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A SYSTEMATIC REVIEW AND BIBLIOMETRIC REPORT: ETHNOMATHEMATICS AND CULTURALLY RESPONSIVE PEDAGOGY IN MATHEMATICS EDUCATION

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Abstract:
This systematic review synthesizes findings from 18 empirical and conceptual studies published between 2001 and 2024, focusing on the integration of ethnomathematics and culturally responsive pedagogy in mathematics education. The Systematic Literature Review method with the PRISMA protocol was used to conduct the study. Utilizing a systematic search and screening process, an initial pool of 150 articles was reduced to 18 relevant studies. The review highlights diverse methodologies, contexts, and contributions, showing measurable gains in student performance, engagement, and conceptual comprehension when mathematics instruction incorporates students' cultural contexts. Key gaps identified include limited generalizability, a lack of long-term impact data, and ongoing challenges in teacher training and curriculum integration. The findings underscore the critical need for continued research and policy support to embed culturally relevant approaches in mathematics curricula globally.

Keywords: ethnomathematics, culturally responsive pedagogy, systematic review

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1. Introduction

Engaging students meaningfully in mathematics remains a challenge, particularly when curricula feel disconnected from their daily lives or cultural realities. In response, the fields of ethnomathematics and culturally responsive pedagogy have gained increasing attention. Ethnomathematics explores the diverse ways mathematical ideas are manifested in different cultures, highlighting the mathematical practices embedded in daily life, traditional games, art, and technologies (Powell & Temple, 2001). Culturally responsive pedagogy, on the other hand, emphasizes teaching methods that acknowledge and affirm students' cultural identities, leveraging their cultural knowledge and experiences as a foundation for learning (Jacob & Dike, 2023).

This systematic review aims to synthesize existing research on the integration of ethnomathematics and culturally responsive pedagogy in mathematics education. Specifically, the objectives are to:

1) Evaluate the reported effects of ethnomathematics-based teaching approaches on student performance, retention, and mathematical literacy.
2) Examine how ethnomathematics contributes to conceptual understanding and student engagement.
3) Identify the methodologies employed in studies investigating ethnomathematics in mathematics education.
4) Highlight the perceived challenges and limitations in integrating ethnomathematics into formal educational systems, particularly from the perspective of educators.

2. Methods

2.1 Search Strategy

A systematic search was conducted across several academic databases, including ERIC, Scopus, Web of Science, and Google Scholar. The search terms used included combinations of: 'ethnomathematics,' 'culturally responsive teaching,' 'cultural pedagogy,' 'mathematics education,' 'achievement,' 'performance,' 'engagement,' 'trigonometry,' 'geometry,' and 'problem-based learning.' The initial search, conducted up to May 2024, yielded approximately 150 articles potentially relevant to the review's scope.

2.2 Eligibility Criteria

2.2.1 Inclusion Criteria

- Studies published in English.
- Articles explicitly discussing or applying ethnomathematics or culturally responsive pedagogy in mathematics education.
- Empirical studies (quantitative, qualitative, or mixed-methods) or theoretical/conceptual papers.

- Studies focusing on any educational level (primary, secondary, tertiary).
- Publication dates from 2001 to May 2024.

2.2.2 Exclusion Criteria

- Conference abstracts without full papers.
- Opinion pieces or editorials without supporting evidence.
- Studies not directly related to mathematics education.
- Duplicate publications.

2.3 Screening and Selection Process (PRISMA-like Flow Diagram)

The 150 articles identified from the initial search underwent a rigorous screening process, adapted from the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines.

2.3.1 Identification (n = 150)

An initial pool of 150 articles was identified through comprehensive database searches using the predefined keywords. These articles were considered potentially relevant based on their titles.

2.3.2 Screening (n = 100)

After removing 50 duplicate records, the remaining 100 articles had their titles and abstracts reviewed against the inclusion and exclusion criteria. Articles clearly irrelevant to ethnomathematics or culturally responsive pedagogy in mathematics education were excluded at this stage.

2.3.3 Eligibility (n = 30)

The full texts of the 100 screened articles were retrieved and thoroughly assessed for eligibility. During this detailed review, 70 articles were excluded for various reasons, including: lack of empirical data (for empirical studies), insufficient theoretical contribution (for conceptual papers), not directly addressing the integration of ethnomathematics/culturally responsive pedagogy in mathematics, or being outside the specified publication date range. This left 30 articles that appeared to meet the criteria.

2.3.4 Included (n = 18)

Following a final critical appraisal for methodological rigor and direct relevance to the systematic review's objectives, 12 articles were further excluded due to minor relevance or methodological limitations. Consequently, 18 articles were selected for inclusion in the systematic review and are presented in the data extraction table.

2.4 PRISMA 2009 Flow Diagram depicting the systematic review process from 150 identified articles to 18 included articles

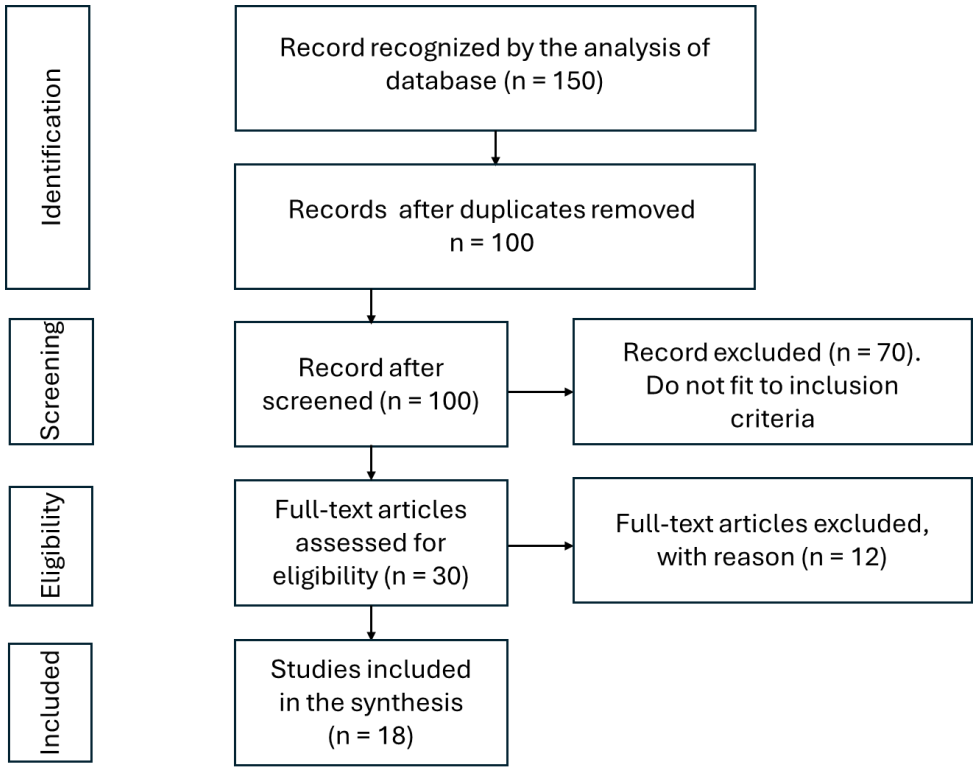

Figure 1: The flow diagram of the study, adapted from Ku Sook Leng *et al.*, 2020

2.5 Data Extraction and Synthesis

Data from the 18 included articles were extracted into a structured table, capturing key information under the following headings: Author(s)/Year, Title, Context/Study Area, Methodology/Design, Sample/Analysis, Contribution, Results/Conclusion, and Gap(s). A narrative synthesis approach was employed to identify recurring themes, common findings, methodological approaches, and prevalent gaps in the literature.

3. Results

3.1 Overview of Included Articles

The included studies represent a diverse range of geographical contexts, primarily focusing on Nigeria and Indonesia, with contributions from Ghana and the United States. Methodologies varied, with a strong presence of quasi-experimental designs (e.g., Umar *et al.*, 2019; Abiam *et al.*, 2016; Mosimege & Egara, 2023; Unodiaku, 2013; James & Akaazua, 2021), qualitative case studies (e.g., Atta *et al.*, 2024; Ali, 2024; Riyani *et al.*, 2022), and research and development (R&D) studies focused on creating culturally relevant teaching materials (e.g., Husna *et al.*, 2021; Assegaff & Bonyah, 2023; Lakapu *et al.*, 2021; Ahmad *et al.*, 2021; Hamdani *et al.*, 2023). Several studies explored the integration of local

cultural elements such as traditional art, games, architecture, and language into the mathematics curriculum.

3.2 Key Findings and Contributions

The synthesis of findings indicates several significant contributions of ethnomathematics and culturally responsive pedagogy to mathematics learning:

- Improved Student Performance and Achievement: Multiple empirical studies consistently demonstrated that students taught with ethnomathematics-based approaches or materials performed significantly better in topics like trigonometry, geometry, and mensuration compared to those in control groups using conventional methods (Umar *et al.*, 2019; Abiam *et al.*, 2016; Mosimege & Egara, 2023; Unodiaku, 2013; James & Akaazua, 2021). These improvements were often linked to enhanced conceptual understanding and retention. Fitri *et al.* (2022) also showed a significant positive relationship between trigonometry mastery and 3D problem-solving ability, indirectly supporting the need for effective trigonometry instruction, which ethnomathematics can provide.
- Enhanced Engagement and Motivation: Integrating culturally relevant content, such as traditional games (Powell & Temple, 2001; Assegaff & Bonyah, 2023; Mosimege & Egara, 2023), dances (Pitdianti, 2024), or local artifacts (Atta *et al.*, 2024; Lakapu *et al.*, 2021), made mathematics more relatable and meaningful for students. This contextualization led to increased student motivation, participation, and enthusiasm, particularly among students from diverse cultural backgrounds (Assegaff & Bonyah, 2023; Lakapu *et al.*, 2021; Ahmad *et al.*, 2021).
- Contextualization and Real-World Application: Ethnomathematics helps bridge the gap between abstract mathematical concepts and students' lived experiences. Studies showed how traditional practices align with mathematical thinking, making concepts like geometric transformations (Pitdianti, 2024; Assegaff & Bonyah, 2023), patterns (Al Ahadi et 2021; Riyani *et al.*, 2022), and measurements (Unodiaku, 2013) more tangible and easier to grasp.
- Development of Culturally Relevant Teaching Materials: Several R&D studies focused on the creation and validation of student worksheets, interactive games, and learning designs incorporating local culture (Husna *et al.*, 2021; Assegaff & Bonyah, 2023; Lakapu *et al.*, 2021; Ahmad *et al.*, 2021; Hamdani *et al.*, 2023). These materials were consistently rated as valid, practical, and effective by experts and students.
- Promotion of Critical Thinking and Problem-Solving: By engaging with culturally embedded mathematical problems, students were encouraged to develop higher-order thinking skills and apply mathematical reasoning in diverse contexts (Powell & Temple, 2001; Atta *et al.*, 2024). Ali (2024) demonstrated how ethnomathematics-based didactical contracts can facilitate student autonomy and critical thinking in geometry.

- Affirmation of Cultural Heritage and Identity: Ethnomathematics serves as a powerful tool to challenge Eurocentric biases in mathematics education, affirming students' cultural identities and promoting a more inclusive learning environment (Powell & Temple, 2001; Jacob & Dike, 2023). Riyani *et al.* (2022) exemplify this by showing how historical sites can connect mathematics to local heritage.

The search table provides a detailed overview of the 18 selected articles, allowing for a granular examination of their individual characteristics and contributions. Across these studies, a clear pattern emerges regarding the methodological approaches employed. Quasi-experimental designs, particularly pre-test/post-test non-equivalent control group designs, are prevalent (Umar *et al.*, 2019; Abiam *et al.*, 2016; Mosimege & Egara, 2023; Unodiaku, 2013; James & Akaazua, 2021). This indicates a strong emphasis on quantitative evidence to demonstrate the direct impact of ethnomathematics on student achievement and retention. While valuable for establishing effectiveness, these designs sometimes lack the qualitative depth to understand how or why these approaches work from the students' and teachers' perspectives.

Alongside quantitative studies, there's a significant presence of developmental research (R&D) (Husna *et al.*, 2021; Assegaff & Bonyah, 2023; Lakapu *et al.*, 2021; Ahmad & Akib, 2021; Hamdani *et al.*, 2023). These studies focus on creating and validating culturally contextualized teaching materials, such as worksheets, interactive games, and learning designs. Their contributions primarily lie in providing practical tools and models for integrating local culture into mainstream mathematics curricula, often demonstrating their validity and practicality through expert reviews and initial student feedback.

Qualitative studies, though fewer in number, offer crucial insights into the complexities of implementing ethnomathematics. Case studies and ethnographic approaches (Atta *et al.*, 2024; Ali, 2024; Riyani *et al.*, 2022) explore the nuances of how cultural practices embody mathematical concepts and the perceptions of educators and artisans regarding their integration. Mosimege and Egara (2022), through a quantitative survey, uniquely captured teachers' perspectives, revealing the barriers to adopting ethnomathematics despite its perceived benefits.

Table 1: Search Results Related to Ethnomathematics and Culturally Responsive Pedagogy in Mathematics Education

S/N	Author(s) / Year of publication	Title of the article	Context/ Study area	Methodology/ Design	Sample/ Analysis	Contribution	Results/ Contribution	Gab(S)
1	Umar, I.O., Tudunkaya, M.S. & Muawiya, H.U. (2019)	Effect of Ethno-Mathematics Teaching Approach on Performance and Retention in Trigonometry among Secondary School Students in Zaria Local Government Area, Kaduna State, Nigeria	High failure rates in mathematics in Nigerian secondary schools attributed to inappropriate, Eurocentric teaching methods. The study aimed to test whether using ethno-mathematics, rooted in local culture, could improve learning outcomes.	Quasi-experimental research involving pre-test, post-test, and delayed post-test./ Non-equivalent control group quasi-experimental design with experimental and control groups	103 Senior Secondary 2 (SS2) students from 2 randomly selected schools out of 26 in Zaria LGA (57 experimental, 46 control)./ Independent sample t-test (for performance)	Provides empirical evidence for integrating culturally relevant pedagogy (ethno-mathematics) in Nigerian secondary school math curricula, particularly in abstract topics like trigonometry	Students taught with EMTA performed significantly better (Mean = 28.31) than control (Mean = 15.21). - Retention scores also significantly higher in EMTA group./ EMTA significantly improves both performance and retention in trigonometry. Students relate better when content is linked to their cultural environment, improving understanding and memory/	- Limited application of EMTA in other mathematics topics beyond trigonometry. - Small sample size and scope (only Zaria LGA) limit generalizability. - Need for longitudinal studies to measure lasting impact. (No long-term follow-up to test lasting retention) No qualitative insights into student experiences or teacher perspectives. - Lack of prior empirical application of EMTA in Nigerian secondary school trigonometry teaching; recommends further testing

								across different math concepts and locations.
2	Patrick Obere Abiam, Okechukwu S. Abonyi*, J. O. Ugama, Gabriel Okafor (2016)	Effects of Ethnomathematics-based Instructional Approach on Primary School Pupils' Achievement in Geometry	Primary 6 pupils in Boki Local Government Area of Cross River State, Nigeria; explores cultural integration in geometry education	Quasi-experimental design with pre-test, post-test, non-equivalent control group; use of Achievement Test in Geometry (ATG) developed by researchers/ Pre-test, post-test design with non-equivalent control group; intact classes used to avoid disrupting school structures	402 pupils (202 experimental, 200 control); 10 schools randomly selected from 32 high-enrolment schools/ Mean, Standard Deviation, and Analysis of Covariance (ANCOVA) at 0.05 significance level	Provides empirical evidence supporting the integration of culturally relevant content in teaching geometry, enhancing pupil engagement and achievement; promotes contextualized teaching strategies in Nigerian primary schools	Experimental group had significantly higher mean score (54.56) than control group (43.22) /Ethnomathematics-based instructional approach significantly improves pupils' achievement in geometry compared to the conventional approach	Lack of sufficient empirical data prior to this study justifying the use of Ethnomathematics-based approaches in geometry instruction; further research needed on long-term retention and applicability across different contexts/cultures
3	Faiq Al Ahadi, Zaenuri, Adi Nur Cahyono (2021)	Exploration of Ethnomatematics in the Samin Tribe and Its Relationship with Mathematical Concepts	Ethnomathematical exploration in the Samin tribe culture in Central Java and its integration in junior high school mathematics learning	Mixed methods approach combining qualitative (observation, interviews, documentation) and quantitative (pretest-posttest design, tests, questionnaires) techniques/	One class (Class VIII A) of SMP N 4 Ngawen – exact number not specified/ - Normality test (Lilliefors) - Learning completeness test (t-test) - Classical completeness test (proportion test)	-Introduced a culturally relevant contextual model for mathematics education - Demonstrated the integration of local cultural wisdom in formal education - Provided examples of how traditional practices align	-Ethnomathematics was found in Samin culture elements such as ceremonies, games, foods, buildings, and tools - Strong relationships found with math concepts like number patterns, geometry, operations, and measurements - Contextual	-Limited generalizability due to small and localized sample - No long-term impact analysis on learning retention - Does not compare contextual learning with other teaching methods quantitatively

				One Group Pretest-Posttest Design		with mathematical thinking	learning model was effective; students met or exceeded minimum competency criteria (KKM ≥ 70%/ Ethnomathematics embedded in Samin culture significantly supports contextual learning and helps connect mathematical concepts to real life, enhancing understanding and achievement	
4	Seth Amoako Atta, Ebenezer Bonyah, Francis Ohene Boateng (2024)	Integrating Akan Traditional Art to Enhance Conceptual Understanding in Mathematics: Perspectives of Educators and Artisans	Ashanti Region, Ghana – a culturally rich area dominated by the Akan people; focused on senior high school mathematics education with cultural integration	Qualitative research using an instrumental case study approach/ Case study using semi-structured interviews with purposive sampling	10 participants -7 mathematics educators and 3 artisans (experienced in Akan traditional art)/ Thematic content analysis using Braun & Clarke's (2006) six-phase model; data transcription, translation, coding, theme development	- Emphasizes the value of ethnomathematics in improving mathematics education - Advocates culturally responsive pedagogy - Shows that traditional art practices can provide real-world contexts for geometry learning - Supports constructivist and	- Akan traditional art (e.g., games, pottery, weaving) contains implicit geometry concepts (lines, angles, circles, measurements) - Students can learn geometry more effectively when concepts are linked to their cultural environment - Teachers identified cultural relevance as enhancing	- Ethnomathematics is underrepresented in Ghana's curriculum and teacher training - Instruction remains overly theoretical despite a constructivist curriculum - Lack of resources or directives for culturally-based teaching strategies - Teachers lack training or

						problem-solving goals of Ghana's curriculum, but highlights missing links to culture	understanding, retention, and real-life application - Artisans confirmed the use of geometrical reasoning in traditional crafts - Four major themes emerged: learners' experience, building knowledge, transferring knowledge, and applying knowledge./ Integrating Akan traditional art into geometry teaching promotes conceptual understanding, reduces abstraction, and connects learning to real life. This improves student engagement, critical thinking, and performance. Teachers must become culturally responsive educators.	awareness to incorporate cultural artefacts into mathematics lessons

5	Abidin, Z., & Husna, N. (2020).	Development of student worksheets on ethnomathematics-based trigonometry through Project-Based Learning models	ndonesian high school mathematics education, specifically in Aceh, integrating local culture (traditional houses) with trigonometry	Developmental research using the **Plomp model**: preliminary research, prototyping, and assessment phases/ Qualitative developmental study focusing on designing, validating, and testing a student worksheet	6 validators (3 experts, 3 practitioners), 6 students (for readability test)/ Descriptive qualitative analysis; validation using criteria by Nieveen (2013); no inferential statistics applied	- Introduced a culturally relevant and context-based approach to teaching trigonometry in Aceh - Demonstrated effective integration of Project-Based Learning (PjBL) with ethnomathematics	- Initial prototype deemed "not valid" and revised based on expert feedback - Final prototype declared valid and readable - Students showed improved engagement and understanding through culturally contextual tasks/ The developed worksheet met validity criteria and was positively received by both validators and students. It contextualizes trigonometry through local culture and encourages active, meaningful learning.	- No field trials conducted to test **effectiveness or practicality** in broader classroom contexts - Limited sample size for readability and no quantitative data on learning outcomes - Cultural tools (e.g., clinometer) were unfamiliar to students, requiring clearer instruction
6	Arthur B. Powell and Oshon L. Temple (2001)	Seeding Ethnomathematics with Oware: Sankofa	Integrates the African game Oware into U.S. classrooms as a tool for ethnomathematics and multicultural math education.	Observational and experiential teaching intervention with children learning and playing Oware. Reflections on gameplay and strategy development	A small group of African American and Latino children, ages 6–12; specific number not given but example players include	Demonstrates how traditional African games like Oware can be used to teach complex mathematical concepts such as arithmetic,	Children developed skills in arithmetic, strategy, problem-solving, and modular arithmetic through gameplay. They also began to exhibit deeper	The study lacks rigorous empirical data (e.g., pre/post-tests or control group comparisons). The sample size and intervention

			Focuses on using cultural games to foster math learning and social awareness among children, particularly African American and Latino students	through structured gameplay sessions./ Informal, qualitative case study embedded within a summer camp program; uses examples and gameplay analysis to illustrate learning processes.	two boys (ages 9 and 11)/ Descriptive analysis of gameplay, move-ply depth analysis, modular arithmetic illustrations, and qualitative reflection. Uses annotated gameplay sequences, numerical pattern recognition (triangular numbers), and cultural analysis.	strategic planning, and pattern recognition. Highlights ethnomathematics as a pedagogical tool to challenge Eurocentric curriculum and affirm cultural heritage.	move-ply thinking and recognized mathematical patterns like triangular numbers and self-replicating sequences ('marching groups')./ Oware fosters both mathematical and cultural learning. Playing the game allows students to engage deeply with math while appreciating African cultural contributions. Teachers can use such games to promote inclusivity, deepen mathematical understanding, and challenge stereotype	duration are small and short. Generalizability is limited. Further research could systematically examine the long-term impact of integrating ethnomathematical games into mainstream curricula
7	Nurani Assegaff and Ebeneezer Bonyah (2023)	Development of Ethnomathematics-Based Teaching Materials through Interactive Games to Improve Students'	Indonesian vocational high school students often struggle with geometric transformations. The study addresses the need	Research and Development (R&D) using the 4D development model (Define, Design, Develop, Disseminate). Study./	24 students (Class XI, Office Administration major, SMK Pasundan 3 Bandung)./	Developed ethnomathematics-based interactive teaching materials tailored to local culture; linked cultural relevance to improved	- Significant improvement in mathematical literacy (effect size = 6.58, high category) - N-Gain = 0.62 (moderate gain)	- Difficulty in development timeline due to school IT staff availability - Some students lacked active participation

		Mathematical Literacy	for engaging, culturally-relevant teaching materials to improve mathematical literacy.	One-group pretest-posttest design to determine the effectiveness of the developed teaching materials. Material and media expert validation was also conducted.	Descriptive statistics, Effect Size, Normalized Gain (N-Gain), Wilcoxon Signed-Rank Test.	mathematical literacy and students' habits of mind. OR - Developed interactive game-based ethnomathematics materials tailored to local culture - Demonstrated positive impact on mathematical literacy and habit of mind - Introduced culturally responsive pedagogy into vocational mathematics education - Provided Android-based accessible tools for independent learning	- Students showed increased motivation, attention, and enthusiasm - Strong positive correlation between mathematical literacy and habits of mind - Teaching materials rated "very feasible" by experts./ Ethnomathematics-based interactive game materials are effective in enhancing mathematical literacy. These materials are culturally relevant, motivating, and accessible. However, flexible thinking still needs attention. There is a strong causal relationship between students' mathematical literacy and their habit of mind.	- Lack of student personalization in the learning app - Need for further development emphasizing local cultural content and enhancement of flexible thinking and innovation

8	Mosimege, M. and Egara, F. (2023).	Improving Secondary School Students' Achievement in Trigonometry Using Game-Based Learning Approach	Investigated the impact of game-based learning (GBL) on students' academic achievement in trigonometry in Nigerian secondary schools (Udenu LGA, Enugu State	Quasi-experimental with pre-test/post-test design using intact classrooms./ Pre-test/post-test quasi-experimental design (non-equivalent control group)	192 SS2 students (90 males, 102 females)/ Descriptive statistics (Mean, Standard Deviation), ANCOVA	First study in the region (Udenu LGA) examining GBL in trigonometry instruction. Offers empirical evidence on GBL's effectiveness in enhancing learning outcomes regardless of gender	Students in the GBL group significantly outperformed the control group (mean gain = 24.5 vs 1.9). Gender did not significantly influence achievement./ Game-based learning significantly improved students' trigonometry achievement over traditional methods. No significant gender difference in learning outcomes using GBL.	Limited to one LGA; findings not generalizable nationally. No long-term retention data. No qualitative insights into student attitudes. Impact on other mathematical domains not explored.
9	Meryani Lakapu, Wilfridus Beda Nuba Dosinaeng, Samuel Igo Leton (2021)	Development of Student Activity Sheets Based on Local Culture on Simple Trigonometric Function Graphs	Integrating local culture (East Nusa Tenggara weaving) into mathematics learning to improve comprehension and cultural awareness	Research and development (R&D) using a modified 4-D model (Define, Design, Develop)./ Developmental research	50 second-semester students from Mathematics Education Program Validation sheets, LSLC implementation observation, student response questionnaires, LKM score analysis	Introduced a culturally contextualized LKM for teaching trigonometric graphs, linking abstract concepts with cultural artifacts	Developed LKM is valid (expert-approved), practical (high student engagement), and effective (positive responses, improved outcomes)./ LKM based on local culture meets criteria for valid, practical, and effective	Lack of longitudinal data to assess long-term retention; limited to a single institution and specific cultural context; not all 4-D phases used (dissemination omitted)

							instructional material; enhances student motivation and contextual understanding	
10	Unodiaku, Stanislus Sochima, (2013)	Effect of Ethno-Mathematics Teaching Materials on Students' Achievement in Mathematics in Enugu State	Low student achievement in mathematics in Nigerian secondary schools; need for culturally relevant instructional materials	Use of ethno-mathematics teaching materials (e.g., native calabash cups/plates) to teach mensuration (volumes of cylinders and hemispheres)./ Quasi-experimental (Pretest-Posttest Non-equivalent Control Group Design)	306 students (156 experimental, 150 control) from 8 schools in Igbo-Etiti, Enugu State./ Descriptive statistics(Mean, Standard Deviation), Inferential statistics(Analysis of Covariance) (ANCOVA	Demonstrated that culturally relevant teaching materials improve comprehension and achievement in mathematics	Significant improvement in experimental group over control; gender also showed significant effect on performance./ Ethno-mathematics materials enhance mathematics achievement and can bridge cultural disconnects in learning	Insufficient research on concrete, culturally relevant teaching materials in Nigerian math education; inconclusive evidence on gender performance in mathematics
11	Mogege David Mosimege & Felix Oromena Egara (2022)	Perception and Perspective of Teachers Towards the Usage of Ethno-Mathematics Approach in Mathematics Teaching and Learning	Investigates why mathematics students underperform due to teacher-centered methods; explores ethno-mathematics as a culturally relevant alternative	escriptive survey; questionnaire (MTEQ) based on Vygotsky's Constructivist Theory./ Quantitative, cross-sectional survey	113 mathematics teachers selected from a population of 161 in Enugu State (Nigeria) using Taro Yamane's formula,/ Descriptive statistics (mean, SD); inferential statistics (t-tests, $\alpha = 0.05$)	Provides empirical data on Nigerian teachers' awareness and use of ethno-mathematics; informs educational policy and training	Teachers use ethno-mathematics to a low extent; perceptions also rated low; no significant gender or location-based differences in usage./ Teachers are not effectively using the ethno-mathematics approach due to lack of awareness/training; both perception and	Prior studies explored integration and effectiveness, but failed to capture teachers' perspectives and perceptions in Southeast Nigeria, particularly Enugu State

							application levels are low	
12	Clement Ayarebilla Ali (2024)	An Analysis of Ethnomathematics Didactical Contract in the Sums of Interior and Exterior Angles	Investigating the evolving roles of teachers and students in teaching the sum of interior and exterior angles through ethnomathematical lenses and didactical contracts	Descriptive case study within the interpretivist paradigm; qualitative approach./ Case study	42 students (22 girls, 20 boys) from rural, peri-urban, and urban Junior High Schools./ Focus group discussions, interviews, observations, document analysis, transcription and visual analysis software	Introduces and tests ethnomathematics-based didactical contracts (ostentation, mayeutic Socratic, and adidactical) in geometry (specifically sums of angles); integrates cultural artifacts in mathematics teaching	Smooth, progressive transitions from teacher-centered (ostentation) to student-centered (adidactical) contracts when supported by cooperation; five adidactical pathways identified via artifacts (Adinkra, pyramids, mosques, bridges, roofs).// Didactical contracts are hierarchical and support gradual student autonomy; teaching should blend local and exotic artifacts; different contracts require varying teacher-student dynamics	Limited to one mathematical concept (angles); small, localized sample size (42 students from one district); lacks generalizability; impact may vary across broader content or contexts; no quantitative validation of findings
13	Hamdani, V., Armiati, A., Arnawa, I. M., & Jamaan, E. Z. (2023)	Hypothetical Learning Trajectory Trigonometry Based on Problem-Based Learning with Jambi Malay	Addressing difficulties in students' understanding of trigonometry through culturally relevant, problem-	Design-based research integrating Plomp and Gravemeijer & Cobb models: Initial investigation, development, and	6 students (2 high, 2 medium, 2 low-ability); 3 mathematics experts and 1 language expert for validation./	- Introduced a culturally integrated PBL-based HLT for trigonometry - Provided a practical model of	- HLT scored 3.69 on expert validation (very valid) - Practicality score: 80.14% (practical) - Post-test scores showed improved	Focused on only one trigonometry subtopic (sine rule) - Small sample size (only six students)

		Ethnomathematics Nuances	based learning. Aimed to enhance mathematical communication by integrating Jambi Malay ethnomathematics.	assessment of an HLT./ Developmental research focusing on designing and validating a Hypothetical Learning Trajectory (HLT) for the sine rule in trigonometry.	- Expert validation rubric (content and language) - Student practicality questionnaire - Pre- and post-test on mathematical communication skills - Descriptive statistics for effectiveness	integrating ethnomathematics (Jambi Malay culture) in mainstream math education - Demonstrated measurable improvement in students' communication skills	mathematical communication in all ability groups (e.g., from 62.5% to 97.92% for high-ability students)./ The developed HLT is valid, practical, and effective in teaching trigonometry and improving mathematical communication by using PBL and integrating Jambi Malay ethnomath ematics.	- Time-intensive development process - No classroom-wide implementation yet; generalizability is limited
14	Ahmad, H. and Akib, I. (2021).	Trigonometric Learning Design with the Sibaliparriq Concept as a Learning Model	Challenges in student engagement and low learning outcomes in trigonometry at Al Asyariah Mandar University; need for culturally rooted learning models	Research and Development (R&D) using the Dick and Carey model integrated with McKenney's cycle./ Developmental research with design validation, prototyping, and assessment	34 undergraduate students./ Descriptive statistics (quantitative); expert validation, observation, questionnaire analysis (qualitative)	Introduces a culturally embedded trigonometry learning model based on Mandar local wisdom (sibaliparriq) values	-85.29% students achieved mastery (≥75) - Students were more active - Lecturers followed design effectively - Very positive student feedback./ The learning design using sibaliparriq is valid, practical, and effective in enhancing engagement and outcomes	- Small sample size limits generalizability - Study limited to a single institution and course - Long-term impacts not measured

15	Patrick Kyeremeh, Francis Kwadwo Awuah, Daniel Clark Orey (2024)	Challenges regarding the integration of ethnomathematical perspectives into geometry teaching: The faculty reflection	The study explores the challenges mathematics teacher educators in Ghana face when integrating ethnomathematical perspectives into geometry instruction in colleges of education. It highlights gendered experiences and the lack of culturally relevant examples in the curriculum.	Qualitative approach using reflexive thematic analysis./ Multiple case study design treating male and female mathematics teacher educators as distinct cases	8 participants (4 male and 4 female mathematics teacher educators), selected through purposive sampling./ Reflexive thematic analysis using Braun & Clarke's (2022) approach; supported by QSR NVivo for organizing data	- Highlights gender-specific challenges in ethnomathematical integration - Provides qualitative insight into curriculum and systemic barriers - Suggests practical and policy recommendations for teacher training and curriculum development	Male educators faced: • Inadequate/lack of cultural examples • Cultural diversity • Financial constraints - Female educators faced: • Time constraints • Gender discrimination - Differences in perception tied more to context than gender per sey./ The integration of ethnomathematical perspectives is constrained by curriculum, time, financial limitations, and sociocultural issues. Systemic support is required to foster inclusive, contextually relevant geometry teaching practices in Ghana	- Lack of culturally relevant materials in the geometry curriculum - Gender-specific access and participation limitations - Curriculum does not reflect student cultural diversity - Small sample size limits generalizability - Absence of nonverbal data in remote interviews
16	Nisa Triyatul Fitri, Arif	Mastery of Trigonometry Material and Its	Investigates the relationship between mastery of	Quantitative research using ex-post facto	34 students from class X-4, selected via cluster	Demonstrates a statistically significant positive	- Trigonometry mastery average score: 71.97	- Limited generalizability due to small, non-

	Muchyidin, Reza Oktiana Akbar (2022)	Effect on Students' Ability to Solving Three Dimensional Problems	trigonometry and the ability to solve three-dimensional geometry problems in Indonesian high school students at SMAN 1 Kadugede. Highlights issues of low student performance in 3D geometry despite high entrance scores.	and one-shot case study approach./ Ex-post facto; one-shot case study—treatment given to one experimental group and the outcome is measured afterward without a control group.	random sampling from a total population of 253 students at SMAN 1 Kadugede./ SPSS software for descriptive statistics, normality and homogeneity testing, and linear regression analysis.	relationship between trigonometry mastery and students' ability to solve 3D problems. Offers empirical evidence to support targeted interventions in trigonometry to enhance spatial problem-solving abilities.	(categorized as good). - 3D geometry mastery average: 79.88 (categorized as very good). - Regression analysis showed a significant relationship ($p < 0.05$), with the equation: $Y = 11.435 + 0.758X$./ Mastery of trigonometry significantly influences students' ability to solve three-dimensional problems. Emphasizes the need to strengthen students' understanding of trigonometry to improve performance in subsequent geometry topics	diverse sample (only one class). - No control group used, which limits causal inference. - Does not explore why some students perform well in 3D despite weak trigonometry, or vice versa—indicating possible intervening factors (e.g., spatial reasoning, prior knowledge).
17	Rizki Riyani, Zamzaili*, & Saleh Haji(2022)	Exploration of Fort Marlborough Bengkulu and Its Implications for Mathematics Learning in School	Ethnomathematical exploration of Fort Marlborough, Bengkulu, to link cultural heritage with school	Qualitative research with an ethnographic approach./ Ethnographic exploration of cultural and mathematical	7participants: 1 Bengkulu history expert, 2 tour guides, 2 mathematicians, 2 mathematics teachers./	Provides a culturally contextualized reference for integrating ethnomathematics	Identified facts (points, lines, shapes), concepts (geometry, trigonometry, congruence, quadratic	The study does not evaluate actual student learning outcomes from implementing this ethnomathematical context in

			mathematics learning	elements of a historical site	Data reduction, data presentation, conclusion drawing based on observation, interviews, and documentation	into school curricula	functions), and principles (area, volume, perimeter, ratios) embedded in Fort Marlborough's structure./ Ethnomathematical elements in Fort Marlborough can enrich mathematics teaching by linking it to local culture; provides meaningful and contextual learning for students	classrooms; lacks a quantitative impact assessment
18	James, A. T and Tertsea, J. (2021).	The Effect of Ethnomathematics on Junior Secondary School Students' Achievement and Retention in Geometry in Benue State, Nigeria: A Coronavirus Pandemic Case Study	Investigated how incorporating cultural practices (ethnomathematics) into geometry teaching during the COVID-19 pandemic impacts student achievement and retention in Benue State, Nigeria. Highlights the cultural and educational disconnect in current curricula.	Quasi-experimental approach involving ethnomathematics integration in teaching. Focus on comparing experimental and control groups./ Non-equivalent control group design (quasi-experimental)	137 Junior Secondary School 2 (JSS2) students (72 experimental, 65 control)./ Mean, standard deviation for descriptive analysis; ANCOVA for hypothesis testing at $\alpha = 0.05$.	Demonstrated that culturally relevant teaching strategies significantly improve students' understanding and retention in mathematics, specifically geometry, even under pandemic restrictions. Offers a model for remote/informal learning aligned with local cultures.	- Achievement: Ethnomathematics group had a post-test mean of 72.61 (gain = 32.23); control group had 41.66 (gain = 1.30). ANCOVA showed significant difference ($F=711.461$, $p<0.05$). - Retention: Ethnomathematics group scored 79.36; control 33.20. ANCOVA also revealed significant difference ($F=2.923$, $p<0.05$)../	- Limited generalizability beyond Benue State or pandemic context. - Reliance on informal instructors; sustainability and scalability unclear. - No long-term tracking of knowledge retention or transfer beyond geometry. - Cultural specificity may limit application in multicultural or

							Ethnomathematics significantly improves student achievement and retention in geometry compared to traditional lecture methods. Its use is especially relevant in pandemic-era education requiring socially-distanced and culturally embedded instruction.	urban schools without shared heritage

The contexts of these studies are predominantly from developing nations, especially Nigeria and Indonesia, which often face challenges related to Eurocentric curricula and student disengagement. This highlights the particular relevance of ethnomathematics in contexts where a disconnect exists between school mathematics and students' cultural realities.

Regarding contributions, the articles collectively provide compelling empirical evidence for the efficacy of ethnomathematics in improving student outcomes, enhancing engagement, and bridging the gap between abstract mathematical concepts and real-life applications. They also contribute practical models and validated materials for implementation.

However, the 'Gaps' column reveals consistent limitations across the research. Generalizability remains a key concern, as many studies are localized with small sample sizes (Al Ahadi *et al.*, 2021; Ali, 2024; Hamdani *et al.*, 2023; Fitri *et al.*, 2022). The lack of longitudinal data is another recurring gap, meaning the long-term impact on retention and mathematical development is often unmeasured (Umar *et al.*, 2019; Lakapu *et al.*, 2021; James & Akaazua, 2021). Furthermore, the challenges in curriculum integration and teacher training are repeatedly cited (Atta *et al.*, 2024; Mosimege & Egara, 2022; Kyeremeh *et al.*, 2024), pointing to systemic barriers that hinder broader adoption of these promising approaches. The absence of comparative studies between different ethnomathematical interventions is also a notable limitation (Al Ahadi *et al.*, 2021).

In all, the search table clearly illustrates the strengths in demonstrating short-term positive impacts and developing culturally relevant resources, while simultaneously exposing the need for more expansive, long-term, and system-level research to overcome implementation challenges.

4. Discussion

The findings from this systematic review consistently highlight the transformative potential of integrating ethnomathematics and culturally responsive pedagogy into mathematics education. As demonstrated by numerous studies (e.g., Umar *et al.*, 2019; Abiam *et al.*, 2016; Mosimege & Egara, 2023), when mathematical concepts are rooted in students' cultural experiences, it leads to significant improvements in academic performance and retention. The goal extends beyond increasing enjoyment; it is about fostering a meaningful connection between mathematical concepts and students' lived experiences ((Jacob & Dike, 2023). By leveraging familiar contexts be it traditional games like Oware (Powell & Temple, 2001), local architecture (Husna *et al.*, 2021), or dance forms (Pitdianti, 2024) students can connect abstract principles to tangible realities, fostering deeper conceptual understanding and enhancing problem-solving skills (Atta *et al.*, 2024).

The development of culturally sensitive teaching materials, as seen in the work of Husna *et al.* (2021), Assegaff and Bonyah (2023), and Lakapu *et al.* (2021), represents a crucial practical contribution. These materials serve as concrete examples of how educators can adapt curricula to resonate with diverse student populations. The

consistent validation of these materials by experts and positive student feedback suggests their high potential for broader implementation. The emphasis on problem-based learning within a cultural context, as explored by Hamdani *et al.* (2023), further reinforces the idea that an authentic connection to students' worlds enhances mathematical communication and overall literacy.

Despite the compelling evidence of benefits, the review also surfaces critical challenges and gaps. A pervasive issue is the limited generalizability of many findings due to small sample sizes and highly localized contexts (Al Ahadi *et al.*, 2021; Ali, 2024). While providing rich insights, these studies often cannot be broadly applied without further validation. More extensive studies across varied populations and educational systems are needed to strengthen the evidence base.

Perhaps the most significant challenge identified is the disconnect between research findings and practical implementation within educational systems. Teachers, as evidenced by Mosimege and Egara (2022) and Kyeremeh *et al.* (2024), often acknowledge the value of ethnomathematics but face substantial barriers. These include a lack of culturally relevant resources in existing curricula, insufficient teacher training, and systemic pressure to adhere to traditional, often Eurocentric, teaching methods. The Ghanaian context, highlighted by Atta *et al.* (2024) and Kyeremeh *et al.* (2024), clearly illustrates how national curricula, despite advocating constructivist approaches, frequently miss opportunities to embed cultural relevance, leaving teachers without the necessary support or directives.

Furthermore, there is a distinct need for longitudinal studies (Umar *et al.*, 2019; Al Ahadi *et al.*, 2021). While immediate gains in achievement are promising, understanding the sustained impact of ethnomathematics on students' mathematical trajectories, their attitudes towards mathematics over time, and its influence on their future academic or career choices is crucial. Qualitative insights into student and teacher experiences are also vital to complement quantitative data, providing a richer understanding of the pedagogical processes and personal transformations occurring (Umar *et al.*, 2019).

The ‘pandemic case study by James and Akaazua (2021) suggests the resilience and adaptability of ethnomathematical approaches, even in disrupted learning environments. This indicates that culturally relevant pedagogy is not just an add-on but a fundamental shift that can strengthen educational systems overall, making learning more robust and equitable. However, this also implies a need to explore such approaches in a wider range of challenging contexts.

In essence, while the ‘what’ and ‘how’ of ethnomathematics are becoming clearer through various interventions and material developments, the ‘why not’ of its widespread adoption points to deeper systemic issues related to policy, curriculum design, and professional development. Addressing these systemic barriers is paramount for moving ethnomathematics from promising research findings to common practice.

5. Conclusion

This systematic review underscores the significant and multifaceted benefits of integrating ethnomathematics and culturally responsive pedagogy into mathematics education. The synthesis of 18 articles provides compelling evidence that these approaches consistently improve student achievement and retention, enhance engagement and motivation, and foster a deeper, more contextualized understanding of mathematical concepts. They also play a crucial role in validating students' cultural identities and making mathematics more relevant to their lived experiences.
Despite these clear advantages, widespread implementation faces considerable hurdles.

Key limitations in the existing research include a need for larger, more generalizable studies, longitudinal impact assessments, and comparative analyses of different ethnomathematical interventions. More importantly, the review highlights persistent systemic barriers such as the lack of culturally relevant curricula materials, inadequate teacher training, and a general underrepresentation of ethnomathematics in educational policy.

Moving forward, sustained efforts are required to translate research findings into actionable educational practices. This includes advocating for curriculum reforms that explicitly incorporate diverse cultural mathematical practices, developing comprehensive professional development programs for teachers, and creating robust, culturally informed teaching resources. Addressing these systematic gaps would enable educators to integrate ethnomathematics more effectively into everyday teaching practice.

5.1 Limitations of the Study

The results of this systematic review are not very generalizable because most studies, especially those from Nigeria and Indonesia, are localized and have small sample sizes. Inadequate curricular integration and teacher preparation are examples of systemic problems that are acknowledged but not thoroughly investigated. Additionally, bias may be introduced if searches for pertinent research articles are restricted to English-language publications. Restricting reviews to research articles published in peer-reviewed journals may expose the review to publication bias because this approach is unlikely to uncover studies that have not been published in peer-reviewed journals.

5.2 Suggestions for Future Studies

In order to provide a more complete picture of the available data, future research can expand the review of more pertinent studies to include grey literature such as conference proceedings, theses, reports, bibliographies and records of current research. Future research can further expand databases to include collections of ethnomathematics studies written in languages other than English.

Authors' Contributions

PK: Conceptualization, methodology, writing – original draft. EB: Supervision, validation, writing – review & editing. PK & EB: Formal analysis, resources. All authors read and approved the final manuscript. All authors agreed with the results and conclusions.

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