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Mapping Research Trends and Thematic Evolution in Ethnomathematics 2020-2025: A Bibliometric Analysis in Mathematics Education

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ABSTRACT

This study maps the development of ethnomathematics research from 2020 to 2025 through a bibliometric analysis of Scopus-indexed publications. Using VOSviewer, publication trends, influential authors, institutional collaborations, and thematic structures were identified and visualised. The findings reveal substantial growth in ethnomathematics publications beginning in 2021, with Indonesia emerging as the most productive contributor. Four dominant thematic clusters were identified: teacher pedagogy, cultural artefacts and symbolism, cognitive development in geometry and spatial reasoning, and sociocultural knowledge systems. Visualisation analyses indicate a thematic transition from traditional cultural documentation toward innovation in instructional media and 21st-century learning approaches. The results highlight the pivotal role of teachers in mediating cultural knowledge within classroom practices. Overall, the study demonstrates that ethnomathematics is evolving into a multidimensional research field that integrates culture, education, cognition, and technology, while offering promising directions for future research in computational ethnomathematics, culturally responsive pedagogy, and digital learning environments.

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1. INTRODUCTION

Ethnomathematics has developed as an educational approach that bridges formal mathematical concepts with cultural practices embedded in everyday community life. Rooted in the theoretical perspective that mathematical knowledge is socially and culturally constructed, ethnomathematics positions culture not merely as contextual decoration but as a legitimate source of mathematical ideas and reasoning. This perspective aligns with sociocultural learning theory, which emphasises that knowledge is formed through interaction between individuals and their cultural environments. Within mathematics

education, such an approach is believed to enrich learning by situating abstract concepts within contexts that are familiar and meaningful to students, thereby enhancing conceptual understanding, engagement, and cultural relevance.

A growing body of empirical research, particularly in Indonesia, has demonstrated that local cultural practices, such as traditional calendrical systems, weaving patterns, architectural forms, and games, contain structured mathematical concepts that can be integrated into formal instruction. Studies on the *Pranatamangsa* system in Yogyakarta, for example, reveal indigenous concepts of time measurement and arithmetic reasoning that provide authentic contexts for teaching number sense and algebraic thinking [1]. Similarly, research on batik motifs and traditional architecture has shown that geometric transformations, symmetry, and proportional reasoning are deeply embedded in cultural artefacts [2], [3]. These findings reinforce the theoretical claim that cultural practices function as coherent mathematical systems rather than supplementary illustrations.

Previous studies further indicate that integrating ethnomathematics into classroom instruction positively affects students' conceptual understanding, representational abilities, and affective engagement with mathematics. Instructional designs that utilise cultural artefacts, such as batik patterns, traditional games, or local spatial designs, have been shown to foster visual reasoning, reflective thinking, and a sense of ownership over mathematical knowledge. For instance, Fitriyah et al. (2025) reported that geometry instruction based on batik motifs significantly enhanced students' visual–spatial reasoning and reflective learning processes [2]. These outcomes suggest that ethnomathematics supports not only cognitive development but also students' cultural identity and positive attitudes toward mathematics.

In recent years, ethnomathematics research has increasingly intersected with technological and pedagogical innovation. The incorporation of digital media, project-based learning, and frameworks such as Technological Pedagogical Content Knowledge (TPACK) has expanded the scope of ethnomathematics beyond traditional classroom practices. Several studies report that integrating technology with local cultural contexts enhances student engagement, facilitates visualisation and simulation of mathematical ideas, and supports higher-order thinking skills through interactive learning environments [4], [5]. This emerging direction positions ethnomathematics as a potential bridge between cultural heritage and 21st-century mathematics education grounded in digital literacy and critical thinking.

Despite the growing number of ethnomathematics studies, a critical problem remains: the absence of systematic mapping of the field at both global and regional levels**.** Existing research largely focuses on classroom implementation, learning outcomes, or cultural analysis, while limited attention has been given to examining publication trends, dominant research themes, collaborative networks, and the evolution of research topics over time. Consequently, the overall structure and trajectory of ethnomathematics research remain fragmented, making it difficult to identify research gaps, emerging themes, and future directions.

To address this gap, the present study employs a bibliometric approach to systematically analyse ethnomathematics research indexed in Scopus from 2020 to 2025, using VOSviewer for data visualisation and network analysis. The objectives of this study

are to: (1) identify publication growth trends in ethnomathematics research; (2) map dominant thematic clusters and their interrelationships; (3) analyse influential authors, institutions, and countries; and (4) examine shifts in research focus over time.

It is expected that the results of this study will provide a comprehensive overview of the intellectual structure and development of ethnomathematics research. By offering empirical insights into research trends and thematic evolution, this study aims to support researchers, educators, and policymakers in identifying future research opportunities, strengthening culturally responsive pedagogy, and advancing the integration of technology within ethnomathematics-based mathematics education.

2. METHOD

The study employs a bibliometric analysis approach to describe the development of ethnomathematics research over the last six years (2020–2025). This approach was selected for its ability to facilitate the identification of changes and trends within a field of study through systematic mapping of publication data. The mapping process includes, among others, keywords, authors, institutions, citation counts, and inter-article relationships. Bibliometric analysis methods of this kind have been widely applied across various disciplines, particularly in education and the social sciences, as a systematic, measurable means of analysing research patterns and revealing the structure and trends of a given scientific field [6].

All data used in this study were obtained exclusively from the Scopus database. The search was conducted using a single keyword, namely "ethnomathematics," applied to the title, abstract, and keywords fields (title–abs–key). To ensure relevance to the research domain, the search was restricted to two Scopus subject areas: Social Sciences and Mathematics. Only journal articles were included in the analysis; other publications, such as conference proceedings, book chapters, and review articles, were excluded. In addition, a language restriction was applied, limiting the articles to English-language articles. This policy of using English aims to maintain consistency in metadata quality and to facilitate bibliometric comparison across international publications, in line with recommendations from several previous bibliometric studies [7].

All search results retrieved from Scopus were exported in RIS (Research Information Systems) format. The RIS format was selected because of its compatibility with bibliometric analysis software such as VOSviewer and its ability to store metadata in a complete and structured manner. The metadata obtained included various types of information, such as article titles, author names, institutional affiliations, abstracts, keywords, publication years, and citation counts. The use of the RIS format has been recommended in numerous previous bibliometric studies, as it helps preserve data completeness and integrity during the import and mapping processes [8].

All exported RIS files were subsequently analysed using VOSviewer. This software was chosen for its ability to construct and interactively visualise bibliometric networks, including author collaboration networks, keyword co-occurrence, co-citation, and bibliographic coupling. Through these visualisations, the study identified annual publication trends, dominant research themes, emerging keyword clusters over the past ten years, and

collaboration networks among authors and institutions [9]. Furthermore, VOSviewer enables analysis based on specific significance measures, such as link counts and total link strength, thereby providing a comprehensive overview of the ethnomathematics research landscape.

Following the initial visualisation, a manual screening of the dataset was conducted to ensure each included article was relevant to the study's focus. This validation step is essential, as Scopus search results may include articles that merely mention the term "ethnomathematics" without substantive discussion. Irrelevant articles were therefore removed from the dataset to maintain the validity and accuracy of the bibliometric analysis. This procedure aligns with recommendations from previous bibliometric researchers who emphasise the importance of manual metadata verification [10], [11].

The final interpretation was carried out by analysing patterns derived from the visualisations and statistical outputs generated by VOSviewer. This analysis included the identification of topic clusters, relationships among concepts, publication growth trends, and emerging research gaps over the past ten years. The findings were used to describe the scholarly landscape of ethnomathematics and to provide recommendations for future research directions.

3. RESULTS AND DISCUSSION (12 PT)

3.1. Results

A bibliometric analysis of publications on ethnomathematics from 2020 to 2025 identified 282 documents based on the specified search criteria: (a) subject areas Social Sciences and Mathematics, (b) article type, and (c) English-language publications as the primary filter. All data were retrieved from Scopus in RIS format and analysed using VOSviewer, which generated three types of visualisations: networks, overlays, and densities.

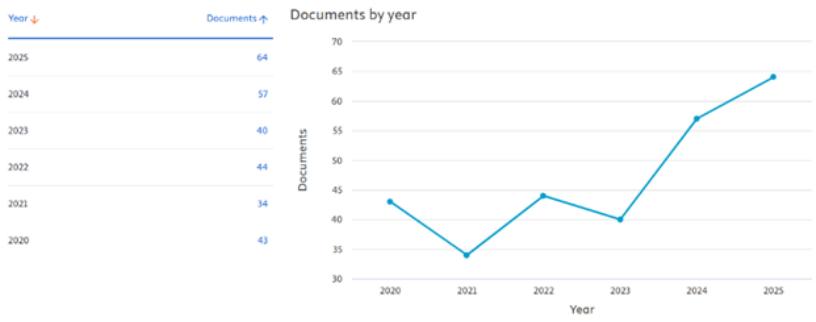

Figure 1. Annual Distribution of Ethnomathematics Publications (2020–2025)

The graph presented in Figure 1 illustrates the development of ethnomathematics publications over time. The Scopus data show that publications from 2020 to 2025 exhibit a fluctuating trend, but the last two years show a notable increase. During the period 2020–2023, the number of documents remained relatively stable, ranging from 34 to 44 publications, indicating consistency without substantial growth. However, in 2024 the number rose sharply to 57 publications, followed by a further increase in 2025 to 64 publications. This pattern suggests a stronger expansion of research interest in ethnomathematics-related issues, aligning with Batiibwe (2024), who reported a significant

rise in ethnomathematics publications in recent years, reflecting a growing global recognition of the importance of integrating cultural perspectives into mathematics education [12]. Sunzuma and Umbara (2025) also confirmed this upward trend, particularly in the context of using technology to support ethnomathematics learning, indicating that the field is developing not only quantitatively but also methodologically through the adoption of educational technology innovations [13].

Nevertheless, interpreting this upward pattern requires caution, as part of the increase may stem from external factors such as national policy changes, the rise of open-access journals, and the growing number of researchers in mathematics education. Donthu et al. (2021) emphasised that in bibliometric analyses, publication trends can be influenced by various systemic factors, including shifts in indexing policies, the proliferation of predatory journals, and cultural shifts in academic publishing toward open access, meaning that growth in publication volume does not always correspond to improvements in research quality or impact [14]. Rosa et al. (2016) further noted that the growth of ethnomathematics publications over the last decade has been partly driven by UNESCO's recognition of the importance of multicultural education and by national education policies in several countries that began incorporating local content into mathematics curricula, prompting more researchers to explore this theme [15]. Moreover, Deda et al. (2024) identified that the increasing participation of researchers from developing countries in international publication platforms such as Scopus is another key factor contributing to the rise in ethnomathematics publications, especially from culturally diverse regions such as Southeast Asia and Latin America [16].

Thus, the graph reflects not only quantitative dynamics but also broader shifts in the research landscape surrounding the integration of culture and mathematics. Deda et al. (2024) argued that the rise in ethnomathematics publications signifies a paradigm shift in mathematics education from a universalistic, abstract orientation toward approaches that are more contextual, inclusive, and responsive to students' cultural diversity, thereby shaping a richer, more varied research agenda [16]. Rosa et al. (2016), although published earlier, predicted that ethnomathematics would become an increasingly important research domain in the 21st century as awareness of knowledge decolonisation and the recognition of non-Western mathematical knowledge systems continued to grow, a prediction that aligns well with current publication trends [15]. Serepinah & Nurhasanah (2023) added that the expansion of ethnomathematics research also represents an academic response to the challenges of globalisation and migration, where classrooms are becoming increasingly multicultural and require pedagogical approaches capable of bridging students' diverse cultural backgrounds, thereby stimulating further research on culturally meaningful and inclusive mathematics teaching [17].

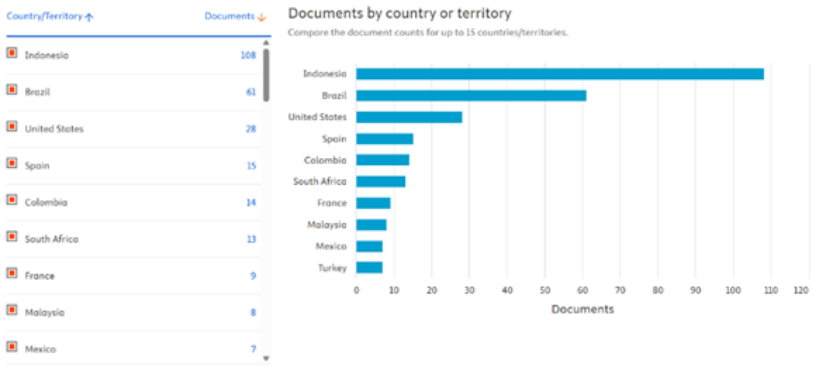

Figure 2. Distribution of Ethnomathematics Publications by Country

The graph in Figure 2 depicting the development of publications by country shows that bibliometric data from Scopus identify Indonesia and Brazil as the two countries with the highest number of ethnomathematics publications worldwide. Indonesia ranks first globally in ethnomathematics research productivity, followed by Brazil in second place and the United States in third. These findings align with other bibliometric studies, which similarly conclude that Indonesian scholars dominate global ethnomathematics publication output [18], and confirm Brazil's significant role as one of the field's leading contributors. This consistent dominance across analyses indicates that Indonesia and Brazil have been at the forefront of ethnomathematics research over the past decade.

Several contextual factors explain why Indonesia and Brazil exhibit such strong dominance. Indonesia's multicultural character, reflected in the national motto "Bhinneka Tunggal Ika" (Unity in Diversity), highlights its vast diversity of ethnicities and cultural traditions. This cultural richness has stimulated extensive research linking mathematical concepts to local practices throughout the archipelago, resulting in a high volume of ethnomathematics publications. Brazil, on the other hand, holds historical importance as the birthplace of the ethnomathematics movement through Ubiratan D'Ambrosio, and continues to be a major force in the field through its strong international collaboration networks [19]. Although Brazil ranks second in publication count, it surpasses most other countries in collaborative influence, demonstrating that Brazilian scholars are deeply engaged in global research partnerships that amplify the reach and impact of their ethnomathematics contributions. Together, Indonesia and Brazil are not only quantitatively productive but also central to the global research community.

This pattern of dominance reflects the growing involvement of developing countries in ethnomathematics research. The prominence of developing nations at the top of global scientific productivity signals a geographical shift in the research landscape. Countries with rich cultural traditions are increasingly leveraging local knowledge to enrich mathematics education and scholarly discourse [19]. The visibility of Indonesia and Brazil demonstrates how cultural diversity and indigenous knowledge systems can drive innovation in mathematics education through ethnomathematical approaches. As global interest in ethnomathematics continues to grow, the field requires stronger institutional support to embed culturally responsive pedagogy into formal mathematics curricula across nations. In essence, the education community is beginning to recognise ethnomathematics as a powerful

bridge between mathematics and local cultural contexts, especially in developing regions with deep cultural heritage.

Beyond these two leading nations, numerous other developing countries have also contributed to the expansion of ethnomathematics research. For example, South Africa and Colombia, although producing fewer publications than the top three, demonstrate substantial global impact as reflected in the high citation counts of their works. This suggests that the quality and influence of ethnomathematics research from developing countries can rival those of more established research nations, even with fewer publications. More broadly, ethnomathematics studies have emerged across a wide range of contexts, including Zimbabwe, Turkey, Nepal, the United Arab Emirates, India, and Colombia [18]. The wide geographic distribution indicates that ethnomathematics is now a globally relevant research theme, no longer limited to specific regions or high-income countries. The strong presence of Indonesia and Brazil, alongside active participation from other developing nations, reflects a shifting scientific landscape in which developing countries are increasingly shaping the evolution of ethnomathematics. This trend illustrates the global appeal of ethnomathematics, particularly for countries that view local wisdom as a strategic resource for innovation in mathematics education. Consequently, the growing engagement of developing nations not only increases publication output but also enriches the cultural contexts represented within the literature, fostering positive transformation in mathematics education worldwide.

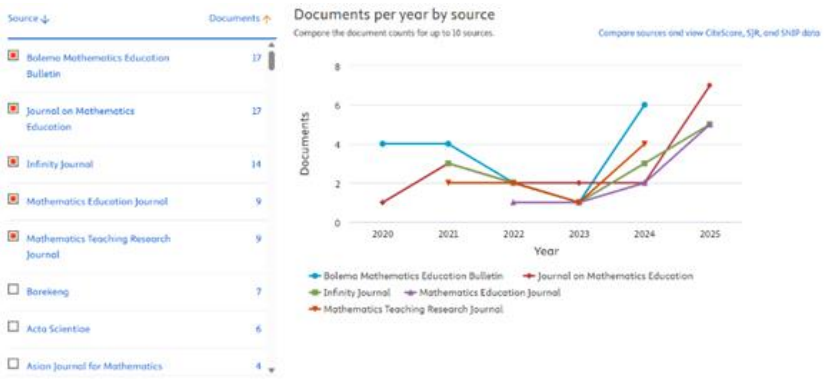

Figure 3. Distribution of Ethnomathematics Publications by Source

The graph in Figure 3 indicates that the Journal on Mathematics Education (JME) is among the most significant sources of ethnomathematics publications. The trend of JME's contribution to ethnomathematics has shown a steady increase over time. Recent bibliometric analyses based on Scopus data from 2012–2022 place JME among the top five global sources of ethnomathematics documents [16]. Over the past decade, JME has published approximately eight ethnomathematics articles indexed in Scopus. Although this number is lower than that of conference proceedings, its quality and scholarly impact are substantial. One ethnomathematics article published in JME (Muhtadi et al., 2017) has even become one of the most frequently cited works in this domain. This achievement indicates that JME plays an important role in disseminating ethnomathematics research, with a noticeable increase in publications in recent years [3].

Infinity Journal also emerges as a major source of ethnomathematics publications, particularly within the Indonesian context. This applied mathematics journal, accredited by SINTA, has increasingly featured ethnomathematics studies, reflecting the growing interest in culturally grounded approaches to mathematics education. A bibliometric study on ethnomathematics in Indonesia identified Infinity Journal as one of the five most productive publication outlets in this field [3]. This highlights the journal's growing contribution to the ethnomathematics literature. Each year, more ethnomathematics articles are published in Infinity, aligning with the overall national rise in ethnomathematics research. The journal's role as a platform for ethnomathematics scholarship underscores the Indonesian mathematics education community's commitment to integrating cultural contexts into mathematics learning.

Bolema – Boletim de Educação Matemática is a leading international journal that consistently publishes on ethnomathematics. Globally, Bolema stands out as one of the main sources of ethnomathematics articles indexed in Scopus. Between 2012 and 2022, Bolema published approximately 14 ethnomathematics documents, second only to JPCS (a conference proceedings outlet) [16]. This substantial contribution reflects the strong interest of the Latin American academic community, particularly in Brazil, toward ethnomathematics. Publication trends in Bolema show steady growth, in line with the increasing recognition of ethnomathematics as an important area of inquiry in mathematics education. Bolema's prominence in international ethnomathematics publications enriches the global literature and reinforces Brazil's historical role in the field's early development.

Figure 4. Distribution of Ethnomathematics Publications by Author

Figure 4 presents the ten most active authors in producing publications in the field of ethnomathematics. M. Rosa ranks first with sixteen publications, followed by D. C. Orey with twelve publications. From Indonesia, R. C. I. Prahmana appears next with nine publications, followed by G. Sunzuma with seven. A. Maharaj and I. P. A. A. Payadnya each contributed six publications. Meanwhile, V. Albanese, F. Hanum, C. A. Rodriguez-Nieto, and U. D'Ambrosio also contributed significantly, each with five publications. This pattern indicates that ethnomathematics research is supported by scholars from various countries, with notable contributions from Brazil, Indonesia, and the United States, reflecting the global development of cultural studies within mathematics education [15], [13], [1].

Table 1. Top 5 Articles with The Highest Citations Per Year From 2020 To 2025

No.	Title	Authors	Source	Year	Citation
1.	Learning Geometry And Values From Patterns Of Yogyakarta, Indonesia	Prahmana, R.C.I., D'Ambrosio, U	Journal on Mathematics Education, 11(3), pp. 439-456	2020	87
2.	Assessment Of Mathematical Creative Thinking: A Systematic Review	Suherman, S.,Vidakovich, T.	Thinking Skills and Creativity, 44, 101019	2022	71
3.	Ethnomathematics : Pranatamangsa System And The Birth-Death Ceremonial In Yogyakarta	Prahmana, R. C. I., Yunianto, W., Rosa, M., Orey, D. C	Journal on Mathematics Education, 12(1), pp. 93-112	2021	49
4.	Teacher's Perception Toward The Use Of Ethnomathematics Approach In Teaching Math	Mania, S., Alam, S.	International Journal of Education in Mathematics Science and Technology, 9(2), pp. 282-298	2021	34
5.	working Between Ethnomathematics, STEAM Education, And The Globalized Approach To Analyze Mathematical Connections In Daily Practices	Rodriguez-Nieto, C.A., Alsina, A	Eurasia Journal of Mathematics Science and Technology Education, 18(3), em2085	2022	30

From Table 1, it can be seen that the most frequently cited articles are from Indonesia, particularly those published in the Journal of Mathematics Education. The fact that an article on batik patterns ranks first indicates that cultural topics are among the most compelling and influential themes in ethnomathematics research [1].

Figure 5 presents the network visualisation generated by VOSviewer. This visualisation illustrates the conceptual structure of ethnomathematics research based on keyword co-occurrence within Scopus-indexed publications. Larger nodes represent keywords that appear most frequently, while the colours indicate clusters of keywords that are strongly interconnected based on their patterns of co-appearance across articles. Overall, the map reveals four major clusters.

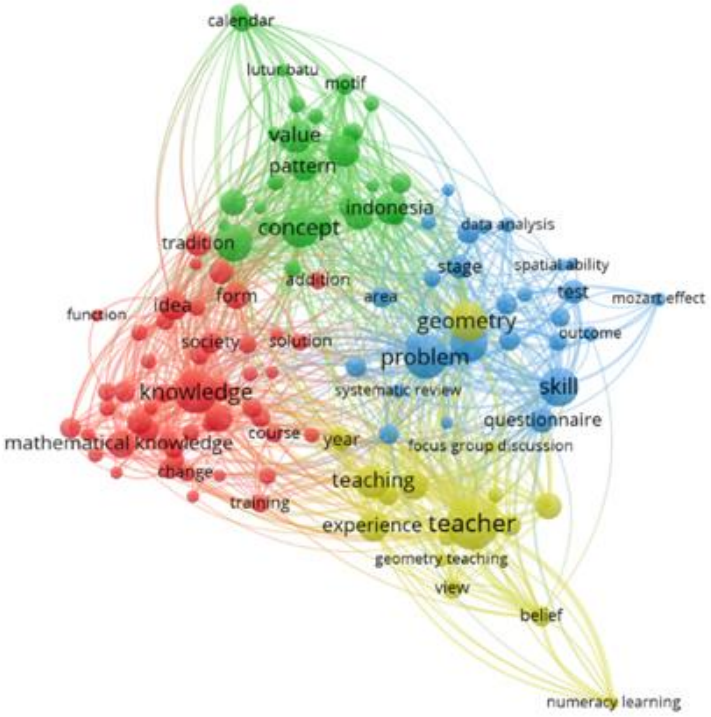

Figure 5. Network visualisation of ethnomathematics from VOSviewer.

The red cluster is dominated by terms such as *knowledge, mathematical knowledge, tradition,* and *concept,* indicating a strong focus in the literature on the relationship between mathematical knowledge and cultural contexts. D'Ambrosio (2016) emphasises that ethnomathematics is fundamentally the study of how mathematical knowledge is constructed and transmitted within diverse cultural settings, reflecting distinctive local traditions and conceptual systems [15].

The green cluster features keywords such as *pattern, motif, value, calendar,* and *Indonesia,* reflecting the prominence of studies rooted in cultural artefacts, such as traditional motifs or cultural practices, and highlighting the strong contribution of Indonesian scholarship to the field. Prahmana et al. (2021), in their study on the Pranatamangsa system and life-cycle ceremonies in Yogyakarta, demonstrate how Indonesian ethnomathematics research consistently explores cultural patterns, traditional motifs, and calendrical systems as authentic sources for mathematics learning [1].

The blue cluster centres on terms such as geometry, problem, skill, and spatial ability, indicating that many studies connect ethnomathematics with geometry instruction and the development of students' spatial skills. Fouze & Amit (2018) show that integrating ethnomathematics into geometry instruction can enhance students' spatial reasoning and problem-solving skills by exploring geometric patterns embedded in cultural artefacts, such as traditional ornaments [20].

Meanwhile, the yellow cluster includes terms such as *teacher, teaching, experience,* and *belief,* pointing to research themes focused on teachers' perceptions, experiences, and

pedagogical practices in integrating ethnomathematics into classroom instruction. Marlissa et al. (2024) find that teachers' beliefs and experiences play a crucial role in the success of ethnomathematics implementation, even though many teachers still face challenges in embedding cultural content into the formal mathematics curriculum [21].

Although this visualisation provides a clear picture of major themes in ethnomathematics research, its interpretation requires caution. Large node sizes do not automatically reflect a concept's theoretical importance; they reflect only its frequency across documents. Likewise, clusters in VOSviewer do not inherently represent established conceptual frameworks; they are statistical groupings based on co-occurrence patterns. Donthu et al. (2021) remind us that, in bibliometric analysis, keyword frequency does not necessarily correlate with theoretical significance or conceptual impact, underscoring the need to consider the substantive context behind quantitative patterns [14].

Connections between clusters also reveal a shift in the ethnomathematics research agenda, from merely describing cultural practices to pedagogical integration, particularly through geometry and teacher practice. Rosa and Orey (2021) identify a trend in which ethnomathematics research has evolved from a documentation phase to an application phase, in which cultural practices are not only recorded but also actively incorporated into innovative mathematics instructional design [15]. However, this pattern also reflects potential research biases, such as the dominance of Indonesian contexts and the recurring use of geometry as the primary mathematical domain linked to cultural elements. Sunzuma & Umbara (2025), in their systematic review of technology-based ethnomathematics in Indonesia, confirm this geographic dominance and note that geometry is frequently examined because cultural patterns are visually identifiable, while other mathematical domains, such as algebra, statistics, or calculus, remain understudied [13].

Overall, the network visualisation not only maps the existing directions and tendencies of ethnomathematics research but also reveals research gaps that warrant further exploration, such as the scarcity of studies in other mathematical domains and the limited number of empirical investigations measuring learning outcomes. Batiibwe (2024) notes that, despite the abundance of theoretical and qualitative studies, there remains a significant lack of experimental or quasi-experimental research that quantifies the impact of implementing ethnomathematics [12]. Furthermore, Wardani (2023) highlights the need to expand ethnomathematics research into domains beyond geometry, such as algebra reflected in traditional trade systems, statistics in agricultural practices, and calculus in traditional navigation technologies to provide a more holistic understanding of how mathematics is embedded in diverse cultural practices [22]. By identifying these gaps, the network visualisation serves not only as a map of existing knowledge but also as a compass guiding future research directions in ethnomathematics.

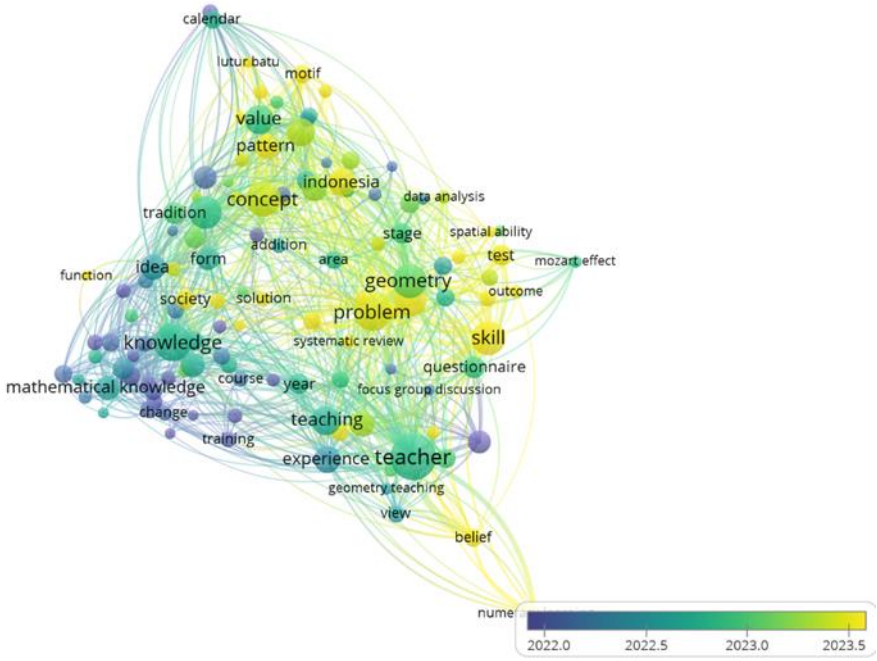

Figure 6. Overlay visualisation results of vosviewer for ethnomathematics publications per year (2020–2025) based on Scopus data.

The overlay visualisation in Figure 6 shows a temporal shift in the themes of ethnomathematics research, based on Scopus-indexed publications from 2020 to 2025. Keywords displayed in darker shades (blue–green), such as *knowledge*, *teacher*, and *tradition*, are associated with earlier publications (before 2022). These keywords indicate that early ethnomathematics studies predominantly emphasised integrating cultural knowledge and the role of teachers in implementing culturally grounded mathematics instruction. Studies such as Mania and Alam (2021) support this pattern, showing that teachers responded positively to ethnomathematical approaches and integrated local games or traditions to enhance students' mathematical understanding and cultural awareness [23].

Conversely, keywords marked in bright yellow, *geometry*, *skill*, *data analysis*, and *Mozart effect*, represent emerging themes in more recent years, particularly around 2023. The presence of *geometry* and *skill* highlights a growing interest in improving specific mathematical competencies through cultural contexts. The emergence of *data analysis* reflects the increasing use of bibliometric and systematic review methodologies within ethnomathematics research. Moreover, new interdisciplinary approaches have emerged, such as combining ethnomathematics with the "Mozart effect." Kusuma et al. (2024) reported that integrating ethnomathematical activities with Mozart-style classical music significantly improved students' mathematical problem-solving abilities and learning motivation, which explains the recent prominence of this keyword [24].

The contrast between earlier and recent keywords signals a notable thematic transition. Earlier research trends focused on cultural knowledge, traditional practices, and teacher involvement, laying the conceptual foundation for ethnomathematics. By contrast, recent studies have shifted toward methodological innovation, skill-oriented learning, and interdisciplinary enrichment. This finding aligns with recent global bibliometric evidence

showing peaks of ethnomathematics publications in 2020 and 2023, along with the emergence of new research directions involving technology, problem-solving enhancement, and evaluation of ethnomathematics-based instruction. Overall, the evolution from 2022 to 2023 reflects a dynamic shift from cultural exploration to more innovative, skill-focused, and contextually responsive approaches in mathematics education.

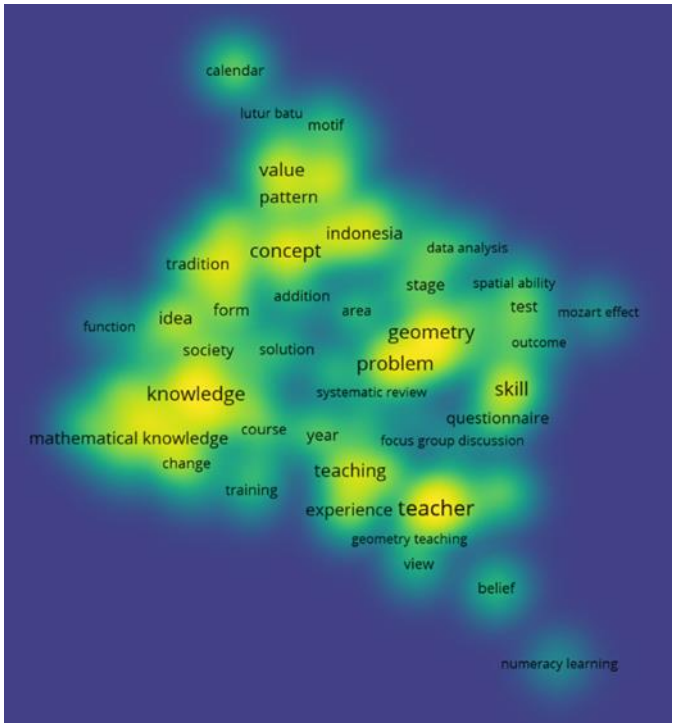

Figure 7. The results of the density visualisation analysis of ethnomathematics research using vosviewer for the years 2020–2025 based on Scopus data.

The density visualisation in Figure 7 highlights the concentration of frequently occurring terms in ethnomathematics publications indexed in Scopus from 2020 to 2025. The terms *knowledge*, *geometry*, *teacher*, and *problem* appear with the highest intensity, indicating their centrality in the research landscape. This pattern suggests that recent ethnomathematics studies predominantly focus on linking local cultural knowledge with formal mathematical concepts, particularly geometry, while underscoring the role of teachers and problem-solving competencies. The prominence of *geometry* aligns with numerous studies that identify geometric structures embedded in cultural artefacts and traditional practices [25]. Meanwhile, the teacher's frequent appearance reflects the growing scholarly attention to the pedagogical dimension of ethnomathematics and to the teacher's role as a mediator between cultural context and mathematical abstraction [26].

The density map also reveals that ethnomathematics research during this period consistently explores the integration of cultural practices, such as traditional calendars, rituals, artistic motifs, indigenous measurements, and daily activities into mathematical learning. For example, studies on traditional calendar systems highlight arithmetic operations and number patterns embedded in cultural routines [27], while research on architectural forms, dances, and craft motifs demonstrates the presence of geometric concepts such as symmetry, area, and volume [25]. These findings reinforce the idea that

cultural environments function as natural laboratories for mathematical exploration [28]. The strong density around *knowledge* suggests an emphasis on leveraging cultural understanding to strengthen students' mathematical representation, connection making, and problem-solving.

Another notable pattern is the persistent visibility of teacher-related keywords. This indicates that pedagogical issues remain central to the development of ethnomathematics, particularly in the Indonesian context. Studies emphasise that teachers hold positive attitudes toward culturally contextualised mathematics instruction and recognise the importance of aligning learning materials with students' cultural backgrounds [23]. Research also shows that teachers who integrate local cultural elements into mathematics lessons can improve student engagement and comprehension, making learning more meaningful and relevant [26], [28]. Thus, the density patterns not only reflect thematic trends but also reaffirm the pivotal role of teachers in the successful implementation of culture-based mathematics education.

Taken together, the density visualisation demonstrates that a strong interplay among cultural knowledge, geometric structures, teacher agency, and problem-solving processes characterises ethnomathematics research from 2020 to 2025. These thematic clusters indicate a research trajectory that increasingly views culture not as a supplementary context but as an essential source of mathematical ideas and pedagogical innovation.

A notable novelty revealed by the overall mapping is that the visualisation indicates a shift in ethnomathematics research from merely documenting local cultural practices to implementing them as systematic pedagogical strategies in formal mathematics education, particularly in geometry, problem-solving, and teacher empowerment. The simultaneous appearance of keywords such as *value*, *tradition*, *belief*, and *society* alongside mathematical terms like *geometry*, *skill*, and *concept* illustrates a shift toward a multidisciplinary orientation that integrates anthropological, sociological, and mathematics education perspectives. The presence of keywords such as *Indonesia*, *lutur batu*, and *motif* further confirms the substantive contribution of developing countries to authentic cultural contexts in global scholarly discourse. At the same time, the dominance of *teacher*, *experience*, *belief*, and *training* underscores a movement away from a purely student-centred orientation toward recognising the crucial role of teachers as cultural mediators who require ongoing professional development.

Moreover, the emergence of keywords such as *society*, *function*, and *knowledge change* suggests that the ethnomathematics research agenda is evolving in response to contemporary global issues, including multiculturalism, knowledge decolonisation, and educational inclusivity. This reinforces the argument that the field continues to develop dynamically to address the increasingly complex and diverse challenges of the modern world. Thus, this bibliometric mapping not only captures the current state of ethnomathematics research but also identifies future directions and research opportunities that align with the needs of culturally grounded mathematics education in the digital era.

3.2. Discussion

The bibliometric mapping results generated using VOSviewer reveal the dynamic development of ethnomathematics research over the past six years (2020–2025) based on Scopus-indexed data. The analysis indicates consistent growth in publication output, reflecting increasing academic attention to integrating cultural contexts into mathematics education. Geographically, dominant contributions originate from Indonesia and Brazil, two countries recognised for their rich cultural heritage and strong traditions, as well as their active engagement in promoting ethnomathematics as a contextual strategy in mathematics learning.

The network visualisation produced by VOSviewer categorises dominant keywords into five thematic clusters, each distinguished by a colour: red, green, blue, yellow, and purple. Each cluster represents a specific thematic focus, such as cultural knowledge and traditions (red), cultural artefacts and patterns (green), geometric and spatial skills (blue), and pedagogical dimensions including teachers and teaching experiences (yellow). The interconnections among these clusters form a mutually reinforcing thematic network, illustrating how ethnomathematics research has evolved from cultural conceptual foundations to contextualised classroom practices responsive to diversity. These findings underscore that ethnomathematics is no longer merely an alternative approach but has emerged as a central direction in transforming mathematics education toward greater inclusivity and meaningful learning.

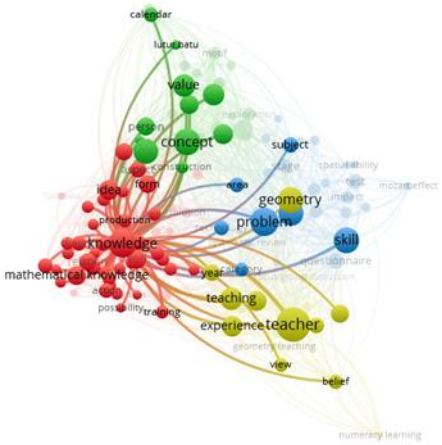

Figure 8. The red cluster group (cluster one) is related to ethnomathematics

The red cluster highlights the interconnection between mathematical knowledge and cultural traditions within society. Ethnomathematics research demonstrates that mathematics is an integral part of culture, embedded in all aspects of community life [29]. Mathematical concepts are rooted in cultural practices and develop alongside local ideas and traditions, meaning that each community possesses distinctive ways of engaging in mathematical activities [29]. Recent findings further support this perspective by emphasising that mathematics "lives" within oral traditions and everyday customs, rather than being confined to formal classroom settings [30]. Accordingly, this cluster reflects research efforts to bridge formal mathematical knowledge with local cultural knowledge, where traditional practices, such as games, crafts, rituals, and other cultural activities, often contain implicit

mathematical ideas. This aligns with the fundamental aim of ethnomathematics, which is to recognise and value the diversity of mathematical knowledge that emerges from community traditions [30].

The green cluster is associated with mathematical concepts and cultural values embodied in patterns, motifs, and traditional calendrical systems. Numerous ethnomathematics studies in Indonesia have examined batik motifs, woven textiles, and traditional carvings, revealing that each motif conveys both philosophical meanings and specific mathematical concepts [31]. For example, batik patterns serve not only aesthetic functions but also embody symbolic and cultural values closely related to geometric concepts such as symmetry and transformation [31]. Additionally, traditional calendar systems are a significant theme within this cluster. Research has shown that the Javanese calendar, for instance, employs principles of modular arithmetic to determine the cycles of market days and the weekly system [32]. Similarly, calendrical systems and seasonal calculations in agrarian cultures, such as the *pranata mangsa*, contain complex mathematical patterns used to determine planting and harvesting periods [30]. Overall, the green cluster underscores that cultural patterns, whether manifested in artistic motifs or calendrical systems, are rich with embedded mathematical ideas. This perspective encourages the use of cultural artefacts, such as batik motifs or local calendars, as meaningful contextual resources in mathematics instruction, enabling students to comprehend abstract concepts through patterns familiar within their own cultural contexts [32], [31].

The blue cluster encompasses keywords such as *geometry*, *problem*, *spatial ability*, and the *Mozart effect*, indicating scholarly attention to the development of cognitive skills through ethnomathematics-based approaches. Several experimental studies, including that of Kusuma (2021), demonstrate that integrating cultural contexts with cognitive stimulation, such as music, can enhance students' spatial understanding and mathematical connections [33].

The yellow cluster, which includes keywords such as *teacher*, *teaching*, *experience*, and *belief*, highlights the central role of teachers in implementing ethnomathematics. Studies by Febriani (2020) and Sholikin et al. (2020) reveal that teachers' knowledge and beliefs are critical factors in the successful application of ethnomathematics, particularly in integrating local culture into the formal curriculum without compromising academic achievement [34], [35].

Overall, the interrelationships among clusters form a comprehensive map of ethnomathematics research, ranging from cultural meaning-making (red and green clusters) to cognitive impacts on students (blue cluster) to teacher readiness and roles (yellow cluster). These findings affirm that ethnomathematics has evolved into an approach that harmoniously and transformatively integrates science, culture, and education [36].

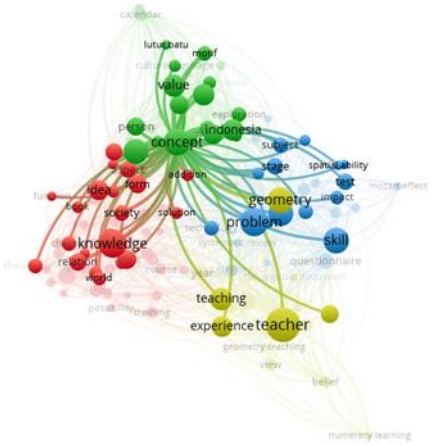

Figure 9. The green cluster (Cluster 2) is associated with ethnomathematics-related themes

Figure 9 shows that the green cluster, positioned at the centre of the visualisation, indicates the dominance of ethnomathematics research focused on the exploration of cultural concepts such as values, patterns, motifs, and calendars, particularly in the Indonesian context. Studies in this cluster emphasise cultural artefacts and traditional systems, such as Pranata Mangsa and batik motifs, as authentic sources for contextualised mathematics learning. These findings are reinforced by Fitriyah et al. (2025) and Prahmana et al. (2021), who identified strong connections between cultural patterns and geometric concepts, as well as between traditional calendrical systems and algebraic and numerical structures [2], [1], [37].

The red cluster focuses on *knowledge*, *ideas*, *society*, and *mathematical knowledge*. This reflects the view of ethnomathematics as a form of cultural knowledge that emerges from the relationship between humans and their environment [18]. Researchers emphasise that mathematics is not merely a universal abstraction, but rather a socially constructed body of knowledge, as affirmed by Tamur et al. (2025) in their systematic review of ethnomathematics research in Indonesia [38], [5].

Keywords such as *geometry*, *spatial ability*, *problem*, and *test* in the blue cluster indicate studies that utilise local culture to teach geometry and to develop students' problem-solving skills. This approach has been shown to enhance spatial abilities through local contexts such as traditional foods or regional games. This is supported by Busrah and Pathuddin (2021) and Pathuddin et al. (2021), who explored geometric concepts embedded in traditional Bugis cuisine [38], [39].

The yellow cluster highlights keywords such as *teacher*, *teaching*, *experience*, and *belief*. Its focus is on how teachers' beliefs and knowledge influence the implementation of ethnomathematics in the classroom. Research by Maulina et al. (2023) indicates that although teachers generally support this approach, targeted professional training is still required to enhance their competence in managing culturally based mathematics instruction [40].

All clusters are interconnected, forming an increasingly complex landscape of ethnomathematics research that continues to evolve toward contextual, inclusive, and culture-based mathematics education.

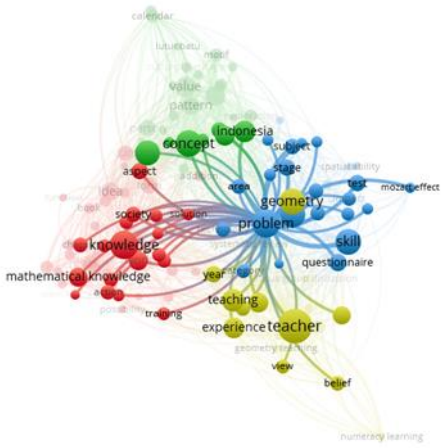

Figure 10. The blue cluster (Cluster 3) is associated with themes related to ethnomathematics.

The blue cluster in Figure 10, centred in the network, contains keywords such as geometry, problem, skill, spatial ability, and the Mozart effect, representing ethnomathematics research focused on the development of mathematical and cognitive abilities, particularly geometry and spatial skills. This cluster highlights pedagogical innovations through the integration of cultural contexts and nonconventional approaches, such as the Mozart effect in learning. Research findings indicate that combining ethnomathematics with classical music stimulation can enhance students' problem-solving abilities, mathematical communication, and positive attitudes toward learning. Overall, the blue cluster underscores the innovative dimension of ethnomathematics in strengthening mathematical competencies through more cognitively engaging learning experiences [41].

The green cluster is characterised by keywords such as *concept*, *value*, *pattern*, *motif*, *calendar*, and *Indonesia*, with a thematic focus on the exploration of cultural patterns and motifs that embody mathematical concepts and philosophical values. Research within this cluster extensively examines cultural artefacts and traditional systems, such as batik motifs, woven textiles, ornaments, and local calendars, to reveal implicit mathematical concepts, particularly geometry, patterns, and time measurement. Overall, the green cluster emphasises the role of ethnomathematics in linking Indonesian cultural patterns with a contextual and meaningful understanding of mathematical concepts [42].

The red cluster is characterised by keywords such as *knowledge*, *mathematical knowledge*, *tradition*, *society*, and *idea*, with a focus on mathematical knowledge that develops from traditions and community life. Research within this cluster emphasises that mathematical concepts are embedded in cultural practices and everyday activities, such as traditional weaving, vernacular architectural measurement systems, and local fishermen's navigation, and are transmitted through the role of community elders. Overall, the red cluster highlights the importance of recognising tradition-based mathematical knowledge as an integral part of the broader mathematical corpus [43].

The yellow cluster is characterised by keywords such as *teacher*, *teaching*, *experience*, and *belief*, with a focus on teachers' roles, teaching experience, and educators' beliefs in the implementation of ethnomathematics. Research within this cluster indicates that teachers generally hold positive attitudes toward ethnomathematics but still face

conceptual limitations that affect their confidence and ability to design culturally based learning. Therefore, teacher training and mentoring are identified as key recommendations [40].

The interrelationships among clusters reveal that ethnomathematics research forms a complementary thematic system, encompassing mathematical knowledge embedded in traditions, the exploration of cultural artefacts, the development of students' cognitive abilities, and pedagogical strategies. This interconnectedness confirms that ethnomathematics is an integrative approach that bridges mathematics and culture to foster more contextual, innovative, and culturally relevant mathematics education.

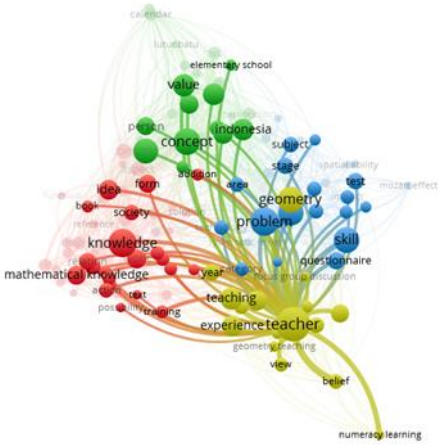

Figure 11. The yellow cluster (Cluster 4) is associated with themes related to ethnomathematics

The yellow cluster in Figure 11 is centred in the network, indicating that topics such as teacher, teaching, experience, and belief constitute the core of ethnomathematics research. This cluster shows numerous connections with other clusters, suggesting that the success of the ethnomathematics approach is largely determined by teacher competence, both in integrating cultural contexts (green cluster) and in delivering geometry and problem-solving instruction (blue cluster). Teachers serve as the primary link between local cultural knowledge and formal mathematics learning.

Strong connections are observed between the yellow and green clusters, which include keywords such as *'concept,' 'motif,' 'pattern,' and 'calendar.'* This indicates that teachers need to understand and utilise cultural values, such as traditional motifs or local calendar systems, as relevant and meaningful learning contexts [4]. The yellow cluster is also closely related to the blue cluster, which includes geometry, problem-solving, and spatial ability, highlighting the expectation that teachers develop students' cognitive skills through culturally based approaches, for example, by relating geometric forms to local artefacts. Additionally, the yellow cluster is connected to the red cluster (*knowledge*, *society*, *idea*), reflecting that teachers' experiences are shaped by social perspectives on mathematics and by how knowledge is transmitted within communities [44]. In summary, the central position of the yellow cluster signifies that teachers are not merely implementers of instruction but key agents who bridge interactions among cultural contexts (green), mathematical cognition (blue), and the social construction of knowledge (red) [40] [45] [4].

In the overlay visualisation, the temporal dimension of the ethnomathematics research landscape is more clearly interpretable. In this map, each keyword is assigned a colour gradient based on its average year of appearance. Bluish tones indicate keywords that appeared predominantly in the earlier period (around 2020–2021), while bright yellow tones represent relatively recent keywords that have emerged intensively over the past two to three years (around 2023–2025). Keywords such as *teacher*, *culture*, and *ethnomathematics* appear in darker shades, indicating that pedagogical themes and cultural approaches have served as foundational elements since the early phase of research development. In contrast, terms such as *spatial ability*, *the Mozart effect, and learning media appear in lighter colours, suggesting that innovative approaches, including cognitive–musical integration and culturally based media, have emerg*ed only in more recent research waves. This pattern reveals a shift in focus from earlier studies centred on teacher roles and cultural value identification toward more experimental and multidisciplinary approaches.

Meanwhile, in the density visualisation, colour indicates the level of keyword occurrence density within the network. Bright yellow areas indicate high concentrations of frequently used and highly interconnected keywords, such as *teacher*, *knowledge*, *pattern*, and *geometry*. This confirms that pedagogical dimensions, understanding of cultural concepts, and the exploration of geometry through local artefacts constitute the core of ethnomathematics discourse. Surrounding these dense areas are green zones containing moderately frequent keywords, such as *motif*, *calendar*, and *tradition*, which play important but less dominant roles within the network structure. This visualisation reinforces earlier findings that two major poles of contemporary ethnomathematics research are: (1) the role of teachers in connecting culture and mathematics, and (2) cultural artefacts as sources for representing mathematical concepts.

The most significant novelty emerging from the overall map lies in shifting the research focus from mere cultural and pedagogical exploration to the integration of cognitive abilities, innovative media, and experiential learning approaches grounded in cultural contexts. The blue cluster, which includes keywords such as *geometry*, *problem*, and *spatial ability*, indicates growing attention to students' cognitive dimensions, particularly how spatial skills and problem-solving abilities can be developed through local cultural contexts. The green cluster, containing *concept*, *motif*, and *calendar*, remains the main theoretical foundation bridging culture and mathematics. The yellow cluster, positioned at the centre of the visualisation, reinforces the role of teachers as the primary link between cultural contexts, instructional design, and the conceptual understanding of mathematics. The red cluster, characterised by keywords such as *knowledge*, *society*, and *idea*, serves as an important reminder that ethnomathematics fundamentally arises from the recognition of non-Western knowledge systems embedded within communities.

Thus, this bibliometric mapping not only captures the current state of ethnomathematics research and development but also points to highly promising future directions: the integration of ethnomathematics with 21st-century contextual learning approaches, the development of culturally based learning media models, and the longitudinal exploration of the impact of ethnomathematics on strengthening students' mathematical thinking skills. In the Indonesian context, which is rich in cultural diversity, such research

opportunities are both wide-ranging and strategic in addressing the need for more inclusive, relevant, and locally grounded mathematics education.

4. CONCLUSION

This study provides a comprehensive overview of the development and intellectual structure of ethnomathematics research during 2020–2025 using a bibliometric approach. Overall, the findings indicate that ethnomathematics has evolved into a dynamic and multidimensional field, characterised by the integration of cultural knowledge, pedagogical practices, cognitive development, and technological innovation. The analysis confirms that research in this field is no longer limited to cultural documentation but is increasingly oriented toward educational transformation and contemporary learning needs.

From both theoretical and practical perspectives, the results imply that teachers play a pivotal role in mediating cultural knowledge into formal mathematics instruction, while cultural artefacts serve as meaningful entry points for developing conceptual understanding and spatial reasoning. Furthermore, the observed shift toward media innovation and 21st-century learning approaches suggests that ethnomathematics has significant potential to support culturally responsive pedagogy and inclusive mathematics education, particularly in contexts with strong local traditions.

Nevertheless, this study is subject to several limitations. The analysis is restricted to publications indexed in the Scopus database and confined to the 2020–2025 period, which may exclude relevant studies published in other databases or earlier foundational works. In addition, the reliance on bibliometric indicators and keyword co-occurrence analysis limits the depth of interpretation regarding classroom implementation and learning outcomes.

Building on these limitations, future research may extend the scope of analysis by incorporating multiple databases, longer time spans, or mixed-method approaches that combine bibliometric mapping with qualitative content analysis. Further studies could also explore integrating ethnomathematics into digital learning environments, STEM-oriented instructional models, and culturally grounded assessment frameworks. Such research would contribute not only to the advancement of mathematics education scholarship but also to the broader public by promoting educational practices that respect cultural diversity, strengthen learners' cultural identity, and support meaningful engagement with mathematics in everyday life.

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