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Ethnomathematics Integration to Enhance Preschoolers' Early Math Problem-Solving Skills: A Qualitative Case Study

Felisitas Ndeot[1*], Sofia Hartati[2], Hapidin[3]
[1,2,3] Early Childhood Education Department, Jakarta State University, Jakarta, Indonesia
* Corresponding Author. E-mail: icananoarta@gmail.com

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ABSTRACT

This study investigates how integrating ethnomathematics into early childhood education can improve the early math problem-solving skills of preschoolers aged 5–6 years. Conducted in Manggarai, Indonesia, the research employed a qualitative case study approach to explore learning activities infused with local cultural elements, including the spider-web rice field layout (lingko), traditional Manggarai houses (mbaru niang), and woven fabric patterns (songke). These cultural artifacts were adapted into problem-based learning tasks to develop children's mathematical thinking. Data were collected through classroom observations, semi-structured interviews with the teacher, and documentation of children's learning outcomes, such as photographs, drawings, and activity records. The data obtained from classroom observations, teacher interviews, and documentation of children's learning outcomes are transcribed verbatim. The coding process is conducted inductively, meaning the codes are not predetermined but emerge from the data itself. The researchers read each transcript and documentation repeatedly to identify statements, actions, or interactions relevant to problem-solving skills. Codes that have similar meanings are then grouped into categories. These subthemes are analyzed further to identify the main theme that reflects the phenomenon as a whole. After the main theme is formed, the researcher interprets the findings by relating them to the research objectives, research questions (RQ1 and RQ2), as well as previous theories or findings. The findings reveal that embedding familiar cultural representations in mathematics instruction enhanced children's problem-solving strategies, persistence, and conceptual understanding. Moreover, using culturally relevant contexts increased children's engagement and confidence. This study highlights the importance of integrating local wisdom into early math education as a pathway to inclusive and resilient learning environments.

INTRODUCTION

Mathematical problem-solving skills are essential cognitive abilities that should be nurtured early. Problem-solving skills are vital for cognitive development in early childhood, as they enhance abilities such as creativity and rational thinking (Dewi et al., 2024). Early childhood is a critical stage for building foundational thinking patterns and developing logical reasoning through play and exploration. Early exposure to problem-solving in mathematics helps children develop a strong foundation for future learning and real-life applications (Anwar, 2015). Problem-solving is a fundamental skill in early childhood development that supports not only cognitive growth but also emotional resilience and adaptive behavior. In the context of early mathematics learning, problem-solving refers to the ability of young children to recognize a problem, explore possible solutions, and apply logical reasoning to achieve an outcome (Diamond, 2018). This skill enables children to engage in inquiry, make predictions, compare quantities, identify patterns, and justify their choices, all of which form the foundation for later

Mathematical thinking. Early problem-solving skills are linked to children's readiness for school and their long-term success in academic and social domains (Walker et al., 2023). Mathematical problem-solving in early childhood is not limited to numerical tasks but includes a range of experiences such as classifying objects, exploring spatial relationships, measuring, and creating patterns. These processes involve critical components of executive function such as attention control, working memory, and cognitive flexibility (Yun, 2016). Therefore, designing learning environments that support these abilities is essential. Research has shown that young children can develop strong problem-solving skills when they are provided with open-ended, exploratory, and context-rich learning tasks (Lambert, 2019).

However, conventional approaches to early mathematic instruction often lack cultural relevance and fail to engage children meaningfully within their everyday contexts. Conventional early math instruction often views mathematics as a decontextualized set of skills, neglecting children's informal knowledge and everyday mathematical activities. This lack of cultural relevance can hinder meaningful engagement and understanding, emphasizing the need for culturally relevant instructional practices (Guberman, 1999). This disconnect between learning materials and children's cultural backgrounds can result in missed opportunities for deeper understanding and long-term retention of mathematical concepts.

Recent literature has emphasized the potential of ethnomathematics, mathematical ideas embedded within cultural practices, as a powerful educational approach that bridges formal learning with local knowledge (D'ambrosio, 1985; Thomas & Jacob, 2021). Ethnomathematics offers a culturally responsive pathway to introduce abstract mathematical concepts through familiar symbols, tools, patterns, and spatial arrangements rooted in community life. A literature review shows the discussion of ethnomathematics in primary education (Herawaty et al., 2019, 2020; Lena et al., 2019; Musawwir et al., 2021; Utami et al., 2020; Vitoria & Monawati, 2020; Widada, Herawaty, Jumri, et al., 2019; Wildfeuer, 2022; Yudianto et al., 2020), Secondary Education (Friansah & Yanto, 2020; Nuryadi et al., 2023; Peni & Baba, 2019; Richardo et al., 2023; Suherman et al., 2021; Umbara et al., 2023; Widada et al., 2020), and some others in higher education. While various studies have explored ethnomathematics integration in elementary and secondary levels, there is limited research on its application in early childhood education, particularly in Indonesia. The study of ethnomathematics in early childhood education includes research on the implications of ethnomathematics in the Ethiopian curriculum, including in early childhood (Tesfamicael et al., 2021), the contribution of ethnomathematics to the teaching process of early childhood education in Brazil by adapting learning situations from Longhini (2009) and observing themes that arise in children related to the solar system and the sky (Monteiro et al., 2020), ethnomathematics to develop a sense of love for the homeland in early childhood (Rahmawati et al., 2022), ethnomathematical elements in marble games (Febriyanti et al., 2019), the ability of PAUD educators to introduce ethnomathematics (Febriyanti et al., 2019), the introduction of the geometric shape of the traditional konjo cake (Nisa & Halifah, 2021), and the introduction of the Kudus culture through ethnomathematical learning (Wanabuliandari, 2017). Although various studies have explored the application of ethnomathematics at various levels of education, research on its application specifically in early childhood education is still limited, and there has not been much in-depth study of how ethnomathematics can be used strategically to develop mathematic problem-solving skills in children aged 5–6 years.

Furthermore, although the role of local wisdom and traditional knowledge systems in supporting early childhood problem-solving skills is gaining interest, it remains underexplored in practical applications. In the Manggarai region of East Nusa Tenggara, cultural elements such as the spider-web rice field (lingko), traditional houses (mbaru niang), and woven motifs (songke) embody rich geometric and spatial structures. A previous study conducted by the author has initiated the integration of these elements into early mathematics learning. However, there is still a lack of documented research specifically focusing on the implementation and effectiveness of ethnomathematical approaches for preschoolers in Manggarai.

This study aims to investigate integrating ethnomathematical elements into early childhood learning activities to improve the problem-solving skills of preschoolers aged 5–6 years. The research highlights how utilizing culturally relevant materials enriches children's mathematical thinking and fosters engagement, confidence, and persistence in solving problems. The research focused on addressing two connected questions:

RQ1: How is ethnomathematics integrated into learning activities to improve preschoolers' problem-solving skills?

RQ2: Is there an observable improvement in preschoolers; problem-solving skills through ethnomathematics-based learning?

METHOD

This study employed a qualitative case study approach to explore how ethnomathematics-based learning can enhance the early math problem-solving skills of preschoolers aged 5–6 years. The research was conducted in an early childhood education center located in Manggarai, East Nusa Tenggara, Indonesia, a region rich in cultural heritage. The participants included one early childhood teacher and a group of ten children aged 5–6 years. The teacher was selected purposively based on her experience in implementing contextual and culturally responsive learning practices. The children were selected from the same class to ensure a consistent learning environment.

Data were collected using three main techniques: classroom observations, teacher interviews, and documentation of children's learning outcomes. Observations focused on how children engaged with problem-solving tasks embedded in cultural contexts, such as interpreting patterns from lingko rice fields, arranging building blocks inspired by mbaru niang, and identifying geometric motifs in songke woven fabrics. During the semi-structured interviews with the teacher, the researcher explored several specific aspects related to the integration of ethnomathematics in the classroom and its impact on children's problem-solving development. The interview protocol was developed to focus on five main areas:

1. Instructional Design and Planning
   Questions were aimed at understanding how the teacher planned and prepared learning activities that incorporated local cultural elements. This included selecting cultural artifacts (e.g., songke, lingko, mbaru niang) and designing problem-solving tasks around them.
2. Implementation Strategies
   The interview explored how the teacher introduced the cultural context to the children, facilitated the activities, and scaffolded children's thinking through questioning and feedback. Indicators included use of open-ended prompts, modeling, and guided discovery.
3. Children's Engagement and Responses
   The teacher was asked to describe how children responded to the culturally-based learning experiences, including their levels of interest, motivation, and participation. Specific attention was paid to how the children interacted with materials, collaborated with peers, and showed persistence.
4. Observations of Problem-Solving Behavior
   The teacher provided examples of children's behaviors that demonstrated problem-solving skills, such as identifying patterns, testing ideas, adjusting strategies, and justifying choices. Indicators of these behaviors were drawn from both verbal and non-verbal cues.
5. Perceived Outcomes and Reflections
   The interview concluded with the teacher's reflections on the overall effectiveness of ethnomathematics-based learning. This included perceived growth in mathematical understanding, cultural awareness, and children's skills to apply problem-solving strategies independently.

Children's learning documentation, including photos of their work and learning journals, was used to support triangulation and deepen the analysis. These artifacts provided concrete evidence of children's engagement, problem-solving progression, and application of mathematical concepts in cultural contexts. For example, children's drawings of symmetrical songke motifs and structural representations of mbaru niang allowed the researcher to identify patterns of visual reasoning, categorization, and spatial understanding. Notes written by the teacher in children's journals also captured reflective comments, instances of persistence, and language use during mathematical exploration.

All qualitative data were analyzed manually using thematic analysis. Transcripts from interviews and classroom observations were coded and categorized inductively without the assistance of computer software. Data organization was managed through structured coding sheets in Microsoft Word and Excel to facilitate tracking, grouping, and interpretation of themes. Thematic analysis was used to identify recurring patterns, behaviors, and strategies that emerged from the data. Codes were developed inductively and grouped into sub-themes and themes to reveal how cultural integration influenced children's problem-solving skills. The trustworthiness of the data was ensured through prolonged engagement, member checking with the teacher, and peer debriefing among early childhood education researchers.

To ensure the credibility and trustworthiness of the findings, data triangulation was employed by comparing and cross-checking information obtained from three sources: classroom observations, teacher interviews, and children's learning documentation. The process began by identifying recurring behaviors or patterns across the data sets, for instance, a problem-solving strategy observed during an

activity was verified through teacher commentary in interviews and supported by artifacts such as children's drawings or photos of completed tasks. Triangulation was conducted in three phases. First, observational notes were coded independently and then aligned with interview transcripts to check for consistency in teacher-reported strategies and children's actual behavior. Second, children's work samples, such as symmetrical motif drawings or categorized object sets, were analyzed to substantiate verbal or behavioral indicators of reasoning and persistence. Finally, emerging themes were compared across data types to ensure that interpretations were not solely reliant on one perspective. This multi-source comparison strengthened the validity of the thematic analysis and provided a more holistic understanding of how ethnomathematics influenced problem-solving skills development.

RESULT AND DISCUSSION

As part of the qualitative data analysis obtained through interviews, observations, and documentation, the table below presents a partial view of the thematic analysis results, illustrating the relationships between quotes, codes, subthemes, and themes that emerged from the collected data. Table 1 provides an initial overview of the understanding of the strategies implemented by teachers in enhancing problem-solving skills among young children.

Tabel 1. Thematic Analysis from Interview, Observation, and Documentation

Data Source	Sample Data Excerpt	Code	Sub-Theme	Theme
Interview	"They tried again with a different shape after the house fell."	Attempting alternative strategies	Problem-solving skills in play	Development of problem-solving skills
Interview	"She said the pattern looks like the fabric her mom wears at ceremonies."	Cultural connection to motif	Recognition of cultural symbols	Cultural relevance enhances engagement
Observation	Children worked together to arrange wooden blocks into a cone shape while referencing mbaru niang.	Collaborative spatial reasoning	Peer collaboration in cultural modeling	Social context supports cognitive engagement
Observation	A child asked, "Is this stone smaller than that one?" during a traditional game activity.	Use of comparison language	Problem solving skills in play	Cultural activities support conceptual learning
Documentation	Drawing of symmetrical songke motif with labels: "same–same–turn–line."	Pattern recognition and reasoning	Visual mathematical thinking	Cultural tools promote abstract reasoning
Documentation	Sequence drawing: big triangle, small triangle, and big triangle.	Creating and extending patterns	Representation of repeating structures	Development of early algebraic thinking
Observation	Teacher asked, "Why do you think the shape fits here?" and the child explained, "Because it's flat."	Justifying choices verbally	Problem-solving skills in play	Teacher strategies foster mathematical thinking
Documentation	Children sorted cards of house parts (roof, wall, base) into categories and named them.	Categorization based on attributes	Classification using real objects	Early geometry through cultural representations

RQ1: How is ethnomathematics integrated into learning activities to improve preschoolers' problem-solving skills?

The integration of ethnomathematics in early childhood learning was implemented through a series of culturally contextualized, problem-based activities. These included matching songke motifs, constructing models of mbaru niang using blocks, and exploring the structure of the lingko rice fields. Through these activities, children were exposed to problem-solving tasks embedded in familiar cultural settings, encouraging them to engage in analytical thinking and experimentation.

The analysis identified three main teaching strategies that supported the development of children's problem-solving skills. First, cultural modeling tasks allowed children to replicate real-life cultural forms, such as traditional houses (mbaru niang) or rice field layouts (lingko) using blocks, drawings, and other manipulatives. These tasks provided tangible, hands-on experiences that helped children internalize mathematical concepts like shape, size, and symmetry in a meaningful way. Second, teachers employed verbal inquiry and reflection by posing open-ended questions to stimulate children's reasoning. Questions such as "What makes these shapes the same?" or "How could we make the structure stand stronger?" encouraged children to think critically, explain their ideas, and explore multiple solutions. Third, collaborative exploration was encouraged through group activities in which children discussed, tested, and revised their ideas together. This strategy fostered communication, peer learning, and social problem-solving, enhancing their ability to reason and negotiate in the context of culturally relevant mathematical challenges.

"I noticed that when they relate shapes to something they see in daily life, they try more and think deeper" (Teacher interview).
"When I showed them the pattern of the songke, they immediately said, 'That looks like my dad's shirt!' and then they started comparing the shapes without me asking." (Teacher interview).
"At first, they just stacked the blocks randomly. But when I told them it should look like the cone-shaped house in our village, they started to plan how to arrange the pieces." (Teacher interview).
"They enjoy solving problems more when we use traditional games. They keep trying even when they fail, like in the stone arrangement activity, they don't give up easily." (Teacher interview).
These approaches provided rich opportunities for children to engage in early mathematical reasoning and decision-making to solve the problem, which served as the foundation for skill development.

RQ2: Is there an observable improvement in preschoolers'; problem-solving skills through ethnomathematics-based learning?

The analysis revealed a clear improvement in preschoolers' mathematical problem-solving skills throughout the intervention. This improvement was evidenced by several behavioral indicators consistently observed across learning sessions. Children began to demonstrate greater independence in attempting to solve tasks without relying on direct adult guidance. Rather than waiting for instructions, many initiated problem-solving attempts on their own. Additionally, they began to employ a wider variety of strategies when facing challenges, for example, rearranging shape blocks in different ways, checking for symmetry in patterns, or adjusting a collapsed block structure after analyzing the cause of failure. Their reasoning and explanation skills also improved, as children became increasingly able to articulate their thought processes, describe their choices, and justify their solutions using simple mathematical language such as "same shape," "bigger," or "turn it around." These behavioral shifts reflect not only a deeper engagement with the tasks but also growing confidence and cognitive flexibility fostered by culturally embedded learning.

Children who initially hesitated to engage in problem-solving skills became more confident and persistent. For example, in early sessions, several children gave up quickly when a structure collapsed. However, by the final session, these same children demonstrated adaptive thinking by experimenting with new strategies, seeking peer support, and revising their approaches. This behavioral shift indicates the development of cognitive flexibility, which is a core component of early problem-solving competence (Diamond & Hsiao, 2019). The teacher's lesson documentation and children's recorded work provided additional evidence of progress in problem-solving development. By the third session, approximately 80% of the children were observed using more than one strategy to complete a task, an indicator of growing metacognitive awareness and problem-solving fluency. This aligns with findings by Fosse, Lange, and Meaney (2020), who observed that young children are capable of complex reasoning when exposed to rich, meaningful contexts. In addition, children's verbal reasoning improved markedly; they began using mathematical terms such as "same shape," "bigger," "turn," and "fit" to justify their decisions. This linguistic development is consistent with Walker et al. (2023), who emphasize that culturally

embedded mathematical instruction supports the emergence of mathematical language in young learners.

Beyond the observed improvements in children's problem-solving abilities, this study highlights the significant role of ethnomathematics in promoting cultural identity and a sense of belonging in the learning environment. When children engage with learning materials that reflect their local traditions, such as the lingko fields, mbaru niang, and songke patterns, they experience affirmation of their cultural background, which contributes to emotional security and motivation. This finding is consistent with Barton (2012) and Meneghetti (2013), who emphasized that integrating culture into mathematics instruction enhances both conceptual learning and socio-emotional development. In this study, children demonstrated greater enthusiasm and willingness to participate when the learning tasks were rooted in familiar contexts. These results affirm that culturally situated mathematics not only supports cognitive growth but also fosters inclusivity, especially in indigenous or marginalized settings. Increased engagement was evident in how children responded enthusiastically to tasks based on traditional patterns. Activities related to mbaru niang construction or songke pattern identification led to spontaneous exploration and sustained attention. This aligns with Greenwood et al. (2019), who found that culturally embedded learning fosters deeper interest and cognitive flexibility among young learners. Moreover, culturally meaningful instruction appeared to reduce anxiety and increase self-confidence during mathematical problem-solving tasks. These outcomes echo the findings of Suarez et al. (2024), who reported that integrating cultural elements into instruction creates a more affirming and less intimidating learning environment for young children.

A notable outcome of this study was the development of children's strategic thinking and the increased use of mathematical vocabulary. As sessions progressed, children began employing more diverse strategies, such as adjusting their building techniques, experimenting with symmetry, and revising their work based on observed outcomes. By the third session, the majority of children were able to describe their thought processes using simple yet accurate mathematical terms like "same shape," "turn," "bigger," and "fit." This finding supports Fosse, Lange, and Meaney (2020), who emphasized that young children are capable of engaging in complex mathematical reasoning when instruction is grounded in meaningful, everyday experiences. These results also point to growth in metacognitive awareness, children were not only acting but also thinking about their thinking, explaining their choices, and anticipating possible outcomes. Such developments demonstrate how the integration of cultural materials supports both cognitive and linguistic aspects of mathematical problem-solving.

The success of the ethnomathematics-based learning design was closely tied to the role of the teacher as a cultural mediator and learning facilitator. The teacher's use of open-ended questioning, culturally relevant visual materials, and dialogic scaffolding enabled children to explore concepts more deeply. For example, questions like "Why do you think this shape fits here?" or "What makes these patterns similar?" invited children to reason beyond surface features. This teaching approach is in line with Walker et al. (2023), who argue that dialogic interactions enhance mathematical discourse and support the development of higher-order thinking in early childhood education. Additionally, the teacher's responsiveness to children's ideas created an environment where mathematical exploration felt safe and meaningful. This strategy of culturally grounded, inquiry-based teaching allowed for both individual expression and collective problem-solving.

One of the clearest indicators of deep learning was the children's ability to transfer problem-solving strategies to new contexts. Toward the end of the study, several children were observed independently grouping classroom materials by shape or pattern, without prompts from the teacher. This type of generalization reflects internalization of mathematical concepts and strategies, which is considered a hallmark of early problem-solving competence (Diamond & Hsiao, 2019). Moreover, the study found that the ethnomathematical approach was flexible and adaptable to different teaching styles. While one teacher emphasized hands-on exploration through traditional games, another focused on conceptual questioning through visual analysis. Despite these differences, both approaches successfully supported children's development of mathematical thinking. This finding reinforces the conclusion by Anis et al. (2024), who argued that culturally responsive pedagogy allows for instructional flexibility while maintaining coherence with children's cultural realities. Ethnomathematics, therefore, serves not only as an enriching content area but also as a strategic method that bridges home and school learning contexts.

The integration of local cultural elements into mathematics learning provided children with experiences that were deeply situated in their daily lives. According to Vygotsky's Sociocultural Theory, learning occurs through interactions within a cultural context and is mediated by tools, symbols, and social collaboration (Vygotsky, 1978). In this study, cultural tools such as songke patterns and lingko rice field structures acted as mediational artifacts, allowing children to engage with mathematical concepts through culturally familiar contexts. This cultural grounding promoted emotional security and

motivated sustained engagement, which are essential for learning within a child's Zone of Proximal Development (ZPD). The children's growing ability to verbalize their strategies and explain their reasoning corresponds with Vygotsky's view of language as a primary tool of thought. As children encountered culturally embedded problems, they were supported by the teacher's scaffolding and gradually internalized problem-solving strategies, transitioning from social interaction to independent thinking. Furthermore, the progression observed, from manipulation of physical materials (building blocks) to identifying visual patterns (motifs), and finally articulating abstract relationships, aligns with Bruner's Theory of Enactive, Iconic, and Symbolic representation (Staffieri & Razavieh, 1969). Children began by physically engaging with objects (enactive), moved to recognizing visual features (iconic), and ultimately expressed their understanding using mathematical language (symbolic). This developmental trajectory reflects how cultural artifacts can support representational learning in young children.

CONCLUSION

This study demonstrates that integrating ethnomathematics into early childhood education significantly enhances the problem-solving skills of preschoolers aged 5–6 years. Through culturally embedded learning tasks grounded in local Manggarai traditions, such as lingko rice fields, mbaru niang architecture, and songke motifs, children engaged with mathematical ideas in familiar, meaningful ways. The integration of cultural context into mathematics learning facilitated not only the development of cognitive strategies such as reasoning, comparison, and classification, but also nurtured confidence, persistence, and verbal articulation in solving problems. The research contributes to the growing body of literature on culturally responsive pedagogy by providing evidence from the early childhood education context in Indonesia, a setting that remains underrepresented in global studies of ethnomathematics. It also illustrates how local cultural artifacts can be transformed into rich educational resources that strengthen both academic and socio-emotional domains of development.

Practically, the findings highlight the importance of preparing early childhood educators to design and implement learning experiences that are contextually and culturally grounded. Teacher training programs should incorporate modules that help educators identify, adapt, and apply local cultural elements into problem-based learning activities. Doing so not only enhances learning relevance but also affirms children's identities and fosters inclusive classroom environments. Future research may expand upon this study by exploring the long-term effects of ethnomathematics-based instruction across different regions and cultural contexts, and by examining its impact on other areas of development, such as creativity, collaboration, and cultural competence. Mixed-method approaches or quasi-experimental designs could also be used to measure changes in learning outcomes more systematically.

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