Development of Ethno-Algebra-Based Deep Learning to Enhance Conceptual Understanding Among Elementary School Students

Fitria Handayani[1], Jaka Wijaya Kusuma[2], Hamidah[3], Mutoharoh[4]
[1,2,3,4]Universitas Bina Bangsa, Indonesia
Email: jakawijayak@gmail.com

Abstract

This study aims to synthesize and develop a conceptual framework for Deep Learning-based Ethnogebra to enhance elementary students' conceptual understanding in mathematics. Ethnogebra integrates Deep Learning (DL), GeoGebra (dynamic mathematics software), and ethnomathematics into a unified instructional approach. A systematic literature review design was employed to analyze 30 peer-reviewed articles published between 2015 and 2025 focusing on deep learning, technology integration, cultural context in mathematics, and conceptual understanding. The findings indicate that DL strengthens reflective and connected thinking, GeoGebra supports dynamic visualization of abstract concepts, and ethnomathematics enhances contextual relevance and learning meaning. The integration of these components forms a reflective, visual, and contextual learning model that potentially improves students' conceptual understanding more comprehensively than partial approaches. This framework contributes theoretically to technology- and culture-integrated mathematics instruction and provides practical guidance for developing innovative learning models in elementary education.

Keywords:Deep Learning, Geogebra, Ethnomathematics, Conceptual Understanding, Geogebra

INTRODUCTION

Mathematics is a fundamental subject that plays a key role in developing elementary school students' logical, critical, and systematic thinking skills. One of the essential competencies in mathematics education is conceptual understanding—that is, students' ability to grasp the meaning of a concept, rephrase it in their own words, connect concepts, and apply them flexibly to solve problems. However, various field findings indicate that elementary school students' conceptual understanding remains suboptimal, particularly regarding geometry and transformations. Learning that remains focused on procedures and routine problem-solving exercises leads students to tend to memorize solution steps without understanding the underlying reasons and conceptual connections.

Advances in educational technology actually present significant opportunities to enhance the quality of mathematics instruction. One widely studied interactive tool is GeoGebra, a dynamic mathematics software capable of visualizing abstract concepts in a more concrete and exploratory manner. Literature reviews conducted by Zengin et al. (2012) and Aprilian (2024) indicate that the consistent use of GeoGebra improves students' understanding of mathematical concepts compared to conventional instruction. GeoGebra helps students build visual representations and strengthen connections between concepts, thereby making learning more meaningful. These findings suggest that dynamic visualization plays a crucial role in deepening conceptual understanding.

On the other hand, the ethnomathematics approach offers the perspective that mathematical concepts are inherently present in the cultural practices of a community. Research on ethnomathematics in the context of traditional Banten batik motifs reveals the presence of geometric transformation concepts such as translation, reflection, rotation, and dilation, which can serve as contextual learning resources (Shiffa Firdaussa et al., n.d.) (Kusuma, 2023). Integrating local culture into mathematics education not only enhances the relevance

of the material but also strengthens students' identity and character. A study developing ethnomathematics-based instructional videos for fourth-grade elementary school students yielded excellent results and had a positive impact on their understanding of plane figure concepts (Putri & Agustika, 2022) (Putri & Agustika, 2022). Furthermore, the integration of ethnomathematics with technologies such as Augmented Reality (AR) has been shown to significantly improve spatial visualization and the understanding of three-dimensional geometric concepts (Zengin et al., 2012).

Nevertheless, most studies still examine GeoGebra and ethnomathematics separately. Research integrating both within a deep learning framework remains limited, particularly at the elementary school level. Deep learning emphasizes the process of reflection, connections between concepts, and the transfer of knowledge to new situations, rather than merely mastering procedures. The integration of GeoGebra and ethnomathematics—referred to in this study as Etnogebra—has the potential to create learning that is not only visually and conceptually robust but also contextual and culturally meaningful. Through Etnogebra, students can explore geometric concepts dynamically while linking them to local cultural artifacts, thereby creating a comprehensive learning experience.

Based on the above, the research questions in this study are: (1) how effective is GeoGebra in enhancing elementary school students' conceptual understanding; (2) how does ethnomathematics contribute to creating contextual and meaningful mathematics learning; and (3) how can a deep learning model based on Etnogebra be synthesized to potentially enhance elementary school students' conceptual understanding.

The objective of this study is to analyze and synthesize findings from previous research related to GeoGebra and ethnomathematics, as well as to formulate a conceptual framework for the development of deep learning based on Etnogebra. This research is important because it aligns with the demands of 21st-century learning and the implementation of the Merdeka Curriculum, which emphasizes contextual, technology-based learning oriented toward deep understanding. The integration of technology and local culture in mathematics learning is not only relevant to current needs but also contributes to strengthening students' character and identity. Conceptually, the hypothesis proposed in this study is that deep learning based on Ethnogebra has greater potential in enhancing elementary school students' conceptual understanding compared to conventional, procedure-based learning. Thus, this study is expected to provide theoretical and practical contributions to the development of innovative mathematics learning in elementary schools.

METHOD

This study employs a Systematic Literature Review (SLR) approach with a qualitative descriptive design to synthesize empirical findings regarding the use of GeoGebra, ethnomathematics, and their integration (Etnogebra) in enhancing students' conceptual understanding. Data were obtained from articles published between 2018 and 2025 via scientific databases such as Google Scholar, SINTA, and other indexed journals. Article selection was conducted purposively based on criteria of relevance, publication quality, and direct relevance to mathematical conceptual understanding. The research process included identifying the focus of the study, selecting articles, extracting data, conducting content analysis, and synthesizing findings to formulate a conceptual model of deep learning based on Etnogebra. Analysis was conducted qualitatively using thematic techniques to identify the effectiveness of GeoGebra, the contribution of ethnomathematics, and the integration of technology and culture in mathematics learning. Validity was ensured through triangulation of sources and repeated readings, while reliability was strengthened by consistent coding. This study was limited to fully accessible articles and did not conduct a quantitative meta-analysis; therefore, it did not calculate effect sizes statistically. Nevertheless, the systematic

approach used provides a comprehensive overview and serves as a foundation for the development of further experimental research as well as the development of models in elementary schools.

RESULT AND DISCUSSION

Based on the literature selection and screening process that has been conducted, the articles analyzed in this study encompass four types of research designs: experimental research, quasi-experimental research, research and development (R&D), and literature reviews. The distribution of these research types is presented in Table 1.

Table 1. Distribution of Research Types Analyzed

Jenis Penelitian	**Jumlah Artikel**	**Presentase (%)**
Eksperimen	10	33%
Quasi Eksperimen	8	27%
Research & Development	7	23%
Studi Literatur	5	17%
Total	**30**	**100%**

Source: Adapted from a literature review, 2026.

As shown in Table 1, the majority of studies used experimental and quasi-experimental designs, accounting for a total of 60%. This indicates that most studies focused on testing the effectiveness of models, approaches, or learning media in improving students' understanding of mathematical concepts.

The results of a thematic analysis of all articles indicate that deep learning has four main characteristics: reflection, connections between concepts, active exploration, and the ability to transfer knowledge to new contexts. Most studies reported significant improvements in indicators of conceptual understanding, particularly in students' ability to explain concepts coherently and relate various mathematical representations. These findings demonstrate that deep learning contributes to strengthening students' conceptual structures.

Of the 30 articles analyzed, 12 specifically discussed the use of GeoGebra in mathematics instruction. The findings indicate that the use of GeoGebra has a positive impact on improving the visualization of abstract concepts, encouraging students' active engagement in the learning process, and strengthening understanding of geometry and transformation concepts. In studies with experimental designs, improvements in conceptual understanding scores fell into the moderate to high categories, with normalized gain values ranging from 0.45 to 0.72. These data indicate that GeoGebra possesses a sufficiently strong effectiveness in supporting the learning of mathematical concepts.

Additionally, nine articles emphasized the importance of integrating local culture into mathematics education through an ethnomathematics approach. The findings show that this approach is capable of increasing student learning motivation, strengthening the relevance of concepts to daily life, and helping students explain concepts in a more contextual manner. The implementation of ethnomathematics is widely applied to geometry, patterns, and transformations through the exploration of batik motifs, traditional house designs, and traditional games as authentic learning resources.

Overall, the analysis results indicate that the integration of deep learning, GeoGebra, and ethnomathematics—hereinafter referred to as Etnogebra—demonstrates synergistic potential in enhancing students' conceptual understanding. A synthesis of each component's contribution to conceptual understanding is presented in Table 2.

Table 2. Synthesis of Each Component's Contribution to Conceptual Understanding

Komponen	**Fokus Utama**	**Dampak terhadap Pemahaman Konseptual**
Pembelajaran Mendalam	Refleksi dan koneksi konsep	Memperkuat struktur konseptual
GeoGebra	GeoGebra	Mempermudah pemahaman konsep abstrak
Etnomatematika	Kontekstualisasi berbasis budaya	Meningkatkan makna dan relevansi
Etnogebra	Visual–reflektif–kontekstual	Pembelajaran bermakna dan komprehensif

Source: Synthesis of literature review findings, 2026.

Table 2 shows that each component plays a specific, complementary role. Deep learning strengthens reflection and conceptual connections, GeoGebra supports dynamic visualization so that abstract concepts are easier to understand, and ethnomathematics provides a cultural context that enhances the meaningfulness of learning. The integration of these three elements forms a visual-reflective-contextual approach that has the potential to yield more comprehensive learning.

Based on this literature synthesis, a conceptual model for the development of deep learning based on Etnogebra was formulated, as shown in Figure 1.

Figure 1. Conceptual Model for the Development of Deep Learning Based on Etnogebra

(Pembelajaran Mendalam)

⬇️

Refleksi – Koneksi – Transfer

⬇️

Integrasi GeoGebra (Visualisasi Dinamis)

⬇️

Integrasi Etnomatematika (Kontekstual Budaya)

⬇️

Peningkatan Pemahaman Konseptual Siswa

Source: The researcher's conceptual development, 2026.

Figure 1 illustrates that the learning process begins with the application of deep learning principles that emphasize reflection, connections, and knowledge transfer. This stage is then reinforced through the integration of GeoGebra as a tool for dynamic visualization and enriched with cultural context through ethnomathematics. This entire sequence culminates in a more comprehensive and meaningful enhancement of students' conceptual understanding.

Discussion

Deep learning has been shown to play a crucial role in enhancing students' conceptual understanding because it emphasizes reflection, connections between concepts, active exploration, and the ability to transfer knowledge to new situations. This approach aligns with Marton and Säljö's deep approach, which emphasizes that meaningful learning occurs

when students understand the meaning of the material, rather than merely memorizing it. Various studies indicate that reflective discussions, conceptual elaboration, and the linking of various mathematical representations can strengthen students' conceptual structures. The views of Kilpatrick, Swafford, and Findell also affirm that conceptual understanding is the primary foundation of mathematical competence that must be built starting in elementary school, so that students not only know the procedures but also understand the reasoning behind them.

The use of GeoGebra provides significant support in visualizing abstract concepts, particularly in geometry and transformation topics. Research by Zengin, Furkan, and Kutluca indicates that the use of GeoGebra improves learning outcomes more effectively than conventional instruction (Zengin et al., 2012). Dynamic visualization allows students to manipulate mathematical objects directly, fostering an exploratory and reflective learning experience. On the other hand, the integration of ethnomathematics introduces a cultural context that strengthens the relevance and motivation for learning. In line with Ubiratan D'Ambrosio's thinking, mathematics is inseparable from the culture of a society; learning through batik motifs or traditional patterns helps students understand concepts contextually. Findings by Putri and Agustika also indicate a significant improvement in the understanding of plane figures in elementary schools through this approach. The integration of deep learning, GeoGebra, and ethnomathematics within the Etnogebra framework offers an approach that is reflective, visual-exploratory, and contextual simultaneously. This model not only strengthens cognitive aspects but also fosters students' emotional engagement and cultural identity. Theoretically, this approach enriches the study of technology and cultural integration in mathematics education and aligns with the implementation of the Merdeka Curriculum, which emphasizes student-centered and contextual learning. However, since this study is based on a literature review without quantitative meta-analysis, the model's effectiveness still needs to be tested through experimental research. The development of modules, worksheets, and assessments based on Ethnogebra is a strategic step to test their impact on students' critical thinking, creativity, and numeracy skills. Overall, Ethnogebra offers an innovative approach with a strong theoretical foundation and significant practical potential for enhancing elementary school students' conceptual understanding.

CONCLUSION

Based on a literature review, the integration of deep learning, GeoGebra, and ethnomathematics within the Etnogebra framework yields a reflective, visual, and contextual approach. Deep learning strengthens cognitive structures through reflection and conceptual connections; GeoGebra helps visualize abstract concepts dynamically; while ethnomathematics provides meaningful cultural contexts. The combination of these three demonstrates greater potential for enhancing conceptual understanding compared to their separate applications. The Etnogebra model offers a conceptual framework that integrates cognitive, technological, and cultural aspects, and is relevant to the demands of 21st-century learning and the Merdeka Curriculum. However, since this study is based on a literature review, its effectiveness still needs to be tested through experimental research so that its impact on conceptual understanding and mathematical competence can be proven empirically and more comprehensively.

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