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Ethnomathematics-Based Learning & the Merdeka Curriculum in the Society 5.0 Era: Indonesian Educational Innovation

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A B S T R A C T

This study explores the relevance and effectiveness of ethnomathematics-based learning in supporting the implementation of the Merdeka Curriculum in the era of Society 5.0. Integrating local culture into mathematics education is believed to enhance students' critical thinking, creativity, collaboration, and communication skills. A Systematic Literature Review (SLR) was conducted by analyzing journals and conference proceedings published between 2019 and 2025. The findings show that ethnomathematics improves students' understanding of mathematical concepts through the Merdeka Curriculum. Moreover, this approach addresses the challenges of Society 5.0 by integrating digital technologies into ethnomathematics-based learning. This study contributes to developing a more holistic and contextual learning model that connects local cultural values with educational demands in the Society 5.0 era

INTRODUCTION

Indonesia continues to face considerable challenges in accommodating its cultural diversity in the Society 5.0 era. Although the Merdeka Curriculum has been implemented to modernize the national education system, data shows that Indonesian students' mathematics literacy rank in PISA 2018 was 72 out of 79 participating countries, and in PISA 2022 it was 69 out of 80 (OCDE, 2023; OECD, 2019). This indicates that existing teaching approaches have not fully succeeded in improving students' critical thinking skills. As a country rich in cultural heritage (Muslimahayati & Wardani, 2019), local cultural integration, such as ethnomathematics, could serve as a solution to make mathematics instruction more relevant to local contexts while meeting global demands (Setiani et al., 2023). However, systematically incorporating local cultural elements into teaching remains limited across many Indonesian schools (Yandani & Agustika, 2022).

Previous research has shown that ethnomathematics-based instruction effectively boosts students' comprehension of mathematical concepts through contextual learning (Mei et al., 2021; Nur et al., 2020). Recent research continues to emphasize the importance of integrating ethnomathematics into mathematics education in Indonesia. For instance, Riski et al., (2024) highlighted substantial progress in utilizing ethnomathematical contexts to improve students' comprehension of mathematical ideas rooted in local cultural practices. Similarly, Amreta, (2024) developed a numeracy assessment tool aligned with the Merdeka Curriculum, showing that contextualizing mathematical concepts through indigenous wisdom can effectively foster student understanding. In addition, Hidayat et al., (2023) underscored the significance of ethnopedagogical approaches in preparing science education for the Society 5.0 era, advocating for the integration of digital technologies such as Augmented Reality (AR) and Virtual Reality (VR) to enhance interactivity and learning outcomes.

Despite these promising developments, many theoretical frameworks do not adequately address how this approach can be integrated within the Merdeka Curriculum or effectively respond to the digital transformation emphasized in Society 5.0. According to D'Ambrosio & Rosa (2017), ethnomathematics facilitates blending local traditions with modern mathematical theory, but empirical research on its effectiveness in the digital age remains scarce. Meanwhile, the Merdeka Curriculum underscores project-based education that is relevant to real-world experiences (Kemendikbudristek, 2022). However, few studies explicitly connect ethnomathematics with the Merdeka Curriculum and the demands of Society 5.0, making this research gap particularly significant (Deby & Yahfizham, 2023; Muhammad, 2023; Muhammad et al., 2023).

This study's primary objective is to investigate how ethnomathematics-based learning can support the implementation of the Merdeka Curriculum within the Society 5.0 era. It aims to identify how an ethnomathematical approach can enhance 21st-century skills—such as critical thinking, collaboration, creativity, and communication—that are central to the Merdeka Curriculum. The study also explores the potential of integrating local cultural perspectives into mathematics teaching in a way that is both contextual and relevant to Society 5.0.

Based on the points above, this research is crucial to address Indonesia's mathematics education challenges, especially in fusing local cultural values with contemporary teaching methods. The working hypothesis is that ethnomathematics-based instruction can bridge local and global values, thereby strengthening the Merdeka Curriculum so that future generations excel not only in mathematical competence but also adapt well to the requirements of Society 5.0. Ultimately, the study can inform the development of a more holistic and contextual learning framework in Indonesia.

LITERATURE REVIEW

In response to the demands of Society 5.0, educational approaches must be innovative, technologically aligned, yet still preserve local cultural identity (Harahap et al., 2023; Indra, 2024). Ethnomathematics holds promise for connecting mathematical concepts with cultural traditions, boosting both comprehension and student engagement (D'Ambrosio, 1985; Prahmana & D'Ambrosio, 2020). The Merdeka Curriculum, with its flexibility, opens space for ethnomathematics-based project learning tailored to students' needs (Langoday et al., 2024; Wardani et al., 2023). Moreover, incorporating digital tools—such as Augmented Reality (AR) and Artificial Intelligence (AI)—can further enrich culture-based teaching, thereby addressing the demands of the digital era (Abdullah et al., 2022; Anggraini et al., 2024). The subsequent literature review will delve deeper into the concepts of ethnomathematics-based learning, the Merdeka Curriculum, and the Society 5.0 era.

1. Ethnomathematics-Based Learning

Ethnomathematics-based instruction is a teaching methodology in mathematics that bridges mathematical concepts with local cultural practices. This perspective was introduced in response to the perception that mathematics is often viewed as an abstract discipline disconnected from students' day-to-day experiences (D'Ambrosio, 1985; Prahmana & D'Ambrosio, 2020). Ethnomathematics acknowledges that mathematical ideas do not solely emerge from Western traditions but also evolve through cultural practices passed down through generations within various communities (Imswatama & Lukman, 2018; Pathuddin et al., 2021). In education, ethnomathematics enriches student learning by grounding mathematical concepts in familiar cultural contexts—like batik patterns, traditional measurement systems, and regional games (Prahmana et al., 2021; Widada et al., 2019).

Ethnomathematics often manifests in several key domains. First, mathematical representations in local art and architecture, for instance, the geometric patterns found in batik motifs and traditional carvings in diverse regions of Indonesia (Prahmana & D'Ambrosio, 2020; Rochmad et al., 2020). Secondly, this includes the adoption of long-standing counting approaches that have arisen in various cultural groups—for example, the numeric systems of Papuan tradition, flat-faced geometric concepts in Bugis-Makassar culture, and the day-to-day measurement methods practiced by Bengkulu communities (Pathuddin et al., 2021; Widada et al., 2019). Third, culturally rooted problem-solving strategies—for example, using weaving patterns to understand

geometric transformations and symmetry (Amalia et al., 2021; Mania & Alam, 2021). Additionally, ethnomathematics-based learning can be carried out through project-based activities that merge mathematical principles with tangible cultural customs (Acharya et al., 2021; Prahmana et al., 2021).

2. The Merdeka Curriculum

The Merdeka Curriculum is a teaching paradigm designed to increase flexibility within the educational process, allowing both students and teachers to choose learning methods aligned with their specific needs (Langoday et al., 2024; Wardani et al., 2023). Introduced by the Indonesian Ministry of Education, Culture, Research, and Technology, this curriculum is part of nationwide educational reforms centered on project-based learning, enhanced literacy and numeracy, and differentiated instruction based on individual student needs (Amiruddin et al., 2023; Jauzaa et al., 2024). Rooted in Ki Hadjar Dewantara's educational philosophy, the Merdeka Curriculum grants students freedom in the learning process, while aligning curriculum design with modern developments and industry demands (Maipita et al., 2021; Marthawati & Adi, 2024). By doing so, learners are expected to acquire 21st-century competencies—critical thinking, creativity, communication, and collaboration—that become crucial in Society 5.0 (Bawadi et al., 2023; Cantika et al., 2022).

Implementing the Merdeka Curriculum can be summarized into three primary facets. First, project-based learning is at its core, pushing students to engage with real-world issues that demand creative problem-solving (Bawadi et al., 2023; Wardani et al., 2023). This model also enhances collaboration and communication skills as students work in teams on authentic tasks (Langoday et al., 2024; Maipita et al., 2021; Marthawati & Adi, 2024); Second, an emphasis on literacy and numeracy as fundamental components for lifting educational quality (Cantika et al., 2022). Literacy now includes digital and financial literacy and the capacity to interpret complex information analytically (Jauzaa et al., 2024). Numeracy extends beyond basic mathematical understanding, applying data analysis and mathematical reasoning in real-life problem-solving (Bawadi et al., 2023; Langoday et al., 2024; Marthawati & Adi, 2024); Third, flexible learning—one of the curriculum's trademarks—grants teachers autonomy to adapt instruction to students' conditions and characteristics (Marthawati & Adi, 2024). This approach allows students to explore diverse learning pathways—academic or otherwise—aligned with their personal interests and talents (Amiruddin et al., 2023; Wardani et al., 2023). By enabling flexibility, learning can be more inclusive and adaptive to the technological and social demands of the modern era (Maipita et al., 2021).

3. The Society 5.0 Era

Society 5.0 emphasizes striking a balance between technological advancements and human well-being, aiming to create inclusive, tech-driven communities (Harahap et al., 2023; Indra, 2024). Humans remain at the center of technological progress, harnessing artificial intelligence, the Internet of Things (IoT), and big data to sustainably improve quality of life (Oktaviana et al., 2022; Rahmawati et al., 2021). Society 5.0 counters the Industrial 4.0 concept, which prioritized industrial automation but was criticized for insufficiently incorporating social and human welfare (Burhanuddin & Pharmacista, 2023; Fukuyama, 2018). In response, Society 5.0 aims to seamlessly integrate digital and

physical realms to address various social and economic hurdles confronting global communities.

In education, Society 5.0's philosophy manifests in at least three ways. First is AI-driven adaptive instruction that tailors mathematical learning to individual student needs (Almarashdi et al., 2024; Harahap et al., 2023; Yaraş & Öztürk, 2022). Second, virtual and augmented reality technologies enhance interactive experiences, allowing students to visualize and internalize complex mathematical ideas more effectively (Indra, 2024; Oktaviana et al., 2022; Reyes, 2015). Third, digital approaches to assessment facilitate more accurate and efficient measurement of students' competencies (Burhanuddin & Pharmacista, 2023; Rahmawati et al., 2021). Society 5.0 additionally promotes problem-based pedagogies that encourage real-world problem-solving (Fukuyama, 2018; Marisa, 2021). Overall, these innovations make mathematics learning more engaging and aligned with contemporary needs.

METHODOLOGY

This research utilized a Systematic Literature Review (SLR) to methodically survey literature pertinent to ethnomathematics-based learning, the Merdeka Curriculum, and Society 5.0. An SLR helps identify, evaluate, and synthesize previous studies to draw comprehensive conclusions (Kitchenham et al., 2009; Snyder, 2019). The process included several stages: formulating research questions, searching literature, establishing inclusion/exclusion criteria, selecting relevant sources, summarizing data, and then synthesizing the findings. Initially, the researchers formulated research questions using the PICO (Population, Intervention, Comparison, Outcomes) framework (Booth et al., 2012). This framework ensures that the research focus is structured and well-defined. In the context of this study, Population refers to students and educators within the Indonesian education system engaged in mathematics learning. The Intervention involves the implementation of ethnomathematics-based instructional approaches, while the Comparison may include conventional mathematics teaching methods that do not incorporate local cultural elements. The desired Outcomes include improved conceptual understanding, increased student engagement, and the development of 21st-century skills such as critical thinking and creativity. By employing the PICO framework, the research questions become more precise and relevant, effectively guiding the selection and analysis of literature included in this review. Four research questions emerged: (1) How is ethnomathematics-based learning implemented within the Merdeka Curriculum? (2) What is the impact of ethnomathematics-based learning on students' mathematical understanding in the Merdeka Curriculum context? (3) How does ethnomathematics-based learning address the challenges of the Society 5.0 era? (4) What research gaps remain regarding the integration of ethnomathematics in mathematics instruction? By formulating these research questions, the study aims to present a comprehensive synthesis of the existing literature and contribute meaningfully to the advancement of ethnomathematics-based instructional approaches in the Indonesian educational context.

In the second stage, the authors performed a literature search across Google Scholar and Scopus, using keywords such as "Ethnomathematics-Based Learning," "Merdeka Curriculum," and "Society 5.0." Relevant articles were screened and summarized, focusing on 2019–2025 publications.

The third stage established inclusion and exclusion criteria. These included works studying ethnomathematics and the Merdeka Curriculum, ethnomathematics in the Society 5.0 context, and results published in national or international journals or proceedings. Irrelevant, duplicate, or non-peer-reviewed articles will be eliminated.

Fourth, selected references were filtered based on these criteria. A total of 21 articles were ultimately considered: 10 on Ethnomathematics and the Merdeka Curriculum, and 11 on Ethnomathematics in Society 5.0 contexts. The findings from these articles were then mapped against the research questions.

RESULTS AND DISCUSSION

A total of 21 articles were found to be relevant to the specified keywords. The researchers then examined studies related to Ethnomathematics, the Merdeka Curriculum, and the Society 5.0 era. Data connected to Ethnomathematics and the Merdeka Curriculum were compiled and recorded, as shown in Table 1.

Table 1. Research Findings on Ethnomathematics and the Merdeka Curriculum

No.	Sources	Journal Name	Authors/ Year	Research Findings
1.	Google Scholar	Seminar Nasional FITK Universitas Negeri Surabaya	Syafitri & Wiryanto 2022	This research investigates the geometric principles of the Gajah Mungkur house in Gresik, illustrating how ethnomathematics can be applied within the Merdeka Curriculum.
2.	Google Scholar	Prosiding Seminar Nasional Pascasarjana, Universitas Negeri Semarang	Iswara et al. 2022	This study explores the implementation of ethnomathematics within the Merdeka Curriculum through cultural hybridization in Semarang City, integrating mathematical concepts into local cultural elements such as Warak Ngendhog, the Denok Deblong dance, and lumpia as learning media.
3.	Google Scholar	MEGA: Jurnal Pendidikan Matematika, 4 (1)	Kiranasari & Suparni 2023	This study investigates how ethnomathematics can be incorporated into mathematics instruction by using Purworejo's distinctive

No.	Sources	Journal Name	Authors/ Year	Research Findings
				market snacks (clorot, geblek, and jenang krasikan), which inherently cover concepts related to plane shapes, solid figures, and measurement units under the Merdeka Curriculum.
4.	Google Scholar	Prosiding Diskusi Panel Nasional Pendidikan Matematika, Universitas Indraprasta PGRI Jakarta	Indriyani et al. 2023	This study explores the ethnomathematics embedded in the traditional snack rengginang as a medium for mathematics learning under the Merdeka Curriculum.
5.	Google Scholar	PRISMA, Prosiding Seminar Nasional Matematika	Maulana & Munahefi 2024	The implementation of Constructivist theory in ethnomathematics-based mathematics instruction under the Merdeka Curriculum grants students the freedom to construct culturally grounded mathematical knowledge.
6.	Google Scholar	Lebesgue: Jurnal Ilmiah Pendidikan Matematika, Matematika dan Statistika	Della et al. 2024	This study explores the ethnomathematical concepts involved in making "kerak telor" as a geometry-based medium for mathematics learning under the Merdeka Curriculum.
7.	Google Scholar	Jurnal Penelitian Pembelajaran Matematika Sekolah (JP2MS), 8 (3)	Ristayani et al. 2024	An ethnomathematics-based Merdeka Curriculum teaching module centered on the North Sumatran Ulos textile, which has been shown to be highly valid, practical, and effective in enhancing students' understanding.
8.	Google Scholar	GeoScienceEd: Jurnal Pendidikan, Sains, Geologi,	Aulya et al. 2024	An ethnomathematics-based Merdeka Curriculum module focused on planar geometry for second-grade elementary

No.	Sources	Journal Name	Authors/ Year	Research Findings
		dan Geofisika, 5 (4)		students, proven to be highly valid and practical in enhancing students' understanding.
9.	Google Scholar	Seminar Nasional FITK UIN Jakarta	Sarah et al. 2024	The Central Kalimantan culture-based e-module on geometric transformations, designed to support the Merdeka Curriculum, has proven effective in enhancing students' understanding.
10.	Scopus	International Journal of Education and Practice, 13 (1)	Purwanto et al. 2025	Mathematics teachers generally view ethnomathematics-based learning under the Merdeka Curriculum in a positive light, although practical challenges persist in its implementation.

Subsequently, the findings on Ethnomathematics and the Society 5.0 era have been compiled and documented as shown in Table 2.

Table 2. Research Findings on Ethnomathematics-Based Learning and the Society 5.0 Era

No.	Sources	Journal Name	Authors/ Year	Research Findings
1.	Scopus	Advances in Social Science, Education and Humanities Research (Atlantis Press), 467	Setiana 2020	The role of ethnomathematics in education for shaping national character during the Society 5.0 era, by integrating cultural values into mathematics instruction to minimize the negative impacts of the industrial revolution.
2.	Scopus	Sustainability (Switzerland), 14(10)	Johnson et al. 2022	The use of an ethnomathematics-oriented learning application coupled with a Bayesian network significantly enhances students' comprehension. Findings indicate that weaving local cultural

No.	Sources	Journal Name	Authors/ Year	Research Findings
				elements into mathematics instruction contributes to greater student interest and improved academic performance.
3.	Google Scholar	Al-Ishlah: Jurnal Pendidikan, 14(1)	Abdullah et al. 2022	Augmented Reality–based mathematics learning media employing an ethnomathematical approach has been shown to enhance students' geometry comprehension and increase their learning motivation.
4.	Google Scholar	Jurnal MATH-UMB.EDU, 9(3)	Nugroho 2022	The Math with Culture (MC) application, introduced as an innovative ethnomathematics-based learning medium in the Society 5.0 era, has been proven effective in enhancing students' mathematical comprehension.
5.	Google Scholar	Prosiding Santika 3: Seminar Nasional Tadris Matematika UIN K.H. Abdurrahman Wahid Pekalongan	Setiani et al. 2023	The role of ethnomathematics in mathematics instruction during the Society 5.0 era supports students in understanding mathematical concepts within their own social and cultural contexts, while also enhancing problem-solving skills through the integration of technology.
6.	Google Scholar	AsTEN Journal of Teacher Education, 8(1)	Supriadi & Hanif 2024	Designing a mobile learning application grounded in Sundanese ethnomathematics to help students grasp mathematical concepts

No.	Sources	Journal Name	Authors/ Year	Research Findings
				through three traditional Sundanese games.
7.	Google Scholar	JOEAI *(Journal of Education and Instruction)*, 7(2)	Anggraini et al. 2024	An Augmented Reality-based learning application that adopts an ethnomathematical approach using the Lengkong traditional house has demonstrated significant improvements in students' geometric understanding and learning motivation.
8.	Google Scholar	International Journal of Multidisciplinary Research and Analysis, 7(3)	Romadon & Kartika 2024	An Augmented Reality-based Student Worksheet utilizing an ethnomathematical approach has been shown to effectively boost elementary students' understanding.
9.	Google Scholar	Indonesian Journal of Science and Mathematics Education (IJSME), 7(3)	Payadnya et al. 2024	This study emphasizes the need for culturally responsive teaching methods to bridge the gap between theory and practice in today's digital education landscape.
10.	Google Scholar	Jurnal Sains, 3(1)	Putri et al. 2024	Local culture, when utilized as an ethnomathematical component in mathematics instruction and supported by Society 5.0 technologies, enhances students' mathematical literacy.
11.	Google Scholar	Prosiding Seminar Nasional Inovasi Pendidikan Dasar pada Kurikulum Merdeka	Khasanah et al. 2024	Augmented Reality-based learning media integrated with ethnomathematics has been proven effective in improving students' understanding and motivation.

(RQ1) how is Ethnomathematics-Based Learning Implemented Within the Merdeka Curriculum?

Ethnomathematics-based instruction in the Merdeka Curriculum attempts to connect mathematical concepts with local wisdom, thereby making it more contextual and meaningful to students. The curriculum's flexibility empowers teachers to create culturally relevant teaching materials aligned with each learner's context (Iswara et al., 2022; Maulana & Munahefi, 2024). Mathematics thus transitions from being taught as a purely abstract subject to one that resonates with cultural experiences and everyday life. For instance, batik or wood carvings can illustrate geometric patterns and symmetry, while Papua's traditional numeric systems can be incorporated as real-life numeracy tools (Kiranasari & Suparni, 2023; Ristayani et al., 2024).

The Merdeka Curriculum supports various culturally oriented projects within its emphasis on project-based instruction (Prahmana et al., 2021; Purwanto et al., 2025). Students not only learn theoretical concepts but also explore cultural artifacts in their vicinity. For example, local foods like kerak telor and rengginang provide hands-on ways to study geometry and volume measurement (Della et al., 2024; Indriyani et al., 2023). Such methods help students see mathematical ideas in everyday contexts and sharpen their problem-solving skills (Sarah et al., 2024; Syafitri & Wiryanto, 2022).

The success of this ethnomathematics approach often depends on teacher readiness and the availability of standardized resources. Studies indicate varying levels of teacher familiarity with ethnomathematics, with many teachers still at a moderate level of understanding (Aulya et al., 2024; Purwanto et al., 2025). Consequently, teacher training on this method is paramount to ensure effective classroom implementation. Moreover, cultural-based teaching resources—such as modules centered on Ulos textile patterns or Gresik's traditional houses—serve as excellent learning materials (Ristayani et al., 2024; Syafitri & Wiryanto, 2022).

(RQ2) what is the Impact of Ethnomathematics-Based Learning on Students' Mathematical Understanding in the Merdeka Curriculum Context?

Integrating ethnomathematics into mathematics classes under the Merdeka Curriculum yields positive outcomes. Research reveals that culturally contextualized teaching sparks stronger student engagement and deeper conceptual grasp (Iswara et al., 2022; Kiranasari & Suparni, 2023). Learning symmetry, for example, through local fabrics or cuisine patterns, fosters clearer comprehension compared to abstract numerical examples. This aligns with constructivist theory, which encourages students to build understanding via hands-on encounters (Maulana & Munahefi, 2024).

Ethnomathematics-based learning also enhances critical thinking and problem-solving abilities. Students who discover math via cultural exploration more readily connect mathematical theories to real-world scenarios (Della et al., 2024; Indriyani et al., 2023). In geometry lessons, they might analyze motifs on traditional houses or carvings, aiding them in recognizing different 2D and 3D shapes. This immersive approach not only enriches their conceptual

understanding but also refines analytical skills—skills that have broader uses beyond the classroom (Aulya et al., 2024; Sarah et al., 2024).

Despite these benefits, challenges persist. Some schools do not yet have the necessary resources—such as culturally grounded learning modules—to support full implementation (Ristayani et al., 2024; Syafitri & Wiryanto, 2022). Many teachers also lack familiarity with ethnomathematics principles, limiting its classroom use. Thus, ongoing teacher development programs are vital for integrating ethnomathematics effectively (Maulana & Munahefi, 2024; Purwanto et al., 2025).

(RQ3) how Does Ethnomathematics-Based Learning Address the Challenges of the Society 5.0 Era?

Society 5.0 brings significant changes to educational landscapes, including mathematics instruction. Ethnomathematics can anchor math lessons in cultural contexts, helping students see mathematics as something more tangible and authentic (Setiana, 2020; Setiani et al., 2023). Students thus learn not just numbers and formulas but also how to apply mathematical principles in culturally informed ways. Such an approach aligns with Society 5.0's vision to integrate advanced technology and human values to create personalized, contextual learning (Nugroho, 2022; Putri et al., 2024). Furthermore, the ethnomathematical approach aligns with the project-driven learning paradigm, recognized as one of the primary pillars in both the Merdeka Curriculum and Society 5.0 (Khasanah et al., 2024; Romadon & Kartika, 2024).

In practice, ethnomathematics can be merged with AI or digital technologies to let students study culture-based math more interactively (Anggraini et al., 2024). For example, augmented reality (AR) and virtual reality (VR) can visually depict geometric aspects of batik patterns or indigenous houses, emphasizing concepts of symmetry and transformation (Abdullah et al., 2022). Digital platforms could also integrate region-specific counting or measurement methods into interactive exercises (Putri et al., 2024; Setiani et al., 2023). Research on integrating ethnomathematics from Sunda tradition into mobile learning solutions for elementary students even highlights growth in creative thinking (Supriadi & Hanif, 2024). Additional research indicates that employing culture-oriented instructional models can significantly heighten students' engagement in grasping abstract concepts, particularly in technology-based environments (Johnson et al., 2022). In this manner, learning not only becomes more captivating but also better aligns with students' needs in today's digital age, where technology plays a pivotal role in numerous aspects of everyday life (Khasanah et al., 2024; Nugroho, 2022).

Moreover, an ethnomathematical approach is highly relevant for confronting the demands of the Society 5.0 era, as it enables students to develop culturally grounded critical thinking and problem-solving skills (Setiani et al., 2023). One of the most significant hurdles in present-day math education is Indonesia's low level of mathematical literacy, as evidenced by PISA results that remain below the global average (Romadon & Kartika, 2024). By weaving local cultural elements into math lessons, learners can perceive the connections between mathematics and their everyday lives more easily, facilitating both comprehension and application in various scenarios (Khasanah et al., 2024; Payadnya et al., 2024; Putri et al., 2024). Additionally, Society 5.0 stresses the

importance of values-based and culturally oriented education to develop students who can better adapt to technological and social transformations (Nugroho, 2022; Setiana, 2020). Consequently, combining ethnomathematics with Society 5.0 technologies can serve as an innovative strategic approach for boosting the quality of mathematics education across Indonesia.

(RQ4) what Research Gaps Remain Regarding the Integration Of Ethnomathematics in Mathematics Instruction?

Despite substantial research on ethnomathematics-based instruction, several gaps remain. One key shortfall is the limited empirical exploration of its long-term effects on students' numeracy skills. Studies have mostly centered on conceptual and theoretical frameworks, whereas large-scale empirical data on how ethnomathematics boosts numeracy and digital literacy under the Merdeka Curriculum is still lacking (Sarah et al., 2024). Additionally, few studies discuss how AI-powered personalization might bolster ethnomathematics-based learning (Anggraini et al., 2024; Maulana & Munahefi, 2024; Setiana, 2020).

Another major gap concerns the use of virtual reality and augmented reality within ethnomathematics-based learning. Most existing studies tend to focus on cultural objects as teaching media, without examining in depth how AR and VR technologies could be leveraged to help students more interactively explore math concepts grounded in local culture (Payadnya et al., 2024). While these tools show promise for improving engagement, empirical research on their effectiveness in project-based learning under the Merdeka Curriculum is still quite limited (Indarta et al., 2022; Nugroho, 2022; Wahyudiono, 2023).

Finally, ethnomathematics research has focused heavily on certain regions—like Java or Bali—while underrepresenting the practices in Sumatra, Kalimantan, or Papua (Cantika et al., 2022). Broader studies are needed to develop adaptable ethnomathematics approaches that honor the rich cultural diversity across Indonesia (Bungawati, 2022; Indriyani et al., 2023; Lestari et al., 2023; Nurhusain et al., 2022). Therefore, further research is essential to develop more flexible and culturally contextualized ethnomathematics-based instructional models that can be effectively implemented across diverse regions of Indonesia. Such efforts would allow for broader adoption of culturally relevant mathematics education, tailored to the unique local traditions and learning environments found throughout the country.

CONCLUSION AND RECOMMENDATION

Ethnomathematics-based learning within the Merdeka Curriculum is an inventive approach connecting mathematical concepts with local cultural identity, making math instruction more contextual. The curriculum's flexibility allows educators to design culturally relevant teaching materials that cater to students' local environments. Implementations of ethnomathematics may involve exploring batik for geometry, traditional measurements for quantity concepts, or folk games to illustrate probability or numeric patterns. Studies indicate that weaving cultural values into mathematics heightens students' engagement and improves conceptual mastery. Nevertheless, obstacles remain—

such as resource constraints, teacher preparedness, and a lack of standardized guidelines to scale up adoption across schools.

Evidence suggests that ethnomathematics has a positive effect on students' learning within the Merdeka Curriculum framework, helping them better comprehend abstract concepts by linking mathematical principles to real-life experiences. This approach also fosters critical thinking, creativity, and problem-solving skills—key competencies in the Merdeka Curriculum. However, additional inquiry is required to verify its effectiveness across all educational levels and in different cultural settings, given Indonesia's cultural complexity.

In the Society 5.0 era, ethnomathematics is increasingly pertinent. Society 5.0 calls for learners who are technologically adept yet grounded in cultural and humanistic values. Integrating cultural dimensions within math education alongside digital innovations like AR/VR and AI offers a strategic path to modernizing instruction without discarding local heritage. This synergy could produce a more adaptive learning environment for students, guiding them to grasp mathematical concepts in a way that respects cultural roots and leverages cutting-edge technology.

Although various studies have been conducted, considerable gaps remain. There is a shortage of robust, long-term data on how ethnomathematics shapes numeracy outcomes at all education levels. Research on using sophisticated digital tools, like AI-driven adaptive learning for ethnomathematics, is also minimal. Moreover, ethnomathematics-based strategies are typically studied in only a few regions, leaving many Indonesian cultural contexts underexplored. Future research is therefore essential to refine and expand ethnomathematics-based learning models to accommodate Indonesia's vast cultural diversity. By addressing these gaps, mathematics education can become more relevant, contextual, and aligned with the digital revolution's demands.

Based on the research findings, it is recommended that ethnomathematics-based learning be systematically integrated into the Merdeka Curriculum through the development of thematic instructional modules that incorporate local cultural elements alongside mathematical concepts. To support this integration, it is imperative for policymakers and educational authorities to provide comprehensive professional development programs aimed at enhancing teachers' competencies in designing and implementing culturally responsive pedagogy while also utilizing digital technologies such as Augmented Reality (AR), Virtual Reality (VR), and Artificial Intelligence (AI). Furthermore, stronger collaboration among schools, local cultural communities, and higher education institutions is essential for the co-creation of contextualized and engaging educational resources tailored to regional characteristics. This approach is expected to foster an inclusive, adaptive, and culturally relevant mathematics education aligned with the competencies required in the Society 5.0 era.

FUTHER STUDY

This study is limited in its geographical scope, as it primarily focuses on regions such as Java and Bali where ethnomathematical documentation is more readily available. Consequently, the findings may not fully capture the cultural diversity that characterizes the broader Indonesian context. Additionally, the current approach does not encompass long-term evaluations of the impact of ethnomathematics-based instruction on students' numeracy literacy across various educational levels. Therefore, future research is encouraged to expand the scope to include underexplored regions with rich yet undocumented cultural traditions. Moreover, longitudinal studies and controlled experiments are recommended to assess the sustained effectiveness and explore the potential of integrating advanced technologies in the personalization of ethnomathematics-based learning.

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