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Mapping the Landscape of Ethnomathematics in Mathematics Education: Trends, Pedagogical Designs, and Future Directions

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Abstract

Ethnomathematics has emerged as a culturally responsive approach to mathematics education, yet its research landscape remains fragmented across geographical, methodological, and thematic dimensions. This study aims to comprehensively map the landscape of ethnomathematics in mathematics education by tracing publication trends, analyzing pedagogical designs, and identifying critical research gaps. A Systematic Literature Review (SLR) was conducted using the PRISMA framework, integrating bibliometric analysis with VOSViewer and qualitative content analysis. Of 663 Scopus-indexed articles published between 2015 and 2025, 13 articles met the inclusion criteria and were selected for in-depth analysis. Findings revealed a significant growth in ethnomathematics publications, particularly after 2023, with the most productive year being 2025. Research focus has shifted from STEAM education and game-based learning toward mathematical literacy, numeracy, critical thinking, problem-solving, and ethno-modeling. Content analysis identified three main categories of cultural artifacts employed in instructional designs: traditional architecture, agricultural and calendrical systems, and artistic and craft traditions. However, four critical gaps were identified: (1) the dominance of qualitative methods with a scarcity of experimental and longitudinal studies; (2) minimal integration of emerging technologies such as VR, AR, and AI; (3) strong geographical concentration in Indonesia with limited cross-cultural representation; and (4) insufficient research on teacher professional development and culturally responsive assessment. Future research is recommended to diversify methodological designs, develop digital ethnomathematics platforms, strengthen international collaboration, and address teacher preparation and curriculum integration systematically. This study contributes a structured research roadmap that supports the development of culturally sensitive mathematics education globally.

Keywords: Landscape Mapping; Ethnomathematics; Mathematics Education; Systematic Literature Review

Abstrak

Etnomatematika telah berkembang menjadi pendekatan responsif budaya dalam pendidikan matematika, namun lanskap penelitiannya masih terfragmentasi secara geografis, metodologis, dan tematik. Penelitian ini bertujuan untuk memetakan secara komprehensif lanskap etnomatematika dalam pendidikan matematika dengan menelusuri tren publikasi, menganalisis desain pedagogis, serta mengidentifikasi kesenjangan penelitian yang masih kritis. Metode yang digunakan adalah *Systematic Literature Review* (SLR) dengan kerangka PRISMA, mengintegrasikan analisis bibliometrik menggunakan VOSViewer dan analisis konten kualitatif. Dari 663 artikel terindeks Scopus yang diterbitkan antara 2015 hingga 2025, sebanyak 13 artikel memenuhi kriteria inklusi dan dipilih untuk dianalisis secara mendalam. Temuan menunjukkan pertumbuhan signifikan publikasi etnomatematika, terutama setelah 2023, dengan tahun paling produktif adalah 2025. Fokus penelitian telah bergeser dari pendidikan STEAM dan pembelajaran berbasis permainan menuju literasi matematika, numerasi, berpikir kritis, pemecahan masalah, dan etomodeling. Analisis konten mengidentifikasi tiga kategori utama artefak budaya yang digunakan dalam desain pembelajaran: arsitektur tradisional, sistem pertanian dan penanggalan, serta tradisi seni dan kerajinan. Namun, empat kesenjangan kritis ditemukan: (1) dominasi metode kualitatif dengan minimnya studi eksperimental dan longitudinal; (2) terbatasnya integrasi teknologi seperti VR, AR, dan AI; (3) konsentrasi geografis yang kuat di Indonesia dengan representasi lintas budaya yang terbatas; dan (4) minimnya penelitian tentang pengembangan profesional guru dan asesmen responsif budaya. Penelitian selanjutnya direkomendasikan untuk mendiversifikasi desain metodologis, mengembangkan platform etnomatematika digital, memperkuat kolaborasi internasional, serta menangani persiapan guru dan integrasi kurikulum secara sistematis. Penelitian ini berkontribusi pada penyusunan peta jalan penelitian terstruktur yang mendukung pengembangan pendidikan matematika yang sensitif budaya secara global.

Kata Kunci: Etnomatematika; Pendekatan; Pendidikan Matematika; Tinjauan Pustaka Sistematis

Introduction

Over the past two decades, ethnomathematics has occupied a central position in the global mathematics education discourse in response to cultural diversity and the demands of educational inclusion. Ethnomathematics views mathematics as knowledge that is rooted in culture and embedded in the practices, languages, values, and knowledge systems of a particular community (D'Ambrósio & Knijnik, 2020). This approach is recognized as effective in linking mathematics learning with the context of local cultures and indigenous peoples' knowledge systems (Batiibwe, 2025) in line with the UNESCO and OECD agendas in achieving SDG 4 on quality and inclusive education. The urgency of this approach is reinforced by the findings of PISA and TIMSS which consistently show that students from diverse cultural contexts particularly in developing countries in Asia, Africa, and

Latin America perform below average in math literacy (Johnstone, 2023). This gap reflects the gap between abstract curriculum and the cultural realities of students, while underlining the urgent need for contextually relevant pedagogical approaches.

As global attention to culturally responsive education increases, ethnomathematical research has grown rapidly, especially in culturally diverse countries such as Indonesia and Brazil (Miftahurrahmi et al., 2024). Researchers have responded positively to the urgency of integrating ethnomathematics into education (Batiibwe, 2025). Winardi & Jupri (2025) emphasize that this approach allows students to build conceptual understanding through their own cultural experiences, a process that essentially demands the existence of a planned and systematic pedagogical design. Ethnomathematics is not only a philosophical perspective, but also requires an instructional design framework that intentionally connects local cultural practices with structured mathematics learning goals (Batiibwe, 2025). Pedagogical design in this context refers to the way teachers and curriculum designers organize culture-based learning experiences including the selection of cultural artifacts, sequences of activities, conceptual scaffolding, and contextual assessments so that mathematical knowledge is not only culturally recognized, but also learned meaningfully.

Hendriyanto dan Muhaimin (2023) highlight that pedagogical innovation through contextual approaches that are relevant to students' daily lives is one of the main strengths of ethnomathematics, while emphasizing that the quality of the design determines the extent to which the potential of ethnomathematics can be realized in the classroom. Furthermore, the integration of ethnomathematics accompanied by a mature pedagogical design has been proven to encourage appreciation of cultural diversity while bridging the gap between academic mathematics and local cultural practices (Hendriyanto & Muhaimin, 2023). In Indonesia, it faces similar challenges, where mathematics education is often considered abstract and disconnected from the social reality of students. The implementation of ethnomathematics serves as a promising alternative strategy to improve mathematical literacy while preserving rich local wisdom (Nst & Batubara, 2024; Simbolon, 2024).

Although the growth of ethnomathematical research is significant, the study of the pedagogical design dimension is still very limited. Most of the existing studies tend to be descriptive-exploratory, as seen in the research of Lidinillah (2022) which analyzes the integration of Sundanese ethnomathematics into curriculum and classroom practice, as well as investigating the contribution of local cultural context

to improving student learning outcomes (Lidinillah et al., 2022). However, the design dimension, namely how ethnomathematical principles are translated epistemologically and pedagogically into concrete learning designs, has not received adequate attention in the literature (Marsigit et al., 2025). This gap is emphasized by the findings of the latest systematic synthesis conducted by Dhema et al. (2025), which reveal that although the implementation of ethnomathematics has developed widely, strategic mapping of pedagogical design including design principles, approach typology, and direction of development is still an area that has not been studied in depth in the existing literature (Dhema et al., 2025). In addition, ethnomathematical research as a whole is still fragmented in various geographical and methodological contexts, making it difficult to obtain an integrated picture of the evolution and contribution of this field (Hendriyanto & Muhaimin, 2023). In contrast, meta-analyses show that ethnomathematics-based teaching has a positive impact on students' mathematical literacy, problem-solving, learning motivation, and cultural identity (Pratama & Yelken, 2024)), underscoring the need for a comprehensive systematic synthesis (Farah et al., 2025).

To respond to these gaps, the Systematic Literature Review (SLR) with the enrichment of bibliometric analysis is the most appropriate approach. SLR enables the synthesis of evidence that is transparent, replicable, and minimizes selection bias, while bibliometric analysis provides quantitative mapping of publication trends, keyword networks, and patterns of research collaboration that cannot be captured through qualitative synthesis alone (Klarin, 2024). The integration of the two presents a dual-lens perspective that reveals the structural landscape as well as the thematic evolution of ethnomathematical research (Abbasnejad et al., 2026). Without this kind of comprehensive landscape mapping, individual studies will remain isolated and their collective contribution to culturally responsive mathematics education will not be clearly visible (Bertrand, 2025).

Therefore, a comprehensive and cutting-edge SLR is needed to consolidate existing knowledge, trace theoretical developments, assess methodological quality, and guide future research directions. Understanding the ethnomathematical research landscape has a multidimensional urgency: first, it enables policymakers and curriculum developers to make evidence-based decisions in integrating cultural contexts into formal mathematics education; second, it identifies methodological blind spots that have been limiting the growth and validity of this field; and third, it provides a roadmap for future researchers to address unanswered questions regarding pedagogy, technology integration, and cross-cultural application. Without comprehensive landscape mapping, individual studies will remain isolated, and

their collective contribution to the advancement of culturally responsive mathematics education will remain inconspicuous.

Based on these needs, this study focuses on mapping the ethnomathematical landscape in mathematics education by examining research trends, evolving pedagogical designs, and the future direction of ethnomathematical integration in 21st-century education. Specifically, the study answered the following three research questions:

- RQ1: How have the developments, global trends, and directions of ethnomathematical research in mathematics education evolved over the past two decades?
- RQ2: How is the ethnomathematical approach designed in the existing literature? What content, context, and modeling tools are used?
- RQ3: What are some of the remaining research gaps regarding ethnomathematical approaches, and what recommendations can be made for future studies?

Methods

This study employed in response to the fragmented and geographically skewed nature of existing ethnomathematics literature. Systematic Literature Review (SLR) method combined with a bibliometric approach were applied to quantitatively assess the literature and identify trends, patterns, and key research entities related to ethnomathematics approaches in mathematics education. The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework was specifically adopted because it provides a standardized, internationally recognized as reporting structure that enhances the transparency, reproducibility, and methodological rigor of systematic reviews (Mishra & Mishra, 2023). PRISMA is particularly appropriate for this study as it prescribes explicit criteria for literature identification, screening, eligibility assessment, and inclusion, thereby reducing researcher bias and improving the verifiability of results. Using the PRISMA framework, this approach ensures a comprehensive and replicable literature examination, providing a clear and transparent overview of the topic under investigation (Sarkis-Onofre et al., 2021). This method was selected because it enables the integration of empirical evidence to understand current challenges, research trends, and future directions in ethnomathematics within mathematics education (Rosa et al., 2016). A bibliometric approach was used to statistically measure scientific contributions and visualize research networks using VOSviewer software, as recommended in similar studies by (Lakapu et al., 2025). Combining bibliometric analysis with a systematic review allows researchers to synthesize

empirical findings and map the research landscape more comprehensively, including identifying key contributors and emerging trends (Ni & Abdullah, 2025). The integration of these two approaches provides a more comprehensive understanding of the study's scope.

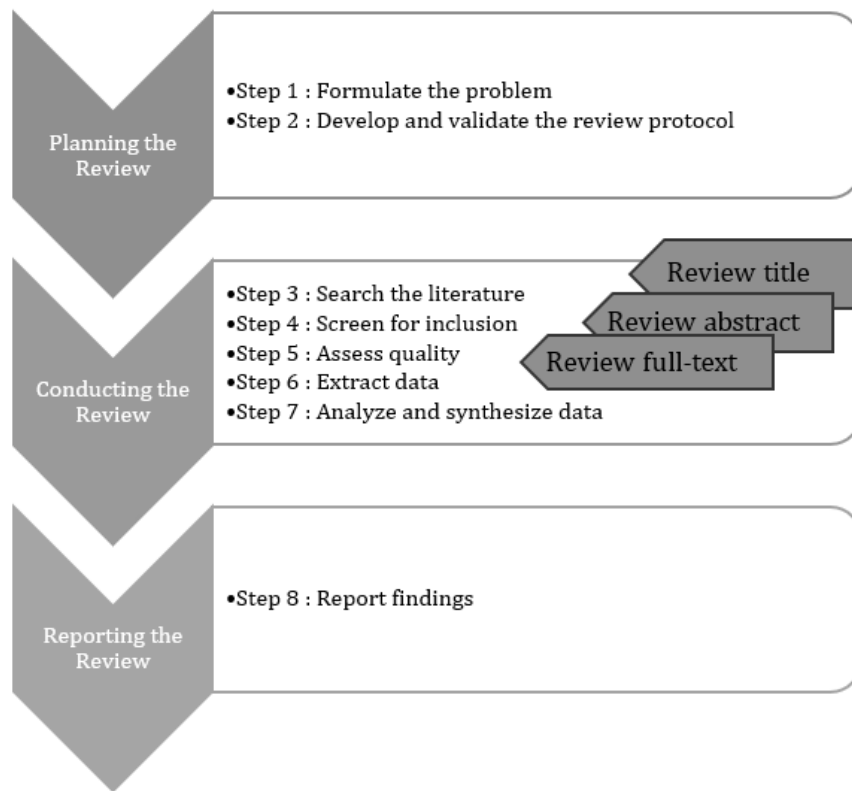


Figure 1. Systematic Literature Review (SLR) steps

The SLR process consists of three main phases planning, execution, and reporting as illustrated in Figure 1 (Azarian et al., 2023).

Planning the Review

In planning the review, the researcher identifies the necessary elements, defines relevant research questions, and develops a systematic review protocol (Azarian et al., 2023). During the protocol development stage, three main methodological decisions were determined, including keyword selection, database selection, and determination of inclusion and exclusion criteria (Foo et al., 2021). First, keywords were systematically constructed to ensure comprehensive literature coverage and high search precision. Second, searches were conducted exclusively through the Scopus database, which was chosen because of its

reputation as a highly reputable database that indexes leading international journals with strict quality standards.

Third, inclusion and exclusion criteria were explicitly established to ensure the relevance and methodological quality of the literature included. Inclusion criteria include: (a) articles that are published in Scopus indexed journals in the Q1 or Q2 quartiles based on CiteScore or SJR, to ensure high standards of publication quality; (b) articles that substantively focus on ethnomathematics in the context of mathematics education; (c) articles that use a methodological approach that can be clearly identified, both quantitative, qualitative, or mixed-methods; and (d) articles are published within the specified time frame and available in English. In contrast, exclusion criteria include: articles that are in the form of editorials, book reviews, conference proceedings, and technical reports that do not go through the peer-review process; articles that are not fully accessible; and studies that do not directly address the integration of ethnomathematics in mathematics learning or curriculum. All articles that passed the initial selection then underwent a methodological quality assessment using a rubric adapted from the *Mixed Methods Appraisal Tool* (MMAT), to evaluate the clarity of the research design, the validity of the measurement, and the consistency between the research question and the method used (Sanfilippo et al., 2020). Only articles that meet the set quality thresholds are included in the final synthesis.

Implementing the Review

This stage included a literature search, screening for inclusion criteria, assessing quality, extracting data, analysing, and synthesizing the data. The literature search began with a broad search, then systematically narrowed and refined to more specific research topics and objectives (Cooper et al., 2018). After reviewing the limitations of previous research and the limited number of studies directly addressing the topic of ethnomathematics, this study included the keyword "Ethnomathematics" as the primary focus in the title, abstract, and keywords sections. The researchers used the Scopus database to conduct the literature review, identify experts in specific fields, and monitor and map future research trends. Furthermore, inclusion and exclusion criteria were established to ensure the significance and quality of the literature. Inclusion criteria included indexed journal articles discussing ethnomathematics in the context of mathematics education, while non-scholarly, duplicate, or irrelevant articles were excluded (Alghar & Radjak, 2024). Table 1 presents the inclusion and exclusion criteria used in this study.

Table 1. Inclusion and exclusion criteria for SLR Ethnomathematics

Criteria	Description
Title Word	"Ethnomathematics"
Keyword	"Ethnomathematics" and "Ethnomathematics Approach" "Ethnomathematics" and "Mathematics Education" "Ethnomathematics" and "Design Research"
Exclusion	a One of the selected keywords does not appear in the title, abstract, keywords, or full text. b Not written in English. c Publisher unknown. d Outside the field of mathematics. e Full text not available/link inaccessible.
Inclusion	a One of the selected keywords appears in the title, abstract, keywords, or full text. b Written in English. c Published in one of the selected databases. d Is a journal article. e Published between 2015-2025.

An initial screening was performed using keywords, titles, and relevant databases. This resulted in the identification of 663 articles from Scopus using the keywords in Table 1, as presented in Table 2.

Table 2. Inclusion and exclusion criteria for SLR Ethnomathematics

Title Word	Keywords	Number of Articles
"Ethnomathematics"	"Ethnomathematics" and "Ethnomathematics Approach"	308
	"Ethnomathematics" and "Mathematics Education"	334
	"Ethnomathematics" and "Design Research"	21
	Total of all articles	663

Of the 663 articles, 33 met the criteria, while 630 did not. Finally, thirteen articles were then assessed as potentially providing answers to the research questions. The document screening process can be seen visually in Figure 2.

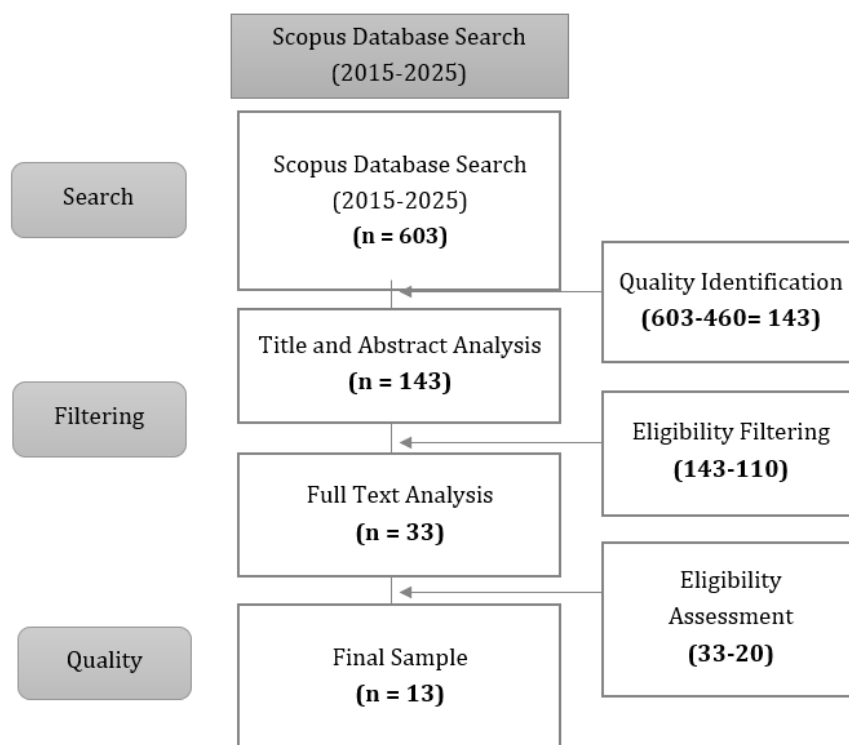


Figure 2. Systematics Literature Review (SLR) of Ethnomathematics using the PRISMA method

As depicted in Figure 2, the PRISMA-based screening process was conducted in four sequential stages. In the identification stage, a total of 663 articles were retrieved from the Scopus database using the defined keyword combinations. In the screening stage, articles were evaluated based on title and abstract review, eliminating 553 records that did not meet the basic relevance criteria (e.g., not related to mathematics education, not in English, or from unknown publishers), leaving 110 articles for further review. In the eligibility assessment stage, full-text articles were evaluated against the inclusion and exclusion criteria detailed in Table 1; 97 articles were excluded at this stage due to reasons such as inaccessible full texts, irrelevance to ethnomathematics pedagogy, or being outside the 2015–2025 publication window. In the final inclusion stage, 13 articles were confirmed as fully meeting all quality and relevance criteria and were selected for in-depth analysis.

After selecting 13 relevant articles, the analysis was carried out through two complementary paths: quantitative bibliometric analysis and content-based qualitative synthesis. Bibliometric analysis was performed using VOSviewer (version 1.6.19) with a minimum occurrence threshold of 1, given the relatively small size of the corpus, resulting in 15 eligible keywords. The keywords were then

mapped into thematic clusters using the VOSviewer modularity-based grouping algorithm. The results were visualized through three display modes, namely network visualization to show inter-thematic interrelatedness, overlay visualization to map the temporal development of the theme, and density visualization to identify the concentration of topics in the literature (Rusli & Safaah, 2023).

Qualitative content analysis was carried out through structured inductive-deductive content analysis. Deductively, the initial coding framework was developed based on three predetermined research questions, covering the dimensions of research trends, pedagogical design, and literature gaps. Inductively, new categories that emerge from the data were allowed to evolve during the coding process. Coding was carried out systematically on all 13 articles using a data extraction matrix that recorded: (a) study characteristics (context, level of education, method); (b) the pedagogical design used, including the selection of cultural artifacts, sequences of activities, scaffolding, and assessment; and (c) the main findings and limitations reported. To ensure encoding consistency, this process was carried out in two rounds by two coders independently, and the degree of agreement between coders was calculated using Cohen's Kappa coefficient (Sanfilippo et al., 2020).

The validity of the synthesis results was maintained through two mechanisms. First, the triangulation method was carried out by comparing the thematic patterns that emerged from bibliometric analysis with the results of qualitative synthesis; the convergence between the two reinforced confidence in the findings, while divergences were flagged and discussed explicitly. Second, the audit trail was fully documented, including all coding decisions, category revisions, and reasons for the inclusion or exclusion of certain themes, so that the synthesis process can be traced and replicated by other researchers.

Reporting the Review Results

The final stage of this study presented comprehensive documentation that can be replicated, including: (1) quantitative descriptive analysis of the literature profile, including the distribution of the year of publication, geographical origin, and methodology; (2) VOSviewer-based bibliometric network analysis; (3) thematic qualitative synthesis based on content analysis; and (4) an integrative critical review that consolidates bibliometric and qualitative findings to answer the three research questions systematically.

Results

The results of this study focus on findings from 13 articles in the Scopus database on Ethnomathematics. This data was obtained by identifying the number of articles published, publication year, and journal sources. This study also highlights the most influential elements in Ethnomathematics, including authors, affiliations, and countries involved. The distribution of Ethnomathematics publications, resulting in data from 2020 to 2025, is shown in Figure 3. In 2020 and 2021, the number of publications remained very low, at only two articles per year. In fact, in 2022, there was a drastic decline, with zero publications. This reflects the fact that during that period, the ethnomathematics approach had not received much attention in global mathematics education research. The growth trend became clearer in 2024–2025. The number of publications increased gradually from zero articles in 2024 to eight articles in 2025. The peak growth occurred in 2025 with a total of eight publications. This surge after 2021 reflects the strengthening position of Ethnomathematics as a strategic approach in modern mathematics education, particularly in supporting the strengthening of cultural literacy, context-based learning, and the development of more meaningful conceptual understanding.

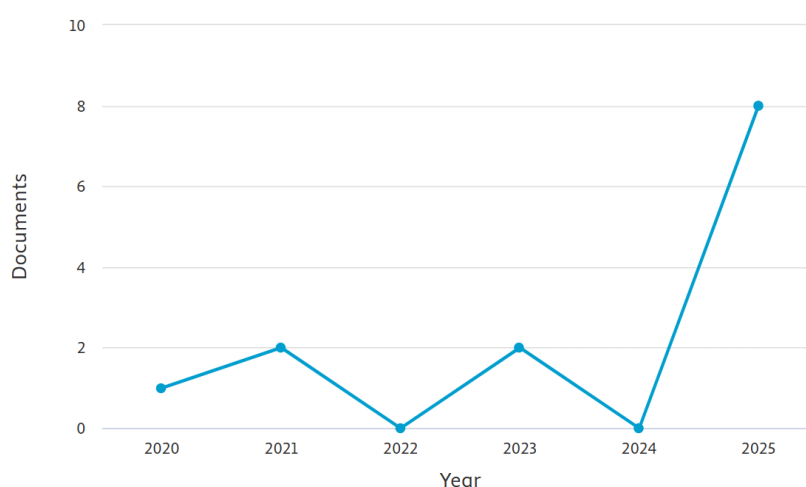


Figure 3. Distribution of Ethnomathematics Publications in 2015-2025

Overall, the pattern of increasing publications indicates that ethnomathematics has developed into an increasingly relevant research topic and is receiving widespread attention within the academic community. The rapid growth over the past three years indicates that this approach is not only theoretical interest but also increasingly being applied in various formal and non-formal educational contexts, particularly in Indonesia. This is illustrated by the distribution of

publications on the ethnomathematics approach to mathematics by country from 2015 to 2025, as seen in Figure 4.

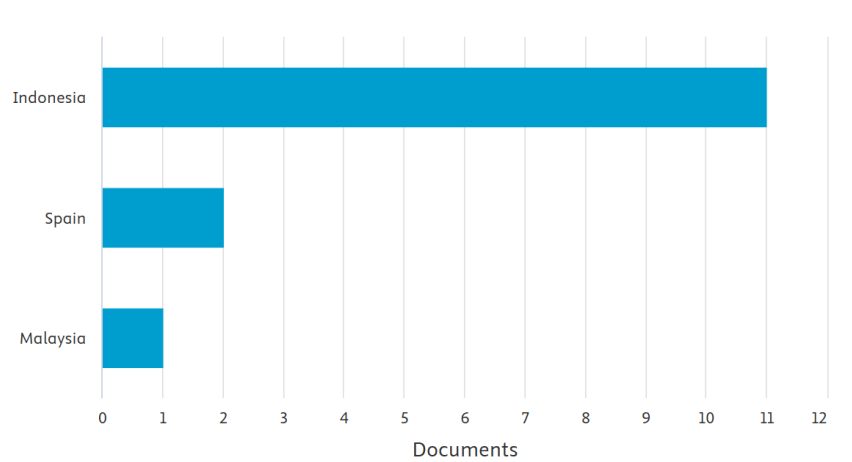


Figure 4. Distribution of ethnomathematics publications by country in 2015-2025

The ethnomathematics approach to mathematics education has experienced rapid development, particularly in Indonesia. This is evident in Figure 4, where the number of documents is very dominant, with approximately 11 publications, far exceeding than other countries. Spain is in second place with approximately 2 documents, followed by Malaysia with approximately 1 document. Overall, this pattern indicates that Indonesia is a major centre for the development of ethnomathematics research, while other countries contribute on a smaller scale, but still indicate a global interest in integrating local culture into mathematics learning. Indonesia's dominance in this field can be attributed to several interrelated factors. First, Indonesia's extraordinary cultural and ethnic diversity with over 300 distinct ethnic groups and 700 living languages provides an exceptionally rich source of ethnomathematical material for researchers (Nst & Batubara, 2024). Second, national educational policies such as the Merdeka Belajar (Freedom to Learn) curriculum reform have explicitly encouraged the integration of local wisdom into learning, incentivizing research in this area. Third, Indonesia has a growing and productive network of mathematics education researchers, particularly concentrated in institutions such as Universitas Negeri Semarang, Universitas Negeri Malang, and Universitas Pendidikan Indonesia, which have made ethnomathematics as a strategic research priority. In contrast, the limited contribution from other countries particularly from Africa, Latin America, and South Asia, which also have rich indigenous mathematical traditions suggests significant geographical inequity in the global ethnomathematics research landscape. This

imbalance points to a critical gap: ethnomathematics as a field risk being perceived as an Indonesia-centric phenomenon rather than the global movement as it aspires to be.

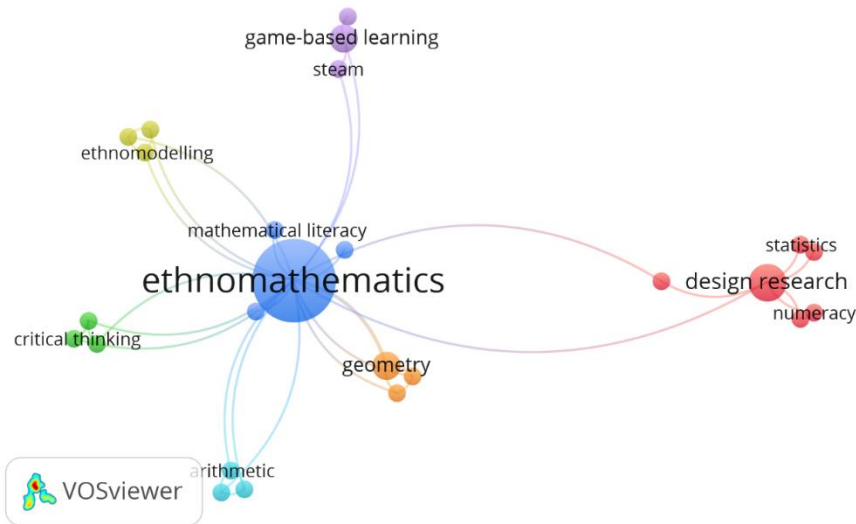


Figure 5. Network Visualization VOSViewer Ethnomathematics

The analysis of keyword relationships in this study used VOSviewer software. Figure 5 presents a visual mapping of keywords, while Table 1 contains detailed information about the keywords in each cluster, including their frequency of occurrence and the strength of their relationships. This keyword network analysis plays a crucial role in identifying relationships between keywords and concepts appearing in the literature, visualizing the overall structure of the field of study, uncovering closely related keyword clusters, measuring the significance of keywords, mapping research trends, and assisting researchers in selecting relevant keywords. Through this technique, researchers can gain a deeper understanding of the literature structure and identify crucial topics with the potential for further research.

Based on Figure 5 (VOSviewer Network Visualization), ethnomathematics research is grouped into six main thematic clusters. (1) The blue cluster places “ethnomathematics” as the largest central node, linked to design research, mathematical literacy, ethno-modelling, and game-based learning, showing that ethnomathematics functions as both a theoretical and pedagogical approach. (2) The red cluster includes design research, statistics, and numeracy, indicating a trend toward empirical, data-driven studies and quantitative evaluation. (3) The light blue cluster connects ethnomathematics with mathematical literacy, geometry, and

arithmetic, emphasizing contextual mathematical literacy through local cultural practices. (4) The yellow cluster highlights ethno-modelling as an approach for constructing mathematical models from local wisdom, bridging formal mathematics and culture. (5) The green cluster centres on critical thinking, reflecting the use of ethnomathematics to develop reflective and analytical skills through social constructivism. (6) The purple cluster links game-based learning and STEAM, signalling a new direction that integrates technology, games, and cultural arts to support experiential mathematics learning.

Overall, this map reflects that ethnomathematics research has moved beyond cultural descriptions to the implementation of local and global context-based learning designs, enriching the landscape of culture-based mathematics education in the 21st century. Furthermore, the results of the overlay visualization generated through VOSviewer are shown in Figure 6 below.

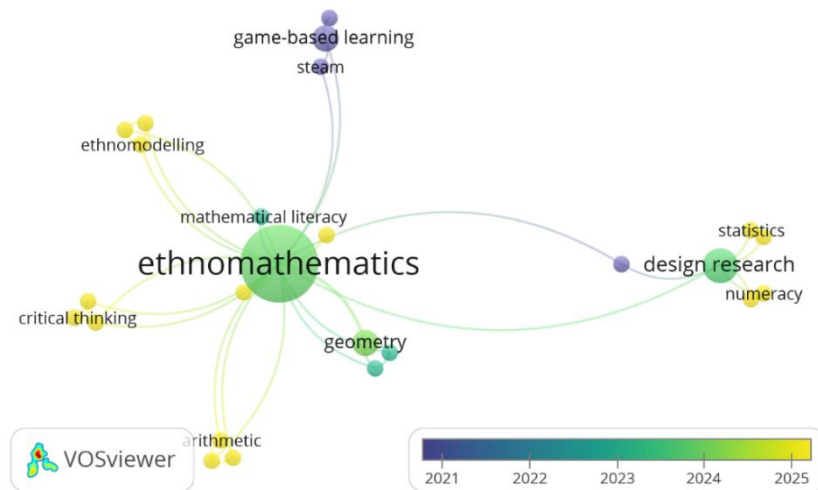


Figure 6. VOSViewer Visualization Overlay Ethnomathematics Approach

The overlay visualization results in Figure 6 show a shift in research focus on ethnomathematics approach from 2021 to 2025. In the initial period (2021), the dominant themes were steam, design research, and game-based learning. Entering 2025, the research focus shifted to numeracy skills, critical thinking, arithmetic, and ethno-modelling. The dominance of green and yellow colours indicates strong and sustained research momentum until 2025, indicating that this field continues to develop as one of the strategic research themes in contemporary mathematics education. Furthermore, the overlay visualization results generated through VOSviewer are shown in Figure 7. Density Visualization in VOSviewer shows the level of density of occurrence and interconnectedness of keywords in the analysed collection of articles. Bright yellow indicates areas with a high concentration of

frequently appearing and interconnected keywords, while green and blue indicate a lower density.

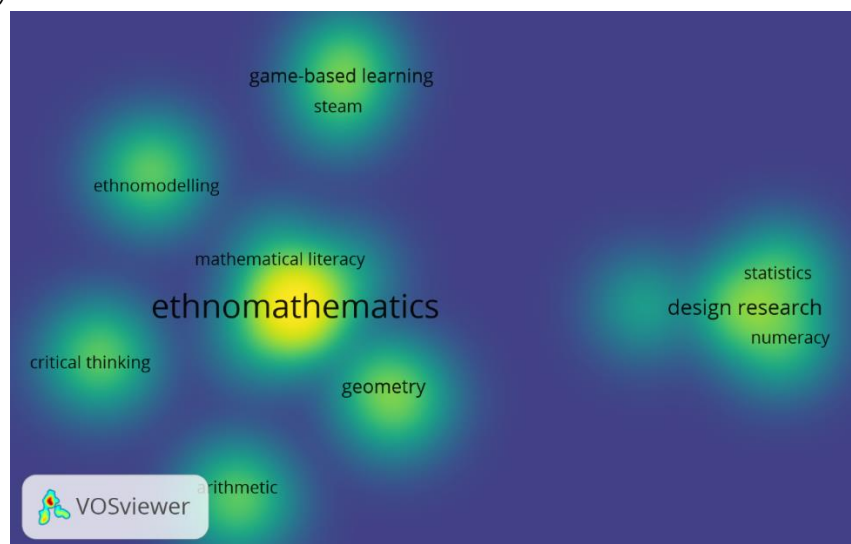


Figure 7. Density Visualization VOSviewer Ethnomathematics Approach

Based on Figure 7, the density visualization results show that ethnomathematics is a major focus of research in mathematics education, with high concentrations in topics such as design research, mathematical literacy, and geometry. This finding confirms that current research focuses not only on relationship between culture and mathematics but also on practical applications in instructional design, numerical literacy, and pedagogical innovation. Furthermore, themes such as ethno-modelling, critical thinking, and game-based learning emerge as supporting areas that enrich the research context and methods. Overall, ethnomathematics research is developing in an integrative, interdisciplinary, and evidence-based direction, marking a shift from theoretical exploration to empirical implementation and culture-based educational innovation.

Next, content analysis, or a qualitative approach, was applied to the reviewed literature to answer RQ2 and RQ3. The analysis was conducted on 13 quality-selected articles. This analysis was based on the research title, author, year of study, country, content used in the study, context, and model used in the study. This analysis was conducted to answer the research questions: How the ethnomathematics approach is designed in the existing literature, what content, context, and modelling tools are utilized? What research gaps remain regarding ethnomathematics approaches, and what recommendations can be proposed for future studies?

Specifically, trends in ethnomathematics research development were analysed based on the literature, as presented in Table 3.

Tabel 3. Context, context level, and question design used in the article

Code	Title	Authors / Journal	Year	Country	Content	Context	Modelling Tools
A1	Ethnomathematics of Pananrang: A guidance of traditional farming system of the Buginese community	Pathuddin, H.; Mariani, A. / Journal on Mathematics Education	2023	Indonesia	Exploration of mathematical concepts (multiplication, addition, modular arithmetic) embedded in the Pananrang traditional farming calendar of the Buginese community.	Buginese traditional farming system using Pananrang to determine farming seasons.	Qualitative ethnographic approach; literature review; structured interviews; content analysis.
A2	Games as STEAM learning enhancers. Application of traditional Jamaican games in Early Childhood and Primary Intercultural Education	María José Espigares-Gámez, Alicia Fernández-Oliveras, María Luisa Oliveras / Acta Scientiae	2020	Spain /Jamaica	STEAM learning, Game-based learning, Traditional Jamaican games, Ethnomathematics	Early Childhood and Primary Education with Jamaican cultural games	Game-based learning methodology, Qualitative-interpretive research, Case study and content analysis
A3	Realistic mathematics learning model based on Mandailing culture assisted by TPACK	M. Ahmad, G.M Pricilia, R. Elindra / Perspektiv y Nauki I Obrazovaniya	2025	Indonesia	Integration of Mandailing ethnomathematics with TPACK to improve students' critical thinking.	Mandailing traditions (birth, wedding, death rituals).	TPACK framework; qualitative design.
A4	Ethnomathematics: Arithmetic and Discrete Mathematics Concepts in Batik Sidomukti Solo	Kholid, M.N.; Husodo, H.D./ Mathematics Education Journal	2025	Indonesia	Identification of arithmetic (modular arithmetic, tiling) and discrete mathematics (graph theory, combinatorics) in Batik Sidomukti Solo patterns.	Batik Sidomukti classical Javanese batik, specifically Isen Ukel curved ornamental patterns from Surakarta.	Qualitative ethnographic approach; Ethnomathematics Guiding Questions; field observation; motif documentation

									n; literature review.
A5	Problem-Solving Learning Model Based on Ethnomathematics to Improve Student's Creative Thinking in Elementary School	Mei, A.; Purwastuti, L.A.; Hidayat, R.; Ayub, A.F.M. / Malaysian Journal of Mathematical Sciences	2025	Indonesia & Malaysia	Development and testing of a problem-solving learning model integrating ethnomathematics of the Sa'o Ria Flores traditional house to improve elementary students' creative thinking.	Sa'o Ria Flores traditional house (Ende Flores culture); flat geometry in elementary school (75 fourth-grade students).			Mixed-methods explanatory sequential design; essay test; structured interview guide; interpretive and descriptive analysis.
A6	Auditory, intellectually, repetition with ethnomathematics nuance in improving students' mathematical problem-solving ability	Zaenuri, L. T. Medyasari, N. R. Dewi / Journal of Physics Conference Series	2021	Indonesia	Mathematical problem-solving ability on trigonometry topic	Senior high school students (Class X SMA Negeri 5 Semarang), learning based on local culture of Semarang			AIR Model (Auditory, Intellectually, Repetition) with ethnomathematics approach; experimental quantitative design; independent t-test; expository learning as comparison
A7	Struggle with Cultural Integration: Elementary School Teachers Designing Mathematics Lessons Using the Javanese Calendar	N. W. Utami, L. Sagita, R. D. Rahmawati / Mathematics Education Journal	2025	Indonesia	Teachers' content knowledge (CK) and pedagogical content knowledge (PCK) in designing mathematics lessons; topics identified include number recognition, multiples, LCM, GCD, data tables, and bar graphs	Elementary school mathematics lesson planning using Javanese Calendar as ethnomathematics context; teachers from Master of Primary Education, Universitas PGRI Yogyakarta			Qualitative thematic analysis; questionnaire lesson plan document analysis, semi-structured interviews; analytical lens of CK & PCK; three integration models: contextual repurposing, superficial, inauthentic

						cultural context	
A8	The potential of ethnomathematical and mathematical connections in the pre-service mathematics teachers' meaningful learning when problems-solving about brick-making	Rodriguez-Nieto, C.A.; Pabon-Navarro, M.L.; Cantillo-Rudas, B.M.; Moll, V.F. / Infinity Journal	2025	Colombia & Spain	Exploration of ethnomathematical and mathematical connections (area, volume, proportional reasoning) in brick-making tasks for pre-service mathematics teachers' meaningful learning.	Brick-making industry in northern Colombia; 14 pre-service mathematics teachers in an ethnomathematics course.	Qualitative ethnographic methodology; workshop (three stages); participant observation; Extended Theory of Connections; Onto-semiotic Approach.
A9	Ethnomathematical research in mathematics education journals in Indonesia: A case study of data design and analysis	Turmuzi, M.; Suharta, I.G.P.; Suparta, I.N. / Eurasia Journal of Mathematics Science and Technology Education	2023	Indonesia	Analysis of trends and research design in Indonesian ethnomathematical publications (2016-2022); dominance of qualitative methods with 49 articles; peak in 2021.	Mathematics education journals in Indonesia; 80 ethnomathematics-themed research articles from 2016 to 2022.	Content analysis; systematic literature review; descriptive analysis of publication trends by design type.
A10	Integrating technology, ethnomathematics, and realistic mathematics education in learning statistics: A learning trajectory	Nursyahidah, F.; Mariani, S.; Wijayanti, K. / Infinity Journal	2025	Indonesia	Design of TE-RME learning trajectory integrating pranata mangsa to teach statistical concepts (central tendency, data dispersion); 32 eighth-grade students.	Pranata mangsa traditional Javanese agricultural calendar system; junior high school in Semarang, Indonesia.	Design Research methodology; Hypothetical Learning Trajectory (HLT); TE-RME framework; animated videos; retrospective analysis.
A11	Ethnomathematics in Architecture: Exploring Geometry and Patterns in the We Tenri Olle Tomb	Naufal, M.A.; Latif, L.A.; Novianti, G.E.; Muhammad, F.;	2025	Indonesia	Identification of planar geometry, spatial geometry (semi-spherical dome), and geometric transformations (reflection,	We Tenri Olle Tomb, Pancana Village, Barru Regency, South Sulawesi;	Qualitative descriptive method; direct observation; literature review; geometric

		Hassan, M.N./ Barekeng			translation, rotation) in the We Tenri Olle Tomb.	Bugis culture with European colonial acculturatio n.	analysis of architectural elements.
A12	Designing Learning Trajectory of Set through the Indonesian Shadow Puppets and Mahabharata Stories	Risdiyanti, I.; Prahmana , R.C.I./ Infinity Journal	2021	Indonesia	Design of Hypothetical Learning Trajectory (HLT) for set theory using Wayang (shadow puppets) and Mahabharata story characters as culturally familiar context.	Wayang (Indonesian shadow puppets) and Mahabharat a stories; junior high school mathematic s education in Yogyakarta.	Design Research; Realistic Mathematics Education (RME); Hypothetical Learning Trajectory (HLT); Local Instructional Theory (LIT).
A13	Bridging geometry and cultures for junior high school level: Rumoh Aceh design from a computational thinking perspective	Nur Azmi, Salmawat y Arif, Hizir Sofyan, Rini Oktavia./ Journal on Mathemat ics Education	2025	Indonesia	Ethnomathemati cs, Computational Thinking, Geometry, Rumoh Aceh (traditional Acehnese house) education.	Junior high school geometry education using Rumoh Aceh architectura l design traditions.	Decompositio n, Pattern recognition, Abstraction, Algorithmic thinking, Ethnographic methods

Discussion

Based on the results of the analysis in this study, ethnomathematics is not only presented as an individual form of implementation, but also reflects an epistemological shift in its development as a field of study. The integrative analysis identified three major patterns: (1) a shift in research focus from cultural documentation toward instructional development; (2) the emergence of tension between the richness of cultural contexts and the still-limited depth of pedagogical implementation; and (3) research fragmentation that has prevented ethnomathematics from developing into a fully integrated scientific program. Therefore, this discussion interprets the findings through these three perspectives by highlighting similarities, differences, and theoretical implications that extend beyond individual studies.

RQ1: Global Trends and Directions of Ethnomathematics Research

The development of publications during the 2015–2025 period not only indicates increasing academic attention toward ethnomathematics, but also reflects the maturity level of this field of study. The stagnation of publications in 2022 and the sharp increase to eight publications in 2025 suggest that research development has not occurred linearly, but has instead been influenced by external factors, such as the implementation of Indonesia's *Merdeka Belajar* policy and the growing emphasis on culturally relevant learning in the post-pandemic era. Nevertheless, the increase in the number of publications has not been fully accompanied by equally strong theoretical consolidation.

Miftahurrahmi et al. (2024) showed that the development of ethnomathematics aligns with UNESCO and OECD agendas related to inclusive quality education (SDG 4). However, the findings of this study indicate that such development has not yet resulted in shared theoretical frameworks or sustainable empirical research programs. In other words, ethnomathematics has expanded more broadly in terms of cultural contexts, research topics, and geographical settings, but it has not yet developed deeply in terms of conceptual integration. This distinction is important because landscape studies should not only demonstrate the growth of research activity, but also identify whether such growth leads toward consolidation or fragmentation within the field.

The thematic changes identified through the VOSviewer visualization also demonstrate a significant epistemological shift. In the earlier period (around 2020–2021), studies primarily focused on STEAM and *game-based learning* (for example, A2). More recent studies, however, have increasingly emphasized numeracy, critical thinking, mathematical literacy, problem-solving, and ethno-modelling (Ahmad et al., 2025.; Azmi et al., 2025; Mei, Purwastuti, et al., 2025; Nursyahidah et al., 2025; Zaenuri et al., 2021). This shift can be interpreted as a transition from “Phase 1 Ethnomathematics,” which focused on demonstrating that mathematics is embedded within culture, toward “Phase 2 Ethnomathematics,” which seeks to utilize cultural contexts to improve students’ formal mathematical competencies.

However, the appearance of terms such as “critical thinking” or “mathematical literacy” in titles and abstracts does not automatically indicate successful achievement of these competencies. Several studies, such as (Ahmad et al., 2025; Naufal et al., 2025; Utami et al., 2025), indeed targeted these abilities, but did not provide strong causal evidence that ethnomathematics-based learning actually improved students’ competencies. Thus, the field remains in a transitional phase: its developmental goals have been clearly formulated, but the supporting

empirical evidence remains limited. This gap between theoretical ambition and empirical validation represents one of the major issues in the current development of ethnomathematics.

The dominance of studies from Indonesia also raises an important issue regarding the universality claim of ethnomathematics. Theoretically, ethnomathematics assumes that all human cultures contain mathematical knowledge within their everyday practices (D'Ambrósio & Knijnik, 2020). However, when most empirical evidence originates from a single country, such universality claims become more assumptive than globally validated.

Indonesia's dominance can be understood considering the country's high cultural diversity, policy support through *Merdeka Belajar*, and strong networks of mathematics education researchers, such as those at Universitas Negeri Semarang and Universitas Pendidikan Indonesia (Nst & Batubara, 2024). Nevertheless, problems arise when findings from Indonesian contexts are generalized to other regions without considering social and cultural differences. The limited number of studies from regions such as Sub-Saharan Africa, South Asia, or Indigenous communities in Latin America indicates that ethnomathematics cannot yet be fully regarded as a truly global movement.

RQ2: Pedagogical Designs in Ethnomathematics Content, Context, and Learning Models

The content analysis of the 13 selected articles demonstrates a wide range of variation in both cultural objects and mathematical topics. The mathematical content discussed includes arithmetic and modular arithmetic (Kholid & Husodo, 2025; Pathuddin & Mariani, 2023) geometry and geometric transformations (Azmi et al., 2025; Naufal et al., 2025), statistics and measures of central tendency (Nursyahidah et al., 2025), discrete mathematics and graph theory (Kholid & Husodo, 2025), set theory (Risdiyanti & Prahmana, 2021), trigonometry (Zaenuri et al., 2021), proportional reasoning and volume (Rodríguez-Nieto et al., 2025), as well as multiples and GCF/LCM (Utami et al., 2025). This diversity indicates that ethnomathematics is not limited to elementary mathematics or basic numeracy. However, the broad scope of mathematical content has not yet been matched by in-depth theoretical development. Studies examining similar mathematical domains, such as geometry in (Azmi et al., 2025; Mei, Marsigit, et al., 2025; Naufal et al., 2025) have not systematically developed interconnected conceptual frameworks. As a result, these studies remain fragmented and have not yet produced a cumulative

theory explaining how specific cultural contexts influence the learning of particular mathematical concepts.

A deeper analysis of cultural contexts reveals three main categories of cultural artifacts. First, traditional architecture and material culture, such as the We Tenri Olle Tomb (Naufal et al., 2025), Rumoh Aceh (Azmi et al., 2025), and the Sa'o Ria Flores house (Mei, Purwastuti, et al., 2025), which embody various geometric and spatial concepts. Second, agricultural and calendrical systems, such as Pananrang (Pathuddin & Mariani, 2023) and Pranata Mangsa (Nursyahidah et al., 2025), which are associated with arithmetic, modular reasoning, and data interpretation. Third, artistic and craft traditions, including Batik Sidomukti (Kholid & Husodo, 2025), Wayang (Pathuddin & Mariani, 2023), and Jamaican games (Espigares-Gómez et al., 2020), which involve combinatorial structures and mathematical relationships. This classification suggests that each cultural category offers distinct opportunities for mathematical learning. Architectural artifacts tend to support spatial reasoning, calendrical systems encourage sequential and modular reasoning, while artistic and game-based traditions promote structural and relational reasoning. These findings reinforce the argument of D'Ambrósio and Knijnik (2020) that mathematical knowledge is embedded within diverse cultural practices.

Various instructional approaches employed in the studies, such as *Design Research with Hypothetical Learning Trajectory* (Nursyahidah et al., 2025; Risdiyanti & Prahmana, 2021), *Realistic Mathematics Education* (Risdiyanti et al., 2021), ethnomodeling (Nursyahidah et al., 2025; Rodríguez-Nieto et al., 2025), TPACK (Ahmad et al., 2025), the AIR model (Zaenuri et al., 2021), *computational thinking decomposition* (Azmi et al., 2025), and the onto-semiotic approach (Rodríguez-Nieto et al., 2025), initially suggest theoretical richness. However, further analysis reveals that similar terms are often used with different meanings and applications. For example, the concept of "ethno-modelling" is interpreted in some studies as a formal mathematical modelling process, while in others it is merely used as a general approach for connecting culture and mathematics. This inconsistency hinders the development of integrated knowledge within the field. Nevertheless, a common pattern emerges across most studies: ethnomathematics learning progresses from cultural artifacts familiar to students, toward informal mathematical reasoning, and eventually to formal mathematical abstraction. This pattern aligns with constructivist theory and Vygotsky's concept of the *Zone of Proximal Development*, which emphasizes that cultural tools assist students in moving from spontaneous concepts toward scientific concepts.

Although similar patterns can be identified in instructional design, the studies also reveal an important contradiction. Most articles report successful integration of culture into mathematics learning. However, the study by (Utami et al., 2025) indicates that elementary school teachers still experience difficulties in designing authentic ethnomathematics lessons. Common issues include using culture merely as additional illustrations, implementing superficial cultural integration, or selecting cultural contexts that are not relevant to students lived experiences.

RQ3: Research Gaps and Recommendations for Future Studies

The synthesis of findings indicates that ethnomathematics research continues to emphasize cultural exploration more than empirical depth, methodological rigor, and conceptual integration. Four major and interconnected gaps were identified. The first gap relates to the dominance of qualitative methods. Of the 13 analysed articles, 12 employed ethnographic, descriptive, or *design-based research* approaches, while only one study (Zaenuri et al., 2021) used a quantitative experimental design. Consequently, the field has not yet been able to determine whether improvements in learning outcomes are genuinely caused by the use of cultural contexts or merely by engaging instructional designs in general. In addition, there is still a lack of longitudinal research examining the long-term impact of ethnomathematics on students' mathematical identities and cultural appreciation. The second gap is the limited integration of digital technology. Although ethnomathematics is frequently positioned as a 21st-century learning approach, most studies still rely on conventional instructional designs. In fact, technologies such as VR, AR, and AI hold significant potential to help students understand the relationship between culture and mathematical concepts in more interactive ways. For example, VR can be used to explore traditional buildings virtually, while AR can directly display mathematical concepts on real cultural artifacts.

The third gap concerns the geographical concentration of studies in Indonesia. This condition limits the ability of ethnomathematics to develop truly universal theories. Therefore, cross-cultural studies are necessary to determine whether ethnomathematics instructional principles can be applied broadly or are only effective within specific cultural contexts. The fourth gap relates to the limited research on teacher education and culturally responsive assessment. Only a few studies investigate teachers' abilities to design ethnomathematics instruction, and almost none examine assessment instruments that are appropriate to cultural contexts. Without adequately prepared teachers and suitable assessment systems, the large-scale implementation of ethnomathematics will remain difficult.

These four gaps are closely interconnected. The lack of experimental research weakens the evidence regarding the effectiveness of ethnomathematics. The limited number of cross-cultural studies restricts theoretical generalization. The lack of teacher education research hinders implementation in schools. Meanwhile, the absence of culturally responsive assessment makes learning outcomes difficult to evaluate fairly and comprehensively. Therefore, future ethnomathematics research requires not only more studies, but also coordinated research programs aimed at strengthening methodology, integrating technology, expanding cultural contexts, and improving teacher capacity and assessment systems. This study contributes by mapping the relationships among these gaps, thereby providing a foundation for the development of more systematic and comprehensive ethnomathematics research programs in the future.

Conclusion

This study demonstrates that ethnomathematics has experienced significant development in mathematics education during the 2015–2025 period. Based on the analysis of publication trends, ethnomathematics research has evolved from merely exploring the relationship between culture and mathematics toward utilizing cultural contexts to enhance students' formal mathematical competencies, such as mathematical literacy, numeracy, critical thinking, and problem-solving skills. However, the dominance of studies conducted in Indonesia indicates that ethnomathematics research still requires broader cross-cultural representation to strengthen its global validity.

Based on the analysis of pedagogical designs, ethnomathematics research reveals considerable diversity in mathematical topics, cultural artifacts, and instructional models employed. Nevertheless, all studies share a relatively similar pattern, namely connecting students' cultural experiences with the process of formal mathematical abstraction. These findings indicate that culture can serve as an effective context for developing more meaningful mathematical understanding.

Furthermore, the analysis of research gaps and future directions shows that ethnomathematics studies are still predominantly dominated by qualitative approaches, have not optimally integrated digital technologies, remain geographically concentrated, and have paid limited attention to teacher professional development and culturally responsive assessment. Therefore, future research should employ mixed-methods and experimental approaches, integrate technologies such as Artificial Intelligence (AI), Virtual Reality (VR), and Augmented

Reality (AR), expand cross-cultural collaborations, and strengthen teacher education as well as culturally responsive assessment frameworks.

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