

Implementasi Pembelajaran Berbasis Etnomatematika melalui Pendekatan Realistic Mathematics Education untuk Meningkatkan Literasi Matematis Siswa sekolah Dasar

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Received: 01 Mei 2026

Revised: 07 Mei 2026

Accepted: 08 Mei 2026

Online: 15 Mei 2026

Abstract

This study aims to analyze the effectiveness of ethnomathematics-based learning implementation through the Realistic Mathematics Education (RME) approach in improving elementary school students' mathematical literacy. The research method used mixed methods with a nonequivalent control group quasi-experimental design involving 60 fifth-grade students, 30 students each in the experimental and control classes. Learning in the experimental class integrated local cultural elements such as traditional games, batik motifs, and woven patterns into mathematical activities, while the control class received conventional learning. Data were collected through mathematical literacy tests (pretest-posttest), observation, interviews, and documentation. The results of the quantitative analysis showed that the experimental class experienced a significant increase in mathematical literacy abilities covering the aspects of formulating, employing, and interpreting compared to the control class, indicated by a higher N-gain value and significant differences based on the t-test. Qualitative analysis revealed that the use of cultural context increased student engagement, clarified understanding of abstract concepts, encouraged mathematical communication, and strengthened connections between mathematics and their real-life experiences. These findings demonstrate that ethnomathematics-based learning within the RME framework is effective as a strategy to comprehensively strengthen mathematical literacy in elementary schools. Thus, this study provides empirical and conceptual contributions to a culture-based contextual learning model that can be adapted across various regions in Indonesia. It also serves as practical recommendations for teachers and schools in developing more meaningful and culturally relevant mathematics learning..

Keywords: Ethnomathematics; Realistic Mathematics Education; Mathematical Literacy; Elementary School; Local Culture.

Abstrak

Penelitian ini bertujuan untuk menganalisis efektivitas implementasi pembelajaran berbasis etnomatematika melalui pendekatan *Realistic Mathematics Education* (RME) dalam meningkatkan literasi matematis siswa sekolah dasar. Metode penelitian menggunakan *mixed methods* dengan desain kuasi-eksperimen tipe *nonequivalent control group* yang melibatkan 60 siswa kelas V, masing-masing 30 siswa pada kelas eksperimen dan kontrol. Pembelajaran pada kelas eksperimen mengintegrasikan unsur budaya lokal seperti permainan tradisional, motif batik, dan pola anyaman ke dalam aktivitas matematis, sedangkan kelas kontrol menerima pembelajaran konvensional. Data dikumpulkan melalui tes literasi matematis (*pretest-posttest*), observasi, wawancara, dan dokumentasi. Hasil analisis kuantitatif menunjukkan bahwa kelas eksperimen mengalami peningkatan signifikan kemampuan literasi matematis yang meliputi aspek *formulating*, *employing*, dan *interpreting* dibandingkan kelas kontrol, ditunjukkan melalui nilai *N-gain* lebih tinggi serta perbedaan signifikan berdasarkan uji *t*. Analisis kualitatif mengungkapkan bahwa penggunaan konteks budaya meningkatkan keterlibatan siswa, memperjelas pemahaman konsep abstrak, mendorong komunikasi matematis, serta memperkuat koneksi antara matematika dan pengalaman nyata mereka. Temuan ini memperlihatkan bahwa pembelajaran berbasis etnomatematika dalam kerangka RME efektif digunakan sebagai strategi untuk memperkuat literasi matematis secara komprehensif di sekolah dasar. Dengan demikian, penelitian ini memberikan kontribusi empiris dan konseptual terkait model pembelajaran kontekstual berbasis budaya yang dapat diadaptasi di berbagai daerah di Indonesia, sekaligus menjadi rekomendasi praktis bagi guru dan sekolah dalam mengembangkan pembelajaran matematika yang lebih bermakna dan relevan secara budaya.

Kata kunci: Etnomatematika; Realistic Mathematics Education; Literasi Matematis; Sekolah Dasar; Budaya Lokal.

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How to cite this article (APA 7th Edition):

Armeyntan T. S., et al(2026). Implementasi Pembelajaran Berbasis Etnomatematika melalui Pendekatan Realistic Mathematics Education untuk Meningkatkan Literasi Matematis Siswa sekolah Dasar,

Introduction

Mathematical literacy is an important skill that needs to be developed from elementary school. Mathematical literacy encompasses not only the ability to calculate but also the ability to use mathematical knowledge to understand, reason, and solve various real-life problems (OECD, 2019; Stacey, 2011). Through mathematical literacy, students are expected to be able to interpret everyday situations using mathematical thinking, thereby making mathematics learning more meaningful and contextual. However, the results of various studies show that many elementary school students still experience difficulty in connecting abstract concepts with concrete experiences in their surroundings. This condition impacts the low achievement of mathematical literacy in various international assessments, including the Programme for International Student Assessment (PISA) (Schoenfeld, 2016; Wijaya et al., 2014).

The gap between formal mathematics taught in schools and the realities of students' lives is a fundamental issue in mathematics education. One approach considered capable of bridging this gap is ethnomathematics. This concept was first introduced by D'Ambrosio (1985), who argued that mathematical ideas can be found in cultural practices and everyday activities. Through an ethnomathematics approach, mathematics learning no longer focuses solely on symbols and procedures, but also links these concepts to the social and cultural contexts in which students live (Barton, 1996; Rosa & Orey, 2011). In this way, students can understand that mathematics is not a science separate from life, but rather an integral part of human activity.

Several studies have shown that the application of ethnomathematics in learning can increase learning motivation, cognitive engagement, and a sense of ownership in mathematics learning (Nkopodi & Mosimege, 2009; Utami et al., 2023). Furthermore, the integration of local cultural values into learning has been shown to strengthen conceptual understanding, critical thinking skills, and positive attitudes toward mathematics as a product of human culture (Achor et al., 2021; Putra et al., 2022). This approach also encourages students to develop mathematical reasoning and communication skills in a more authentic context.

Despite its great potential, the implementation of ethnomathematics-based learning in elementary schools still faces various challenges. Many teachers lack sufficient knowledge on how to identify local cultural elements relevant to mathematics. Furthermore, limited learning resources and pedagogical guidance often limit ethnomathematics learning to a limited cultural introduction without a deep connection to mathematical concepts (Shirley, 2017; Muhtadi et al., 2020). Furthermore, most students still view mathematics as abstract and distant from real life them, so that their ability to apply mathematical reasoning in real contexts is low (Nugraheni & Rahmawati, 2021).

Various studies have explored the potential of the ethnomathematics approach to improving students' mathematical and numeracy literacy. For example, a quasi-experimental study in an elementary school using the traditional game "congklak" as an ethnomathematics context found that the experimental class using this approach experienced a higher increase in mathematical literacy skills than the control class. Likewise, a literature review study shows that the application of ethnomathematics in elementary education can deepen students' understanding of mathematical concepts and strengthen their cultural identity. Furthermore, specifically regarding numeracy literacy, studies show that the cultural context of ethnomathematics can be an alternative learning method for measuring and improving students' numeracy skills. From a methodological perspective, a Systematic Literature Review (SLR) of mathematics learning using the ethnomathematics-based Realistic Mathematics Education

(RME) approach concluded that this approach has proven effective in improving various types of mathematical skills.

However, there are still several gaps that need to be filled. First, much research is still conducted at the junior high or senior high school level and has not specifically and comprehensively targeted elementary school students with ethnomathematics contexts that are relevant to local culture. For example, although there are reports of the use of ethnomathematics-based worksheets in elementary schools, the coverage of holistic mathematical literacy, including aspects of reasoning, communication, and mathematical connections, is still limited. Second, some research focuses on the development of ethnomathematics-based tools or worksheets (LKS) without always examining in depth their impact on overall mathematical literacy in elementary schools. Third, the need to improve the mathematical literacy of elementary school students in Indonesia is urgent because international results (e.g., PISA) show a still concerning position. Therefore, the development of ethnomathematics-based learning that is appropriately designed for elementary school students, links to local culture, and comprehensively measures mathematical literacy is an urgent need.

This research aims to address this gap by offering an ethnomathematics-based learning framework specifically designed for elementary school students, where local culture is integrated as a bridge to more meaningful mathematical literacy. The novelty of this research lies in three main aspects, namely (1) focusing on the relatively small elementary school level with a specific cultural context close to the students; (2) not only measuring the “counting” or numeracy aspect, but also comprehensive mathematical literacy (including understanding, application, reasoning, communication); (3) designing and implementing a learning model that explicitly links local cultural elements to mathematics and literacy activities, and evaluating its impact. Thus, It is hoped that this research can provide empirical and conceptual contributions to the development of contextual, culture-based, and literacy-oriented mathematics learning at the elementary school level.

2. Literature Review

Recent research shows that ethnomathematics approaches are beginning to be widely applied at the elementary school (SD) level or equivalent in Indonesia. Gumala and Syifa (2024), through a systematic review of 30 articles published between 2019 and 2024, found that ethnomathematics is widely applied at the elementary school level through learning media such as traditional games, worksheets (LKS), and contextual modules (Gumala & Syifa, 2024). Meanwhile, Nurhaswinda et al. (2023) emphasized that integrating local culture into elementary school mathematics learning has the potential to strengthen conceptual understanding and enhance students' cultural identity. Alditia, Witono, and Nurmawanti (2025) also developed local wisdom-based teaching materials for the volume of geometric shapes for fifth-grade students, providing evidence that the use of cultural context can help students understand concepts more concretely. Overall, these findings indicate that: (i) research attention to ethnomathematics in elementary schools continues to increase, (ii) the majority of research focuses on developing culturally based teaching materials or modules, and (iii) there is still little research that measures mathematical literacy comprehensively, especially aspects of mathematical reasoning and communication (Alditia, Witono & Nurmawanti, 2025).

The relationship between ethnomathematics and mathematical literacy has been widely studied. Munthahana, Budiarto, and Wintarti (2024) reviewed 15 Sinta/Scopus-indexed articles

and found that ethnomathematics can strengthen basic numeracy, especially in the aspect of number operations, although not many studies have examined broader dimensions of mathematical literacy such as communication and reasoning (Munthahana, Budiarto & Wintarti, 2024). Furthermore, research by Nurhanan and Santoso (2023) showed that the integration of ethnomathematics in fifth grade can improve students' mathematical communication skills. These findings are reinforced by Safina and Budiarto (2024) who describe the relationship between local culture and mathematical literacy through aspects of content, context, and process. In summary, ethnomathematics has great potential in improving literacy and numeracy, but most research is still focused on limited aspects and has not covered all dimensions of mathematical literacy such as reasoning, representation, and communication as a whole (Nurhanan & Santoso, 2023).

The development of local culture-based learning media has become a strong trend in ethnomathematics research. Priyani (2024) developed an ethnomathematics puzzle game application to strengthen students' numeracy literacy in border schools (Priyani, 2024). Another study by Rahmah, Ibrahim, and Yazid (2023) showed that culturally based illustrated storytelling media is effective as a means of literacy and numeracy in elementary schools (Rahmah, Ibrahim & Yazid, 2023). Furthermore, Winardi and Jupri (2025) highlighted that traditional games are one of the most frequently used forms of ethnomathematics implementation as a learning medium (Winardi & Jupri, 2025).

In general, these findings indicate that local culture-based media, such as games, stories, and digital applications, are effective in fostering mathematical interest and understanding. However, most research focuses on media development and has not yet empirically measured its impact on comprehensive mathematical literacy at the elementary school level.

Ethnomathematics has great potential, but its implementation in elementary schools faces various obstacles. Several studies highlight the challenges in implementing ethnomathematics in elementary schools. For example, Astuti and Rozikin (2025) revealed that one of the main obstacles is the lack of teacher training and the lack of standard teaching materials that can be used uniformly across schools. Furthermore, the education system, which is still exam-oriented, makes contextual approaches such as ethnomathematics less accessible in learning practices (Astuti & Rozikin, 2025). A 2025 study on teacher perceptions also found that teacher readiness to implement ethnomathematics was still in the "sufficient" category, indicating a need for competency improvement, ongoing training, and policy support. This suggests that teachers' understanding and readiness to implement the ethnomathematics approach still need to be strengthened through training and school policy support.

Thus, although various studies have shown the effectiveness of ethnomathematics in improving mathematical understanding, implementation barriers remain an issue that needs to be addressed, particularly in terms of teacher readiness, availability of learning resources, and evaluation policies that support culture-based contextual learning so that it can be implemented systematically and have an impact on mathematical literacy.

3. METHODS

Research Design

This study employed a mixed methods approach with a quasi-experimental nonequivalent control group design combined with a descriptive qualitative approach. The quantitative approach was used to measure the improvement in students' mathematical literacy before and after the implementation of ethnomathematics-based learning. The qualitative

approach was used to analyze the learning process, student responses, and supporting and inhibiting factors that emerged during the activity. This design was chosen because it enabled researchers to obtain comprehensive empirical data, not only on learning outcomes (quantitative), but also on the process and meaning of learning (qualitative).

Participants or Data Sources

This research was conducted at an elementary school in Wonogiri Regency, which boasts strong local cultural heritage, including traditional games, batik motifs, and traditional architecture still recognized and used in everyday life. The research location was selected based on the consideration that authentic local culture, close to students' lives, is highly relevant to supporting the implementation of ethnomathematics-based learning. This ensures that the cultural context used in learning is not artificial, but is truly experienced and understood by the students. Furthermore, the selected school was willing to cooperate and support the research, both through school policies and the involvement of classroom teachers as collaborators.

The research subjects were 60 fifth-grade elementary school students, divided into two classes: an experimental class of 30 students and a control class of 30 students. The selection of fifth-grade students was based on the consideration that students' cognitive development is at the concrete operational stage, moving towards formal operational stages. Therefore, students are considered capable of linking mathematical concepts to the local cultural context and communicating reasoning and problem-solving strategies in a more structured manner. Furthermore, at the fifth grade level, the mathematics topics studied, such as geometry, number patterns, and number operations, were deemed highly suitable for integration with ethnomathematics elements.

The experimental and control classes were determined by considering the equivalence of students' initial abilities, relatively homogeneous classroom conditions, and similarity of teachers and learning time allocation. The use of two existing classes (intact groups) was chosen due to the researcher's limited ability to conduct full subject randomization, making the quasi-experimental design an appropriate and realistic choice in the context of educational research in schools. Class teachers were involved as collaborators to assist with the implementation of the learning, ensure the model's implementation according to plan, and provide reflection on the process of implementing ethnomathematics-based learning.

The research variables consist of: (1) independent variables in the form of ethnomathematics-based learning, namely learning that integrates local cultural elements such as weaving patterns, congklak games, cloth motifs, and traditional buildings into mathematics learning activities; (2) dependent variables in the form of elementary school students' mathematical literacy which includes the ability to formulate (formulate mathematical problems), employ (use mathematical concepts and procedures), and interpret (interpret results in real contexts); and (3) control variables in the form of teaching materials, learning time, and teaching teachers which are the same in both classes to maintain the validity of the research results.

Research Procedures

The research was conducted through four main stages: preparation, implementation, data collection, and data analysis.

In the preparation stage, researchers analyzed the curriculum and mapped mathematical literacy indicators relevant to the core competencies of fifth-grade elementary school students. Mathematical literacy indicators focused on conceptual understanding, reasoning, representation, and mathematical communication. Next, researchers identified local cultural elements related to mathematical concepts through field observations and interviews with local

cultural figures. The identified cultural elements included traditional games, Wonogiri batik motifs, traditional house architecture, and daily community practices. Based on these identification results, researchers developed ethnomathematics-based learning tools, including Lesson Plans (RPP), Student Worksheets (LKS), learning media, and assessment instruments. All learning tools were then validated by mathematics education experts and cultural experts to ensure content appropriateness, conceptual accuracy, cultural appropriateness, and clarity of language.

The implementation phase involved implementing ethnomathematics-based learning in the experimental class for 3–4 meetings. Teachers integrated local cultural contexts directly into the mathematics material, for example, through activities such as calculating volume using traditional house models, analyzing patterns in batik motifs, or linking traditional games to geometric concepts and arithmetic operations. The learning was designed collaboratively and discussion-based to encourage active student engagement. Meanwhile, the control class was taught using conventional learning, relying on textbooks and lecture or question-and-answer methods without integrating local culture. Throughout the learning process, researchers conducted observations to record student activities, learning interactions, and learning dynamics in both classes.

During the data collection stage, research data was obtained through several instruments. Mathematical literacy tests were administered in the form of pretests and posttests to measure improvements in students' mathematical literacy skills. Learning observations were conducted to record student and teacher engagement, group interactions, and the use of cultural elements in learning. Furthermore, semi-structured interviews were conducted with several students and teachers to explore learning experiences, perceptions of ethnomathematics-based learning, and challenges faced. Supporting data was also obtained through documentation in the form of photographs of learning activities, student work, and field notes.

Data Analysis

Analisis data dilakukan menggunakan dua pendekatan. Data kualitatif dianalisis menggunakan model Miles dan Huberman yang meliputi tahap reduksi data, penyajian data, dan penarikan kesimpulan. Analisis ini bertujuan untuk mengidentifikasi tema-tema utama terkait proses pembelajaran, respon siswa, serta nilai-nilai budaya yang muncul selama pembelajaran berlangsung. Sementara itu, data kuantitatif dianalisis menggunakan uji N-gain untuk mengetahui tingkat peningkatan literasi matematis siswa dan uji independent sample t-test untuk mengetahui perbedaan yang signifikan antara kelas eksperimen dan kelas kontrol.

Research Instruments

The research instruments used included a mathematical literacy test in the form of essay questions with real-life contexts, developed based on the PISA (OECD) framework and adapted to the characteristics of elementary school students. Additionally, observation instruments were used to record teacher and student learning activities, and interview guides were used to explore perceptions and learning experiences. Visual documentation and student work products were used as supporting data and as part of data triangulation.

Validity, Reliability, and Methodological Integrity

The content validity of the research instrument was assessed by three experts: an elementary school mathematics education lecturer, an ethnomathematics expert, and a practicing elementary school teacher. Test reliability was tested using Cronbach's Alpha coefficient, with a value greater than 0.70 indicating a good level of consistency. Qualitative

data validity was ensured through the application of source and method triangulation by comparing data from observations, interviews, and documentation.

Ethical Considerations

This research was conducted in accordance with ethical principles of educational research. The researchers obtained official permission from the school and the local education office before conducting the study. The identities of students and teachers were kept confidential, and the entire research process was conducted with respect for the local cultural values and norms used as the learning context.

Expected Output

Through the application of this research method, it is hoped that empirical evidence will be generated regarding the effectiveness of ethnomathematics-based learning in improving elementary school students' mathematical literacy. Furthermore, this research is expected to produce a conceptual model of contextual mathematics learning based on local culture that can be adapted across various regions in Indonesia, as well as provide practical recommendations for teachers and schools in implementing ethnomathematics learning in the classroom.

4. Results

Qualitative analysis was conducted on data from learning observations, interviews with students and teachers, field notes, and documentation of student activities and products. This analysis aimed to gain a deeper understanding of how ethnomathematics-based learning influences student learning, classroom interaction dynamics, and teacher and student perceptions of mathematics learning.

The data analysis process followed the stages of data reduction, data presentation, and conclusion drawing. During the data reduction stage, various field information was coded and grouped into key themes relevant to mathematical literacy and the context of ethnomathematics. The data reduction results revealed four main themes: student engagement in learning, conceptual understanding through the context of local culture, the role of the teacher as a facilitator, and challenges in implementing ethnomathematics-based learning.

The first theme relates to student engagement in learning. Observations showed that students in the experimental class appeared more enthusiastic and active during the learning process. Students not only paid attention to the teacher's explanations but also directly engaged in discussions, group activities, and the use of local culturally based media, such as batik motifs, congklak games, and woven patterns. Many students spontaneously asked questions, discussed with their group mates, and competed for the opportunity to convey their answers or thoughts in front of the class.

The second theme demonstrates that local cultural context plays a crucial role in helping students understand mathematical concepts. Students are able to connect abstract concepts, such as patterns, symmetry, comparison, and repetition, to cultural objects they are already familiar with in their daily lives. For example, when studying Wonogiri batik motifs, students can identify repeating patterns and lines of symmetry with relative ease. In the congklak game, students not only play but also explain the strategies they use with mathematical reasoning, such as counting the number of seeds and quick addition strategies. These findings suggest that conceptual understanding emerges more naturally when learning is connected to students' cultural experiences.

The third theme relates to the teacher's role as a learning facilitator. Observations and interviews revealed that teachers in the experimental class primarily guided students to discover concepts independently through prompting questions and discussions, rather than providing direct answers. Teachers utilized local cultural media as a tool to explain abstract concepts, making learning more concrete and easier for students to understand. Teachers also stated that using cultural context helped increase student participation and enrich classroom interactions.

The fourth theme highlighted challenges in implementing ethnomathematics-based learning. Teachers revealed that this approach requires more time and preparation, particularly in preparing learning materials and selecting cultural elements appropriate to the mathematics material. Furthermore, not all cultural elements can be directly linked to specific mathematical concepts, requiring teachers to make selections and adapt. Some students also require additional guidance in interpreting cultural contexts into formal mathematical representations.

Qualitative findings are presented narratively to provide a more concrete picture of the learning process. During the learning process, students in the experimental class were actively involved in observing, discussing, and completing local culture-based assignments. In the pattern and symmetry section, students analyzed Wonogiri batik motifs and were able to independently demonstrate repeating patterns and folded lines. In the congklak game, students discussed the best strategies for achieving maximum results, which indirectly trained number operations and mental calculation skills. Meanwhile, in the spatial geometry section, students drew miniature traditional houses and identified various geometric shapes within them.

Interview results showed that students responded positively to ethnomathematics-based learning. Most students stated that mathematics became easier to understand because it was linked to examples relevant to everyday life. Furthermore, students found learning more enjoyable and less monotonous. Interestingly, students who had previously tended to be passive appeared more confident in expressing their opinions and explaining their thinking.

Teachers also responded positively to ethnomathematics-based learning. They stated that this approach helped explain abstract concepts more concretely, increased student interest and engagement, and fostered students' confidence in presenting mathematical reasoning. However, they emphasized the need for further training to better prepare teachers to integrate local cultural elements into mathematics learning.

Documentation of student work and field notes supported these findings. Student work demonstrated their ability to accurately draw mathematical patterns from batik motifs and create more detailed representations of plane and solid shapes compared to before the intervention. Student explanations in the worksheets also appeared more diverse and reflected improved mathematical reasoning and communication skills. Field notes revealed a more dynamic classroom atmosphere, lively group discussions, and student interaction with cultural media that stimulated a more natural understanding of concepts.

Quantitative analysis was conducted based on the results of students' mathematical literacy tests, which included a pretest and posttest. The pretest results showed that the initial mathematical literacy abilities of students in the experimental and control classes were relatively equivalent.

Tabel 2. Hasil Tes

Kelas	Rata-rata <i>Pretest</i>	Rata-rata <i>Posttest</i>	<i>N-Gain</i>	Kategori
Eksperimen	48.20	78.10	0.58	Sedang-Tinggi
Kontrol	47.50	63.40	0.30	Rendah-Sedang

The average pretest score for the experimental class was 48.20, while the control class was 47.50. This finding indicates that before the treatment was administered, there was no significant difference in ability between the two classes.

After 3–4 sessions of learning, posttest results showed an increase in mathematical literacy skills in both classes, but the increase was greater in the experimental class. The average posttest score for the experimental class reached 78.10, while the control class only achieved 63.40. This difference indicates that ethnomathematics-based learning had a more significant impact on improving students' mathematical literacy.

The N-gain calculation results indicate that the improvement in students' mathematical literacy skills in the experimental class was in the moderate to high category, with an average score of 0.58. Meanwhile, the control class only showed improvement in the low to moderate category, with an N-gain score of 0.30. This finding reinforces the indication that conventional, less contextual learning is less effective than ethnomathematics-based learning.

A difference test using an independent sample t-test on posttest scores showed a significance value (p-value) of less than 0.05. These results indicate a statistically significant difference between students' mathematical literacy skills in the experimental and control classes after the treatment was administered. Therefore, it can be concluded that ethnomathematics-based learning has a significant effect on improving elementary school students' mathematical literacy.

Observations of learning activities showed that student engagement in the experimental class was higher than in the control class. Students in the experimental class were more active in asking questions, discussing, and expressing opinions, and were more easily able to connect mathematical concepts with local cultural objects or activities.

Tabel 3. Persentase Keterlibatan

Kelas	Persentase Keterlibatan
Eksperimen	85%
Kontrol	55%

Students' enthusiasm was also evident when working on assignments because the learning context was close to everyday experiences. Quantitatively, the percentage of active student engagement in the experimental class reached 85%, compared to only 55% in the control class.

In terms of teacher activity, learning in the experimental class was characterized by the use of local cultural media, facilitating discussions, and providing opportunities for students to explain problem-solving strategies. In contrast, learning in the control class focused more on the textbook and teacher explanations.

Interviews with students indicated that they found mathematics learning more engaging and easier to understand when connected to their cultural background. Students also felt more confident in explaining their problem-solving processes. Interviews with teachers confirmed that the ethnomathematics approach helped students understand concepts more deeply and increased classroom engagement, although it required additional time to prepare learning materials.

Documentation in the form of activity photos, field notes, and student products demonstrated that students in the experimental class were able to produce more varied and meaningful mathematical representations. Overall, student products in the experimental class demonstrated better conceptual understanding and mathematical communication skills compared to students in the control class.

5. Discussion

The quantitative analysis results showed that the N-gain scores for mathematical literacy of students in the experimental class were in the moderate to high category and significantly higher than those in the control class. This finding indicates that integrating local culture into mathematics learning can strengthen students' abilities to formulate problems, employ mathematical concepts and procedures, and interpret results in real-life contexts, as emphasized in the PISA (OECD) mathematical literacy framework.

Theoretically, ethnomathematics-based learning provides an authentic context that lowers the level of mathematical abstraction and bridges the gap between formal concepts and students' everyday experiences. This finding is consistent with the views of D'Ambrosio (1985) and Barton (1996), who assert that mathematics is not culturally neutral but rather develops from the social and cultural practices of a community. Empirically, this study aligns with the findings of Nkopodi and Mosimege (2009), who reported that the use of traditional games in mathematics learning significantly improved conceptual understanding and student engagement. Similarly, research by Putra et al. (2022) demonstrated that an ethnomathematics approach for elementary school students can increase the relevance and meaningfulness of mathematics learning.

When compared with international studies, this research confirms the findings of Rosa and Orey (2011) and Shirley (2017), who stated that ethnomathematics contributes positively to the development of mathematical literacy by utilizing culture as a source of learning context. The Scopus-indexed research by Achor, Imoko, and Uloko (2021) also shows that an ethnomathematics approach significantly impacts student achievement and retention in geometry learning, which aligns with the improvement in mathematical literacy in the spatial and representational aspects of this study.

Unlike several previous studies that emphasized numeracy or basic calculation skills, the results of this study show relatively even improvements across the three main dimensions of mathematical literacy: conceptual understanding, mathematical reasoning, and mathematical communication.

In conceptual understanding, students were able to meaningfully connect mathematical concepts with local cultural elements. For example, the concepts of symmetry and patterns were understood through batik motifs, number operations through the game of congklak, and spatial geometry through representations of traditional houses. These findings reinforce the research of Wijaya, van den Heuvel-Panhuizen, and Doorman (2014), which emphasized that context-based mathematics tasks enhance students' opportunities to learn and conceptual understanding.

In mathematical reasoning, culture-based learning activities encouraged students to explain the rationale behind solution strategies, rather than simply following procedures. This aligns with Schoenfeld's (2016) perspective, which emphasizes the importance of sense-making and metacognition in mathematics learning. International research by Stacey (2011) also confirms that mathematical literacy requires the ability to reason in contextual situations, not just procedural skills.

Regarding mathematical communication, interview results indicate that students become more confident in explaining their ideas, solution steps, and the results of their thinking. This finding aligns with empirical research showing that contextual and culture-based learning improves students' ability to express mathematical ideas both orally and in writing (Shirley, 2017; Rosa & Orey, 2011). Thus, this study strengthens the evidence that ethnomathematics impacts not only cognitive outcomes but also students' mathematical communication skills.

Observations showed that student engagement in the experimental class was significantly higher than in the control class. This finding can be explained by the theory of situated learning, which states that learning is more effective when knowledge is constructed within a social and cultural context that is meaningful to students. In this study, local culture served as an activation of background knowledge, enabling students to more easily understand problems and actively engage in the learning process.

This finding is consistent with research by Nkopodi and Mosimege (2009) and Achor et al. (2021), which showed that cultural context and traditional games increase student motivation and participation in mathematics learning. Furthermore, this study extends findings from the OECD (2019, 2022), which emphasize the importance of contextual learning for improving mathematical literacy, especially in countries with diverse cultural backgrounds.

Despite showing positive results, this study also identified several challenges in implementing ethnomathematics-based learning. Teachers require additional time and effort to prepare media and learning tools relevant to local cultures. Furthermore, the lack of standard guidelines for systematically integrating cultural elements into the curriculum presents a significant obstacle.

6. Conclusion

This study demonstrates that ethnomathematics-based learning is effective in improving elementary school students' mathematical literacy. The results of the N-gain analysis and t-test confirmed that students who learned by integrating local culture achieved significantly higher mathematical literacy gains compared to students who participated in conventional learning. This confirms that the local cultural context can strengthen students' abilities to formulate, use, and interpret mathematical concepts.

The integration of local cultural elements also helps students understand mathematical concepts in a more concrete and meaningful way. The connection between abstract concepts and everyday cultural experiences fosters improved conceptual understanding, reasoning, and mathematical communication. Furthermore, ethnomathematics-based learning has been shown to increase student engagement and confidence in the learning process.

However, the implementation of ethnomathematics-based learning still faces challenges, particularly related to teacher readiness, media availability, and the lack of systematic guidance. Therefore, support in the form of teacher training and the development of learning tools is needed so that this approach can be implemented sustainably and optimally in elementary schools.

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