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Pedagogical Exploration of Ethnomathematics: Efforts to Contextualize Numeracy Strategies for Elementary School Children

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Abstract

This study aims to integrate ethnomathematics into numeracy instruction in non-formal education settings and to test the effectiveness of its application in improving the numeracy skills of elementary school-aged children through non-formal education, with the goal of creating contextual and meaningful learning experiences. The study was conducted in Sukodono Village, Pacitan, which possesses a wealth of contextual cultural practices that serve as a resource for numeracy learning. The methods used were a mixed-methods study with an ethnographic approach to explore cultural practices, as well as a one-group pretest–posttest pre-experimental design to test improvements in numeracy skills. The research subjects consisted of cultural experts, teachers, elementary school-aged children, and parents, with a sample size of 16 students selected using purposive sampling. Quantitative data were analyzed using a paired samples t-test and N-Gain, while qualitative data were analyzed using the Miles and Huberman model. The research findings indicate that various local cultural practices contain mathematical concepts relevant to numeracy learning, such as geometry, measurement, patterns, and comparisons, which were identified in the contexts of agate stones, the Ceprotan traditional ceremony, and Rontek art. The findings suggest a trend toward improved student numeracy skills, as evidenced by moderate N-Gain scores and significant differences in paired t-test results. These findings confirm that the integration of ethnomathematics into numeracy learning not only strengthens contextual conceptual understanding but also serves as a relevant and meaningful alternative learning strategy, particularly within non-formal education pathways rooted in local culture.

Keywords: exploration, ethnomathematics, contextualization, numeracy, elementary school children

INTRODUCTION

Literacy and numeracy are essential basic skills for elementary school children as a foundation for academic development (Iasha et al., 2025). Numeracy is a person's ability to understand, use, and communicate mathematical concepts in everyday life (Thompson et al., 2017). Numeracy is not limited to the ability to perform calculations; it also encompasses an understanding of numbers, patterns, measurement, spatial concepts, data, and probability. However, various surveys show that the literacy and numeracy levels of children in Indonesia still require serious attention (Kurniasih & Priyanti, 2023). The Minimum Competency Assessment (AKM) by the Ministry of Education, Culture, Research, and Technology shows that many students have difficulty understanding basic mathematical concepts and applying them in everyday life. In addition, data from the 2022 Programme for International Student Assessment (PISA), conducted by the Organisation for Economic Co-operation and Development (OECD), shows a significant decline in scores compared to the previous year, with 2022 scores of 366 in mathematics, 359 in reading, and 383 in science. These scores are much lower compared to 2018, when the scores were 379 in mathematics, 371 in reading, and 396 in science. The main challenges are teaching methods that focus on memorization, a lack of contextual approaches, and an inability to relate to real life (Simms, 2016). Therefore, innovative approaches are urgently needed to improve children's understanding of mathematics, especially numeracy.

Low levels of numeracy literacy in elementary education remain a critical challenge in Indonesia's education system. Although various formal efforts have been made, there is often a gap between the mathematical concepts taught in the classroom and the realities of students' daily lives. This gap is particularly evident in rural areas, where the standard curriculum often feels abstract and lacks relevance to the local knowledge possessed by students.

A similar situation is observed in the Sukodono, Donorojo, and Pacitan areas. Pacitan Regency was selected as the research site due to its unique cultural context, which stands in stark contrast to the challenges in local numeracy achievement. As a region known for its rich traditions such as the Ceprotan ritual, Rontek art, and the agate industry Pacitan holds abundant yet unexplored potential in ethnomathematics, both academically and pedagogically. Until now, this cultural richness has been viewed merely as a traditional heritage without recognition of its mathematical value, resulting in a research gap where literature on the integration of Pacitan's specific culture into a numeracy framework remains extremely limited.

In addition, the choice of nonformal education in this study was based on its flexibility in accommodating community-based learning. Non-formal education in Sukodono Village serves as a vital bridge to reach elementary aged children outside of formal school hours, providing a more flexible space for implementing non rigid learning models. The rationale for using this non-formal context aims to strengthen students' learning ecosystems through an ethnomathematics approach, so that mathematics is no longer viewed as a foreign subject but rather as an integral part of their own cultural identity.

One approach that can be used to improve numeracy is ethnomathematics (D'Ambrosio, 1985; Setiana et al., 2021). The term ethnomathematics describes everything that shapes the cultural identity of a group, while mathematics encompasses a broad view of arithmetic, classifying, sorting, concluding, and modeling (Marsigit et al., 2018). Ethnomathematics serves to express the relationship between culture and mathematics. This approach is highly relevant to Indonesia, which is rich in culture and local wisdom (Muqtadiroh et al., 2015), and mathematical concepts often appear in daily activities, making numeracy concepts more meaningful and easier to understand (Aulia & Rista, 2019).

At elementary school age, children are in the concrete operational stage where they need tangible representations to understand abstract concepts. Through ethnomathematics-based pedagogical exploration, numeracy strategies are no longer imposed mechanistically, but contextualized through the cultural heritage familiar to students. This not only enhances cognitive understanding, but also strengthens students' cultural identity and character.

Although ethnomathematics has been widely studied in various countries, qualitative research in Indonesia still needs to be explicitly examined. Many studies stop at the stage of identifying cultural elements without formulating how these elements are integrated into an adaptive numeracy curriculum. For example, the Ethnomathematics Exploration of the Jiwa Temple (Fitri et al., 2023), An Exploration of the History of Mathematics in the Architecture of Fort Rotterdam in Makassar (Talib et al., 2025), and an Exploration of Ethnomathematics in Traditional Dances and Games of East Flores (Dhiki et al., 2024). Research or exploration of mathematics in local cultures also often highlights general issues, such as the development of media and teaching materials (Mania & Alam, 2021; Munthahana et al., 2023).

Although research on ethnomathematics has advanced significantly in Indonesia (Muqtadiroh et al., 2015; Setiana et al., 2021), the reality is that contextual mathematics learning approaches based on local culture have yet to be optimally implemented in classroom practice. This indicates that the problem lies not in a lack of ethnomathematics studies, but rather in the limited implementation of research findings into practical and sustainable instructional designs. Most ethnomathematics research still stops at the stage of identifying and exploring mathematical concepts within culture, without being followed by the development of empirically tested learning interventions to improve students' numeracy skills. Consequently, the potential of ethnomathematics as a contextual approach has not been fully utilized in the learning process.

In light of this gap, this study offers an approach that not only explores elements of ethnomathematics within local culture but also integrates them into numeracy instruction that is empirically tested. Thus, this study is expected to bridge the gap between ethnomathematics research findings and their implementation in teaching practice, particularly in improving the numeracy skills of elementary school aged children.

This study focuses on exploring the relationship between local cultural practices and mathematics learning, particularly in the development of numeracy skills among elementary school-aged children. The uniqueness of this study lies in its effort to highlight the local cultural context as an authentic learning resource in numeracy education, thereby emphasizing not only cognitive aspects but also contextual relevance in students' daily lives. Therefore, the objectives of this study are to explore how mathematical concepts emerge in local cultural practices in the Sukodono, Donorojo, Pacitan area; to analyze the relationship between elements of ethnomathematics and the numeracy competencies of elementary school aged children; and to analyze the pedagogical implications of applying ethnomathematics in numeracy instruction for elementary school-aged children

METHODS

This study employs a mixed-methods approach with an exploratory sequential design, meaning the research begins with a qualitative phase to explore elements of ethnomathematics within the local culture, followed by a quantitative phase to test the effectiveness of numeracy instruction based on the findings of that exploration. This design was chosen based on the need to develop contextual learning instruments and interventions rooted in community cultural practices, so that the integration of qualitative and quantitative data can be carried out systematically and complementarily.

The research was conducted in Sukodono Village, Donorojo Subdistrict, Pacitan Regency in September 2025. Research subjects were selected using purposive sampling, taking into account their direct relevance to the research objectives. In the qualitative phase, informants included one local cultural expert, two elementary school teachers from SDN 3 Sukodono, two parents/guardians, and two community leaders. The criteria for selecting informants included: (1) possessing knowledge and experience related to local culture, (2) being involved in daily cultural practices, and (3) being willing to provide in-depth information. Meanwhile, in the quantitative phase, the research subjects were 16 fourth- and fifth-grade elementary school students participating in non-formal learning activities. The selection of fourth and fifth grades was based on the consideration that students at these levels already possess basic numeracy skills, enabling them to participate in the contextual numeracy tests developed for this study. The learning activities in this study were conducted in a community-based non-formal setting, specifically through learning sessions held outside of formal school hours in the afternoons at one of the learning spaces located in Sukodono Village.

The qualitative phase employed an ethnographic approach aimed at identifying and exploring ethnomathematical practices within the local culture of the community. Data collection was conducted through participant observation, in-depth interviews, and documentation of various cultural activities (Creswell & Poth, 2017), such as traditional measurement systems, weaving patterns, folk games, and local economic practices (Iswara et al., 2022; Risdiyanti & Indra Prahmana, 2017). This study established operational parameters for observation and criteria for respondents. Observation parameters focused on cultural activities containing elements of ethnomathematics, including: (1) shapes and patterns (e.g., in weaving or artifacts), (2) traditional measurement systems, (3) counting practices in local economic activities, and (4) social interactions demonstrating the contextual use of mathematical concepts. Qualitative data were analyzed using the interactive model by Miles, Huberman, and Saldaña (2014), which includes data reduction, data presentation, and drawing conclusions and verification.

The validity of the data in this study is ensured through the systematic application of methodological triangulation and source triangulation. Methodological triangulation was conducted by comparing data obtained through various data collection techniques, namely participant observation, in-depth interviews, and documentation. Data from observations regarding ethnomathematics practices in cultural activities were verified against interview results from informants and supported by documentary evidence in the form of photographs, field notes, and cultural artifacts. Meanwhile, source triangulation was conducted by comparing information obtained from various informants including cultural experts, teachers, parents/guardians, and community leaders to ensure the consistency and depth of the data.

The validity of the instrument was assessed through content validity by involving three experts in the fields of mathematics education and local culture. The results of the expert evaluation indicated that all test items met the alignment with numeracy indicators and were relevant to the cultural context addressed, and were deemed suitable for use following minor revisions to the wording and clarity of the item context.

Additionally, construct validity was assessed through the alignment between the numeracy indicators and the developed test items. Furthermore, the instrument was tested via a pilot study with students sharing similar characteristics to the research subjects to ensure readability, difficulty level, and clarity of the question context. The pilot test results showed that most test items were well understood by students and were able to measure numeracy skills in accordance with the established indicators. Reliability testing using Cronbach's Alpha coefficient yielded a value of ≥ 0.70, indicating that the instrument possesses good internal consistency. Thus, the instrument used in this study meets the criteria for validity and reliability, making it suitable for measuring improvements in students' numeracy skills.

The quantitative phase employed a one-group pretest–posttest pre-experimental design to test the effectiveness of ethnomathematics-based numeracy instruction. The research procedure included administering a pretest, conducting the instruction, and administering a posttest. Quantitative data were analyzed using inferential statistics, which included a normality test to ensure the data distribution, a paired samples t-test to determine significant differences between pretest and posttest scores, and an N-Gain calculation to determine the level of improvement in students' numeracy skills.

The integration of qualitative and quantitative data is carried out systematically through three stages: connecting, building, and merging. In the connecting stage, the results of the qualitative exploration are used as the basis for determining indicators and the context of the numeracy instrument. In the building stage, the qualitative findings serve as the foundation for developing an ethnomathematics based learning design that is then tested quantitatively. Furthermore, in the merging stage, the results of the quantitative analysis are interpreted by referring to the qualitative findings to provide a more comprehensive understanding of the role of cultural context in improving numeracy skills. Thus, this study not only produces findings in the form of a statistical increase in numeracy skills but also provides a contextual explanation of how ethnomathematics practices in local cultures contribute to the learning process.

RESULTS AND DISCUSSION

The results of the study indicate that numeracy learning in elementary school children can be effectively contextualized through an ethnomathematics approach sourced from the local wisdom of Pacitan, namely agate stones, the Ceprotan Traditional Ceremony, and rontek art. This contextualization is carried out by integrating basic mathematical concepts into cultural activities that are close to the lives of students.

Exploration of Cultural Objects in the Pacitan Region and Their Implementation in Numeracy

Agate is a natural mineral formation of chalcedony and quartz that is formed in volcanic and metamorphic rocks. It is often used as jewelry accessories and is believed to have various benefits. Agate in Pacitan mostly comes from areas such as Kladen Village and Wareng Village. The agate industry in Pacitan is supported by the traditional skills of craftsmen and also the agate market in tourist areas such as Tabuhan Cave in Wareng Village. Characteristics and Popularity Pacitan agate is known for its unique and beautiful natural colors and patterns. Although some types are already well-known worldwide, the quality and beauty of Pacitan stones continue to be a trend in the international gemstone market (Sutriyanto & Swasono, 2018). Famous types of Pacitan agate include Red Baron (also called Red Brown), which is reddish-brown in color, Golden Supreme with a golden sheen, and Snow White, which is clear and white in color, as well as other types such as Chalcedony and Anggur with various natural patterns and colors. Examples of Pacitan agate are shown in Figure 1 below.

Figure 1. Gemstone

In the context of agate stones, numeracy skills can be used to count and estimate the number of stones in a collection; assess prices; understand the economic value of agate stones based on their type, quality, and characteristics; select stones and identify physical features by measuring, recognizing shapes, and identifying grain patterns. Ethnomathematical concepts in agate include: 1) Geometry and patterns, patterns on agate, such as lines or rings on bacan stone, can be analyzed mathematically using the concepts of geometry and fractals. 2) Calculation and measurement, craftsmen use mathematical knowledge to cut, shape, and measure stones to fit rings and other jewelry. 3) Classification: the naming system for agate stones, although informal, often reflects an understanding of physical characteristics, such as size, shape, and quality, which are indirectly related to mathematical concepts.

The Ceprotan Traditional Ceremony in Sekar Village, Pacitan, is an annual tradition in the form of a village cleansing ritual involving the throwing of young coconuts between two groups of young men. This tradition is held in the month of Longkang (Dzulqaidah) on Monday Kliwon in the Javanese calendar. The story is rooted in the tale of Dewi Sekartaji and Panji Asmorobangun, who met Ki Godek (the village land opener) and disposed of the young coconut water. Young coconuts are called cengkir, which is also an abbreviation of "kencenging pikir," symbolizing the importance of having a sharp mind, principles, and firm stance. The purpose and meaning of the Ceprotan traditional ceremony are: to cleanse the village (cleansing the village of all calamities and disasters); to facilitate agriculture (bringing blessings to agricultural activities); a symbol of perseverance (teaching the values of perseverance and never giving up in the face of life's challenges); enhancing togetherness (maintaining unity, kinship, and mutual cooperation among residents); a cultural tourism asset (this tradition attracts tourists and is a cultural asset of Pacitan). An example of the implementation of the ceprotan traditional ceremony is shown in Figure 2 below.

Figure 2. Ceprotan Traditional Ceremony

Ethnomathematics numeracy in the Ceprotan Traditional Ceremony consists of Calculation and Measurement, as well as Spatial Arrangement (Geometry and Spatial). The concepts of calculation and measurement are: 1) Calendar and Time: The selection of the day and time for the ceremony, which is Monday Kliwon in the month of Longkang (Dzulqaidah) in the Javanese calendar; if there is no Monday Kliwon, the ceremony is held on Sunday Kliwon. 2) Calculation and Proportion: The need for a certain number of young coconuts as throwing tools also involves a process of calculation and planning. In 2024, more than 3000 young coconuts were prepared for the throwing ritual, demonstrating the aspect of quantity or measurement. 3) Group Division: The placement of two opposing camps performing the same activity (throwing coconuts) shows a symmetrical pattern and division between the groups. 4) Duration: The peak of the ceremony takes place from around 10:00 a.m. to 6:00 p.m. Western Indonesian Time, which is the duration measured from the start to the end of the activity.

Meanwhile, the concept of spatial arrangement from a geometric and spatial perspective is represented through the positioning and interactions among participants during the ceremony. For example, during the procession, the positioning of participants, spectators, and key performers such as the coconut thrower forms specific patterns within the space. The distance of the coconut throw, the trajectory, and the angle of elevation during the throw can be analyzed as representations of geometric concepts, such as distance, angle, and direction in space. Additionally, the placement of spectators and ceremony participants surrounding a specific area also reflects organized spatial layout and patterns. Thus, spatial elements in this context are not merely about geographical location but rather how space is utilized and organized within cultural practices, which implicitly incorporate mathematical concepts linked to numeracy skills.

The next cultural object is Rontek Art in Pacitan, which originally was a tradition of waking residents for suhoor during Ramadan using a bamboo musical instrument called “thethek” that is struck. Over time, Rontek has developed into the Pacitan Rontek Festival, an annual art festival that combines rontek music, gamelan, and dance to preserve culture and support MSMEs in Pacitan. Here is an example of a performance by a Pacitan Rontek art group (Figure 3).

Figure 3. Rontek Art

Numeracy concepts that can be explored from Rontek art include: 1) Geometry, namely determining the position and number of holes in bamboo. 2) Arithmetic, by calculating the length and diameter of bamboo that will be used to produce different tones. 3) Patterns, by creating different rhythm patterns when playing the rontek musical instrument. Ethnomathematics concepts in rontek beat/strike patterns. To produce a dynamic rhythm in Rontek, the pattern of the bamboo strikes must be calculated. 4) Fractions. In a single measure, one beat can be considered a “whole,” which is then divided into several equal parts. For example, if a measure is divided into two equal parts, each beat is worth 1/2; if divided into four parts, each beat is worth 1/4. Children can understand that the more divisions there are in a single rhythm, the faster and shorter the duration of each sound becomes. Thus, the concept of fractions is not only understood as a part of the whole, but can also be directly observed through the rhythmic patterns they hear and practice. 5) Comparison, namely the comparison of the number of male and female players, in order to present a dynamic and beautiful musical and dance performance.

Implementation of Ethnomathematics Based Numeracy Instruction

The implementation of ethnomathematics-based numeracy learning was carried out in non-formal learning activities for elementary school-aged children in the Pacitan region, involving 16 children. The activity began with a pretest and ended with a posttest to determine the effect of ethnomathematics on numeracy skills. The learning was designed to develop basic numeracy skills, including understanding numbers, simple arithmetic operations, measurement, and recognition of patterns and regularities, through the context of local culture. The implementation of ethnomathematics-based non-formal learning for elementary school-aged children can be seen in Figure 4 below.

Figure 4. Implementation of Non-Formal Learning

In the context of agate ethnomathematics, numeracy is taught through activities such as observing, grouping, and counting stones based on color, size, and shape. These activities are used to practice counting, comparing quantities and sizes, and understanding simple measurement concepts in a concrete way.

Numeracy learning based on the Ceprotan Traditional Ceremony is carried out through visual observation and simulation that links the ceremony procession with counting activities, such as counting the number of participants, estimating material requirements, and arranging the sequence of activities. This context is used to practice simple arithmetic operations, estimation, and numeracy problem solving in real situations.

In rontek-based learning, numeracy is developed through activities such as counting the number of musical instruments, calculating the volume of kentongan (traditional percussion instruments), following beat patterns, and recognizing repetitive rhythms. These activities are used to reinforce understanding of number patterns, simple multiples, and regularity.

Overall, the implementation of numeracy learning took place in a flexible and enjoyable non-formal setting. The children showed active involvement in each activity and found it easier to understand numeracy concepts because they were presented in a familiar and meaningful local cultural context (Anwar & Ramadhani, 2025). The following is an example of contextualization of problems in the context of ethnomathematics, in the form of problem-based learning (PBL) story questions as shown in Table 1 (Himmah et al., 2024).

Table 1. Examples of Numeracy Ethnomathematics Questions

Gemstones	Ceprotan Traditional Ceremony	Rontek Art
1. A craftsman has 72 agate stones. A total of 45 stones are used for rings and 14 stones are used for pendants. a. How many agate stones are unused? b. If each ring requires 1 agate stone, how many rings can be made from the stones available for rings? 2. Look at the following agate picture.  a. Name the flat shape of each agate stone. b. Which agate stone has 4 sides of equal length? Explain your reasoning. c. If a rectangular agate stone is 6 cm long and 4 cm wide, what is the perimeter of the agate stone?	1. In a traditional Ceprotan ceremony, there are six groups of residents. Each group brings eight coconuts for the ceremony procession. a. How many coconuts were brought to the ceremony? b. If 10 coconuts were used for one session of the ceremony, how many sessions could be held? 2. The Ceprotan traditional ceremony consists of the following series of activities. Preparations begin at 2:45 p.m. and last for 35 minutes. The main procession begins 15 minutes after preparations are complete and lasts for 2 hours and 20 minutes. The closing ceremony begins 10 minutes after the main procession ends. a. What time will preparations be completed? b. What time will the main ceremony begin and end? c. What time will the entire Ceprotan traditional ceremony conclude?	1. A Rontek art group consists of 5 kentongan players, 3 drum players, 2 gong players, and 15 dancers. a. How many players are there in one Rontek group? b. If there are 4 Rontek groups performing, how many players are there in total? 2. One bamboo pole for the Rontek kentongan, shaped like a tube, 40 cm long and 10 cm in diameter. a. What is the radius of the bamboo? b. Calculate the volume of one bamboo stalk (use $\pi = 3.14$). c. If one Rontek group needs 6 bamboo stalks, what is the total volume of bamboo used?

Analysis of the Pedagogical Implications of Applying Ethnomathematics in Numeracy Learning

This study involved 16 elementary school students who participated in non-formal learning based on ethnomathematics through the contexts of agate stones, the Ceprotan traditional ceremony, and Pacitan rontek art. Numeracy skills were assessed using a pretest and a posttest. The following are the results of the quantitative data analysis.

Table 2. Paired Samples Statistics

	Mean	N	Std. Deviation	Std. Error Mean
Pretest_Numerasi	63.13	16	6.210	1.553
Posttest_Numerasi	81.31	16	5.842	1.460

Based on the Paired Samples Statistics output, the average numeracy score of elementary school children on the pretest was 63.13, while on the posttest it increased to 81.31. These results indicate an increase in numeracy skills after being given non-formal learning based on ethnomathematics.

Table 3. Paired Samples Correlations

	N	Correlation	Sig.
Pretest & Posttest	16	.781	.000

Based on the Paired Samples Correlations table, a correlation coefficient of $r = 0.781$ was obtained with a significance level of 0.000 ($p < 0.05$). This indicates a strong and significant positive relationship between students' pretest and posttest numeracy scores. This high correlation value is not used to measure the effectiveness of the intervention but rather indicates the stability of the measurement instrument and the consistency of students' developmental patterns. The high correlation indicates that students' ability rankings or positions tend to remain stable; that is, students with high initial ability remain in the top group, and students with low initial ability tend to remain in the bottom group after the intervention.

Pedagogically, these findings suggest that the ethnomathematics approach can improve overall numeracy scores without altering the ranking of foundational skills among students (Oktarisa et al., 2025). This demonstrates that the instrument used is reliable in capturing the developmental nature of numeracy skills through repeated and contextual learning experiences. To demonstrate the significance of the intervention's impact on these improvements, the analysis will focus on the results of the Paired Samples T-Test, which directly compares differences in mean scores.

Table 4. Paired Samples Test

	Paired Differences					
	Mean	Std. Dev.	Std. Error Mean	t	df	Sig.(2-tailed)
Pretest - Posttest	-18.188	8.785	2.196	-8.274	15	.000

The results of the paired samples t-test showed a t-value of -8.274 with df = 15 and a significance level of 0.000 ($p < 0.05$). These findings confirm the existence of a statistically significant difference in students' numeracy skills between before and after the intervention. The mean difference of -18.188 explicitly indicates that the posttest scores were higher than the pretest scores, with students' average scores increasing by 18.188 points following the implementation of the ethnomathematics approach. This demonstrates that cultural interventions in mathematics education have a tangible positive impact on students' numeracy achievement.

Inferentially, these results indicate that ethnomathematics-based numeracy learning has a significant effect on improving students' numeracy skills. The paired t-test is designed to detect changes in ability in the same group before and after treatment, so these significant results indicate that the changes that occurred were not due to chance factors.

These findings support a contextual learning approach that emphasizes the connection between mathematical concepts and children's real-life experiences. Numeracy is not only measured through arithmetic skills, but also through the ability to use mathematical concepts in everyday contexts (Arief.SA et al., 2024). Therefore, the significant increase in posttest scores shows that children not only master numerical procedures but are also able to apply numeracy in contextual situations.

To determine the positive impact of instruction on improvements in numeracy skills, Normalized Gain (N-Gain) was calculated based on pretest and posttest scores. The use of N-Gain in this one-group design aimed to assess the significance of the average score increase within the group before and after the intervention, with the following results.

Table 5. Normalized Gain (N-Gain) calculation

N-Gain Category	Number of Children	Percentage
High ($g \geq 0,7$)	3	18,75%
Medium ($0,3 \leq g < 0,7$)	11	68,75%
Low ($g < 0,3$)	2	12,50%
Total	16	100%

The average N-Gain value of 0.49 falls into the moderate category, indicating that ethnomathematics-based learning is quite effective in improving the numeracy skills of elementary school children. The N-Gain analysis results show that ethnomathematics-based numeracy learning produces an average N-Gain value of 0.49, which falls into the moderate category. These findings indicate that the implemented learning is able to improve the numeracy skills of elementary school children quite effectively, although it has not yet reached the high improvement category overall.

The distribution of N-Gain scores shows that most children (68.75%) are in the moderate improvement category, while 18.75% are in the high category and 12.5% in the low category. This pattern indicates that the local culture-based learning approach has a relatively even positive impact on most students, although the level of improvement is still influenced by differences in each child's initial abilities and learning experiences.

Moderate N-Gain scores can be understood as a consequence of the characteristics of the research subjects, who were elementary school children with heterogeneous initial numeracy abilities. Children with lower initial abilities tended to show significant but gradual improvement, while children with higher initial abilities had more limited room for improvement. This is in line with the N-Gain function, which considers the initial score position in determining the level of learning improvement.

The results of the N-Gain calculations for the contexts of ethnomathematics related to agate stones, the Ceprotan traditional ceremony, and rontek art are presented in the following table.

Table 6. N-Gain Scores by Learning Context

No	Learning Context	Pretest Average	Posttest Average	N-Gain	Category
1	Ethnomathematics of Agate	62,50	79,00	0,46	Medium
2	Ceprotan Traditional Ceremony	61,75	80,50	0,50	Medium
3	Rontek Art	63,00	82,25	0,53	Medium
	Overall Average	62,42	80,58	0,49	Medium

When viewed in terms of learning context, the highest N-Gain values were obtained in learning based on rontek art (0.53), followed by the Ceprotan Traditional Ceremony (0.50), and agate ethnomathematics (0.46). This difference shows that learning contexts involving patterns, rhythms, and regularities tend to be more effective in improving certain aspects of numeracy, particularly pattern recognition and number regularities. These findings reinforce the view that numeracy develops not only through counting activities, but also through experiences of recognizing patterns in non numerical contexts.

Conceptually, the moderate N-Gain results support the ethnomathematics approach, which views mathematics as part of cultural practices, as stated by Ubiratan D'Ambrosio (2006). Numeracy learning linked to local culture allows children to build meaningful understanding, even though the improvement is gradual and contextual, not instantaneous.

Compared to conventional mathematics learning, which often emphasizes symbolic exercises, the increase in N-Gain in this study shows that ethnomathematics-based numeracy learning is more oriented towards conceptual understanding than just final results. Thus, even though the N-Gain value is in the moderate category, these results still show substantive and sustainable learning improvement, especially in the context of non-formal education.

Overall, the N-Gain results indicate that ethnomathematics based numeracy learning is effective in improving the numeracy skills of elementary school children, particularly in building a contextual and meaningful understanding of numeracy concepts. The moderate N-Gain score also indicates opportunities for further development, either through adding to the duration of learning, strengthening numeracy reflection, or differentiating activities according to the initial abilities of the students (Rusminati et al., 2025).

Overall, the three statistical analysis results complement each other in explaining the effectiveness of ethnomathematics based numeracy learning. The strong correlation shows individual consistency, the paired t-test proves that there is a significant difference, and N-Gain describes the quality of learning improvement proportionally. The combination of the three provides a strong empirical basis that local culture-based numeracy learning is effective and deserves further development.

The improvement in numeracy skills evident in the posttest scores provides evidence that contextualizing numeracy strategies through ethnomathematics makes a positive contribution to non-formal learning in small groups. With a sample size of 16 children, the learning process could proceed with more intensive guidance, which fostered active student engagement in every activity. However, it should be noted that this small sample size is a major limitation of the study, so these findings cannot yet be widely generalized. Although the results indicate positive outcomes within this limited group, further testing on a larger scale (macro scale) is essential to comprehensively validate the consistency and effectiveness of this strategy.

CONCLUSION

Cultural objects around Sukodono Village, Donorojo, Pacitan, East Java, include agate stones, the Ceprotan Traditional Ceremony, and Rontek Art. Ethnomathematical elements that can be applied in mathematics learning in the context of agate stones include geometry and patterns, calculations and measurements, and classification. Numeracy ethnomathematics in the Ceprotan Traditional Ceremony include calendars and time, calculations and proportions, group division, duration, geometry, and spatial awareness. Numeracy concepts in Rontek Art include geometry, arithmetic, patterns, fractions, and comparisons.

Ethnomathematics based nonformal learning that utilizes these three cultural contexts provides evidence of a positive contribution to improving the numeracy skills of elementary school children. This improvement is indicated by moderate N-Gain scores and the results of a paired samples t-test, which show a significant difference between pretest and posttest scores. Thus, the ethnomathematics approach can be considered as an alternative strategy for contextual and meaningful numeracy learning within the non-formal education sector. However, given the limited number of participants, these findings still have limitations regarding generalizability.

Given these limitations, future research is recommended to involve a larger and more diverse sample size to achieve stronger external validity. Additionally, future research could develop an experimental design involving a control group to test effectiveness more comprehensively. The development of ethnomathematics contexts from other local cultures, as well as integration with learning technologies, also presents opportunities to enrich numeracy learning strategies across various educational pathways, both formal and non-formal.

REFERENCES

Anwar, A., & Ramadhani, S. (2025). Pengembangan Modul Matematika Berbasis Etnomatematika Budaya Lokal Untuk Meningkatkan Literasi Numerasi Siswa SMP Negeri 1 Yogyakarta. *Journal of Science and Mathematics Education*, *1*(2), 46–54. https://doi.org/10.70716/josme.v1i2.175

Arief.SA, K., Bella Saragih, R. M., & Harahap, Y. N. (2024). Pengaruh Penggunan

Lembar Kerja Peserta Didik Matematika (Lkpd) Berbasis Etnomatematika Untuk Meningkatkan Kemampuan Literasi - Numerasi. *Numeracy*, *11*(1), 30–42. https://doi.org/10.46244/numeracy.v11i1.2587

Aulia, L., & Rista, L. (2019). Identifikasi Konsep Matematika Melalui Aktivitas Etnomatematika Petani Sawah. *Jurnal Pendidikan Matematika (JUDIKA EDUCATION)*, *2*(2), 110–117. https://doi.org/10.31539/judika.v2i2.857

Creswell, J. W., & Poth, C. N. (2017). *Qualitative inquiry & research design: Choosing among five approaches* (4th ed.). Sage.

D'Ambrosio, U. (1985). Ethnomathematics and Its Place in the History and Pedagogy of Mathematics. *For the Learning of Mathematics*, *5*(1). www.jstor.org/stable/40247876

D'Ambrosio, U. (2006). *Ethnomathematics: Link between traditions and modernity*. Sense Publishers. https://doi.org/10.1007/s11858-008-0163-3

Dhiki, Y. Y., Paron, F. G., Blolon, M. A., & Didin, M. (2024). Eksplorasi Etnomatematika Pada Tarian dan Permainan Tradisional Flores Timur. *Jurnal Ilmiah Pendidikan Citra Bakti*, *11*(1), 47–57. https://doi.org/10.38048/jipcb.v11i1.2252

Fitri, A., Rahman, R., Aris, I., & Maharbid, D. A. (2023). Eksplorasi Etnomatematika pada Bangunan Candi Jiwa sebagai Sumber Belajar Matematika di Sekolah Dasar. *DWIJA CENDEKIA: Jurnal Riset Pedagogik*, *7*(2). https://doi.org/10.20961/jdc.v7i2.69171

Himmah, W. I., Hidayah, N., & Azzahra, S. (2024). Designing of Numeracy Questions for Middle School Level Students. *Hipotenusa: Journal of Mathematical Society*, *6*(1), 101–113. https://doi.org/10.18326/hipotenusa.v6i1.1663

Iasha, V., Zulfah, M., Amelia, M., Dari, Y. W., Ayu, D. S., Halimatussadiah, H., Jamilah, S., Mahendra, D. A., Salsabila, N. E., & Setiawan, B. (2025). Pentingnya Literasi Numerasi sebagai Fondasi Pendidikan Sekolah Dasar untuk Membangun Kecerdasan dan Kemandirian Siswa di Masa Depan. *Action Research Journal Indonesia (ARJI)*, *6*(4). https://doi.org/10.61227/arji.v6i4.279

Iswara, H. S., Ahmadi, F., & Ary, D. Da. (2022). Numeracy Literacy Skills of Elementary School Students through Ethnomathematics-Based Problem Solving. *Interdisciplinary Social Studies*, *2*(2), 1604–1616. https://doi.org/10.55324/iss.v2i2.316

Kurniasih, E. S., & Priyanti, N. (2023). Pengaruh Pendekatan Pembelajaran Diferensiasi Terhadap Kemampuan Literasi Baca, Tulis Dan Numerasi Pada Anak Usia Dini. *Jurnal Ilmiah Potensia*, *8*(2), 398–498. https://doi.org/10.33369/jip.8.2.398-498

Mania, S., & Alam, S. (2021). Teachers' Perception toward the Use of Ethnomathematics Approach in Teaching Math. *International Journal of Education in Mathematics, Science and Technology*, *9*(2), 282–298. https://doi.org/10.46328/ijemst.1551

Marsigit, M., Setiana, D. S., & Hardiarti, S. (2018). Pengembangan Pembelajaran Matematika Berbasis Etnomatematika. *Prosiding Seminar Nasional Pendidikan Matematika Etnomatnesia*. https://jurnal.ustjogja.ac.id/index.php/etnomatnesia/article/view/2291

Miles, M. B., Huberman, A. M., & Saldana, J. (2014). *Qualitative data analysis: A methods sourcebook* (Vol. 59). Sage Pub.

Munthahana, J., Budiarto, M. T., & Wintarti, A. (2023). The Application of Ethnomathematics in Numeracy Literacy Perspective: A Literature Review. *Indonesian Journal of Science and Mathematics Education*, *6*(2), 177–191. https://doi.org/10.24042/ijsme.v6i2.17546

Muqtadiroh, F. A., Nisafani, A. S., & Rizany, R. (2015). Analisis dan Desain Website Culture-Vid Berbasis Video Share dalam Rangka Melestarikan Budaya Bangsa dan

Kearifan Lokal Nusantara. *Sisfo*, *05*(03). https://doi.org/10.24089/j.sisfo.2015.03.011

Oktarisa, L., Putra, Z. H., Erlisnawati, E., & Fendrik, M. (2025). Development Of Ethnomathematics-Based Numeracy Literacy Tasks Using Pacu Jalur Lopek Tradition Context For Elementary Students. *AKSIOMA: Jurnal Program Studi Pendidikan Matematika*, *14*(1), 246. https://doi.org/10.24127/ajpm.v14i1.10139

Risdiyanti, I., & Indra Prahmana, R. C. (2017). Ethnomathematics: Exploration in Javanese culture. *Journal of Physics: Conference Series*, *943*, 012032. https://doi.org/10.1088/1742-6596/943/1/012032

Rusminati, S. H., Fanani, A., & Fanny, A. M. (2025). The Integration of Ethnomathematics In Enhancing Numeracy Literacy: A Literature Review. *INVENTA: Jurnal Pendidikan Guru Sekolah Dasar*, *9*(2). https://doi.org/https://doi.ohttps://doi.org/10.36456/inventa.9.2.a11228

Setiana, D. S., Ayuningtyas, A. D., Wijayanto, Z., & Kusumaningrum, B. (2021). Eksplorasi etnomatematika Museum Kereta Kraton Yogyakarta dan pengintegrasiannya ke dalam pembelajaran matematika. *Ethnomathematics Journal*, *2*(1), 1–10. https://doi.org/10.21831/ej.v2i1.36210

Simms, V. (2016). Mathematical mindsets: unleashing students' potential through creative math, inspiring messages and innovative teaching. *Research in Mathematics Education*, *18*(3), 317–320. https://doi.org/10.1080/14794802.2016.1237374

Sutriyanto, S., & Swasono, B. T. (2018). Pelatihan Pengolahan Batu Alam Bagi Keluarga Miskin Daerah Aliran Sungai (Das) Sooka, Desa Sooka, Kecamatan Punung, Kabupaten Pacitan, Jawa Timur. *Abdi Seni: Jurnal Pengabdian Kepada Masyarakat*, *9*(1). https://doi.org/https://doi.org/10.33153/abdiseni.v9i1.2453

Talib, A., Putri, M. A., & Hamin, M. N. I. (2025). Eksplorasi Sejarah Matematika dengan Pendekatan Etnomatematika pada Bangun Geometri Arsitektur Benteng Fort Rotterdam Makassar. *Kognitif: Jurnal Riset HOTS Pendidikan Matematika*, *5*(2). https://doi.org/10.51574/kognitif.v5i2.3151

Thompson, R. J., Napoli, A. R., & Purpura, D. J. (2017). Age-related differences in the relation between the home numeracy environment and numeracy skills. *Infant and Child Development*, *26*(5). https://doi.org/10.1002/icd.2019