



INTEGRATING GEOENZO-BASED ETHNOMATHEMATICS TO IMPROVE ELEMENTARY STUDENTS' MATHEMATICAL CONNECTION ABILITY

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Abstract. The development of digital technology offers strategic opportunities to improve the quality of mathematics learning in elementary schools, particularly by strengthening students' relatively weak mathematical connection skills. This study aims to test the effectiveness of using ethnomathematics-based GeoEnzo digital demonstration media in improving elementary school students' mathematical connection skills through contextual and meaningful learning. The study used a quasi-experimental design with a pretest–posttest control group. The research subjects consisted of an experimental group that received learning using ethnomathematics-based GeoEnzo media and a control group that followed conventional learning. The research instrument was a mathematical connection ability test that had been validated by experts and met reliability criteria. Data analysis was carried out using a mean difference test and Hedges' g to calculate the effect size and determine the strength of the intervention's influence. The results showed that the increase in students' mathematical connection skills in the experimental group was significantly higher than in the control group, with a Hedges' g value of 0.83, which is classified as a large effect. The increase in ability was seen in connections among mathematical concepts, with other disciplines, and with everyday life contexts. These findings confirm the effectiveness of integrating digital media and ethnomathematics and provide empirical and conceptual contributions as a basis for further research at broader levels, in materials, and in mathematical abilities.

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INTRODUCTION

Students' mathematical connection skills are an important competency in mathematics learning, reflecting the extent to which students can connect various concepts and apply them in real-life contexts (Jawad, 2022; Kenedi et al., 2019). Mathematical connections encompass not only relationships between topics in mathematics but also connections with other disciplines and everyday situations (Mumcu & Aktaş, 2018). Unfortunately, numerous studies indicate that this ability is still relatively low in elementary school (Baiduri et al., 2020). Students tend to learn concepts separately without understanding the interconnections between concepts, making it difficult to apply mathematics meaningfully (Diana et al., 2020; Mumcu & Aktaş, 2018).

The low mathematical connection skills are rooted in learning patterns that are still procedural and teacher-centered (Diana et al., 2020; Jawad, 2022; Mumcu & Aktaş, 2018). In many cases, students are directed to memorize formulas without understanding the conceptual meaning behind them (Paloloang et al., 2020; Sulistiyowati & Wahyuni, 2024). This approach hinders the development of higher-order thinking skills, including building connections between mathematical ideas (Azzahra et al., 2025; Baiduri et al., 2020; Septiarani & Handayani, 2020). Therefore, learning innovations are needed that can provide active, contextual, and meaningful learning experiences for elementary school students.

One promising alternative for strengthening students' mathematical connections is through the use of digital visual aids (Nurjanah et al., 2020; Tamur, 2023; Tamur et al., 2020). Digital media offers dynamic, interactive, and engaging visualizations, helping students understand the relationships between concepts more concretely (Juandi et al., 2021; Kusumah et al., 2020; Tamur

et al., 2020). In this context, GeoEnzo, a geometry-based digital visual aid, offers features that enable the visual exploration of mathematical concepts (Age et al., 2021). The use of GeoEnzo is believed to foster conceptual understanding and encourage students to discover connections between mathematical ideas through hands-on learning experiences (Age, 2024; Mauladaniyati & Kurniawan, 2018).

The combination of GeoEnzo digital visualization and ethnomathematics creates an innovative, context-based learning model. Digital visualizations help students understand mathematical structures and relationships concretely, while the local cultural context strengthens the meaning and relevance of learning (Fokuo et al., 2023; James & France, 2024; Margarita et al., 2024). The collaboration of these two approaches has the potential to increase students' motivation, active participation, and ability to connect mathematical concepts with real-life experiences. This approach also supports the principles of the Independent Curriculum, which emphasizes meaningful learning and is oriented towards 21st-century competencies.

Several previous studies have shown that the use of digital media such as GeoGebra and GeoEnzo can improve students' conceptual understanding and critical thinking skills (Age, 2024; Age et al., 2021; Mauladaniyati & Kurniawan, 2018). However, there is still limited research integrating ethnomathematics aspects into the use of these digital media, especially in elementary school contexts. The novelty of this research lies in the development of GeoEnzo digital demonstration media, adapted to the local cultural context, to strengthen students' mathematical connections. Thus, this research is expected to provide an empirical contribution to innovation in technology- and culture-based mathematics learning.

Based on the description above, this study aims to examine the effectiveness of ethnomathematics-based GeoEnzo digital demonstration media in improving elementary school students' mathematical connection abilities. Specifically, this study seeks to (1) analyze the differences in mathematical connection abilities between students who learn using ethnomathematics-based GeoEnzo media and those who learn through conventional methods, and (2) determine the magnitude of the effect of using ethnomathematics-based GeoEnzo media on students' mathematical connection abilities. The findings of this study are expected to contribute both theoretically and practically. Theoretically, this research enriches the literature on integrating digital technology and ethnomathematics into mathematics learning, particularly by strengthening mathematical connections at the elementary level. In practice, this study provides an innovative learning alternative for teachers by offering a contextual, technology-based approach that can enhance students' engagement, conceptual understanding, and ability to relate mathematical ideas to real-life situations.

RESEARCH METHODS

This study used a quasi-experimental design with a pretest-posttest control group. This design was chosen because it allows researchers to objectively compare the effects of treatments on the experimental and control groups, even though group assignment was not completely random. In this design, both groups were given a pretest to determine students' initial mathematical connection abilities. Then, the experimental group received treatment using GeoEnzo digital demonstration media based on ethnomathematics, while the control group was taught using conventional instruction. After the treatment was completed, both groups were given a posttest to measure improvements in mathematical connection abilities.

The participants in this study were fifth-grade students at Konggang Elementary School (SDI), Ruteng, Indonesia, enrolled in two parallel classes, VA and VB. Class VA was designated as an experimental class with 20 students, while class VB was designated as a comparison (control) class with 21 students. The class assignment was based on students' academic abilities and on coordination with the class teacher. All students were actively involved in the learning process, which took place over four 70-minute meetings. This study was conducted in the 2025/2026 academic year.

The research instrument was a mathematical connection ability test developed based on three main indicators: (1) connections between mathematical concepts, (2) connections between



mathematics and other disciplines, and (3) connections between mathematics and everyday life. This instrument consisted of eight descriptive questions validated by three mathematics education experts and piloted on students with similar characteristics outside the research sample. Validity tests using product-moment correlation showed all items had coefficients above 0.40, while test reliability, calculated using Cronbach's Alpha, was 0.87, which is considered very high. The test data were used to measure the level of improvement in mathematical connection ability before and after treatment.

The data collection procedure was carried out in four stages: (1) administering a pretest, (2) implementing learning using ethnomathematics-based GeoEnzo media in the experimental class, (3) implementing conventional learning in the control class, and (4) administering a posttest. The test data were analyzed quantitatively using an independent samples t-test to determine differences in improvement in mathematical connection ability between groups. In addition, effect sizes were calculated using Hedges' *g* to estimate the strength of the treatment effect. The analysis was conducted using SPSS version 26 software with a significance level of 0.05.

RESULTS AND DISCUSSION

This study aims to determine the effect of using ethnomathematics-based GeoEnzo digital visual aids on improving elementary school students' mathematical connection skills, compared to conventional learning. Mathematical connection skills include students' ability to connect mathematical concepts, relate mathematics to other disciplines, and relate mathematical concepts to everyday life contexts. To achieve this goal, students' mathematical connection skills were assessed using pretests and posttests in both the experimental and control groups.

The data analyzed in this study were mathematical connection skill test scores obtained from both groups before and after the treatment. The ideal score for the mathematical connection skill test in this study was 20, based on five questions with a maximum score of 4 per item. The results of the descriptive analysis are presented in Table 1.

Table 1. Statistical Description of Students' Mathematical Connection Ability

Experimental Class				Control Class		
Ideal Score	N	$\bar{x}$	S_d	N	$\bar{x}$	S_d
20	20	19.76	5.24	21	14.87	6.38

Table 1 presents differences in mean scores and standard deviations, indicating a tendency toward higher scores and a more homogeneous distribution in the experimental class compared to the control class. These scores were then analyzed descriptively and inferentially to illustrate data trends and statistically test differences and the effects of the treatments.

Before conducting the mean difference test, the pretest and posttest data on mathematical connection skills in the experimental and control groups were first tested for analysis prerequisites. A normality test was conducted to ensure that the data distributions in both groups met the assumptions of normality. Table 2 presents the results of the data normality test.

Table 2. Normality Test Results

No	Kelas	Shapiro-Wilk		Interpretasi
		Df	Sig	
1	Experiment	19	0.16	normally distributed
2	Control	20	0.28	normally distributed

The results of the normality test presented in Table 2 indicate that the pretest and posttest data in both the experimental and control groups were normally distributed, as indicated by *p*-values greater than 0.05. Furthermore, a homogeneity-of-variance test was conducted to assess the similarity of variances across groups. Table 3 summarizes the results of the homogeneity-of-variance test.

Table 3. Results of homogeneity test

No	Statistic Levene	Sig.
1	2.26	0.79



The results of the homogeneity test indicate that the variances of the mathematical connection ability data in the experimental and control groups are homogeneous, with a p-value greater than 0.05. Thus, the research data meet the assumptions for parametric statistical analysis using the t-test. Next, to examine whether there were significant differences in students' mathematical connection skills between the experimental and control groups after the treatment, a posttest score comparison was conducted using an independent-samples t-test. This statistical procedure was chosen to identify differences in mean performance between two groups treated independently during the learning process. This analysis was based on the assumption that both groups met the necessary conditions for parametric testing, including normality and homogeneity of variance. The results of this analysis are presented in Table 4, which summarizes the results of the independent t-test.

Table 4. Summary of t-test results

No	Sig. (2-tailed)	Interpretation
1	0.01	Ho rejected

The results of the independent-samples t-test revealed a statistically significant difference in the mean scores between the experimental and control groups, as indicated by a p-value below 0.05. This result suggests that the observed difference in students' mathematical connection skills is unlikely to have occurred by chance. In other words, the use of ethnomathematics-based GeoEnzo digital demonstration media meaningfully improved students' performance compared to conventional instruction. Therefore, it can be inferred that the implemented learning approach has a significant positive effect on enhancing elementary school students' mathematical connection abilities.

The magnitude of the effect of using GeoEnzo digital demonstration media based on ethnomathematics was analyzed using Hedges' g effect size. The effect size was calculated using CMA software. Based on the Hedges formula, the effect size value of the application of GeoEnzo digital demonstration media based on ethnomathematics was 0.83 [CL: 0.19-1.43]. Based on the classification of Cohen et al. (2018), this value is accepted as a large effect size, indicating a strong impact of the treatment. The magnitude of this effect indicates that integrating GeoEnzo digital demonstration media based on ethnomathematics is not only statistically significant but also practically meaningful. In other words, this learning strategy makes a real contribution to improving students' mathematical connection abilities.

Based on the analysis of each indicator, the experimental group's ability to connect mathematical concepts was more prominent than that of the control group. Students were able to link various mathematical concepts, such as the relationships among geometry, measurement, and arithmetic operations, more integratively. For the indicator of connecting mathematics to other disciplines, the experimental group demonstrated improved ability to link mathematical concepts to elements of culture, art, and social knowledge presented through the ethnomathematics context. In contrast, improvement in the control group tended to be limited to procedural academic contexts. Meanwhile, for the indicator of connecting mathematics to everyday life contexts, the experimental group's ability improved significantly compared to other indicators. Students were better able to connect mathematical concepts to real-life situations that closely relate to their cultural experiences and social environment, as reflected in their answers to contextual questions.

The results of this study indicate that using GeoEnzo as an ethnomathematics-based digital demonstration medium significantly enhances elementary school students' mathematical connection skills. This improvement can be understood through the linkage between geometric concepts, such as the cone visualized in GeoEnzo, and the roof structure of traditional Manggarai houses, which share similar forms, as illustrated in Figure 1.



Figure 1. GeoEnzo-Based Exploration of Geometric Concepts in an Ethnomathematical Context

Figure 1 presents how the concept of a cone is connected to a cultural representation, which is then visualized through GeoEnzo and explored by students during group-based investigation activities. Such contextual and visual connections facilitate students' abstraction of geometric concepts from real-world objects into formal mathematical representations.

This finding aligns with the research objective, which was to examine the effectiveness of integrating digital media and local cultural contexts in developing mathematical connection skills. Theoretically, mathematical connection skills are essential for students to understand the interrelationships among mathematical concepts and relate them to other disciplines and everyday life (Jawad, 2022; Kenedi et al., 2019; Mumcu et al., 2022). The greater improvement in the experimental group indicates that a learning approach that emphasizes connections and context positively contributes to students' mathematical understanding.

The effectiveness of GeoEnzo digital demonstration media can be explained through the role of interactive digital media in facilitating the visualization and exploration of mathematical concepts (Fokuo et al., 2023; James & France, 2024; Margarita et al., 2024). Digital media allows for dynamic, manipulable presentation of concepts, enabling students to observe relationships between concepts directly (Juandi et al., 2021; Nurjanah et al., 2020; Tamur, 2023; Tamur et al., 2020; Tamur et al., 2025). The interactivity offered by GeoEnzo media encourages active student engagement in the learning process, which supports the formation of a deeper and more integrated conceptual understanding (Age, 2024; Age et al., 2021; Mauladaniyati & Kurniawan, 2018), particularly in developing mathematical connection skills.

Furthermore, the ethnomathematics context integrated into learning media plays a crucial role in building the meaning and relevance of mathematics learning. The use of local cultural contexts helps students connect abstract mathematical concepts with real-life experiences (Deda, Disnawati, et al., 2024; Deda, Rosa, et al., 2024; Kadir et al., 2021; Zuliana et al., 2023). This aligns with the constructivist perspective, which emphasizes that learning becomes more meaningful when students can connect new knowledge to cognitive structures and prior experiences (Tamura, Sennen, & Guzman, 2025; Zulkardi et al., 2020). Thus, ethnomathematics serves as a bridge between school mathematics and students' socio-cultural realities.

The findings of this study align with various previous studies that reported that digital media-based learning and contextual approaches can improve students' mathematical connection skills (Fitri & Khairina, 2026; Putri et al., 2024; Septian, 2022). However, several previous studies have shown that the use of digital media alone is not necessarily effective unless accompanied by meaningful context (Kariadinata et al., 2023; Tamur et al., 2023; Tamur, Sennen, & Guzman, 2025). This difference emphasizes that learning success is determined not only by technological sophistication, but also by the relevance of the context presented in the learning process.

Another important finding emerging from this study concerns the pattern of students' responses during the learning process. Students in the experimental group demonstrated a greater

ability to explain relationships between concepts, both procedurally and conceptually, compared to those in the control group. They were better able to link geometric representations to real-life cultural objects and articulate these connections in their own words. This indicates that integrating GeoEnzo and ethnomathematics does not merely support cognitive outcomes but also strengthens students' mathematical communication, which is closely related to their ability to build and express mathematical connections.

In addition, the learning environment created through the use of ethnomathematics-based GeoEnzo media appears to foster higher levels of student engagement and participation. Students were more actively involved in discussions, exploration, and collaborative problem-solving activities, as the learning tasks were perceived as meaningful and relevant to their daily lives (Prahmana et al., 2020; Sudirman et al., 2020). This increased engagement plays a crucial role in supporting deeper learning, as students are not passive recipients of information but active constructors of knowledge. Consequently, the combination of interactive digital tools and culturally relevant contexts contributes to a more holistic learning experience that supports both conceptual understanding (Tamur, Sennen, & Guzman, 2025; Tamur, Sennen, & Vaz, 2025), and the development of higher-order thinking skills.

The implications of this research suggest that elementary school teachers should integrate interactive, context-rich digital learning media to develop students' mathematical connection skills. Furthermore, this research contributes to the development of technology-based learning media and local culture by demonstrating that their synergy can produce significant learning impacts. Theoretically and practically, this research enriches the study of mathematics education by providing empirical evidence of the importance of integrating digital media and ethnomathematics to support meaningful, contextual mathematics learning that develops students' mathematical connection skills.

CONCLUSIONS AND SUGGESTIONS

This study demonstrates that integrating GeoEnzo digital manipulative media, grounded in ethnomathematics, effectively improves elementary school students' mathematical connection skills. As proposed in the Introduction, this study aimed to test whether digital media enriched with local cultural contexts can help students overcome their persistent difficulty in meaningfully connecting mathematical concepts. The findings and discussion confirm that students learning through GeoEnzo-based ethnomathematics demonstrated significantly higher mathematical connection skills than those experiencing conventional instruction, with consistent improvements observed across connections between mathematical concepts, across disciplines, and with real-life contexts. These results suggest that the synergy between interactive digital visualizations and culturally meaningful contexts facilitates deeper conceptual understanding and supports the development of higher-order mathematical thinking.

Beyond confirming the research's expectations, this study offers opportunities to enrich future research and teaching development. Further investigation could explore the long-term impact of ethnomathematics-based digital media on students' conceptual retention, problem-solving, and reasoning skills across various mathematics topics and educational levels. Furthermore, expanding the design of GeoEnzo-based media to incorporate diverse cultural contexts and adaptive digital features could further strengthen its pedagogical potential. In this regard, this study makes both theoretical and practical contributions to mathematics education by highlighting the importance of culturally responsive digital learning environments and laying a foundation for future innovations in technology-enhanced, context-based mathematics teaching.

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