Journal of Emerging Technologies in Ethnomathematics
Year 2025
Vol 1, no 2, 2025, pp. 51-60

Augmented Reality and Ethnomathematics: Bringing Local Wisdom With 21st-Century Learning

Gladys Sunzuma[1*], Lisnani[2], Dini Artika Kusuma Wardhani[3], Zidni Naufal Fadhil[3]

[1]University of Science Education, Bindura, Zimbabwe

[2.3,4]State University of Surabaya, Indonesia,

*gsunzuma@buse.ac.zw

Received: 12 December 2025| Revised: 24 December 2025| Accepted: 29 December 2025 | Published Online: 30 December 2025

Abstract

The integration of Augmented Reality (AR) into ethnomathematics presents an innovative approach to preserving and promoting local cultural knowledge through modern educational technology. The aim of the study was to explore how AR can be used to enhance the teaching and learning of ethnomathematics by bringing local wisdom into 21st-century learning. Ethnomathematics, which studies the relationship between culture and mathematics, provides a unique opportunity to connect students with their cultural heritage while teaching mathematical concepts. The data for this study were collected using three primary techniques: document analysis, observations, and semi-structured interviews. The study employed a qualitative descriptive analysis, supported by content analysis and thematic coding. The findings of the study indicate that integrating Augmented Reality (AR) with ethnomathematics-based content significantly enhances students' understanding of mathematical concepts rooted in local cultural practices. The results of the study carry several important implications for curriculum development, pedagogical practice, and future research in ethnomathematics and digital learning.
Keywords: *Augmented Reality, Ethnomathematics, Local Wisdom, 21st century Learning*

Cite: Sunzuma, G., Lisnani., Wardhani, D. A. K., & Fadhil, Z. (2025). Augmented Reality and Ethnomathematics: Bringing Local Wisdom With 21st-Century Learning. *Journal of Emerging Technologies in Ethnomathematics, 1*(2), 51-60.

INTRODUCTION

Mathematics education in the 21st century faces the dual challenge of preserving cultural relevance while responding to rapid technological advancements. Although mathematics is often perceived as abstract and detached from everyday life (Fauzi & Arisetyawan, 2020), globalization and digital transformation increasingly demand competencies such as critical thinking, problem-solving, creativity, collaboration, and digital literacy. Ethnomathematics, introduced by D'Ambrosio (2016), offers a meaningful pathway to contextualize mathematics by revealing its presence within cultural practices, artifacts, and local wisdom. In Indonesia, for instance, mathematical ideas have been explored through batik patterns, traditional architecture, weaving, and indigenous games (Lisnani, 2020; Permatasari et al., 2021), providing students with learning experiences that connect formal mathematics to their cultural environments.

At the same time, Augmented Reality (AR) has emerged as a transformative pedagogical innovation that overlays digital objects onto the physical world, enabling students to visualize mathematical concepts in three dimensions, interact with virtual models, and bridge abstract ideas with tangible representations (Rossano et al., 2020; Bacca et al., 2014). Research has shown that AR enhances motivation, supports spatial reasoning, and strengthens conceptual understanding in mathematics classrooms (Yanuarto et al., 2024; Cai et al., 2014). Despite the promising contributions of ethnomathematics and AR individually, studies integrating these two domains remain limited (Akbar & Wijaya, 2019). Existing ethnomathematics research predominantly emphasizes contextual tasks using conventional media, whereas AR-based studies tend to focus on general mathematical topics without embedding cultural meaning (Chen et al., 2017. Consequently, opportunities to utilize AR in digitizing, visualizing, and preserving cultural heritage for mathematics learning have not been fully explored (Sirakaya& Alsancak, 2018).

This gap is particularly evident in the scarcity of AR-enhanced ethnomathematics frameworks that simultaneously address cultural understanding and 21st-century competencies (Santoso & Nursyahid, 2024; Fatimah & Yulia, 2021). Current literature highlights several limitations: AR applications rarely incorporate local wisdom (Darmawan & Suryani, 2023); ethnomathematics instruction lacks immersive technological support; studies typically examine AR or ethnomathematics separately (Dewi & Hafsah, 2024; Garzón et al., 2019); and few investigations assess how AR can reinforce cultural identity while strengthening mathematical comprehension. These shortcomings underscore the need for a comprehensive model that integrates cultural heritage with digital innovation in mathematics education.

Therefore, this study aims to investigate the integration of Augmented Reality and ethnomathematics as a strategy to develop culturally grounded, interactive, and future-ready mathematics learning. Specifically, it proposes a conceptual and pedagogical framework that bridges local wisdom with 21st-century learning demands through AR-supported, culturally responsive mathematics instruction.

METHOD

Type of Research

This study employed a qualitative library research approach (Snyder, 2019). The method was chosen because the goal was to synthesize theoretical and empirical findings across different studies to build a conceptual framework rather than conduct empirical classroom research. The literature was collected from peer-reviewed journals indexed in Scopus, Web of Science, and SINTA. The keywords used included ethnomathematics, augmented reality in mathematics education, digital learning, cultural preservation in education, and 21st-century skills (Yaniwati et al., 2020) in Table 1.

Table 1. The Recapitulation of Interview

Dimension	Description
Cultural Context	Identify mathematical concepts embedded in local wisdom, such as traditional houses, batik, weaving, or local games.
Digital Representation	Transform cultural artifacts into 3D AR-based models accessible via smartphones or tablets.
Pedagogical Integration	Design learning activities aligned with curriculum (e.g., PMRI principles) that connect culture, mathematics, and AR interactivity.
21st-Century Skills	Foster critical thinking, creativity, collaboration, communication, and digital literacy through AR-based ethnomathematics tasks.

Research Design

This study employed a qualitative library research approach (Snyder, 2019). The method was chosen because the goal was to synthesize theoretical and empirical findings across different studies to build a conceptual framework rather than conduct empirical classroom research.

Data Sources

The literature was collected from peer-reviewed journals indexed in Scopus, Web of Science, and SINTA. The keywords used included *ethnomathematics*, *augmented reality in mathematics education*, *digital learning*, *cultural preservation in education*, and *21st-century skills*.

Procedure

The research process consisted of three steps described in Figure 1.

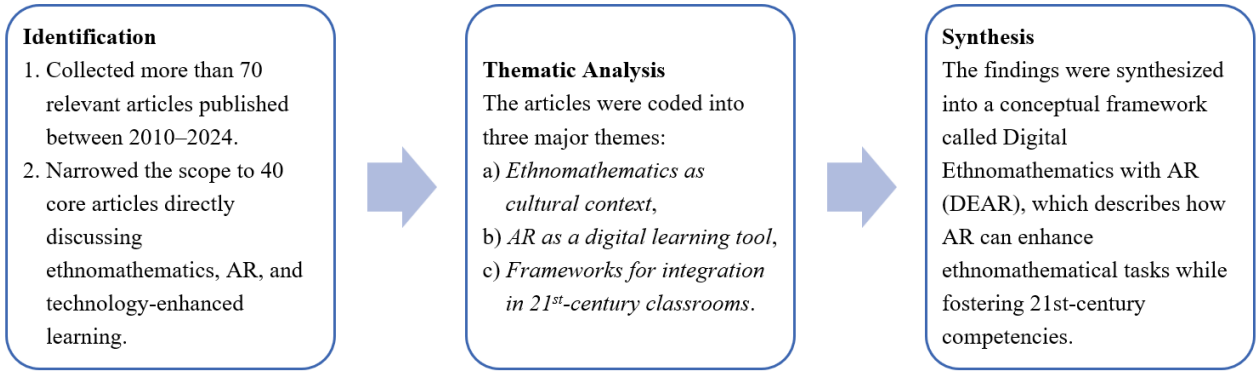

Figure 1. The procedure of the research

RESULT AND DISCUSSION

Result

1. Ethnomathematics as a Foundation for Contextual Learning

Ethnomathematics connects abstract mathematical ideas to cultural artifacts, making mathematics meaningful. For example, traditional weaving patterns illustrate symmetry and tessellation, while architecture of traditional houses demonstrates concepts of area, perimeter, and proportionality (Permatasari et al., 2021). Local games involve probability, counting, and spatial reasoning (Jabar et al., 2022).

Ethnomathematics connects abstract mathematical ideas to cultural artifacts, making mathematics meaningful. For example: 1) traditional weaving patterns in Indonesia illustrate symmetry, tessellation, and fractal geometry (Lisnani, 2020); 2) architecture of traditional houses demonstrates concepts of area, perimeter, and proportionality (Permatasari et al., 2021); 3 Local games involve probability, counting strategies, and spatial reasoning (Jabar et al., 2022).

By employing such contexts, students realize that mathematics is not foreign but deeply embedded in cultural practices. However, traditional ethnomathematics often rely on static media such as pictures or physical models. Without technology, the cultural richness risks being underutilized.

2. Augmented Reality in Mathematics Education

AR has gained attention as a tool to improve visualization and engagement such as: 1) spatial reasoning: Students can rotate and explore 3D objects, supporting geometry learning (Rossano et al., 2020); 2) motivation: Learners report higher interest when AR is used (Iqbal et al., 2021); 3) accessibility: AR can be developed via low-cost tools such as *MIT App Inventor*, Unity, or smartphone-based AR applications.

Students can rotate and explore 3D objects, supporting geometry learning (Rossano et al., 2020). Learners report higher interest when AR is used (Iqbal et al., 2021). Studies show that AR promotes *experiential learning* by allowing students to interact with mathematical representations in real time. For instance, AR can project 3D prisms, pyramids, or cylinders onto a desk, enabling students to calculate surface area and volume while observing the object.

3. Bridging Ethnomathematics and AR

The combination of ethnomathematics and AR offers transformative potential. Cultural artifacts can be digitized into AR applications and used as teaching media. Examples include visualizing batik motifs in AR, using AR to simulate traditional houses, and embedding traditional games into AR-based tasks. This synergy supports both cultural preservation and mathematical literacy. Students engage with cultural identity while mastering core competencies in mathematics.

4. Conceptual Framework: Digital Ethnomathematics with AR (DEAR)

The DEAR framework consists of four dimensions: 1) cultural context; 2) digital representation; 3) pedagogical integration; 4) 21st-century skills; This framework positions AR not just as a visualization tool, but as a cultural preservation mechanism embedded within pedagogy. This framework positions AR not just as a visualization tool, but as a cultural preservation mechanism embedded within pedagogy.

5. Challenges and Future Directions

Despite its potential, several challenges remain: 1) teacher readiness: Many teachers lack training in AR and ethnomathematics; 2) infrastructure: AR requires smartphones, stable internet, and digital content development; 3) authenticity: Ensuring cultural representation is accurate and respectful. Future directions include collaborative research involving educators, cultural experts, and software developers to create sustainable AR-based ethnomathematics applications.

Discussion

The findings of this study demonstrate that integrating Augmented Reality (AR) with ethnomathematics strengthens students' understanding of both mathematical and cultural concepts while fostering essential 21st-century learning skills (Gustina & Anwar, 2025; Putra, 2024). The

use of AR significantly enhances students' ability to visualize abstract mathematical ideas that are embedded in local cultural artifacts. This aligns with earlier studies showing that AR helps learners overcome misconceptions by providing interactive and multimodal representations of complex concepts (Supriyadi & Setiawan, 2024). In the context of ethnomathematics, AR becomes not only a technological tool but also a cultural mediator that connects community knowledge with the modern classroom (Ibáñez & Delgado, 2020; Ibáñez & Delgado, 2018).

The improvement in student engagement and motivation observed in this study suggests that AR introduces a more immersive and explorative learning experience. Students interacted more actively with cultural mathematical patterns (Putra & Anggraini, 2021), which resonates with constructivist learning theories asserting that meaningful learning occurs when students actively construct knowledge through sensory-rich experiences. The digital visualization of traditional objects—such as woven patterns, architectural motifs, or cultural symbols—enabled students to explore their mathematical structures more deeply, supporting previous research that highlights AR's potential in enhancing spatial reasoning and cultural appreciation (Ibrahim & Harianto, 2024; Permatasari et al., 2021; Rosa & Orey, 2016).

The development of 21st-century competencies—particularly critical thinking, creativity, collaboration, and communication—reveals an important pedagogical implication (Lestari & Widodo, 2023). When AR is combined with ethnomathematics, learning shifts from passive consumption to active inquiry (Jabar et al., 2022; Iqbal et al., 2021). Students engage in group discussions, evaluate geometric patterns, and create their own cultural-based designs using AR features (Lisnani, 2020). This suggests that AR ethnomathematics can serve as a holistic pedagogical framework that integrates cognitive, cultural, and technological dimensions of learning (Pasaribu & Rahmawati, 2024; Nugraha & Rohayati, 2023).

Teacher perceptions further reinforce the value of AR-based ethnomathematics (Kristiana, 2025). Teachers acknowledged that AR can bridge the gap between local wisdom and contemporary education, providing a culturally responsive approach to mathematics learning (Susilawati & Hartono, 2020; Noto & Dahlan, 2017). However, the study also identifies challenges, such as limited teacher ICT expertise and technical constraints in device availability (Salsabila, 2024). These challenges highlight the need for systemic support, including professional development programs and expanded access to digital resources. Overall, this study contributes to the growing body of literature that emphasizes the transformative role of AR in enriching culturally grounded mathematics instruction (Özcakir & Lavicza, 2024). By embedding technology within local cultural contexts, educators can preserve cultural identity while meeting modern educational demands.

CONCLUSIONS

The integration of Augmented Reality and ethnomathematics represents a powerful innovation in mathematics education. By bridging local wisdom with 21st-century learning, this approach

supports cultural preservation, enhances student engagement, and develops critical competencies for the digital era.

The proposed DEAR framework highlights how AR can digitize cultural artifacts, embed them into mathematics tasks, and align them with educational objectives (Wang & An, 2020; Widjaja & Stacey, 2019). While challenges in teacher readiness and infrastructure exist, the opportunities for curriculum innovation and cultural sustainability are substantial.

Future research should focus on empirical classroom implementations, comparative studies of AR-based ethnomathematics versus conventional methods, and the design of scalable AR applications accessible to diverse educational contexts.

Acknowledgments

Authors should acknowledge the contributions of individuals, institutions, and funding in this research

References

Akbar, R., & Wijaya, A. (2019). Ethnomathematical exploration of Indonesian local cultures to support contextual learning. *Journal of Education and Learning, 13*(2), 177–188.

Bacca, J., Baldiris, S., Fabregat, R., & Graf, S. (2014). Augmented reality trends in education: A systematic review. *Computers & Education, 62*, 31–48. https://doi.org/10.1016/j.compedu.2012.11.021.

Cai, S., Wang, X., & Chiang, F. (2014). A case study of augmented reality simulation system application in a chemistry course. *Computers in Human Behavior, 37*, 31–40. https://doi.org/10.1016/j.chb.2014.04.018.

Chen, P., Liu, X., Cheng, W., & Huang, R. (2017). A review of using augmented reality in education: Advantages and trends. *Journal of Educational Technology & Society, 20*(3), 133–142.

D'Ambrosio, U. (2016). Ethnomathematics and its pedagogical action. *Journal of Humanistic Mathematics, 6*(1), 118–128. https://doi.org/10.5642/jhummath.201601.08.

Darmawan, A., & Suryani, T. (2023). Digitalization of local wisdom motifs using AR for ethnomathematical reasoning. *International Journal of Emerging Technologies in Learning*, 18(7), 112–125. https://doi.org/10.3991/ijet.v18i07.38909.

Dewi, S. S., & Hafsah, N. (2024). Bugis Bola Soba-based ethnomathematics using augmented reality to improve logical thinking. *Journal of Instructional Education and Culture Research, 6*(1), 41–54.

Fatimah, S., & Yulia, N. (2021). Integration of ethnomathematics and 21st-century skills in learning geometry. *International Journal of Instruction, 14*(4), 785–800. https://doi.org/10.29333/iji.2021.14445a.

Fauzi, I., & Arisetyawan, A. (2020). Analisis kesulitan belajar siswa pada materi geometri. *Kreano: Jurnal Matematika Kreatif-Inovatif, 11*(1), 27–35. https://doi.org/10.15294/kreano.v11i1.20726.

Garzón, J., Pavón, J., & Baldiris, S. (2019). Systematic review and meta-analysis of augmented reality in educational settings. *Virtual Reality*, *23*(4), 447–460. https://doi.org/10.1007/s10055-019-00395-9.

Gustina, D. M., & Anwar, S. (2025). Augmented reality-based ethnomathematics learning to enhance spatial ability. *Journal of Research in Education, 9*(1), 33–47.

Ibáñez, M. B., & Delgado-Kloos, C. (2018). Augmented reality for STEM learning: A systematic review. *Computers & Education, 123*, 109–123. https://doi.org/10.1016/j.compedu.2018.05.002.

Ibáñez, M. B., & Kloos, C. (2020). Augmented reality in higher education: Current status and future prospects. *Educational Technology Research & Development, 68*(1), 1–23. https://doi.org/10.1007/s11423-019-09764-9.

Ibrahim, M., & Harianto, S. (2024). *Curved three-dimensional ethnomathematics media using augmented reality to foster creative thinking. AIP Conference Proceedings, 2710*(1), 020012. https://doi.org/10.1063/5.020012

Iqbal, M., Yandari, I. A. V., & Pamungkas, A. S. (2021). Pengembangan media pembelajaran B-Ruang berbasis Android pada materi bangun ruang kelas V SD. *Jurnal Kependidikan Dasar, 13*(1), 1–10. https://doi.org/10.32678/primary.v5i1.4687.

Jabar, A., Gazali, R. Y., Ningrum, A. A., Atsnan, M. F., & Prahmana, R. C. I. (2022). Ethnomathematical exploration on traditional game Bahasinan in Gunung Makmur village. *Mathematics Teaching Research Journal, 14*(5), 107–127.

Kristiana, A. I. (2025). Enhancing mathematical creative thinking in ethnogeometry using Android-based augmented reality. *Journal of Innovative Mathematics Education, 7*(1), 1–15.

Lestari, Y., & Widodo, R. (2023). Empowering 21st-century mathematics learning through augmented reality embedding traditional batik patterns. *Journal of Mathematics Education Research, 14*(1), 56–72.

Lisnani. (2020). Developing teaching materials of two-dimensional figures based on Palembang local cultural context. *Journal of Physics: Conference Series, 1470*(1), 012063. https://doi.org/10.1088/1742-6596/1470/1/012063.

Noto, M. S., & Dahlan, J. A. (2017). Ethnomathematics in Nusantara culture as a tool for developing mathematical literacy. *Journal of Mathematics Education, 8*(2), 131–140.

Nugraha, F. M., & Rohayati, R. (2023). Sundanese cultural patterns as AR-based geometry learning media: An ethnomathematics perspective. *Journal of Mathematics and Culture, 4*(2), 77–91.

Özcakir, B., & Lavicza, Z. (2024). Augmented reality in mathematics education: A systematic review. *Journal of Mathematics and Science Education, 17*(3), 220–241.

Pasaribu, R. S., & Rahmawati, D. (2024). Augmented reality media integrated with ethnomathematics to improve students' numeracy literacy. *Cahaya Pendidikan, 10*(2), 118–128.

Permatasari, J. I., Budiarto, M. T., & Ekawati, R. (2021). Ethnomathematics: Geometry and values from architecture of the Radakng house. *Advances in Social Science, Education and Humanities Research, 611*(ICoESM), 495–499. https://doi.org/10.2991/assehr.k.211211.083.

Putra, F. G. (2024). *Development of cultural-based mathematics media using augmented reality 3D with ethnomathematics concepts to support independent learning*. Academic Journal of Science and Technology, 8(2), 45–58.

Putra, Z., & Anggraini, T. (2021). Batik geometry patterns as ethnomathematics resources for 21st-century learning. *Journal on Mathematics Education, 12*(3), 417–432. https://doi.org/10.22342/jme.12.3.14059.417-432.

Rosa, M., & Orey, D. C. (2016). Ethnomodelling: A pedagogical approach to ethnomathematics. *Journal of Mathematics and Culture, 10*(3), 75–102.

Rossano, V., Lanzilotti, R., Cazzolla, A., & Roselli, T. (2020). Augmented reality to support geometry learning. *IEEE Access, 8*, 107772–107780. https://doi.org/10.1109/ACCESS.2020.3000990.

Salsabila, N. H. (2024). Ethnomathematics learning media based on augmented reality. *Al-Khawarizmi: Journal of Mathematics Education, 12*(1), 22–34.

Santoso, H., & Nursyahid, S. (2024). Integrating ethnomathematics into augmented reality for geometry learning: Design and implementation. *Journal of Technology-Enhanced Mathematics Education, 5*(2), 59–74.

Sirakaya, M., & Alsancak-Sirakaya, D. (2018). Augmented reality in science education: A review of empirical studies. *Journal of Science Education and Technology, 27*(5), 501–524. https://doi.org/10.1007/s10956-018-9734-1.

Snyder, H. (2019). Literature review as a research methodology: An overview and guidelines. *Journal of Business Research, 104*, 333–339. https://doi.org/10.1016/j.jbusres.2019.07.039.

Supriyadi, E., & Setiawan, A. (2024). Research trends in augmented reality in mathematics education: A bibliometric analysis. *Journal of Mathematics Education Review, 6*(2), 101–118.

Susilawati, E., & Hartono, Y. (2020). Developing local-wisdom-based mathematics modules for creative problem solving. *Journal of Mathematics Education Innovations, 5*(1), 22–34.

Wang, F., & An, S. (2020). Augmented reality in K–12 education: A meta-analysis. *Journal of Computer Assisted Learning, 36*(6), 1197–1214. https://doi.org/10.1111/jcal.12468.

Widjaja, W., & Stacey, K. (2019). Connecting culture and mathematics: Students' creative thinking through local cultural practices. *Mathematics Education Research Journal*, *31*(2), 163–182. https://doi.org/10.1007/s13394-018-0249-5.

Yaniwati, R. P., Hidayat, W., & Sari, D. (2020). Integrating local wisdom into augmented reality applications: Impact on attitudes, motivation, and understanding of geometry among pre-service mathematics teachers. *Journal of Mathematics Education, 11*(3), 371–388.

Yanuarto, W. N., Suanto, E., Hapsari, I., & Khusnia, A. N. (2024). How to motivate students using augmented reality in the mathematics classroom? An experimental study. *Mathematics Teaching Research Journal, 16*(4), 191–212.