DEEP LEARNING BASED ON ETHNOMATHEMATICS TO STRENGTHEN LITERACY AND NUMERACY SKILLS IN ELEMENTARY SCHOOL STUDENTS

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Abstract

Abstract: The low achievement of elementary students in literacy and numeracy highlights the need for contextual and deep understanding-oriented instruction. This article aims to formulate an integrative model combining deep learning and ethnomathematics to strengthen numeracy literacy. A literature review method was employed through critical analysis of reputable publications from 2021–2026 addressing mathematical literacy, deep learning pedagogy, and ethnomathematics. The synthesis reveals that deep learning enhances conceptual connections, metacognitive reflection, and knowledge transfer, while ethnomathematics provides culturally responsive and authentic contexts that increase student engagement. The main contribution of this study is the formulation of a five-phase model: cultural engagement, conceptual exploration, collaborative reflection, mathematical abstraction, and transfer and application. This model offers a systematic pedagogical framework for contextual mathematics instruction at the elementary level. It is concluded that the integration possesses strong theoretical and empirical foundations and is relevant for supporting primary education reform.

Keywords: Deep learning, ethnomathematics, numeracy literacy, elementary education, pedagogical innovation

INTRODUCTION

Strengthening literacy and numeracy is a strategic priority in the 21st-century global education transformation. The Programme for International Student Assessment (PISA) report published by the OECD (2023) emphasizes that mathematical literacy is not merely about procedural skills in solving problems, but encompasses an individual's ability to formulate, apply, and interpret mathematics in various contexts. The OECD (2023) emphasizes that mathematical literacy is not merely about procedural skills in solving problems, but encompasses an individual's capacity to formulate, apply, and interpret mathematics in various real-life contexts. This perspective positions numeracy as a functional competency linked to decision-making, social participation, and readiness to address global complexities.

On the other hand, UNESCO (2023) emphasizes that improving basic literacy requires contextual, inclusive, and responsive learning that accounts for students' socio-cultural backgrounds. Learning detached from students' life experiences tends to result in superficial understanding (surface learning), while learning that connects local contexts and cultural experiences has proven more effective in fostering engagement and deep understanding.

Within a contemporary pedagogical framework, deep learning is understood as a learning process that enables students to build meaningful conceptual connections, develop reflective skills, and transfer knowledge to new situations. This concept is reinforced by the idea of educational transformation proposed by Michael Fullan, which emphasizes the importance of global competencies, collaboration, and complex problem-solving (Fullan et al., 2018). Deep learning shifts the paradigm from mere content mastery toward the development of critical, creative, and adaptive thinking skills.

In mathematics education, this approach aligns with the recommendations of the National Council of Teachers of Mathematics (NCTM, 2021), which emphasize the importance of conceptual understanding, mathematical reasoning, and meaningful mathematical practices. This means that mathematics instruction must be designed so that students are not only able to perform calculations but also understand the meaning behind the procedures and apply them in daily life.

One approach with strong potential to integrate deep learning and strengthen numeracy literacy is ethnomathematics. Ethnomathematics views mathematics as a cultural product that evolves through human social activities. This perspective positions local cultural practices—such as weaving patterns, traditional architecture, folk games, traditional measurement systems, and local economic practices—as authentic sources of mathematical learning.

Various recent studies indicate that the integration of culture into mathematics education contributes to improved mathematical literacy, student engagement, and the strengthening of students' academic identity. A recent meta-analysis (2024–2025) demonstrates that ethnomathematics-based learning has a significant effect on enhancing conceptual understanding, mathematical representation skills, and learning motivation among elementary school students. However, although empirical studies demonstrate the effectiveness of ethnomathematics, there remains a scarcity of conceptual articles that systematically synthesize the integration of deep learning and ethnomathematics as an integrated pedagogical model for strengthening literacy and numeracy. Therefore, this article aims to develop a conceptual synthesis regarding the integration of ethnomathematics-based deep learning and to formulate its pedagogical implications within the context of Indonesian elementary education.

RESULT AND DISCUSSION

2.1 Theoretical Foundations of Deep Learning in Mathematics Education

Deep learning is rooted in cognitive and social constructivism. From this perspective, knowledge is constructed through active interaction between individuals and their environment. Deep learning emphasizes conceptual connections, metacognitive reflection, and knowledge transfer.

Within the PISA (2022) framework, mathematical processes encompass three main processes: formulating, employing, and interpreting. These three processes align with the higher-order thinking skills that form the core of deep learning. When students are able to formulate contextual problems into mathematical models, they are engaging in conceptual abstraction. When employing procedures and strategies, they integrate conceptual understanding with operational skills. When interpreting results, they reconnect concepts with reality.

Several studies indicate that concept-based learning significantly enhances students' long-term knowledge retention and facilitates knowledge transfer to new situations, as students build stronger conceptual connections through active exploration and reflection (Mailani et al., 2025). The deep learning approach is positively correlated with the development of students' higher-order thinking skills (HOTS) and critical thinking skills.

A literature review concludes that the integration of pedagogical deep learning and HOTS significantly fosters students' critical and reflective thinking (higher-order thinking) (Hafidzni et al., 2025). Furthermore, the implementation of deep learning-based instructional materials has been shown to improve HOTS scores in learning activities, particularly in the domains of analysis, evaluation, and creation (higher-order thinking) (Chosya & Takiddin, 2025). The application of this approach is also associated with a significant improvement in

students' critical thinking skills in studies on the development of learning modules (Basrahwati et al., 2026).

Recent research indicates that deep learning-based instruction enhances long-term retention and cognitive flexibility. Students who learn through conceptual exploration demonstrate better transfer skills compared to those who learn procedurally.

At the elementary school level, deep learning is crucial because this phase marks the formation of the cognitive structure of numeracy. Misconceptions formed in the early stages have the potential to hinder the development of mathematical literacy in subsequent levels.

2.2 Ethnomathematics as a Bridge for Conceptual Contextualization

The ethnomathematics approach broadens the definition of mathematics by acknowledging mathematical practices embedded in various cultures, including non-dominant cultures, making it relevant in the context of multicultural elementary education. Studies indicate that traditional cultural objects such as food, games, or local artifacts possess high mathematical potential and can be used to contextualize formal concepts, thereby enhancing the meaning of learning for students from diverse cultural backgrounds (Solihin et al., 2025; Susanti et al., 2025)

Ethnomathematics acknowledges that every culture possesses unique mathematical practices. This approach aligns with culturally responsive pedagogy, which positions students' cultural experiences as a source of learning. In a global context, culturally responsive instruction has been shown to enhance students' sense of belonging and academic identity. When students see their culture acknowledged in learning, they feel valued and motivated to engage actively.

International research indicates that culture-based learning, including instruction responsive to students' cultural backgrounds (culturally responsive instruction), enhances student engagement and strengthens academic identity within multicultural learning contexts. For instance, a study by Cambaya & Sariana (2025) found a positive correlation between culture-based instruction and students' sense of belonging in the classroom, which contributes to more positive attitudes toward mathematics. Another study in China by Chuanzhu & Hashim (2025) reported a strong relationship between cultural learning approaches and student engagement in learning.

Other empirical findings indicate that when content is linked to students' local cultural experiences, active student engagement increases significantly. The integration of cultural context has also been shown to enhance understanding of geometric concepts and mathematical patterns (Pratama & Yelken, 2024). Furthermore, a study in the International Journal of Science and Mathematics Education (2022) indicates that culturally-based contextual learning enhances students' mathematical representation and communication skills.

2.3 Conceptual Synthesis: An Integrative Model of Deep Learning Based on Ethnomathematics

Based on the literature synthesis, an integrative model of deep learning based on ethnomathematics can be formulated into the following five phases

1. Cultural Engagement
   Guru menghadirkan fenomena budaya sebagai stimulus pembelajaran untuk membangun relevansi dan rasa ingin tahu siswa.
2. Conceptual Exploration
   Siswa mengidentifikasi struktur matematis dalam praktik budaya melalui eksplorasi terbimbing.
3. Collaborative Reflection
   Diskusi kelompok dan refleksi kritis untuk memperdalam makna konseptual.

4. Mathematical Abstraction
   Formalisasi konsep ke dalam notasi dan simbol matematika standar.
5. Transfer and Application
   Penerapan konsep pada konteks baru untuk memastikan terjadinya transfer pengetahuan.

This model aligns with the principles of culturally responsive teaching (Teacher's Guide, 2025) and strengthens numeracy literacy through authentic learning experiences. Culturally Responsive Teaching (CRT) is a pedagogical approach that places students' cultural experiences at the foundation of learning, making instruction more inclusive and meaningful. Its core principles include valuing cultural diversity, creating an inclusive learning environment, connecting content to students' experiences, fostering positive teacher-student relationships, cultural reflection by educators, and employing diverse and flexible teaching strategies to accommodate students' needs (CRT). In the implementation of CRT, students feel culturally valued, motivated, and more actively engaged in the learning process (Kompas.com, 2023).

This model systematically integrates the principles of deep learning and culturally responsive pedagogy. This integration enables contextual, reflective, interdisciplinary, and real-world experience-based learning.

2.4 Cognitive, Affective, and Social Dimensions in Model Integration

The integration of deep learning and ethnomathematics impacts not only cognitive aspects but also affective and social dimensions (Habibi, 2025). Cognitively, students develop more robust conceptual frameworks. Affectively, students demonstrate increased motivation and self-confidence. Socially, culture-based collaborative learning strengthens class identity and cohesion.

This approach also supports the development of metacognition. Reflection on cultural practices encourages students to become aware of their own thought processes, thereby enhancing self-regulation in learning.

2.5 Strategic Implications for Teachers and the Curriculum

Pedagogically, this integration requires:

- Reorientation of instructional design based on local contexts
- Development of teaching materials based on local culture/ethnomathematics
- Teacher training in contextual learning design
- Authentic assessment based on process and reflection

From a policy perspective, this model aligns with the national numeracy enhancement agenda and the Merdeka Curriculum, which emphasizes contextual learning, differentiation, and the strengthening of the eight graduate profiles.

2.6 Implementation Challenges and Mitigation Strategies

Some challenges that may arise include:

- Limited cultural literacy among teachers
- Lack of culture-based instructional materials
- Resistance to pedagogical change
- Time constraints within the curriculum

Mitigation strategies include community-of-practice-based training, collaboration with local cultural figures, and the integration of culture-based digital learning resources.

2.7 Theoretical Contributions and Novelty of the Article

This article offers a conceptual contribution in the form of a five-phase integrative model that explicitly combines the principles of deep learning and ethnomathematics within a numeracy literacy framework. The novelty lies in the systematic synthesis between the global literature on deep learning and contextual ethnomathematics studies in Indonesia

CONCLUSION

The integration of deep learning and ethnomathematics has a strong theoretical and empirical foundation in both global and national educational literature. This approach enhances literacy and numeracy through the contextualization of concepts, critical reflection, and knowledge transfer.

The five-phase integrative model formulated in this article provides a systematic conceptual framework for elementary school teachers to design meaningful, inclusive, and culturally responsive mathematics instruction. In the Indonesian context, this approach not only improves numeracy achievement but also strengthens cultural identity as a source of learning. Therefore, ethnomathematics-based deep learning deserves to be positioned as an innovative pedagogical strategy in elementary education reform.

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