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Elementary Teachers' Perspectives on Ethnomathematics: Understanding and Perceived Challenges in Mathematics Classrooms

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Abstract

This study examines elementary teachers' perspectives on the integration of ethnomathematics in mathematics classrooms in Surakarta, Indonesia. Although ethnomathematics has been widely advocated as a culturally responsive approach that enhances engagement and meaningful learning, its consistent implementation in formal school settings remains uneven. Using an explanatory sequential mixed methods design, data were collected from 63 elementary teachers through a structured survey and follow-up semi structured interviews. Quantitative analysis revealed strong positive teacher attitudes toward ethnomathematics and favorable perceptions of student engagement. However, reported classroom implementation was comparatively limited. Perceived structural and pedagogical barriers, including curriculum alignment challenges and time constraints, were moderately high. Qualitative findings further indicated that while teachers recognize the value of culturally grounded instruction, many experience difficulty translating cultural contexts into mathematically rigorous and curriculum-aligned lessons. The results highlight a gap between belief and practice. This study contributes to the literature on culturally responsive mathematics education by providing an integrated mapping of teachers' understanding, perceptions, practices and perceived barriers within a culturally rich context. The findings underscore the need for structured pedagogical frameworks that support sustainable integration of ethnomathematics in elementary mathematics classrooms.

Keywords: Culturally Responsive Pedagogy, Elementary Mathematics Education, Ethnomathematics, Implementation Challenges, Teachers' Perspectives.

Introduction

Mathematics education plays a fundamental role in developing learners' logical reasoning, problem-solving abilities, critical thinking and quantitative literacy. In contemporary educational contexts, mathematics learning is no longer viewed solely as the acquisition of procedural skills but also as a process of constructing conceptual understanding and applying mathematical ideas to real-world situations. Consequently, increasing attention has been directed toward instructional approaches that connect mathematics with students' lived experiences and sociocultural environments, thereby promoting more meaningful, equitable and inclusive learning opportunities (1, 2). The importance of contextualized mathematics learning is particularly evident in elementary education. Elementary school years constitute a critical developmental stage during which learners establish foundational mathematical concepts, develop learning dispositions and form attitudes toward mathematics that may influence future academic achievement. Research has consistently shown that students learn mathematics more effectively when new concepts are connected to familiar contexts and prior experiences. Such contextualized learning experiences can enhance engagement, support conceptual understanding and facilitate meaningful knowledge construction (3, 4). Therefore, identifying instructional approaches that bridge formal mathematical knowledge and students' everyday experiences remains an important priority in elementary mathematics education. The theoretical foundations of contextualized mathematics instruction can be understood through constructivist and sociocultural perspectives on learning. Constructivist theory posits that learners actively construct knowledge through interaction with experiences and environments rather than passively receiving information. Similarly, sociocultural theory emphasizes that learning is mediated by language, culture and social interaction. From this perspective,

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mathematical understanding develops through participation in culturally meaningful activities and community practices. Consequently, culture should not be viewed merely as a background variable in mathematics education but as an integral component of knowledge construction and meaning-making processes (4).

Building upon these perspectives, culturally responsive pedagogy has emerged as an influential framework for promoting inclusive and meaningful learning experiences. Culturally responsive teaching recognizes students' cultural backgrounds, experiences and community knowledge as valuable assets that can enrich learning processes and improve educational outcomes. Within mathematics education, culturally responsive approaches seek to connect formal mathematical concepts with learners' cultural experiences and social realities. Previous studies have reported that culturally responsive mathematics instruction can increase student participation, improve engagement and support more equitable learning opportunities across diverse educational settings (1, 5).

One important manifestation of culturally responsive mathematics education is ethnomathematics. Originally ethnomathematics emphasizes that mathematical ideas, reasoning processes and problem-solving practices are embedded within cultural activities and social traditions. Rather than viewing mathematics as a culturally neutral body of knowledge, ethnomathematics acknowledges that diverse cultural groups develop and apply mathematical understanding through everyday practices, artefacts, technologies and social interactions (6–8). Recent studies have further highlighted the potential of ethnomathematics to strengthen cultural identity, enhance student engagement and facilitate meaningful learning by linking formal mathematical concepts with authentic cultural contexts (9–11).

Indonesia provides a particularly relevant context for ethnomathematics research due to its extensive cultural diversity. In Surakarta, Central Java, various cultural artefacts and practices offer substantial opportunities for integrating mathematical concepts into classroom instruction. Traditional batik motifs contain geometric transformations, symmetry, tessellation and pattern structures that can be explored through mathematics learning. Likewise, traditional market activities, local craft production and architectural elements of the Surakarta Palace provide authentic contexts for investigating measurement, ratio, spatial reasoning and geometric concepts. These cultural resources offer significant potential for culturally grounded mathematics instruction. However, the existence of rich cultural resources does not automatically ensure their effective integration into formal mathematics education.

Over the past decade, increasing scholarly attention has been directed toward ethnomathematics and culturally responsive mathematics education. Empirical studies have reported positive outcomes, including enhanced student engagement, stronger conceptual understanding, improved cultural awareness and more meaningful learning experiences (9, 11). Nevertheless, researchers have also identified recurring implementation challenges. These include difficulties in aligning cultural contexts with curriculum requirements, limited instructional resources, insufficient pedagogical guidance and time constraints within formal school systems (10, 12, 13). Such findings suggest that while ethnomathematics is widely valued conceptually, its practical implementation remains complex.

Research focusing on teachers has further demonstrated that educators generally express positive attitudes toward ethnomathematics and culturally responsive instruction. However, positive perceptions do not always translate into consistent classroom practices. Teachers frequently encounter difficulties in identifying mathematically meaningful cultural contexts, transforming cultural practices into curriculum-aligned learning activities and balancing contextual relevance with mathematical rigor (10, 12). These findings indicate that successful ethnomathematics implementation depends not only on teachers' beliefs but also on their conceptual understanding, pedagogical competence and the institutional conditions within which teaching occurs.

Although previous studies have examined teacher attitudes, implementation challenges, culturally responsive teaching practices and student outcomes associated with ethnomathematics, many of these investigations have focused on individual dimensions in isolation. Consequently, current knowledge remains fragmented regarding

how teachers simultaneously understand ethnomathematics, perceive its pedagogical value, implement it in classroom practice and experience barriers to its integration. Furthermore, comprehensive investigations examining these interconnected dimensions among elementary school teachers in culturally rich Indonesian contexts remain limited. This limitation restricts a holistic understanding of the cognitive, pedagogical and contextual factors that influence ethnomathematics implementation in elementary mathematics education.

This study addresses these gaps by providing an integrated examination of elementary teachers' perspectives on ethnomathematics through an explanatory sequential mixed-methods design. Unlike previous studies that have primarily focused on isolated aspects of ethnomathematics implementation, this research simultaneously investigates teachers' conceptual understanding, pedagogical perceptions, reported classroom practices, perceived barriers and views regarding student responses within a single analytical framework. By focusing on elementary school teachers in Surakarta, Indonesia, the study contributes a comprehensive mapping of factors that support and constrain ethnomathematics integration and provides empirical evidence that may inform the development of more context-sensitive and culturally responsive mathematics instruction.

In the context of Surakarta, various cultural practices provide opportunities for ethnomathematics integration in elementary mathematics education. Traditional batik motifs, such as geometric and repetitive patterns, can be used to introduce concepts of symmetry, transformation, tessellation and geometric reasoning. Activities in traditional markets offer authentic contexts for learning arithmetic operations, ratios, percentages and financial literacy. Furthermore, traditional games and local architectural designs may support the exploration of measurement, spatial reasoning and pattern recognition. These examples demonstrate how cultural practices can serve as meaningful contexts for connecting formal mathematical concepts with students' everyday experiences.

Therefore, this study aims to investigate elementary teachers' perspectives on ethnomathematics integration in Surakarta, Indonesia. Specifically, the study examines teachers' conceptual understanding of ethnomathematics, perceived pedagogical value, reported classroom practices, perceived barriers and perceptions of student responses. By integrating quantitative and qualitative evidence, this study contributes to the growing literature on culturally responsive mathematics education and provides empirical insights into conditions that support or constrain the sustainable implementation of ethnomathematics in elementary mathematics classrooms.

Methodology

Research Design

This study employed an explanatory sequential mixed-methods design to investigate elementary school teachers' perspectives on the integration of ethnomathematics in mathematics classrooms. In this design, quantitative data collection and analysis were conducted first, followed by a qualitative phase intended to explain and elaborate the quantitative findings (14). The explanatory sequential approach was selected because the study sought not only to identify patterns in teachers' understanding, perceptions, implementation practices, perceived barriers and views of student responses, but also to gain deeper insights into the factors underlying those patterns. The qualitative findings were therefore used to provide contextual explanations for the quantitative results and to strengthen the overall interpretation of the study.

Research Context

The study was conducted in Surakarta, Central Java, Indonesia, a region recognized for its rich cultural heritage, including batik traditions, traditional architecture, local markets and various community-based cultural practices. These cultural resources provide meaningful opportunities for integrating ethnomathematics into elementary mathematics instruction. However, despite the availability of such cultural contexts, empirical evidence regarding how elementary school teachers perceive and implement ethnomathematics remains limited. Therefore, Surakarta was selected as an appropriate setting for examining teachers' perspectives on ethnomathematics integration within a culturally rich educational environment.

Participants

The quantitative phase involved 63 elementary school teachers from public and private schools in Surakarta. Participants were selected through voluntary participation and represented diverse teaching backgrounds, educational qualifications and levels of professional experience. The sample consisted of both classroom teachers and mathematics subject teachers, allowing the study to capture a broad range of perspectives regarding ethnomathematics implementation.

For the qualitative phase, ten teachers were purposively selected from the survey participants to participate in in-depth semi-structured interviews. The selection considered variation in teaching experience, educational background and reported engagement with ethnomathematics-related practices. This purposive sampling strategy enabled the researchers to obtain diverse perspectives and richer explanations of the quantitative findings (15).

Instrument Development and Validation

Data were collected using a researcher-developed questionnaire and semi-structured interview protocol. The questionnaire was constructed based on the literature on ethnomathematics, culturally responsive pedagogy and mathematics education (1, 8, 16). The instrument consisted of five domains:

(a) Understanding of Ethnomathematics,
(b) Integration Practices,
(c) Perceptions and Attitudes,
(d) Perceived Barriers and
(e) Student Response.

The Understanding domain assessed teachers' conceptual knowledge of ethnomathematics and its relevance to mathematics education. The Integration Practices domain examined the extent to which teachers incorporated cultural contexts into mathematics instruction. The Perceptions and Attitudes domain explored teachers' beliefs regarding the educational value of ethnomathematics. The Perceived Barriers domain investigated challenges encountered in implementing ethnomathematics, while the Student Response domain examined teachers' observations of students' engagement and participation during culturally contextualized mathematics learning.

Content validity was established through expert review involving two specialists in mathematics education. The experts evaluated the relevance, clarity and representativeness of each item in relation to the intended constructs. Their feedback was used to refine wording, improve item clarity and ensure alignment with the research objectives. All questionnaire items were measured using a five-point Likert scale. The Understanding domain used response categories ranging from Strongly Do Not Understand to Strongly Understand. The Integration Practices domain ranged from Never to Very Often, while the remaining domains employed response categories from Strongly Disagree to Strongly Agree.

Internal consistency reliability was assessed using Cronbach's alpha coefficients (17). The results demonstrated satisfactory reliability across all domains. The Understanding of Ethnomathematics domain achieved an alpha coefficient of 0.933, Integration Practices 0.956, Perceptions and Attitudes 0.860, Perceived Barriers 0.821 and Student Response 0.684. These results indicate acceptable to excellent internal consistency for the instrument domains.

Data Collection Procedures

Quantitative data were collected through questionnaire administration to the participating teachers. After preliminary analysis of the survey results, the qualitative phase was conducted. Semi-structured interviews were carried out with ten selected participants to explore their experiences, perceptions, instructional practices and challenges related to ethnomathematics implementation in greater depth.

The interview protocol included questions concerning teachers' understanding of ethnomathematics, examples of cultural contexts used in mathematics instruction, perceived benefits, implementation challenges, student responses and professional support needs. The semi-structured format allowed flexibility while maintaining consistency with the study objectives (18).

Data Analysis

Quantitative data were analyzed using descriptive statistics, including means and standard deviations, to examine teachers' perspectives across the five domains. Reliability analysis was also conducted using Cronbach's alpha coefficients to assess the internal consistency of the questionnaire domains (17).

Qualitative interview data were transcribed and analyzed using thematic analysis following the

procedures proposed in past studies (19). The analysis involved familiarization with the data, initial coding, theme development, theme review and refinement. Emerging themes were then compared with the quantitative findings to identify areas of convergence and divergence.

Integration of quantitative and qualitative findings occurred during the interpretation stage. Qualitative themes were used to explain, contextualize and elaborate patterns identified in the survey results, consistent with the principles of explanatory sequential mixed-methods research (14).

Ethical Considerations

Participation in this study was voluntary. All participants provided informed consent prior to data collection and were informed of the purpose of the research. Confidentiality and anonymity were maintained throughout the study and all data were used solely for academic and research purposes. Ethical procedures were implemented in accordance with accepted standards for educational research.

Results

Participant Characteristics

A total of 63 elementary school teachers participated in this study. Demographic information was collected to provide contextual insights into participants' backgrounds and to support the interpretation of findings related to ethnomathematics integration. The collected demographic variables included gender, teaching experience, grade level taught, teaching status and educational background.

As shown in Table 1, female teachers constituted the majority of participants (68.3%), while male teachers represented 31.7% of the sample. Regarding teaching experience, most participants (55.6%) had more than 15 years of teaching experience, indicating that the study primarily captured the perspectives of experienced educators. Teachers with less than five years of experience accounted for 19.0% of the sample, while those with five to ten years and ten to fifteen years of experience represented 20.6% and 4.8%, respectively.

Table 1: Demographic Characteristics of Participants

Variable	Category	n	%
Gender	Male	20	31.7
	Female	43	68.3
Teaching Experience	< 5 years	12	19.0
	5–10 years	13	20.6
	10–15 years	3	4.8
	> 15 years	35	55.6
Grade Level Taught	Grade 1	20	31.7
	Grade 2	18	28.6
	Grade 3	22	34.9
	Grade 4	18	28.6
	Grade 5	21	33.3
	Grade 6	17	27.0
Teaching Status	Classroom Teacher	50	79.4
	Subject Teacher	13	20.6
Educational Background	Bachelor's Degree (S1)	54	85.7
	Master's Degree (S2)	9	14.3

Note: n = Number of Participants, % = Percentage.

Participants represented all elementary grade levels, ensuring that the findings reflected perspectives from different stages of elementary education. Most respondents were classroom teachers (79.4%), whereas subject teachers accounted for 20.6% of the sample. In terms of educational qualifications, the majority held a bachelor's degree (85.7%), while a smaller proportion possessed a master's degree (14.3%). These characteristics suggest that the findings were derived from a diverse and experienced group of elementary school teachers.

Teachers' Understanding of Ethnomathematics

Teachers' understanding of ethnomathematics was examined through five questionnaire items focusing on conceptual knowledge, recognition of mathematical ideas embedded in cultural practices, pedagogical relevance, instructional

purposes and the role of teachers in ethnomathematics-based learning. The descriptive results are presented in Table 2.

The overall mean score for the Understanding domain was 3.36 (SD = 0.78), indicating a moderate level of understanding among the participating teachers. This finding suggests that while teachers generally possess awareness of ethnomathematics and its educational relevance, variations remain in the depth of their conceptual understanding.

Table 2: Teachers' Understanding of Ethnomathematics (N = 63)

Statement	Mean	Interpretation
I understand ethnomathematics as an instructional approach that connects mathematical concepts with culture.	3.24	Moderate
I understand that local cultural practices contain mathematical concepts.	3.48	High
I understand that ethnomathematics is relevant to elementary mathematics education.	3.41	High
I understand that ethnomathematics helps students understand concepts and solve mathematical problems.	3.33	Moderate
I understand that teachers act as facilitators who help students connect culture with mathematical concepts.	3.33	Moderate
Overall Mean	**3.36**	**Moderate**

Among the five indicators, the highest mean score was obtained for the statement that ethnomathematics is relevant to elementary mathematics education (M = 3.41). This finding indicates that most teachers recognize the potential value of integrating cultural contexts into mathematics learning. Similarly, teachers reported a relatively high level of agreement regarding the recognition of mathematical concepts embedded in local cultural practices (M = 3.48), suggesting awareness that cultural activities may serve as meaningful contexts for mathematics instruction.

Participants also demonstrated positive understanding of the instructional objectives of ethnomathematics, particularly its role in helping students understand mathematical concepts and develop problem-solving abilities (M = 3.33). In addition, teachers generally acknowledged their role as facilitators who support students in connecting cultural experiences with mathematical ideas (M = 3.33).

The lowest mean score was found for the item assessing teachers' general conceptual understanding of ethnomathematics as an instructional approach that links mathematics with culture (M = 3.24). Although the result remains within the moderate category, it may indicate that some teachers possess practical awareness of ethnomathematics without fully understanding its broader theoretical foundations. Overall, the findings suggest that teachers demonstrate a functional understanding of ethnomathematics and generally recognize its relevance to elementary mathematics education. However, the moderate overall score indicates opportunities for strengthening teachers' conceptual knowledge through professional development programs, workshops and greater exposure to ethnomathematics-based instructional practices.

Integration Practices of Ethnomathematics in Mathematics Instruction

The extent to which teachers integrated ethnomathematics into classroom instruction was examined through five indicators related to the use of cultural contexts, culturally relevant learning activities, student engagement with cultural practices and the continuity of ethnomathematics-based instruction. The results are presented in Table 3.

Table 3: Integration Practices of Ethnomathematics in Mathematics Instruction (N = 63)

Statement	Mean	Interpretation
I use local cultural contexts when explaining mathematical concepts.	2.94	Moderate
I relate mathematical problems or activities to students' cultural experiences.	3.10	Moderate
I involve students in observing or discussing cultural practices related to mathematics.	2.97	Moderate
I encourage students to identify mathematical concepts from their own cultural environment.	3.05	Moderate

I consistently implement ethnomathematics-based learning across different mathematics topics.	2.76	Moderate
Overall Mean	**2.96**	**Moderate**

The overall mean score for the Integration Practices domain was 2.96, indicating a moderate level of ethnomathematics implementation among participating teachers. Although teachers generally reported positive understanding of ethnomathematics, the findings suggest that classroom implementation has not yet reached a consistently high level.

Among the five indicators, the highest mean score was obtained for the item stating that teachers relate mathematical problems or activities to students' cultural experiences (M = 3.10). This finding suggests that many teachers attempt to connect mathematics learning with familiar cultural contexts, thereby making learning more meaningful and relevant to students' everyday lives.

Similarly, teachers reported moderate engagement in encouraging students to identify mathematical concepts within their own cultural environments (M = 3.05) and involving students in observing or discussing cultural practices related to mathematics (M = 2.97). These findings indicate that elements of ethnomathematics have begun to be incorporated into instructional practice, although implementation remains uneven.

The lowest mean score was observed for the item concerning the consistent implementation of ethnomathematics-based learning across different mathematics topics (M = 2.76). This result suggests that ethnomathematics is often used selectively or occasionally rather than as a sustained instructional approach. Many teachers may incorporate cultural examples during certain lessons but have not yet fully integrated ethnomathematics into their regular teaching practices.

Overall, the findings indicate that while teachers demonstrate moderate levels of ethnomathematics integration, implementation remains less developed than their conceptual understanding and positive attitudes toward ethnomathematics. This discrepancy suggests the existence of practical and pedagogical challenges that may limit the consistent application of ethnomathematics in elementary mathematics classrooms.

Teachers' Perceptions and Attitudes Toward Ethnomathematics

Teachers' perceptions and attitudes toward ethnomathematics were examined through five indicators related to its perceived effectiveness, relevance and contribution to meaningful mathematics learning. The results are presented in Table 4.

Table 4: Teachers' Perceptions and Attitudes Toward Ethnomathematics (N = 63)

Statement	Mean	Interpretation
Ethnomathematics-based learning can help students understand mathematical concepts more effectively.	3.57	High
Ethnomathematics can increase students' interest and motivation in learning mathematics.	3.60	High
Ethnomathematics-based learning is relevant to students' daily lives.	3.62	High
Ethnomathematics is appropriate to be integrated into elementary mathematics education.	3.45	High
Ethnomathematics can support meaningful mathematics learning.	3.46	High
Overall Mean	**3.54**	**High**

The overall mean score for the Perceptions and Attitudes domain was 3.54, indicating a high level of positive perception toward ethnomathematics among participating teachers. Compared with the previous domains, this result represents one of the highest scores obtained in the study, suggesting that teachers generally hold favorable views regarding the integration of cultural contexts into mathematics instruction.

The highest mean score was found for the statement that ethnomathematics-based learning is relevant to students' daily lives (M = 3.62). This finding indicates that teachers recognize the value of connecting mathematical concepts with students' cultural experiences and everyday contexts. Similarly, teachers strongly agreed that ethnomathematics can increase students' interest and motivation in learning mathematics (M = 3.60)

and improve students' understanding of mathematical concepts (M = 3.57).

Participants also expressed positive views regarding the role of ethnomathematics in supporting meaningful learning experiences (M = 3.46) and its suitability for integration into elementary mathematics education (M = 3.45). These findings suggest that teachers generally perceive ethnomathematics as an educationally valuable approach that can enhance both the relevance and effectiveness of mathematics learning.

Overall, the results demonstrate that teachers hold positive attitudes toward ethnomathematics and believe that culturally contextualized learning can contribute to student engagement, conceptual understanding and meaningful learning experiences. The high perception scores further indicate a strong level of teacher support for the integration of ethnomathematics in elementary mathematics classrooms.

Table 5: Perceived Barriers to Ethnomathematics Integration (N = 63)

Statement	Mean	Interpretation
My knowledge of ethnomathematics is still limited.	3.21	Moderate
I have difficulty identifying cultural examples that align with mathematics topics.	3.08	Moderate
I lack instructional materials and teaching resources that support ethnomathematics-based learning.	3.34	Moderate
I experience difficulties connecting cultural contexts with specific mathematical concepts.	3.15	Moderate
Implementing ethnomathematics requires more preparation than conventional instruction.	3.42	Moderate
Overall Mean	**3.24**	**Moderate**

Perceived Barriers to Ethnomathematics Integration

Teachers' perceptions of barriers to ethnomathematics integration were examined through five indicators related to knowledge limitations, cultural resource identification, instructional materials, pedagogical challenges and preparation requirements. The results are presented in Table 5.

The overall mean score for the Perceived Barriers domain was 3.24, indicating a moderate level of perceived challenges in implementing ethnomathematics. These findings suggest that although teachers generally support ethnomathematics and recognize its educational value, several practical and pedagogical obstacles continue to influence classroom implementation.

Among the identified barriers, the highest mean score was associated with the perception that ethnomathematics-based instruction requires greater preparation than conventional teaching approaches (M = 3.42). This finding indicates that teachers view the integration of cultural contexts into mathematics instruction as a process that demands additional planning, resource development and instructional adaptation.

Teachers also reported moderate concerns regarding the availability of instructional materials and teaching resources (M = 3.34). Many participants perceived a lack of structured learning materials, examples and teaching guides that could facilitate the integration of ethnomathe-matics into mathematics lessons.

Furthermore, respondents indicated moderate challenges related to their own knowledge of ethnomathematics (M = 3.21) and the difficulty of connecting cultural practices with specific mathematical concepts (M = 3.15). These findings suggest that successful implementation requires not only positive attitudes but also sufficient pedagogical knowledge and instructional support.

The lowest mean score was found for the difficulty of identifying cultural examples relevant to mathematics topics (M = 3.08). Although this issue was perceived as less problematic than other barriers, it nevertheless indicates that some teachers continue to experience uncertainty when selecting appropriate cultural contexts for mathematics instruction.

Overall, the findings indicate that barriers to ethnomathematics implementation are primarily related to instructional preparation, resource availability and pedagogical capacity rather than negative teacher attitudes. These results help explain why implementation levels remain moderate despite teachers' relatively positive understanding and perceptions of ethnomathematics.

Student Responses and Readiness for Ethnomathematics-based Learning

Teachers' perceptions of student responses and readiness toward ethnomathematics-based learning were examined through five indicators related to student interest, participation, conceptual understanding, attitudes toward mathematics and adaptation to active learning approaches. The results are presented in Table 6.

Table 6: Student Responses and Readiness for Ethnomathematics-based Learning (N = 63)

Statement	Mean	Interpretation
Students show interest when mathematics learning is connected to their culture.	3.72	High
Students participate more actively during ethnomathematics-based learning.	3.58	High
Some students experience difficulty understanding the relationship between culture and mathematics.	3.01	Moderate
Students' attitudes toward mathematics influence the success of ethnomathematics-based learning.	3.43	High
Some students are not accustomed to active learning approaches in ethnomathematics-based instruction.	3.18	Moderate
Overall Mean	**3.38**	**High**

The overall mean score for the Student Responses domain was 3.38, indicating generally positive student readiness and engagement toward ethnomathematics-based learning. According to teachers' perceptions, students tend to respond favorably when mathematics instruction incorporates familiar cultural contexts and experiences.

The highest mean score was obtained for the statement that students show greater interest when mathematics learning is connected to their cultural background (M = 3.72). This finding suggests that culturally contextualized learning environments may enhance students' curiosity and engagement by making mathematical concepts more meaningful and relevant to their everyday lives.

Teachers also reported that students tend to participate more actively during ethnomathematics-based learning activities (M = 3.58). This result indicates that cultural contexts may encourage interaction, discussion and exploration, thereby creating more engaging learning experiences. Furthermore, respondents perceived that students' attitudes toward mathematics play an important role in determining the success of ethnomathematics-based instruction (M = 3.43).

Despite these positive findings, some challenges were also identified. Teachers reported that certain students experience difficulties in understanding the relationship between cultural practices and mathematical concepts (M = 3.01). In addition, some students were perceived as being unfamiliar with learning approaches that require active participation and independent exploration (M = 3.18). These findings suggest that successful implementation of ethnomathematics may require gradual adaptation and appropriate instructional support.

Overall, the results indicate that students are generally receptive to ethnomathematics-based learning. Teachers perceived that integrating cultural contexts into mathematics instruction can enhance student interest and participation, although some students may require additional guidance in adapting to culturally contextualized and student-centered learning approaches.

Comparative Overview of Quantitative Findings

To obtain a broader understanding of teachers' perspectives on ethnomathematics, the mean scores of all five quantitative domains were compared. The comparison provides an overall picture of teachers' understanding, implementation practices, perceptions, perceived barriers and observations of student responses toward ethnomathematics-based mathematics learning. The comparison of quantitative findings is presented in Table 7.

Table 7: Comparative Overview of Quantitative Findings

Domain	Mean	Interpretation
Understanding of Ethnomathematics	3.36	Moderate
Integration Practices	2.96	Moderate
Perceptions and Attitudes	3.54	High
Perceived Barriers	3.24	Moderate
Student Responses	3.38	High

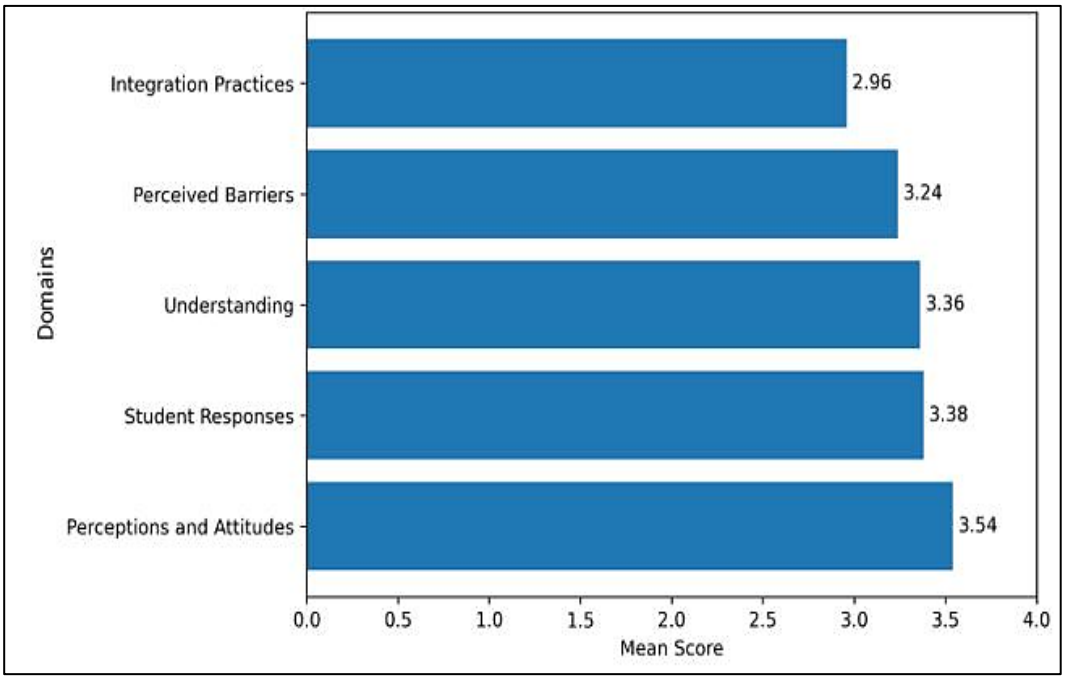

Figure 1: Comparison of Mean Scores Across Quantitative Domains

Figure 1 illustrates the comparative mean scores across the five quantitative domains. Teachers reported the highest scores in Perceptions and Attitudes (M = 3.54) and Student Responses (M = 3.38), while Integration Practices showed the lowest mean score (M = 2.96), indicating a gap between positive perceptions and actual classroom implementation of ethnomathematics.

The comparison reveals several important patterns. Teachers reported the highest mean score in the Perceptions and Attitudes domain (M = 3.54), indicating strong support for the educational value of ethnomathematics. Participants generally believed that ethnomathematics can enhance students' understanding, engagement and motivation while making mathematics learning more meaningful and relevant.

Positive results were also observed in the Student Responses domain (M = 3.38), suggesting that students are generally receptive to culturally contextualized mathematics instruction. According to teachers' perceptions, students tend to show greater interest and participation when mathematics learning is connected to familiar cultural experiences.

In contrast, the Integration Practices domain produced the lowest mean score (M = 2.96). Although teachers demonstrated moderate understanding of ethnomathematics (M = 3.36) and expressed highly positive perceptions toward its implementation, these favorable views were not consistently reflected in classroom practice. This discrepancy suggests that positive beliefs alone may be insufficient to ensure effective implementation.

The Perceived Barriers domain (M = 3.24) further helps explain this pattern. Teachers identified several challenges related to instructional preparation, resource availability and pedagogical implementation. These obstacles may contribute to the gap between teachers' positive perceptions of ethnomathematics and their actual classroom practices.

Overall, the comparative findings suggest that teachers generally recognize the value of ethnomathematics and perceive positive student responses toward culturally contextualized

learning. However, practical and instructional challenges continue to limit the consistent implementation of ethnomathematics in elementary mathematics classrooms.

Qualitative Findings

To provide deeper insights into the quantitative findings, semi-structured interviews were conducted with ten elementary school teachers. Thematic analysis identified four major themes related to teachers' understanding, implementation practices, perceived barriers and professional support needs regarding ethnomathematics integration.

Theme 1: Understanding the Educational Value of Ethnomathematics

Most participants demonstrated a positive understanding of ethnomathematics and acknowledged its educational value in mathematics learning. Teachers generally described ethnomathematics as an approach that connects mathematical concepts with students' cultural experiences and everyday lives. Participants believed that integrating cultural contexts could help students better understand abstract mathematical concepts by relating them to familiar situations.

Several teachers emphasized that local cultural practices, traditional games, batik patterns and community activities provide meaningful contexts for mathematics instruction. They perceived ethnomathematics as a way to make learning more relevant, engaging and culturally meaningful for students.

Theme 2: Positive Perceptions but Limited Classroom Implementation

Although participants expressed positive attitudes toward ethnomathematics, many acknowledged that implementation in classroom practice remained limited. Teachers reported occasionally incorporating cultural examples into mathematics lessons; however, ethnomathematics was rarely used as a systematic instructional approach.

Several participants indicated that cultural contexts were often introduced only when relevant examples were readily available. As a result, the integration of ethnomathematics tended to occur sporadically rather than being consistently embedded across different mathematics topics. This finding supports the quantitative results showing a gap between teachers' positive perceptions and their actual implementation practices.

Theme 3: Barriers to Ethnomathematics Integration

Participants identified several challenges that limited the implementation of ethnomathematics in mathematics classrooms. The most frequently mentioned barriers included limited instructional resources, insufficient teaching materials, lack of practical examples and difficulties aligning cultural contexts with curriculum objectives.

Teachers also reported that developing ethnomathematics-based learning activities required additional preparation time and instructional planning. Some participants expressed uncertainty regarding how to translate cultural practices into mathematically meaningful learning experiences while maintaining curriculum standards and learning objectives.

Theme 4: Need for Professional Development and Instructional Support

A recurring theme across interviews was the need for greater professional support. Participants expressed interest in receiving training, workshops and practical guidance related to ethnomathematics-based instruction. Teachers indicated that professional development opportunities could help them identify mathematical concepts within local cultural practices and develop more effective classroom activities.

Several participants also emphasized the importance of instructional resources, including lesson plans, teaching modules and examples of ethnomathematics-based learning activities. According to participants, such resources would increase their confidence and facilitate more consistent implementation of ethnomathematics in mathematics education.

Overall, the qualitative findings provide additional support for the quantitative results. Teachers generally demonstrated positive perceptions and understanding of ethnomathematics; however, practical challenges related to resources, instructional preparation and professional capacity continue to influence classroom implementation.

Integration of Quantitative and Qualitative Findings

The integration of quantitative and qualitative findings revealed a consistent pattern regarding

teachers' perspectives on ethnomathematics in elementary mathematics education. The quantitative results indicated that teachers generally demonstrated moderate to high levels of understanding (M = 3.36) and highly positive perceptions toward ethnomathematics (M = 3.54). In addition, teachers perceived that students responded positively to culturally contextualized mathematics learning (M = 3.38). However, the implementation of ethnomathematics in classroom practice remained comparatively moderate (M = 2.96). This pattern is consistent with previous studies indicating that teachers often express positive attitudes toward culturally responsive mathematics education while experiencing challenges in translating these beliefs into consistent classroom practices (1, 20, 21).

The qualitative findings provided deeper explanations for this discrepancy. Although teachers recognized the educational value of ethnomathematics and expressed strong support for its integration, many reported that implementation was often limited to occasional use of cultural examples rather than systematic instructional practice. Participants explained that practical challenges, including limited instructional resources, insufficient training and additional preparation requirements, constrained their ability to consistently integrate ethnomathematics into mathematics lessons. These findings are consistent with previous studies showing that successful implementation of culturally responsive mathematics instruction requires teachers to possess not only positive attitudes but also sufficient pedagogical knowledge, instructional resources and institutional support (10, 12, 22).

The quantitative findings regarding perceived barriers (M = 3.24) were further supported by interview data. Teachers identified difficulties related to instructional planning, curriculum alignment and the availability of teaching materials. These findings suggest that the gap between teachers' positive perceptions and actual classroom implementation is influenced more by contextual and pedagogical factors than by negative attitudes toward ethnomathematics. Similar observations emphasized that culturally responsive mathematics teaching requires careful alignment between cultural contexts, curriculum objectives and mathematical learning outcomes (13). Likewise, past study showed that meaningful connections between community knowledge and school mathematics require deliberate instructional planning rather than the isolated use of cultural examples (3).

Furthermore, both quantitative and qualitative findings consistently highlighted the importance of professional development and instructional support. While teachers generally demonstrated awareness of ethnomathematics and its potential benefits, many expressed a need for practical guidance, teaching resources and examples of ethnomathematics-based learning activities. This convergence across data sources suggests that strengthening teacher capacity may be a key factor in promoting more effective implementation of ethnomathematics in elementary mathematics education. Previous studies similarly recommend sustained professional development programs that equip teachers with culturally responsive instructional strategies and opportunities to integrate local cultural knowledge into mathematics learning (20, 23, 24).

Overall, the integration of findings indicates that teachers are receptive to ethnomathematics and perceive positive student responses toward culturally contextualized learning. However, successful implementation requires systematic support through professional development, instructional resources and curriculum guidance that enables teachers to translate positive beliefs into sustained classroom practice.

Implications for Structured Model Development

The integration of quantitative and qualitative findings provides important insights for the development of a more structured approach to ethnomathematics-based mathematics education. The findings indicate that teachers generally possess positive perceptions and a moderate understanding of ethnomathematics, while classroom implementation remains constrained by practical and pedagogical challenges. This pattern suggests that successful integration requires a systematic framework capable of bridging the gap between teachers' beliefs and instructional practices.

The study identified four key elements that may serve as foundational components for future model development. First, conceptual understanding of ethnomathematics is essential to

ensure that teachers recognize the educational value of connecting cultural contexts with mathematical learning. Second, practical implementation strategies are needed to help teachers translate cultural knowledge into meaningful classroom activities. Third, instructional support in the form of teaching materials, lesson plans and assessment tools is necessary to facilitate consistent implementation. Fourth, professional development opportunities are required to strengthen teachers' pedagogical competence and confidence in ethnomathematics-based instruction.

The findings further suggest that effective ethnomathematics integration should involve a systematic process that begins with the identification of culturally relevant contexts, followed by the exploration of embedded mathematical concepts, the design of culturally contextualized learning activities and the implementation of student-centered instructional practices. Such a framework may help teachers move beyond occasional use of cultural examples toward more sustained and meaningful integration of ethnomathematics in mathematics education.

Based on these findings, future research may focus on developing and validating an ethnomathematics-based instructional model that explicitly addresses teacher preparedness, curriculum alignment, resource development and student engagement. The present study therefore provides an empirical foundation for the design of more comprehensive approaches to culturally responsive mathematics education in elementary schools.

Discussion

Teachers' Understanding and Positive Perceptions of Ethnomathematics

The findings indicate that elementary school teachers generally possess a moderate understanding of ethnomathematics (M = 3.36) and highly positive perceptions toward its integration into mathematics education (M = 3.54). In addition, teachers reported positive student responses toward culturally contextualized mathematics learning (M = 3.38). These results suggest that teachers recognize the educational value of ethnomathematics and view it as a meaningful approach for connecting mathematical concepts with students' cultural experiences and everyday lives.

The positive perceptions observed in this study are consistent with the theoretical foundations of ethnomathematics, which emphasize the relationship between mathematical knowledge and cultural practices (6, 16). From this perspective, mathematics is not merely a collection of abstract concepts but also a form of knowledge that is embedded within social and cultural contexts. Teachers' favorable attitudes toward ethnomathematics therefore reflect an awareness that learning can become more meaningful when mathematical ideas are linked to students' lived experiences and cultural backgrounds.

The findings also align with principles of culturally responsive pedagogy, which advocate the integration of students' cultural knowledge and experiences into classroom instruction to enhance engagement and learning outcomes (1). Teachers in this study generally believed that ethnomathematics could increase students' interest, motivation and participation in mathematics learning. Similar findings have been reported in previous studies showing that culturally contextualized instruction contributes to greater student engagement and strengthens connections between school knowledge and community experiences (3, 4).

Furthermore, the positive perceptions reported by participants may reflect growing recognition of the importance of contextualized learning in elementary mathematics education. At the elementary level, students often develop mathematical understanding more effectively when abstract concepts are introduced through familiar and meaningful contexts. Ethnomathematics provides opportunities for such contextualization by drawing upon local cultural practices, traditions and community knowledge as learning resources (10, 11).

However, despite these encouraging findings, the moderate level of conceptual understanding suggests that teachers may still possess varying interpretations of ethnomathematics. Interview findings revealed that some participants primarily viewed ethnomathematics as the use of cultural examples in mathematics lessons rather than as a broader pedagogical and epistemological framework. This observation suggests that while teachers generally support ethnomathematics,

deeper conceptual understanding may still require further professional development and academic engagement. Strengthening teachers' understanding of the theoretical foundations of ethnomathematics may therefore be important for promoting more meaningful and sustainable implementation in classroom practice.

The Gap Between Understanding and Classroom Implementation

One of the most significant findings of this study is the discrepancy between teachers' understanding and positive perceptions of ethnomathematics and their actual classroom implementation practices. While teachers demonstrated moderate understanding of ethnomathematics (M = 3.36) and highly positive perceptions toward its educational value (M = 3.54), the reported level of implementation remained comparatively lower (M = 2.96). This pattern indicates that positive beliefs and conceptual awareness do not automatically translate into consistent instructional practice.

The gap between understanding and implementation has been widely discussed in educational research. Teacher beliefs are often regarded as important determinants of instructional decision-making; however, classroom practices are also influenced by contextual, institutional and pedagogical factors (23, 25). Consequently, teachers may support innovative educational approaches in principle while experiencing difficulties in applying them consistently within the realities of classroom instruction.

The qualitative findings provide additional insight into this discrepancy. Although teachers acknowledged the value of ethnomathematics and expressed enthusiasm toward culturally contextualized learning, many reported that implementation was often limited to occasional use of cultural examples rather than systematic instructional integration. Participants indicated that cultural contexts were commonly introduced as supplementary illustrations rather than being embedded throughout the learning process. This finding suggests that ethnomathematics has not yet become a routine pedagogical practice in many classrooms.

Similar patterns have been reported in previous studies. Research on culturally responsive mathematics education has shown that teachers frequently express support for culturally grounded instructional approaches while facing challenges in translating these ideas into sustained classroom practices (12, 20). Teachers often recognize the potential of ethnomathematics but require additional pedagogical support to implement it effectively and consistently (10).

The discrepancy observed in this study may also reflect differences between conceptual understanding and pedagogical translation. Understanding that cultural practices contain mathematical ideas does not necessarily imply that teachers possess the pedagogical knowledge required to transform those ideas into meaningful learning activities. Effective ethnomathematics integration requires teachers to identify mathematical concepts embedded within cultural contexts, align them with curriculum objectives and design instructional experiences that maintain both cultural relevance and mathematical rigor (1).

These findings suggest that efforts to promote ethnomathematics should move beyond raising awareness and fostering positive attitudes. Professional development initiatives should focus on strengthening teachers' pedagogical capacity to operationalize ethnomathematics within classroom instruction. By bridging the gap between understanding and implementation, teachers may be better positioned to transform positive beliefs into meaningful and sustainable teaching practices.

Barriers to Ethnomathematics Integration

The findings of this study indicate that teachers perceive several challenges that influence the implementation of ethnomathematics in elementary mathematics classrooms. The Perceived Barriers domain produced a moderate mean score (M = 3.24), suggesting that although teachers generally support ethnomathematics, they encounter practical and pedagogical difficulties when attempting to integrate cultural contexts into mathematics instruction. These findings help explain the discrepancy observed between teachers' positive perceptions and their comparatively lower levels of implementation.

One of the most frequently reported challenges relates to instructional preparation and resource availability. Both quantitative and qualitative findings revealed that teachers often experience difficulties in identifying suitable cultural

examples, developing learning materials and designing ethnomathematics-based activities that align with curriculum requirements. Participants also reported that preparing culturally contextualized lessons requires additional time and effort compared with conventional instructional approaches. Similar challenges have been identified in previous studies, where limited instructional resources and inadequate teaching materials were found to constrain the implementation of ethnomathematics and culturally responsive mathematics education (10, 12).

Another important barrier concerns pedagogical translation. Although teachers generally recognize the existence of mathematical ideas within cultural practices, many expressed uncertainties about how to transform cultural knowledge into mathematically meaningful learning experiences. This finding supports previous research suggesting that successful ethnomathematics integration requires more than cultural awareness; it also demands strong pedagogical content knowledge and the ability to connect cultural contexts with formal mathematical concepts (1, 8). Without sufficient pedagogical guidance, teachers may struggle to move beyond the use of isolated cultural examples toward deeper and more systematic integration.

Curriculum-related challenges also emerged as a significant concern. Several participants reported difficulties in aligning ethnomathematics activities with curriculum objectives, learning outcomes and assessment requirements. Similar concerns have been documented in studies examining culturally responsive mathematics education, which often identify tensions between contextualized learning approaches and standardized curriculum expectations (2, 13). As a result, teachers may perceive ethnomathematics as an additional instructional responsibility rather than as an integrated component of mathematics teaching.

Importantly, the barriers identified in this study appear to be structural and pedagogical rather than ideological. Teachers generally demonstrated positive attitudes toward ethnomathematics and acknowledged its educational value. Therefore, the primary challenge lies not in convincing teachers of the importance of ethnomathematics but in providing the necessary conditions that enable effective implementation. This interpretation is consistent with research indicating that institutional support, professional development and access to contextualized instructional resources play critical roles in facilitating culturally responsive teaching practices (20, 23).

Overall, the findings suggest that addressing barriers to ethnomathematics integration requires a comprehensive approach that combines teacher professional development, curriculum support and the provision of practical instructional resources. Such efforts may help reduce the gap between teachers' positive perceptions and their classroom implementation practices, thereby promoting more sustainable integration of ethnomathematics in elementary mathematics education.

Implications for Curriculum and Classroom Practice

The findings of this study have important implications for curriculum development and classroom practice in elementary mathematics education. Teachers demonstrated highly positive perceptions of ethnomathematics (M = 3.54) and reported favorable student responses toward culturally contextualized learning (M = 3.38). These findings suggest that ethnomathematics has considerable potential to support meaningful mathematics learning by connecting abstract concepts with students' cultural experiences and everyday realities.

From a curriculum perspective, the findings support the integration of local cultural contexts into mathematics instruction as a means of enhancing relevance and engagement. Contemporary educational frameworks increasingly emphasize contextualized learning, cultural responsiveness and the development of meaningful learning experiences. Ethnomathematics aligns well with these objectives because it enables students to explore mathematical concepts through familiar cultural practices, thereby strengthening connections between school knowledge and community experiences (3, 4).

The positive student responses reported by teachers indicate that culturally contextualized mathematics instruction may contribute to increased participation, motivation and engagement. These findings are consistent with previous studies demonstrating that students often learn more effectively when mathematical ideas are introduced through contexts that are

meaningful and relevant to their lives (1, 11). In elementary education, where students are still developing foundational mathematical understanding, such contextualization may play an especially important role in supporting conceptual development and sustaining learning interest.

However, the findings also suggest that successful curriculum integration requires more than simply incorporating cultural examples into lessons. Effective implementation depends on careful instructional design that connects cultural contexts with explicit mathematical learning objectives. Teachers must be able to guide students from concrete cultural experiences toward formal mathematical reasoning through structured learning activities and appropriate scaffolding. This process is essential to ensure that contextual relevance contributes not only to engagement but also to conceptual understanding (13, 20).

The results further highlight the importance of providing teachers with curriculum resources that support ethnomathematics integration. These resources may include lesson plans, instructional modules, classroom activities and assessment strategies that explicitly connect cultural practices with mathematical concepts. Such support can reduce implementation challenges and increase teachers' confidence in applying ethnomathematics within diverse classroom contexts.

Overall, the findings suggest that ethnomathematics should be viewed not merely as an enrichment activity, but as a potentially valuable component of elementary mathematics education. When supported by appropriate curriculum design and instructional guidance, ethnomathematics can contribute to culturally responsive, meaningful and engaging mathematics learning experiences.

Critical Considerations in Ethnomathematics Implementation

While the findings of this study demonstrate the potential benefits of ethnomathematics in enhancing student engagement and contextualizing mathematics learning, several critical considerations should be acknowledged. Ethnomathematics should not be viewed as a universally applicable solution, as its effectiveness depends largely on the quality of pedagogical design, curriculum alignment and teachers' ability to facilitate meaningful connections between culture and mathematics.

One important concern relates to the risk of superficial implementation. Teachers may incorporate cultural artifacts, traditions, or examples into mathematics lessons without adequately exploring the underlying mathematical concepts. In such cases, culture functions primarily as a decorative or motivational element rather than as a meaningful source of mathematical understanding. Previous studies have warned that ethnomathematics may lose its educational value when cultural contexts are included only symbolically without supporting conceptual development (8, 26).

Another challenge concerns the balance between cultural relevance and mathematical rigor. While contextualized learning can enhance engagement, excessive emphasis on cultural context may divert attention from the development of formal mathematical reasoning if not carefully structured. Effective ethnomathematics instruction requires teachers to help students transition from contextual experiences to abstract mathematical concepts through purposeful scaffolding and conceptual generalization (13, 20). Without such processes, students may remain focused on contextual details while failing to develop transferable mathematical understanding.

The diversity of cultural contexts also presents practical challenges. Cultural practices vary across communities and regions, making it difficult to develop universally applicable instructional resources. Consequently, teachers may need to adapt ethnomathematics activities to local circumstances while ensuring alignment with curriculum objectives and learning outcomes. This requirement places additional demands on teachers' pedagogical knowledge and instructional design skills (10).

Furthermore, there is a need to avoid essentializing or oversimplifying culture. Cultural knowledge is dynamic, complex and continuously evolving. Therefore, ethnomathematics should not be approached as a fixed collection of cultural examples but rather as a process of exploring the relationships between cultural practices and mathematical thinking. Adopting such a perspective may help prevent stereotypical representations of culture and support more authentic learning experiences.

These considerations suggest that successful ethnomathematics implementation requires

careful planning, strong pedagogical competence and continuous reflection. Rather than viewing ethnomathematics solely as a strategy for increasing student motivation, educators should approach it as a comprehensive pedagogical framework that integrates cultural relevance, conceptual understanding and mathematical rigor. Such an approach can maximize the educational benefits of ethnomathematics while minimizing potential limitations and unintended consequences.

Conclusion

This study investigated elementary teachers' perspectives on the integration of ethnomathematics in mathematics classrooms in Surakarta, Indonesia. Using a mixed methods approach, the findings reveal a coherent and meaningful pattern. Teachers demonstrate strong positive attitudes toward ethnomathematics and recognize its pedagogical value. They also observe positive student engagement when cultural contexts are incorporated into mathematics instruction.

However, reported classroom implementation remains limited. Moderate levels of conceptual understanding, combined with perceived structural and pedagogical constraints, appear to restrict consistent enactment. The findings indicate that the challenge of ethnomathematics integration lies not in ideological resistance but in practical and instructional complexities.

The study contributes to the growing body of research on culturally responsive mathematics education by providing an integrated mapping of teachers' understanding, perceptions, practices and perceived barriers within a specific cultural context. By situating these dimensions within both quantitative and qualitative evidence, the research highlights the need for structured instructional support that bridges the gap between positive beliefs and sustainable practice.

This study has several limitations. First, the study was conducted in a single cultural context in Surakarta. Second, the findings relied primarily on self-reported teacher perceptions. Third, classroom observations were not conducted to verify reported instructional practices. Therefore, the findings should be interpreted within these limitations.

Future research may focus on the design, implementation and evaluation of structured pedagogical models that operationalize ethnomathematics in elementary mathematics education. Such efforts may help transform culturally grounded mathematics from an aspirational idea into a consistently enacted classroom reality.

Abbreviations

M: Mean, SD: Standard Deviation.

Author Contributions

Nur Julianto, Sarwanto: Conceptualization, Methodology, Data Collection, Formal Analysis, Writing–Original Draft, Sarwanto: Methodology, Supervision, Murni Ramli: Conceptualization, Writing–Review, Editing, Formal Analysis, Writing Review, Editing, Supervision.

Conflict of Interest

The author declares no conflict of interest.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declaration of Artificial Intelligence (AI) Assistance

The authors declare that no generative AI or AI-assisted technologies were used in the writing process of this manuscript. The authors take full responsibility for the content's originality, interpretation and accuracy.

Ethics Approval

This study was conducted in accordance with ethical standards. Informed consent was obtained from all participants prior to data collection.

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