs when students are able to connect mathematical symbols, representations, and contextual experiences.

Recent developments in mathematics education have emphasized the importance of contextual and culturally relevant learning approaches. One approach that has received considerable attention is ethnomathematics. Ethnomathematics views mathematics as a cultural product embedded in human activities and social practices (d'Ambrosio, 1985; Rosa & Orey, 2021; Hidayati & Prahmana, 2022). Through ethnomathematics, mathematical concepts can be introduced through local cultural practices, traditional artifacts, architecture, games, and patterns that are familiar to students' daily experiences ((Wardani & Budiarto., 2022); Amirah & Budiarto, 2022; Irmayanti & Danial, 2019).

Several studies have demonstrated the educational potential of ethnomathematics in mathematics learning. Research has shown that ethnomathematics-based learning can improve students' conceptual understanding, mathematical literacy, and learning engagement (Prasetyawan & Masitoh, 2025; Pratama & Yelken, 2024; Istiani et al., 2026). Studies also indicate that culturally contextualized learning environments positively influence students' participation and motivation during mathematics learning (Yaniawati et al., 2020; Yuliana et al., 2023; Ramadhani et al., 2023).

In geometry learning, cultural objects such as traditional houses, batik motifs, mosque architecture, dance movements, and local ornaments provide concrete representations of geometric concepts that make abstract ideas easier to understand (Agustian et al., 2025; Maryati et al., 2025; Susanti et al., 2023). Cultural patterns and artifacts found in local traditions also contain mathematical concepts related to symmetry, shapes, transformations, and spatial structures (Habibah et al., 2022; Nuryami & Apriosa, 2024; Prahmana & d'Ambrosio, 2020). Furthermore, ethnomathematical exploration has been identified in various regional cultures and traditional activities, including games and local artistic patterns, which can become meaningful learning resources in elementary mathematics instruction (Irmayanti & Danial, 2019; Wardani & Budiarto, 2022; Gbormittah et al., 2026).

Ethnomathematics-based learning is also aligned with sociocultural learning perspectives, which emphasize that students construct knowledge through interaction with their cultural and social environments (Nasir et al., 2008). Learning activities connected to students' lived experiences can increase participation, motivation, and conceptual engagement in mathematics learning because students perceive mathematics as relevant to their everyday lives and social environments (Yuliana et al., 2023; Yaniawati et al., 2020; Pratama & Yelken, 2024).

Although previous studies have reported positive impacts of ethnomathematics, several research gaps still exist. Many studies have focused on classroom action research or experimental interventions conducted within short durations. Comparative studies examining naturally occurring learning experiences between ethnomathematics-based learning and conventional instruction are still limited (Sunzuma et al., 2021; Gbormittah et al., 2026). In addition, studies specifically investigating elementary students' understanding of geometry concepts remain underrepresented, particularly studies using ex post facto comparative approaches.

Based on these considerations, this study aims to examine and compare elementary school students' understanding of geometry concepts between students who experienced ethnomathematics-based learning and those who received conventional instruction. The novelty of this study lies in its comparative ex post facto approach focusing specifically on geometry conceptual understanding at the elementary school level through naturally implemented ethnomathematics-based learning experiences.

RESEARCH METHODS

This study employed an ex post facto comparative design to compare students' understanding of geometry concepts between students who experienced ethnomathematics-based learning and those who received conventional instruction. The design was selected because the researcher did not directly manipulate the instructional treatment, but examined differences that had already occurred naturally in the learning process.

Participants

The participants of this study were all fifth-grade students at SDIT Akhlak Mulia 04 Bekasi Regency. A total of 54 students participated in the study and were divided into two groups consisting of 27 students each. One group consisted of students who had experienced ethnomathematics-based learning, while the other group consisted of students who had received conventional instruction. The grouping was determined based on the learning approach previously implemented in each classroom.

Instrument

Data were collected using a geometry concept understanding test consisting of five essay questions. The instrument measured students' abilities in verbal representation, symbolic representation, and visual representation related to geometry concepts. The instrument had previously undergone validity and reliability testing with a content validity coefficient of 0.92 and a Cronbach's Alpha reliability coefficient of 0.86, indicating that the instrument was valid and reliable.

Description of Ethnomathematics-Based Learning

Ethnomathematics-based learning in this study was implemented through contextual learning activities integrating local cultural elements into geometry instruction. Students were introduced to cultural objects such as traditional houses, batik motifs, and local architectural patterns relevant to geometric concepts. Students then identified geometric elements including shapes, symmetry, spatial structures, and patterns found within these cultural artifacts.

After the exploration stage, students analyzed relationships among geometric elements and connected their observations with formal mathematical concepts. Students subsequently represented their findings using mathematical symbols, diagrams, and formulas. Finally, students discussed and presented their findings collaboratively in classroom discussions. These learning activities were designed to help students connect abstract geometry concepts with meaningful cultural contexts.

Data Collection Procedure

The data collection process was conducted in three stages. First, students were grouped according to the learning approach they had experienced. Second, the geometry concept understanding test was administered under similar classroom conditions. Third, students' responses were collected and scored using predetermined assessment criteria.

Data Analysis

Data analysis involved descriptive and inferential statistical techniques. Descriptive statistics included mean and standard deviation calculations for each group. Before conducting hypothesis testing, assumption tests were performed using the Shapiro-Wilk test for normality and Levene's test for homogeneity of variance.

Because the homogeneity assumption was not satisfied ($p < 0.05$), Welch's t-test was employed to compare the mean scores between groups. The significance level for all statistical analyses was set at $\alpha = 0.05$.

RESULTS AND DISCUSSION

The results of the comparison between the ethnomathematics group and the conventional group are presented in this section.

Table 1. Results of the Normality Test for the Ethnomathematics and Conventional Groups

Group	N	Mean	Std. Deviation	Sig. (p)
Ethnomathematics	27	83.96	4.743	0.710
Conventional	27	71.15	2.583	0.390

Table 1 shows that students in the ethnomathematics group achieved a higher mean score than students in the conventional group. The ethnomathematics group obtained a mean score of 83.96, while the conventional group obtained a mean score of 71.15. This finding indicates that students who experienced ethnomathematics-based learning tended to demonstrate better conceptual understanding of geometry.

Table 2. Results of the Normality Test Using Shapiro-Wilk

Group	Statistic	df	Sig. (p)	Interpretation
Ethnomathematics	0.974	27	0.710	Normal
Conventional	0.961	27	0.390	Normal

Table 2 indicates that the significance values for both groups were greater than 0.05. Therefore, the data in both groups were normally distributed.

Table 3. Results of the Homogeneity Test Using Levene's Test

Variable	F	Sig. (p)	Note
Understanding of Geometry Concepts	9.418	0.003	Variances were not homogeneous

As presented in Table 3, the significance value was below 0.05, indicating that the homogeneity assumption was not fulfilled.

Table 4. Descriptive Statistics of Learning Outcomes Based on Instructional Models (*Independent Sample T-test*)

Group	N	Mean	Std. Deviation
Ethnomathematics	27	83.96	4.743
Conventional	27	71.15	2.583

Table 4 shows the descriptive statistics of students' learning outcomes based on the instructional models used in the study. The ethnomathematics group achieved a higher mean score (83.96) than the conventional group (71.15). In addition, the ethnomathematics group showed slightly greater score variation, as indicated by the higher standard deviation value.

Tabel 5. Results of the Test of Differences in Student Ability Using Welch's t-test

Statistical Test	t	df	Sig.
Welch's t-test	12.33	40.17	< 0.001

Table 5 demonstrates that there was a statistically significant difference between the ethnomathematics group and the conventional group ($p < 0.001$).

The contextual and culturally embedded characteristics of ethnomathematics-based learning may explain the stronger geometry conceptual understanding demonstrated by students in this study. Through culturally familiar objects and activities, students were able to connect abstract geometric concepts with meaningful real-life experiences. Such contextual learning environments support meaningful knowledge construction because students do not merely memorize formulas or procedures but actively interpret mathematical ideas within situations that are relevant to their social and cultural backgrounds. Learning experiences that are closely connected to students' daily contexts are known to facilitate deeper cognitive engagement and conceptual meaning-making (Amirah & Budiarto, 2022; Irmayanti & Danial, 2019).

The findings are consistent with previous studies reporting that ethnomathematics-based learning contributes positively to students' conceptual understanding and mathematical engagement (Gustina et al., 2025; Pratama & Yelken, 2024; Istiani et al., 2026). Systematic review studies have also emphasized that integrating cultural contexts into mathematics instruction helps students construct mathematical meaning more effectively because mathematics is perceived as more relevant and applicable to their everyday experiences (Kyeremeh et al., 2023; Zainovi et al., 2025; Sunzuma et al., 2021). From this perspective, cultural contexts function not only as instructional complements but also as cognitive bridges that connect formal mathematical concepts with students' prior experiences and intuitive understanding.

Another possible explanation relates to the use of concrete and visual cultural representations during learning activities. Cultural artifacts such as traditional houses, batik motifs, ornaments, temple structures, and traditional dance movements contain geometric concepts including symmetry, transformation, spatial relationships, and patterns. These representations may reduce the abstractness of geometry concepts and help students visualize relationships between shapes and structures more meaningfully (Agustian et al., 2025; Habibah et al., 2022; Wardani & Budiarto, 2022). Similar findings were reported in studies exploring geometry concepts in mosque architecture, traditional patterns, and local cultural practices, which demonstrated that cultural artifacts can serve as effective resources for geometry learning because they provide authentic visual and spatial representations of mathematical ideas (Nuryami & Apriosa, 2024; Gbormittah et al., 2026).

The findings can also be interpreted through the conceptual and procedural knowledge framework proposed by Hiebert & Lefevre, 2013. According to this framework, conceptual understanding develops when students are able to connect symbols, representations, procedures, and contextual experiences into coherent mathematical relationships. Ethnomathematics-based learning appears to facilitate these connections because students actively explore, analyze, discuss, and formalize mathematical ideas derived from cultural contexts. These processes encourage students to construct understanding through interpretation and interaction rather than relying solely on memorization of procedures (Prahmana & d'Ambrosio, 2020).

In contrast, conventional instruction tends to emphasize procedural exercises and teacher-centered explanations. Such instructional practices may provide fewer opportunities for students to explore mathematical ideas independently or connect concepts with meaningful contexts. As a result, students may develop procedural fluency without fully understanding the underlying mathematical relationships, limiting their ability to apply concepts flexibly in different situations (Fauzi & Arisetyawan, 2020; Masitoh & Prabawanto, 2016). Previous studies similarly reported that ethnomathematics-based approaches were more supportive of conceptual learning than conventional approaches because students were more actively involved in exploration and contextual reasoning processes (Sunzuma et al., 2021; and Gbormittah et al., 2026).

Students' motivation and engagement may also have contributed to the observed learning differences. Learning activities that incorporate cultural elements tend to increase students' interest and participation because students perceive mathematics as connected to their own identities, experiences, and environments (Ramadhani et al., 2023; Yaniawati et al., 2020; Höft & Bernholt, 2019). Increased engagement may strengthen conceptual understanding because students become more actively involved in interpreting, discussing, and applying mathematical ideas during the learning process.

Several limitations should nevertheless be considered when interpreting these findings. Because the study employed an ex post facto design, the researcher could not directly control instructional implementation or external variables such as classroom environment, teacher characteristics, and differences in learning conditions. In addition, the study involved a relatively limited sample from a single school context, which may limit the broader generalizability of the findings. The unequal variances identified between groups also indicate possible heterogeneity in instructional conditions, although this issue was statistically addressed using Welch's t-test. Therefore, further studies using experimental or longitudinal designs are needed to examine the causal mechanisms and long-term effects of ethnomathematics-based learning on students' conceptual understanding.

Overall, the study supports the view that culturally contextualized mathematics learning can provide meaningful opportunities for students to construct geometry concepts more deeply and meaningfully. Integrating local cultural contexts into elementary mathematics instruction may therefore serve as a relevant and pedagogically valuable alternative for supporting conceptual learning in geometry.

CONCLUSION

This study found a statistically significant difference in students' understanding of geometry concepts between students who experienced ethnomathematics-based learning and those who received conventional instruction. Students in the ethnomathematics group achieved higher average scores, indicating better conceptual understanding.

However, because this study employed an ex post facto design, the findings should be interpreted as associative rather than causal. The results suggest that ethnomathematics-based learning is positively associated with students' geometry conceptual understanding, but causal conclusions cannot be established.

The findings indicate that integrating cultural contexts into mathematics instruction has the potential to support meaningful conceptual learning in elementary schools, particularly in geometry learning. Future studies are recommended to use experimental designs with larger and more diverse samples to further examine the effectiveness of ethnomathematics-based learning across different mathematical topics and educational settings.

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