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Implementation of an Ethnomathematics-Based Deep Learning Approach in Mathematics Education: A Case Study of Teaching Practices in Secondary Schools

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A B S T R A C T

Purpose: This study aims to describe the implementation of an ethnomathematics-based deep learning approach in mathematics education at the secondary school level. The primary focus of the study is to analyse how teachers integrate local cultural contexts into the learning process to foster deep conceptual understanding, critical thinking, and reflection.

Methods: This study employed a qualitative, descriptive case study design. The research subjects consisted of one mathematics teacher and 30 eighth-grade students at a secondary school that implements local culture-based learning. Data were collected through participant observation, semi-structured interviews, and documentation of instructional materials and student work. Data analysis was conducted using the interactive model by Miles, Huberman, and Saldaña, which includes data condensation, data presentation, and conclusion. Data validity was ensured through triangulation of sources and techniques.

Results: The findings indicate that the teacher successfully integrated elements of local culture, such as batik motifs and traditional games, as an initial context for exploring concepts in geometry and social arithmetic. Learning took place through stages of exploration, group discussion, contextual problem-solving, and reflection—hallmarks of deep learning. Students demonstrated increased active engagement and the ability to connect mathematical concepts with cultural phenomena around them. However, implementation faced challenges, including time constraints and the complexity of designing activities that deeply connect culture with mathematical concepts.

Conclusion: An ethnomathematics-based deep learning approach has the potential to create meaningful, contextually relevant, and student-centred mathematics learning. The integration of local culture not only aids conceptual understanding but also strengthens students' cultural identity. This study recommends developing instructional modules and providing teacher training to optimise the implementation of this approach.

1. INTRODUCTION

Mathematics education in the 21st century faces the challenge of not only equipping students with procedural skills but also with critical, creative, communicative, and collaborative thinking abilities. Effective mathematics learning must connect abstract concepts to students' real-life contexts, making learning meaningful and relevant. However, the reality on the ground shows that many mathematics teaching practices in schools remain oriented toward memorising formulas and mechanically solving problems, resulting in limited conceptual understanding and low student motivation (Andari et al., 2022).

One approach believed to address this challenge is deep learning. Unlike surface learning, which emphasises only the reproduction of information, deep learning encourages students to understand core ideas, connect new knowledge with prior knowledge, and reflect on their thought processes (Al-Qoyyim & Nabila, 2025). In the context of the Merdeka Curriculum, deep learning is at the core of a pedagogy that demands student-centred, meaningful, and contextual learning (Zainal et al., 2025; Hasruddin et al., 2025).

In parallel with the need for meaningful learning, ethnomathematics has emerged as an approach that recognises mathematics as a cultural product. Mathematical concepts are not confined to the classroom. However, they are also embedded in people's daily activities, such as in batik patterns, traditional house architecture, traditional trading systems, and folk games (Andari et al., 2022; Husain et al., 2025). The integration of ethnomathematics into learning can bridge the gap between formal mathematics in school and students' cultural experiences, making learning more contextual and easier to understand.

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Although much research on ethnomathematics has been conducted, most studies still focus on exploring mathematical elements within a culture (Andari et al., 2022; Rachman et al., 2025). Research on systematically integrating ethnomathematics into a deep learning framework to create meaningful learning experiences remains very limited. Therefore, this study aims to address this gap by exploring the implementation of an ethnomathematics-based deep learning approach in middle school mathematics education, with a focus on the learning process, student activities, and the challenges teachers face.

Deep learning in an educational context refers to a learning process that results in lasting understanding and the ability to transfer knowledge to new situations. Al-Qoyyim and Nabila (2025) conducted a bibliometric analysis and confirmed that the trend in deep learning research in Indonesia has increased significantly since 2025, in line with its designation as a core approach in the Merdeka Curriculum. Continuous activities of exploration, elaboration, confirmation, and reflection characterise deep learning. Hasruddin et al. (2025) add that deep learning requires teachers to design instructional modules that foster critical and creative thinking, as well as to utilise digital technology to enrich the learning experience.

This approach is highly relevant to Vygotsky's theory of social constructivism, which holds that knowledge is constructed through social interaction and collaboration. Oktafiani and Irawan (2026) demonstrated in their classroom action research that deep learning grounded in local maritime wisdom effectively enhances students' critical thinking skills and science literacy. These findings indicate that deep learning impacts not only cognitive aspects but also character development and 21st-century skills.

Ethnomathematics, as introduced by D'Ambrosio, is the mathematics practised by specific cultural groups. Andari et al. (2022) explored mathematical concepts in salt-making educational tourism in Madura, identifying concepts such as circles, rotation, plane figures, social arithmetic, and statistics. This research demonstrates that daily activities such as salt production are rich in mathematical ideas that can serve as a learning context. Similarly, Husain et al. (2025) noted in their literature review that the game of congklak effectively represents basic mathematical operations and character values. This game helps students gradually understand concepts, progressing from the enactive to the symbolic stage, in line with Bruner's learning theory.

The integration of ethnomathematics is also supported by research by Rachman et al. (2025), which introduced traditional games such as engklek and congklak. The results showed that 87% of students were introduced to these traditional games for the first time, and 92% were interested in playing them again. This indicates that ethnomathematics can serve as a bridge to preserve culture while teaching mathematical concepts. Furthermore, Nur et al. (2026) emphasise that integrating local wisdom into sociology instruction strengthens students' cultural identity. The same principle applies to mathematics: when students see mathematics within their own culture, they will value it more and be more motivated to learn it.

Conceptual Framework for the Implementation of Ethnomathematics-Based Deep Learning

Based on a literature review, the conceptual framework of this study integrates three main pillars: (1) the context of ethnomathematics as a source and initial stimulus for learning, (2) deep learning activities that include exploration, discussion, problem-solving, and reflection, and (3) the role of the teacher as a facilitator who designs learning experiences and guides students to develop a deep understanding. The implementation of this approach is expected to result in meaningful, contextually relevant, and student-centred mathematics learning, while also strengthening appreciation for local culture.

2. METHODS

This study employs a qualitative approach with a descriptive case study design. This approach was chosen to gain a holistic, in-depth understanding of implementing an ethnomathematics-based deep learning approach in the natural context of a mathematics classroom. The research was conducted at a public junior high school in [County Name] County, which actively integrates local culture into its learning process. The research subjects consisted of one mathematics teacher, selected through purposive sampling for their experience in developing culture-based learning, and 30 eighth-grade students participating in the learning activities.

Data were collected using three main techniques. Participatory observation was conducted over four sessions to directly observe teacher-student interactions, learning activities, and the use of ethnomathematics media. Semi-structured interviews were conducted with the teacher to explore their understanding, strategies, challenges, and perceptions regarding deep learning and ethnomathematics. Interviews were also conducted with six randomly selected students to understand their learning

experiences. Documentation included an analysis of teaching modules, student worksheets (LKPD), photos of activities, and instructional videos.

Data analysis was conducted interactively following the model proposed by Miles, Huberman, and Saldaña, which includes: (1) data condensation, which is the process of selecting, simplifying, and transforming data; (2) presenting data in the form of narratives and tables; and (3) drawing conclusions and verifying them. Data validity was ensured through source triangulation (comparing data from teachers, students, and documents) and methodological triangulation (comparing data from observations, interviews, and documentation).

3. RESULT AND DISCUSSION

This section presents the research findings based on the analysis of observational data, interviews, and documentation. The findings are divided into three main themes: (1) Instructional Planning and Design, (2) Instructional Delivery, and (3) Implementation Challenges.

Instructional Planning and Design

Teachers designed instruction based on the principles of deep learning and the Merdeka Curriculum. In the instructional modules they developed, teachers explicitly outlined learning objectives that emphasised conceptual understanding and critical thinking skills, rather than merely procedural skills. Ethnomathematics contexts are carefully selected. In geometry lessons, teachers use traditional regional batik patterns as a starting point for exploring symmetry, transformations, and plane figures. In social arithmetic lessons, teachers use the context of the traditional congklak game to help students understand the concepts of profit, loss, and interest.

Hasruddin et al. (2025) emphasise the importance of developing deep learning-based instructional modules that foster critical and creative thinking. This is reflected in the worksheets designed by the teacher, which contain open-ended questions such as “Why does this batik pattern have fold symmetry?” and “How do you calculate the maximum profit in a ‘game of congklak?” These questions encourage students not only to memorise but also to analyse and evaluate.

Implementation of Learning: Ethnomathematics-Based Deep Learning Activities

Observations indicate that learning occurs in several phases that reflect the characteristics of deep learning.

Cultural Exploration Phase: In the first session, the teacher displayed several images of batik motifs and a short video about the batik-making process. Students were asked to observe and identify the geometric patterns that appeared. This activity aligns with the findings of Andari et al. (2022), who found that cultural exploration can be an effective learning method. Students enthusiastically identified the circles, squares, and lines of symmetry they observed.

Discussion and Collaboration Phase: After the exploration, students were divided into small groups. They discussed the worksheet questions. The teacher circulated among the groups to facilitate the discussion, ask guiding questions, and ensure every group member participated. This social interaction is at the core of Vygotsky’s social constructivism, as cited by Husain et al. (2025).

Contextual Problem-Solving Phase: The teacher presents a context-based problem related to culture. For example, “A batik artisan wants to create a new design with rotational symmetry. Help them determine the centre point and the angle of rotation.” This problem requires students to apply the concepts they have learned in an authentic situation. This approach is similar to the Problem-Based Learning (PBL) model implemented by Islamia et al. (2025) and Br—Simbolon & Manurung (2024), which is effective in enhancing mathematical reasoning.

Reflection Phase: At the end of the lesson, the teacher asks students to write a brief reflection on what they learned, how they learned it, and the connection between mathematics and culture. This reflection activity is a key component of deep learning (Al-Qoyyim & Nabila, 2025). One student remarked, “I just realised that batik is actually full of math. Learning has become more fun and less boring.”

Implementation Challenges

Although it has succeeded in creating meaningful learning, implementing this approach is not without its challenges. Teachers acknowledge that designing activities that deeply connect mathematical concepts with culture requires significant time and creativity. “Not all math material is easy to link to local culture,” a teacher explained in an interview. Additionally, time constraints are a major obstacle. The exploration and discussion phases often take longer than planned, so teachers must be skilled at time management.

Another challenge arises from student readiness. Some students, accustomed to conventional learning (lectures and problem-solving exercises), initially found it difficult to adapt to a learning style that demands independence and critical thinking. This aligns with the findings of Islamia et al. (2025), who

noted that low student self-confidence and suboptimal group collaboration can act as barriers to problem-based learning.

The research results show that integrating ethnomathematics into a deep learning framework can create a dynamic and meaningful learning environment. These findings reinforce the argument that mathematics is not an isolated entity but rather an integral part of human life and culture (Andari et al., 2022; Husain et al., 2025). When students are presented with cultural contexts they are familiar with, such as batik or congklak, learning becomes more relevant and easier to understand. This reduces the perception of abstraction that often serves as a barrier to learning mathematics.

The learning process observed in this study reflects a comprehensive, deep learning cycle. It begins with exploration that sparks curiosity, followed by collaborative discussions that build shared understanding, then problem-solving that applies knowledge, and concludes with reflection that solidifies understanding. This cycle aligns with the principles of the Merdeka Curriculum, which emphasises student-centred learning and the development of the Pancasila Student Profile (Zainal et al., 2025; Al-Qoyyim & Nabila, 2025).

The teacher's role as a facilitator is crucial in this approach. Teachers are no longer the sole source of knowledge but rather designers of learning experiences, discussion guides, and catalysts for reflection. This requires a high level of pedagogical competence. Teacher training and mentoring, as conducted by Zainal et al. (2025) and Hasruddin et al. (2025), are essential to ensure that teachers can effectively implement this approach. The use of digital technology, such as the Kahoot and Quizizz apps for interactive quizzes (Hasruddin et al., 2025; Fauzi Muhammad Amin KMS & Ivanna, 2025), can also enrich the learning experience, although its use in this study remains limited.

The challenges teachers face, particularly in instructional design and time management, are common in implementing innovative curricula. Adelia et al. (2026), in their study on the challenges novice teachers face in implementing the Merdeka Curriculum, found that conceptual-pedagogical limitations and structural barriers were the primary issues. Therefore, systemic support from schools—such as providing teacher learning communities and allocating dedicated time for planning—is essential. The development of structured instructional materials, such as teaching modules and worksheets, as recommended by Sembiring et al. (2025) and Kabatiah et al. (2025), can help teachers overcome design challenges.

From the students' perspective, this approach not only enhances conceptual understanding but also fosters cultural awareness. Students come to appreciate local cultural heritage better and view it as a source of knowledge. This aligns with the national educational goal of shaping a generation of character-driven individuals who love their homeland. The findings of Oktafiani and Irawan (2026) regarding the improvement of science literacy and critical thinking through learning grounded in local maritime wisdom provide empirical evidence that similar approaches are effective across disciplines.

4. CONCLUSION

This study concludes that implementing an ethnomathematics-based deep learning approach in middle school mathematics instruction can create meaningful, contextual, and student-centred learning experiences. The integration of local cultural elements, such as batik motifs and traditional games, successfully bridges abstract mathematical concepts with students' real-life experiences, thereby enhancing their engagement and understanding. The learning process—which includes exploration, discussion, problem-solving, and reflection—encourages students to build deep understanding rather than merely memorising procedures.

Although effective, implementing this approach faces challenges, particularly regarding complex instructional design, time constraints, and student readiness. Therefore, sustained support for teachers is needed through training, mentoring, and the development of standardised instructional materials. This study contributes to the development of innovative mathematics learning practices that address 21st-century needs and align with the spirit of the Merdeka Curriculum. Further research is recommended to test the effectiveness of this approach using quantitative or mixed-methods approaches, as well as to explore its application to a wider variety of mathematics topics and cultural contexts.

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