The Evolution of Ethnomathematics in Technology Enhanced Learning in Indonesia

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Abstract.

This study examines the evolution of ethnomathematics in technology-based learning in Indonesia. The study's background highlights the importance of ethnomathematics in Indonesian education and the role of technology in modern learning. This study aims to analyse the integration of ethnomathematics in learning technology, identify specific patterns in technology adoption and adaptation, and reveal existing gaps in practice and research. The methodology used includes a comprehensive literature review and case descriptions. Cases were selected to provide an in-depth picture of how ethnomathematics manifests in daily activities and cultural practices, and how technology is integrated into the learning process. Key findings include patterns in the introduction and exploration of ethnomathematics through technology, the use of technology to connect mathematical concepts with local cultural contexts, and teachers' and students' adaptation of technology. Identified gaps include the gap between the potential of ethnomathematics and its actual implementation, as well as the gap between the availability of technology and its effective use. The study provides recommendations for the teaching practices of teachers, education policymakers, and technology developers, and identifies areas for further exploration in future research.

Keywords: *Ethnomathematics; Technology-Enhanced Learning (TEL); Culture-Based Learning; Mathematics Education; Indonesia; Educational Technology and Case Studies.*

I. INTRODUCTION

Education in Indonesia faces a major challenge in providing students with relevant and meaningful learning. Curricula that are often disconnected from students' cultural contexts can lead to a lack of interest and a deep understanding of mathematical concepts (Prahmana et al., 2021). Ethnomathematics, as the study of mathematics in a cultural context, offers a solution to this challenge. Ethnomathematics recognises that mathematics exists not only in textbooks and classrooms, but also in everyday cultural practices, such as art, crafts, traditional games, and cultural ceremonies (Rosa & Orey, 2016). This approach has the potential to increase student engagement, deepen their understanding of mathematical concepts, and connect learning to real-world experiences.Technological developments have changed the global education landscape, and Indonesia is no exception. Technology-Enhanced Learning (TEL) provides a range of tools and platforms to support mathematics learning, including interactive applications, simulations, and online learning environments (Hendratmoko et al., 2023). The integration of TEL with ethnomathematics has great potential to create a more engaging, contextual, and effective learning experience.

Technology can be used to document, simulate, and explore mathematical concepts found in cultural practices, as well as to facilitate collaboration and communication between students and teachers (Iskandar et al., 2025). Although the potential of ethnomathematics and TEL is enormous, their implementation in Indonesia still faces various challenges. One of these is the gap between traditional knowledge (ethnomathematics) and formal learning practices, which are often separated from the cultural context. Many teachers may lack adequate knowledge or training in ethnomathematics or in integrating it with technology. In addition, access to adequate technology and infrastructure remains a problem in some areas of Indonesia (Subroto et al., 2023). The digital divide can exacerbate inequality in learning opportunities. Furthermore, there is a need for more research on how technology can be used effectively to support ethnomathematics learning in Indonesia. Existing research is often limited to small case studies or evaluations of specific technologies, without providing a comprehensive picture of patterns, gaps, and directions for future research. This study aims to fill this gap by providing an in-depth analysis of the evolution of ethnomathematics in

technology-based learning in Indonesia. This study is important for several reasons. First, it contributes to the understanding of how ethnomathematics and technology can be used to improve the quality of mathematics education in Indonesia.

Second, it identifies specific patterns in the adoption and adaptation of technology for ethnomathematics learning, offering guidance for teachers, curriculum developers, and policymakers. Third, it reveals existing gaps in practice and research, which can serve as a basis for future research. Fourth, it offers practical recommendations to improve the implementation of ethnomathematics and TEL in Indonesia. This study is relevant for policymakers, educators, and educational technology developers. The findings can be used to develop more culturally inclusive curricula, design effective teacher training programs, and develop technologies that support ethnomathematics learning. Thus, this study contributes to efforts to create a more equitable, relevant, and effective education system in Indonesia. This research focuses on developing educational technology to support ethnomathematics learning in Indonesia. It covers the use of various technologies, such as mobile applications, online learning platforms, simulation software, and other digital resources. This research will explore how this technology is used to connect mathematical concepts with local cultural contexts, increase student engagement, and facilitate collaboration and communication between students and teachers.

II. METHODS

This study uses a qualitative approach, specifically a case study. The qualitative approach was chosen because it allows researchers to gain an in-depth understanding of the phenomena of ethnomathematics and TEL in the context of Budaya Nusantara Elementary School. Case studies were chosen because they allow researchers to study a single complex case in depth and identify patterns, themes, and relationships that emerge (Yin, 2018). This approach allows researchers to gain a rich and deep understanding of how ethnomathematics and technology are integrated into learning practices. The research design used is a single case study. A single case study was chosen because it allows researchers to focus on a single case representative of the implementation of ethnomathematics and TEL. This study will explore in depth the school context, learning practices, and the experiences of students and teachers. Researchers will collect data from various sources to gain a comprehensive understanding of the phenomenon being studied.

III. RESULT AND DISCUSSION

Evolution of Integration

The integration of ethnomathematics and technology at Budaya Nusantara Elementary School has undergone a significant evolution. Initially, the main focus was on using technology to present information about Sundanese culture and mathematical concepts separately. Teachers used PowerPoint presentations and videos to introduce the subject matter. Over time, the approach evolved into a deeper integration, in which technology was used to facilitate the exploration of mathematical concepts within the context of Sundanese culture. This change was driven by several factors, including improvements in teachers' digital skills, better availability of technological resources, and the school's commitment to culture-based education. Teachers began using mobile applications and simulation software to help students visualise mathematical concepts and explore ideas in greater depth. They also used online learning platforms to facilitate collaboration and communication between students and teachers.

Patterns in Technology-Based Ethnomathematics Learning

This study identified several patterns in technology-based ethnomathematics learning at SD Budaya Nusantara:

1. Introduction and Exploration Pattern: Technology is used to introduce students to ethnomathematics concepts and encourage further exploration. An example is a mobile application that displays traditional Sundanese architecture and related geometric concepts.
2. Pattern of Connecting Abstract Concepts with Cultural Context: Technology is used to connect abstract mathematical concepts with the local cultural context. For example, students use GeoGebra to model geometric shapes found in Sundanese crafts.

3. Pattern of Student Collaboration: Technology is used to facilitate student collaboration in understanding ethnomathematics. Students work in groups using online learning platforms to discuss and solve mathematical problems related to cultural practices.
4. Technology Adaptation Pattern: Teachers and students adapt to technology to meet local needs. Teachers develop learning materials tailored to the Sundanese cultural context, and students learn to use technology to express their understanding of mathematical concepts.

Research conducted at SD Budaya Nusantara reveals several specific findings on the impact of educational technology in ethnomathematics learning. These findings provide a more detailed picture of how technology affects the teaching and learning process and the achievement of learning objectives.

Facilitating Conceptual Understanding Through Technology

One of the main findings is how educational technology effectively facilitates a better understanding of mathematical concepts. The use of mobile applications and simulation software has proven to be very useful in helping students understand abstract concepts. For example, students can use interactive applications to visualise geometric shapes, understand fractions through object division simulations, or explore number patterns in a cultural context. This is in line with the findings (Rosa & Orey, 2016), which emphasise the importance of using tools and models in ethnomathematics to understand mathematical concepts in a holistic context. Technology allows students to interact directly with mathematical concepts. For example, students can use AR (Augmented Reality) applications to view three-dimensional models of geometric shapes in traditional Indonesian architecture, such as houses or mosques. This not only improves conceptual understanding but also makes learning more interesting and relevant. The use of this technology also supports the development of higher-order thinking skills (Hendratmoko et al., 2023).The use of ethnomathematics-based e-modules, such as those developed by Patri and Heswari (2021), has also been shown in improve students' logical thinking skills. These e-modules are designed to use local cultural values in present mathematical concepts, so that students can connect their learning to their daily experiences.

Increased Engagement and Motivation to Learn

Educational technology has been shown to have a significant positive impact on student engagement and learning motivation. Students tend to be more motivated to learn mathematics when they can use technology and connect it to their culture. This is supported by findings from Simamora et al. (2018), who show that guided, discovery-based learning that integrates local culture can improve students' problem-solving and self-efficacy.Engaging learning media, such as AR-based ethnomathematics comics (Pramulia et al., 2024), have been shown in increase students' interest and understanding of the subject matter. These comics combine mathematical concepts with stories relevant to local culture, allowing students to feel more connected to the subject matter.In addition, Android-based applications integrated with culture, such as those developed by Rachman et al. (2025), offer an interactive and enjoyable learning experience. These applications use cultural elements, such as traditional dances, to teach mathematical concepts. This is in line with Borba's (2021) idea about the importance of considering the role of media in learning.

Challenges in Technology Implementation

Although educational technology offers many benefits, its implementation also faces several challenges. Limited access to adequate technology and infrastructure is a major obstacle. Not all students have access to the hardware and internet connection necessary to participate in technology-based learning. In addition, a lack of digital literacy among teachers and students can hinder effective use of technology. This is in line with the findings of (Subroto et al., 2023), which highlight the gap in access to technology and infrastructure in Indonesia. Another challenge is the lack of learning content relevant to the local cultural context and students' needs. Most available learning applications and software were developed outside Indonesia and may not be relevant to students' culture and experiences. Therefore, it is necessary to develop learning materials adapted to the local cultural context, as suggested by Wulandari et al. (2024).

In addition, adequate teacher training in using technology and integrating it with ethnomathematics is essential. Teachers need the skills to develop and use technology effectively in learning, as well as to connect mathematical concepts to the local cultural context. This study identifies several gaps in the implementation of technology-based ethnomathematics. The first gap is between the potential of technology

and the reality of its implementation. Although technology offers many opportunities to improve learning, its implementation is often constrained by limited access, insufficient teacher training, and a lack of relevant content.The second gap is between the availability of technology and its effective use. Although many schools have access to technology, it is not necessarily used optimally in learning. This is due to a lack of knowledge about how to use technology effectively to support ethnomathematics learning.The third gap is in curriculum or policy support. Existing curricula may not fully support the integration of ethnomathematics and technology. There needs to be policies that support the development and use of ethnomathematics-based learning materials, as well as adequate teacher training.

Patterns in Technology-Based Ethnomathematics Learning

This study also identified several patterns in technology-based ethnomathematics learning. These patterns provide an overview of how technology is used to support ethnomathematics learning at SD Budaya Nusantara.The first pattern is the introduction and exploration of ethnomathematics through technology. Students use technology to learn mathematical concepts related to their culture. For example, students can use applications to learn geometric patterns in traditional architecture or use simulations to understand the concept of proportion in traditional crafts.The second pattern is the use of technology to connect abstract mathematical concepts with the local cultural context. Teachers use technology to present mathematical concepts in contexts that are relevant to students' experiences. For example, teachers can use videos or images to illustrate how mathematical concepts are applied in daily activities and cultural practices. This is in line with the idea (Furuto, 2014) of the importance of connecting learning with students' cultural knowledge. The third pattern is student collaboration in using technology to understand ethnomathematics. Students work in groups to complete tasks that use technology to learn mathematical concepts related to their culture. For example, students can work together to create multimedia presentations on the application of mathematics in traditional arts or to create simple applications that teach mathematical concepts in a cultural context.The fourth pattern is the adaptation of technology by teachers and students to accommodate local needs. Teachers and students actively modify and adapt available technology to meet their own needs. For example, teachers can develop additional learning materials or adapt existing applications to suit the local cultural context better. Students can use technology to create projects that reflect their own interests and experiences.

Discussion

The above findings provide valuable insights into the evolution of ethnomathematics in technology-based learning. The following discussion will explore the implications of these findings in greater depth, linking them to the existing literature and analysing the factors that drive this evolution.The main findings of this study indicate that educational technology has great potential to enhance learning in ethnomathematics. Technology facilitates better conceptual understanding, increases student engagement, and motivates them to learn. However, implementing technology also faces several challenges, including limited access, low digital literacy, and a lack of relevant content. The improvement in conceptual understanding through technology can be explained by technology's ability to visualise abstract concepts and connect them to the real world. Mobile applications, simulation software, and other interactive media allow students to interact directly with mathematical concepts, making them easier to understand. This is in line with the view (Were, 2003) that emphasises the role of objects as agents that activate mathematical thinking.Increased engagement and motivation to learn can be explained by technology's ability to make learning more interesting and relevant. The use of technology allows teachers to present lesson material in engaging ways for students, such as through AR-based ethnomathematics comics or Android applications that integrate culture. This is in line with the idea (Morales-Chicas et al., 2019) of the importance of using a culturally responsive approach in education. The findings of this study are in line with many previous studies on ethnomathematics and educational technology.

Many studies have shown that integrating ethnomathematics can improve understanding of mathematical concepts, increase student engagement, and improve learning outcomes. For example, research (Simamora et al., 2018) shows that guided discovery learning that integrates local culture can improve students' problem-solving abilities and self-efficacy. This research also supports the idea that technology can

be a powerful tool for facilitating ethnomathematics learning. Technology can be used to present mathematical concepts in contexts that interest students, to visualise abstract concepts, and to connect learning to students' everyday experiences. This is in line with the findings (Sunzuma & Orey, 2021) that emphasise the importance of using an ethnomathematics approach in STEM education.However, this study also highlights the challenges faced in implementing technology. Limited access, lack of digital literacy, and lack of relevant content are major obstacles. This is in line with the findings (Subroto et al., 2023), which show that gaps in access and technological infrastructure can limit the effectiveness of technology implementation in education.Several factors influence the evolution of the integration of ethnomathematics and technology in this case.

The first factor is support from schools and communities. Schools and communities need to provide strong support for integrating ethnomathematics and technology, including access to technology, teacher training, and the development of learning materials.The second factor is teachers' commitment. Teachers need to have a strong commitment to integrating ethnomathematics and technology into learning. They need to be willing to learn and adapt to new technologies, and to develop learning materials relevant to the local cultural context. The third factor is student involvement. Students need to be actively involved in the learning process. They need the opportunity to use technology, collaborate with their peers, and explore mathematical concepts in their cultural context. The fourth factor is the availability of resources and infrastructure. The availability of adequate hardware, software, and internet connections is essential for the successful implementation of technology. In addition, technical support and ongoing training for teachers are also necessary.The gaps identified in this study have important implications for education. The gap between the potential of technology and its actual implementation indicates that efforts to integrate technology into education have not been entirely successful. To address this gap, greater efforts are needed to improve access to technology, train teachers, and develop relevant learning materials. The gap between the availability of technology and its effective use shows that technology is not yet being used optimally in learning.

To address this gap, efforts are needed to improve digital literacy among teachers and students and to develop effective learning strategies that leverage technology's potential.The gap in curriculum or policy support indicates that existing curricula and policies may not fully support the integration of ethnomathematics and technology. To address this gap, efforts are needed to revise curricula and policies and to provide greater support to teachers in integrating ethnomathematics and technology into instruction.The technologies used in this case, such as mobile applications, simulation software, and other interactive media, have important practical implications for education. These technologies can be adopted or adapted for other contexts to enhance learning in ethnomathematics.Mobile applications can be developed to teach mathematical concepts related to local culture. These applications can be designed to be attractive to students, easy to use, and relevant to their daily experiences. This is in line with the idea (Pramulia et al., 2024) about the importance of using attractive media in learning.Simulation software can be used to visualise abstract mathematical concepts. Simulations can help students understand difficult mathematical concepts and see the relationship between mathematics and the real world. This is in line with the idea (Hendratmoko et al., 2023) of the importance of developing higher-order thinking skills.Interactive media, such as videos, images, and animations, can be used to present lesson material in an engaging context. Interactive media can help students engage in learning, understand mathematical concepts, and connect learning to their daily experiences. This is in line with the idea (Lestari et al., 2021) about the importance of using a contextual approach in learning.

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IV. CONCLUSION

This study makes a significant contribution to the understanding of the evolution of ethnomathematics in technology-based learning in Indonesia. The findings of this case study show that educational technology has great potential to improve understanding of mathematical concepts, increase student engagement, and motivate them to learn. However, implementing technology also faces several challenges, such as limited access, low digital literacy, and a lack of relevant content. By overcoming these challenges and following the recommendations provided, Indonesia can harness the potential of

ethnomathematics and educational technology to improve the quality of mathematics education. This study emphasises the importance of a holistic approach in integrating ethnomathematics and technology in education. This involves support from schools and communities, teacher commitment, student engagement, and adequate resources and infrastructure. By implementing this approach, Indonesia can create a more relevant, engaging, and effective learning environment for students. Further research is needed to further explore the potential of ethnomathematics and educational technology in improve the quality of education in Indonesia. The effective integration of technology and cultural context, as suggested by Gueudet et al. (2016), can lead to more meaningful and relevant learning for students.

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