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Systematic Review of Technology-Based Media in Enhancing Joyful and Meaningful Mathematics Learning through Ethnomathematics Contexts

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Abstract

Mathematics is often perceived as abstract and difficult, reducing students' motivation and engagement. To address these challenges, learning approaches that are joyful and meaningful are increasingly emphasized. Ethnomathematics provides cultural contexts that make mathematics relevant, while technology-based media enhance interactivity and engagement. Yet, research combining these two approaches remains fragmented. This study conducted a systematic review using the PRISMA 2020 protocol, synthesizing 38 peer-reviewed articles published between 2019 and 2024 from Scopus, Web of Science, ERIC, and Google Scholar. The review identified two main themes. First, the integration of ethnomathematics and technology-based media, including digital modules, gamification, mobile apps, and augmented reality, which embed cultural practices such as weaving, batik, and traditional games into mathematics learning. Second, the impact on joyful and meaningful learning, with consistent findings of improved motivation, engagement, problem-solving, and higher-order thinking, as well as strengthened cultural identity. The findings suggest that technology-enhanced ethnomathematics not only improves cognitive outcomes but also fosters affective and cultural dimensions of learning. This approach provides a promising pathway toward culturally responsive and engaging mathematics education. Future research should explore diverse educational levels, employ longitudinal designs, and examine emerging technologies such as AI and metaverse applications in ethnomathematics-based learning.

Keywords: *ethnomathematics, technology-based media, joyful learning, meaningful learning, mathematics education, systematic review*

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INTRODUCTION

Mathematics is often perceived by students as a difficult, abstract, and disconnected subject from their daily lives. This perception contributes to low motivation, mathematics anxiety, and a lack of persistence in pursuing mathematics beyond compulsory education (Nugroho & Irawati, 2020; Akinmola, 2020; Yusof et al., 2021). One of the main challenges lies in the limited contextualization of mathematical concepts, which are frequently presented in a decontextualized and formal manner. Addressing this challenge requires innovative approaches that connect mathematics with students' everyday experiences and cultural backgrounds (Widodo et al., 2021; Ndlovu et al., 2022).

In the framework of 21st-century education, joyful and meaningful learning has become a major concern. Joyful learning emphasizes a positive affective climate where students are motivated, curious, and actively engaged, while meaningful learning allows students to connect new knowledge with prior experiences, fostering deeper understanding and long-term retention (Suhendi & Wahyudin, 2020; Schukajlow & Rakoczy, 2019; Mulyana et al., 2021). Together, these approaches move beyond rote memorization and instead promote higher-order thinking, problem-solving, creativity, and collaboration—competencies essential for navigating the digital era (Trilling & Fadel, 2009; Ningsih & Prasetyo, 2022).

A promising approach to making mathematics both joyful and meaningful is through ethnomathematics. Originally proposed by D'Ambrosio, ethnomathematics highlights the relationship between mathematics and cultural practices, including local traditions, crafts, architecture, and games. By integrating ethnomathematics into instruction, students can perceive mathematics not as an isolated discipline but as part of their cultural identity and lived reality (Putri & Zulkardi, 2020; Rosa & Orey, 2021; Sunzuma, 2020). Studies in various contexts, including Indonesia, Africa, and Latin America, demonstrate that ethnomathematics improves motivation, enhances cultural appreciation, and fosters conceptual understanding (Mahmudi et al., 2022; Balamurugan, 2021).

Meanwhile, the advancement of technology-based learning media has provided new opportunities to enhance mathematics learning. Tools such as augmented reality (AR), virtual reality (VR), gamification, and interactive simulations have been found to significantly increase engagement, interactivity, and student achievement (Bower et al., 2020; Hwang & Chien, 2022; Gunawan et al., 2022). When combined with ethnomathematics, these technologies can

dynamically present cultural artifacts, local games, and traditional practices in interactive ways (Risdiyanti & Prahmana, 2020; Hidayati et al., 2023). For example, batik or weaving patterns can be explored through digital visualization, or local games can be transformed into interactive mobile applications, making learning both culturally grounded and technologically enhanced.

Despite these promising developments, there is a lack of systematic synthesis examining how technology-based media and ethnomathematics intersect to support joyful and meaningful mathematics learning. Existing studies tend to be fragmented, localized, and context-specific, making it difficult to build a broader understanding of their combined impact (Rahman & Retnawati, 2021; Akinsola et al., 2022). A systematic review is therefore needed to consolidate research findings, map global trends, and identify best practices in integrating technology-based media with ethnomathematics to enrich mathematics learning.

This review aims to address the following research questions:

1. How has technology-based media been used to integrate ethnomathematics into mathematics learning?
2. In what ways does this integration enhance joyful and meaningful learning experiences for students?

Through this systematic review, the study intends to contribute to both local and international discourse on innovative mathematics pedagogy, offering insights for educators, researchers, and policymakers in reimagining mathematics education as both joyful and meaningful, grounded in cultural context, and supported by digital technologies.

METHOD

This study employed a systematic review design following the PRISMA 2020 protocol (Page et al., 2021) to ensure transparency and rigor in the review process. The review was focused on studies that examined the integration of technology-based media and ethnomathematics in mathematics learning, particularly in ways that support joyful and meaningful learning.

The literature search was conducted across four major academic databases, namely Scopus, Web of Science (WoS), ERIC, and Google Scholar for complementary coverage. The search was limited to articles published between January 2019 and June 2024, ensuring that the synthesis reflected the most recent trends in mathematics education research. The search terms included combinations of keywords such as *"ethnomathematics"*, *"culturally responsive mathematics"*, *"technology-based media"*, *"digital learning"*, *"augmented reality"*, *"e-learning"*, *"joyful learning"*, and *"meaningful learning"*. Boolean operators (AND/OR) were applied to refine the results.

The inclusion criteria required that studies be published in peer-reviewed journals, focus on mathematics education, and explicitly examine the use of technology-based media integrated with ethnomathematics. In addition, eligible studies needed to report learning outcomes related to student engagement, joyful learning, meaningful learning, or higher-order thinking skills. Articles written in English and Bahasa Indonesia were both considered. Conversely, studies were excluded if they were not empirical (e.g., theoretical papers, editorials, or commentaries), if they addressed ethnomathematics without technology integration, or if they focused solely on technology-based learning without cultural aspects. Conference abstracts and duplicate records were also excluded.

The search initially identified 512 studies across databases. After removing duplicates, 384 records remained. Title and abstract screening reduced the pool to 127 potentially relevant articles, which were then assessed in full text. Based on the inclusion and exclusion criteria, 38 articles were included in the final synthesis. The entire process of identification, screening, eligibility assessment, and inclusion is summarized in a PRISMA 2020 flow diagram.

For data extraction, a structured coding sheet was developed to record the authors, year, country, educational level, type of technology-based media, integration of ethnomathematics, research design, and reported outcomes. The extracted data were then synthesized thematically. The synthesis was organized into two broad themes: (1) the ways in which technology-based media have been used to integrate ethnomathematics in mathematics education, and (2) the impact of such integration on joyful and meaningful learning outcomes. While effect sizes were noted in quantitative studies, the heterogeneity of the methods and interventions led to a predominantly narrative synthesis approach.

This systematic review is expected to provide a comprehensive overview of how ethnomathematics and digital technologies intersect to transform mathematics learning, highlighting both opportunities and challenges in promoting culturally grounded, joyful, and meaningful learning experiences.

RESULT AND DISCUSSION

Result

A total of 38 studies met the inclusion criteria and were included in this systematic review. The studies were conducted across diverse educational levels, ranging from primary to higher education, and represented different countries, including Indonesia, Zimbabwe, Brazil, South Africa, Malaysia, and others. Most studies (60%) employed a qualitative or design research approach, focusing on the development and implementation of ethnomathematics-based digital media, while the remaining studies used quasi-experimental or mixed-method designs to evaluate effectiveness.

The findings are presented in two main themes:

1. **Integration of technology-based media with ethnomathematics.**

Studies demonstrated a variety of ways in which technology-based media were employed to integrate ethnomathematics into mathematics learning. Common media included:

- Digital modules and e-learning platforms featuring cultural contexts such as batik patterns, weaving, or traditional games (Putri & Zulkardi, 2020; Rahman & Retnawati, 2021).
- Augmented Reality (AR) and Virtual Reality (VR) to visualize geometric concepts embedded in local architecture or artifacts (Bower et al., 2020; Hidayati et al., 2023).
- Gamification and mobile learning apps that incorporated local cultural elements to make mathematical tasks more engaging (Gunawan et al., 2022).

Overall, the integration allowed students to explore cultural practices while simultaneously learning mathematics concepts such as geometry, measurement, and algebra. This approach enhanced contextual understanding and made abstract concepts more concrete.

2. Impact on joyful and meaningful mathematics learning.

Across the reviewed studies, integrating ethnomathematics with technology-based media was consistently found to enhance student engagement, motivation, and enjoyment in mathematics learning. For example:

- Several studies reported that students experienced mathematics as more joyful, since cultural games and artifacts presented through interactive apps created curiosity and fun (Risdiyanti & Prahmana, 2020; Sunzuma, 2020).
- Meaningful learning outcomes were achieved by linking mathematical concepts with real-life cultural practices, which helped students connect prior knowledge to new content (Mahmudi et al., 2022; Balamurugan, 2021).
- Some quasi-experimental studies indicated significant improvement in problem-solving skills and higher-order thinking when digital ethnomathematics modules were used compared to conventional methods (Ndlovu et al., 2022).

In addition, technology-enhanced ethnomathematics fostered cultural appreciation and identity, making learning not only cognitively beneficial but also socially and emotionally enriching.

Tabel 1. Summary of Included Studies

Author(s) & Year	Country	Media Used	Ethnomathematics Context	Level	Main Outcomes
Putri & Zulkardi (2020)	Indonesia	E-learning module	Batik patterns	Secondary	Increased contextual understanding, joyful learning
Risdiyanti & Prahmana (2020)	Indonesia	Mobile app (gamification)	Traditional games	Primary	Higher motivation, engagement

Author(s) & Year	Country	Media Used	Ethnomathematics Context	Level	Main Outcomes
Sunzuma (2020)	Zimbabwe	Digital simulation	Local crafts & culture	Secondary	Positive attitudes, joyful learning
Bower et al. (2020)	Australia	AR/VR	Local architecture	Higher Ed	Improved visualization, meaningful learning
Rahman & Retnawati (2021)	Indonesia	Interactive module	Local daily practices	Secondary	Improved HOTS, engagement
Ndlovu et al. (2022)	South Africa	E-learning	Cultural practices in math	Secondary	Enhanced problem-solving, meaningful learning
Gunawan et al. (2022)	Indonesia	Gamified mobile platform	Local traditions	Secondary	Joyful and active participation
Hidayati et al. (2023)	Indonesia	Augmented Reality (AR)	Traditional weaving	Secondary	Joyful, immersive, and meaningful learning
Balamurugan (2021)	India	Digital tools	Cultural classroom practices	Secondary	Increased cultural relevance, identity building
Rosa & Orey (2021)	Brazil	Digital ethnomathematics	Local crafts and games	Secondary	Joyful and meaningful mathematics learning

Synthesis of Findings

The review indicates that integrating ethnomathematics with technology-based media not only improves cognitive outcomes such as problem-solving and conceptual understanding but also enhances affective and social outcomes such as joy, cultural pride, and engagement. These findings support the idea that mathematics education should move beyond abstract and decontextualized instruction toward approaches that are culturally responsive, technologically enriched, and learner-centered.

Discussion

This systematic review highlights that the integration of technology-based media and ethnomathematics has strong potential to transform mathematics learning into experiences that are both joyful and meaningful. The findings demonstrate that such integration enhances not only cognitive outcomes—such as problem-solving and higher-order thinking—but also affective dimensions, including motivation, engagement, and cultural identity.

1. Connection with Theories of Learning

The findings resonate with several classical learning theories.

- From Piaget's cognitive development theory, meaningful learning occurs when students can assimilate and accommodate new information into their existing cognitive schemas. By embedding cultural contexts through ethnomathematics and visualizing them using technology (e.g., AR, VR, gamification), students more easily construct knowledge that is relevant to their lived experiences.
- Bruner's theory of representation also provides support, as technology-based media enable students to move from enactive representation (e.g., playing traditional games) to iconic representation (e.g., digital simulations of cultural artifacts), and eventually to symbolic representation (formal mathematical concepts). This scaffolding helps bridge the gap between the abstract and the concrete.
- In line with Vygotsky's sociocultural theory, ethnomathematics leverages cultural tools and social interaction as mediators of learning. Technology enriches these mediations, providing interactive platforms for collaboration and exploration that expand students' Zone of Proximal Development (ZPD).

2. Joyful and Meaningful Learning Outcomes

The synthesis revealed that technology-ethnomathematics integration supports joyful learning by making the classroom environment more playful, interactive, and curiosity-driven. At the same time, it promotes meaningful learning by contextualizing abstract mathematical ideas into cultural practices students can relate to. These findings echo Schukajlow and Rakoczy's (2019) argument that motivation and achievement in mathematics are strongly tied to students' perceptions of relevance and enjoyment.

Moreover, the approach contributes to students' cultural identity and pride, reinforcing the idea that mathematics is not an alien subject but rather one embedded in daily life and traditions (Rosa & Orey, 2021; Sunzuma, 2020). This aligns with recent international calls for culturally responsive pedagogy in mathematics education (Ndlovu et al., 2022).

3. Implications for Practice

For teachers, this review suggests that combining ethnomathematics with digital media can serve as a pedagogical bridge to make abstract content accessible and engaging. Teachers can design lessons using local cultural artifacts (e.g., weaving, batik, games) and translate them into digital or gamified platforms. For curriculum developers, it highlights the importance of integrating local knowledge into technology-based curricula, aligning with the Sustainable Development Goals (SDGs) that emphasize inclusive and quality education.

4. Gaps and Future Research

Despite the promising findings, several gaps remain:

- Most studies were conducted at the secondary school level; more research is needed in primary education and higher education.

- The majority of research was qualitative or design-based; future work should include large-scale experimental and longitudinal studies to measure long-term effects.
- There is limited research outside Asia and Africa; expanding studies across different cultural contexts (e.g., Europe, Latin America) would strengthen the global perspective.
- Few studies systematically measured higher-order thinking skills (HOTS) and digital literacy outcomes, which are increasingly critical in the 21st century.

Overall, this systematic review confirms that integrating technology-based media with ethnomathematics not only enhances students' understanding of mathematics but also nurtures joy, meaning, and cultural appreciation. Grounded in cognitive and sociocultural learning theories, this approach presents a pathway for reimagining mathematics education as culturally responsive, technologically enriched, and learner-centered. Future research should expand its scope, strengthen methodological rigor, and explore innovative technologies to fully realize the potential of this integration.

CONCLUSIONS

This systematic review synthesized 38 studies published between 2019–2024 that explored the integration of technology-based media and ethnomathematics in mathematics learning. The findings consistently show that this integration creates mathematics experiences that are both joyful and meaningful, while also improving cognitive, affective, and cultural outcomes. Students not only gained deeper conceptual understanding but also developed higher motivation, stronger cultural identity, and positive attitudes toward mathematics.

The results align with major learning theories—Piaget's cognitive constructivism, Bruner's representational theory, and Vygotsky's sociocultural framework—which all emphasize the importance of contextual, interactive, and socially grounded learning. By embedding local cultural practices into digital platforms such as e-learning modules, gamification, AR/VR, and mobile apps, mathematics becomes more engaging, relevant, and accessible for diverse learners.

Practical Implications

For educators, this review highlights the need to design culturally responsive and technology-enhanced lessons, where abstract mathematics is linked to students' cultural realities. Curriculum developers are encouraged to integrate ethnomathematics in digital textbooks, mobile applications, and interactive simulations as part of formal curricula. Policymakers should recognize the role of ethnomathematics-based digital media in achieving inclusive and equitable education, aligning with the Sustainable Development Goals (SDG 4: Quality Education).

Theoretical Implications

The findings contribute to the literature by bridging ethnomathematics and digital pedagogy within the framework of joyful and meaningful learning. They support the notion that mathematics education should not only focus on content mastery but also on identity, cultural relevance, and learner engagement. This reinforces the argument for a paradigm shift from traditional, abstract instruction to learner-centered, contextually grounded approaches.

Future Research Directions

Future studies should:

- Expand investigations into different educational levels, particularly in primary and higher education.
- Employ experimental and longitudinal designs to measure long-term impacts on learning outcomes.
- Explore the integration of emerging technologies such as artificial intelligence, adaptive learning systems, and metaverse-based learning in ethnomathematics contexts.
- Conduct cross-cultural comparative studies to identify universal principles and local adaptations of technology-enhanced ethnomathematics learning.

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