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Integrating Ethnomathematics into Primary Mathematics Instruction to Enhance Students' Mathematical Communication Skills

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Abstract. This study investigates the impact of integrating ethnomathematics into primary school mathematics instruction on students' mathematical communication skills. Motivated by the lack of contextualized learning environments that affirm students' cultural identities and foster expressive competence, the research adopts a quasi-experimental design with pretest-posttest control groups. Participants consisted of 60 fifth-grade students in West Java, Indonesia, divided into an experimental group taught through ethnomathematics-based learning and a control group taught with conventional methods. A validated mathematical communication test assessed students' abilities to express ideas verbally, symbolically, and visually. Results show a statistically significant improvement in both groups; however, the experimental group demonstrated a considerably higher effect size (Cohen's $d = 1.97$) than the control group (Cohen's $d = 1.25$). Moreover, independent t-test results ($t(58) = 6.851$, $p < .001$) confirm that culturally contextualized instruction more effectively fosters communication-rich learning environments. The study highlights the importance of meaningful cultural contexts in enhancing mathematical communication and calls for broader adoption of ethnomathematics-based pedagogies. Limitations and recommendations for future research are also discussed.

Introduction

In many primary classrooms, mathematics instruction is still characterized by abstract symbols, rigid procedural routines, and problem sets detached from students' real-world experiences (Wasserman, 2016). This traditional approach limits student engagement and reinforces the perception of mathematics as a static and irrelevant discipline. When mathematical concepts are introduced without meaningful connections to students' lives, they often become incomprehensible and disconnected from practical utility (Vos, 2018). This challenge is particularly evident among primary school learners in a critical stage of cognitive and social development. Teaching practices disregarding students' cultural and contextual backgrounds reduce motivation and hinder active participation in mathematical learning (Arsaythamby & Zubainur, 2014). One of the most visible consequences is the underdevelopment of students' mathematical communication skills—namely, their ability to explain, represent, and justify mathematical reasoning through verbal, visual, or symbolic means (Rohid & Rusmawati, 2019; Rusdi et al., 2020). Without contextualized and dialogic instruction, students are rarely exposed to discourse-rich environments that encourage them to make their thinking visible and comprehensible to others (Tong et al., 2021).

Given these limitations, scholars and educators have increasingly turned to more culturally responsive pedagogies, such as ethnomathematics, as a promising alternative. Ethnomathematics refers to mathematical knowledge embedded in specific communities' daily practices, traditions, and cultural systems (D'Ambrosio & Rosa, 2017; François, 2010). Unlike conventional approaches that often

privilege formal, Western mathematical structures, ethnomathematics emphasizes the cultural relativity of mathematical thinking and practices. When students are encouraged to explore mathematics through contexts familiar to their lived experiences—such as traditional games, indigenous measurement systems, crafts, or local architecture—they are more likely to find personal relevance in mathematical content and engage with it meaningfully (Rosa et al., 2017). This approach affirms students' cultural identities and promotes equity and inclusiveness in mathematics classrooms (Cimen, 2014; Abdulrahim & Orosco, 2020). However, while the general benefits of culture-based learning have been well documented, empirical research that specifically investigates the role of ethnomathematics in developing students' mathematical communication skills—especially at the elementary level—remains scarce.

To address this gap, the present study explores how integrating ethnomathematical elements into mathematics instruction can enhance students' capacity to communicate mathematical ideas. Several studies have demonstrated that embedding local cultural knowledge in mathematical learning can significantly improve students' ability to express, represent, and justify their reasoning (Hartinah et al., 2019; Herawaty et al., 2019). By incorporating familiar cultural contexts—such as traditional artifacts, games, and measurement systems—students are better able to verbalize mathematical thinking in ways that are both meaningful and accessible. This research identifies how culturally meaningful learning experiences support primary students in developing mathematical communication skills, particularly regarding their verbal articulation, symbolic representation, and conceptual justification (Hilliyani et al., 2024). Furthermore, this study seeks to uncover instructional strategies that foster communication-rich mathematics learning environments, especially in culturally diverse classroom settings where students' cultural identities intersect with formal learning. By situating mathematics education within local knowledge systems, the study aims to provide theoretical and practical insights into how ethnomathematics can be a powerful vehicle for strengthening conceptual understanding and promoting rich mathematical discourse in early education.

Theoretical Review

This study is built upon two interrelated theoretical perspectives: ethnomathematics and mathematical communication. These frameworks collectively provide the foundation for analyzing how cultural contexts influence students' ability to express and construct mathematical meaning. Ethnomathematics recognizes that mathematics is not culturally neutral and that various forms of mathematical thinking arise from the daily practices of different communities (Bimantara, 2024; Civil, 2002; Pratiwi et al., 2022). By acknowledging local knowledge and values, ethnomathematics situates mathematics within students' lived realities, enabling learning that is more meaningful and accessible. Meanwhile, mathematical communication emphasizes the importance of expressing, sharing, and interpreting mathematical ideas as central to learning (O'Halloran, 1998; Steinbring, 2000). Students construct and refine their understanding of mathematical concepts through discourse, symbols, and representations. Together, these frameworks offer a powerful lens through which to examine mathematics learning that is both culturally responsive and communicatively rich, particularly in primary education settings where foundational thinking and expression are being formed.

Ethnomathematics in Primary Education

Ethnomathematics refers to the understanding and use of mathematical ideas that emerge from cultural traditions and community practices (Budiarto, Artiono, & Setianingsih, 2019). It encompasses diverse ways of reasoning, measuring, and solving problems that are embedded within specific social and cultural contexts (Wager, 2012). In the context of primary education, ethnomathematics serves as a pedagogical bridge connecting students' cultural knowledge with formal mathematical instruction (Aguirre & Zavala, 2013; Hernandez, Morales, & Shroyer, 2013). For instance, traditional crafts, games, architectural patterns, and local units of measurement can be utilized to contextualize mathematical

concepts such as geometry, arithmetic, and spatial reasoning (Supriadi, 2019; Nugraha, Maulana, & Mutiasih, 2020; Naidoo, 2021).

By engaging students with cultural artifacts and familiar practices, teachers can foster a more meaningful and accessible learning environment, enabling students to draw from their lived experiences and cultural identities in constructing mathematical understanding (Tsindoli, Ongeti, & Chang'ach, 2018). This culturally responsive approach enhances students' motivation and creativity and promotes equity and inclusivity in the classroom (Jang & Choi-Koh, 2009). However, while much of the existing literature emphasizes ethnomathematics' motivational and contextual relevance, its potential to support and enhance students' mathematical communication remains underexplored. Therefore, this study investigates how ethnomathematical learning tasks can open spaces for students to articulate mathematical ideas more clearly and confidently, fostering conceptual understanding and expressive competence in mathematics learning.

Mathematical Communication

Mathematical communication is a fundamental component of learning mathematics, encompassing the ability to convey ideas through speech, symbols, diagrams, and written language (Yabaş & Altun, 2016). In primary education, developing this ability supports students in making sense of mathematical ideas, engaging in reasoning, and participating in meaningful discussions with peers and teachers (Abidin, 2018). Communication in mathematics goes beyond explaining final answers; it involves constructing meaning collaboratively, justifying reasoning, and reflecting on thought processes (La'ia & Harefa, 2021).

However, in many classrooms, opportunities for mathematical communication are often constrained by teacher-centered approaches, where students act more as passive recipients rather than active participants (Fauzi & Masrukan, 2018). To cultivate richer communication, instructional designs must include dialogic spaces, multiple modes of representation, and culturally contextualized tasks that resonate with students' lived experiences (Manurung, Sari, & Dachi, 2024). Research indicates that such meaningful engagement enhances students' mathematical language development, conceptual clarity, and confidence in expressing ideas (Munandar, 2023; Purnamasari & Afriansyah, 2021). When students are encouraged to articulate their mathematical thinking using culturally and personally relevant representations, they are more likely to internalize and transfer their learning (Zaditania & Ruli, 2022). This study, therefore, posits that culture and communication are deeply intertwined, and that fostering both in mathematics instruction leads to more equitable and effective learning outcomes.

Methods

This study employed a quantitative approach with a quasi-experimental design, specifically the pretest-posttest control group design, to examine the effect of integrating ethnomathematics into mathematics instruction on students' mathematical communication skills. This design enables researchers to investigate causal relationships where random assignment is not feasible while maintaining control over internal validity threats (Creswell, 2012). The research was conducted in two parallel fifth-grade classes at a public elementary school in West Java, Indonesia. The classes were selected using purposive sampling, considering that both groups had comparable academic ability, curriculum exposure, and demographic background characteristics. The participants were divided into two groups: the experimental group, which received instruction using ethnomathematics-based learning tasks, and the control group, which received conventional mathematics instruction. Both groups were administered a pretest before the intervention and a posttest after the intervention to measure changes in their mathematical communication abilities.

The experimental design is illustrated in the following table:

Table 1. Experimental Design Structure

Group	Pretest	Treatment	Posttest
Experimental	O	Ethnomathematics-Based Learning	O
Control	O	Conventional Mathematics Instruction	O

The data collection instrument consisted of a mathematical communication test, developed based on indicators such as:

1. The ability to express mathematical ideas verbally and in written form,
2. the use of appropriate mathematical symbols and visual representations, and
3. The construction of logical arguments to explain problem-solving processes.

The test comprised six essay items, contextualized in data representation, geometry, and real-life mathematical problem-solving. To ensure the validity and reliability of the instrument, the test underwent expert review by three senior mathematics education lecturers, followed by item analysis. The Content Validity Index (CVI) yielded a score of 0.87, indicating strong content alignment and clarity. Furthermore, the instrument was piloted on 30 students from a neighboring school that was not included in the main study sample. The reliability coefficient, computed using Cronbach's Alpha, was 0.82, indicating that the instrument met the threshold for high internal consistency. The collected data were statistically analyzed using paired sample t-tests to assess within-group improvements and independent sample t-tests to evaluate differences between the experimental and control groups. The level of statistical significance was set at 0.05. Additionally, the effect size was calculated using Cohen's *d* to determine the magnitude of the treatment's impact. This analytical strategy ensured that the findings were both statistically valid and educationally meaningful in assessing the improvement of students' mathematical communication skills due to the integration of ethnomathematics in instruction.

Results And Discussion

Result

The primary aim of this study was to examine the effect of integrating ethnomathematics into mathematics instruction on students' mathematical communication skills. The statistical analysis involved paired sample t-tests (within-group comparison) and independent sample t-tests (between-group comparison). Table 2 presents the descriptive statistics of pretest and posttest scores for both groups.

Table 2. Descriptive Statistics of Pretest and Posttest Scores

Group	N	Pretest Mean	Posttest Mean	Mean Gain	Std. Deviation
Experimental	30	61.27	83.20	21.93	7.52
Control	30	60.87	70.47	9.60	8.11

As shown in Table 2, both groups exhibited improvement from pretest to posttest. However, the experimental group showed a significantly greater gain in mathematical communication scores than the control group. The paired sample t-test results in Table 3 indicate that the experimental and control groups experienced statistically significant improvements.

Table 3. Paired Sample *t*-Test Results

Group	*t*	df	*p*	Effect Size (Cohen's *d*)
Experimental	13.521	29	$< .001$	1.97 (Large)
Control	6.881	29	$< .001$	1.25 (Large)

The results of the paired sample *t*-test reveal a statistically significant improvement in mathematical communication skills for both the experimental and control groups. For the experimental

group, the analysis yielded $t(29) = 13.521$, $p < .001$, with a Cohen's d of 1.97, which is categorized as a huge effect size. This indicates that the integration of ethnomathematical-based learning substantially impacted students' mathematical communication abilities. The effect's magnitude suggests statistical significance and strong practical significance, meaning the improvement was not merely incidental or due to chance, but directly attributable to the instructional intervention. The statistical results in the control group showed significant improvement, with $t(29) = 6.881$, $p < .001$ and Cohen's d of 1.25, which also qualifies as a large effect size. Although the gain was significant, the smaller effect size relative to the experimental group highlights that while traditional instruction contributed to learning gains, it was less effective in enhancing students' ability to express and communicate mathematical ideas. These findings suggest that while both instructional models can improve students' mathematical communication, ethnomathematics-based instruction leads to deeper, more meaningful gains. The large effect sizes in both groups validate the reliability of the instructional interventions. However, the enormous effect in the experimental group emphasizes the pedagogical value of integrating cultural contexts into mathematics learning. To determine the effectiveness of the ethnomathematics-based instruction relative to the conventional method, an independent sample t-test was conducted on the posttest scores. The results are presented in Table 4.

Table 4. Independent Sample *t*-Test on Posttest Scores

Group	Mean	Std. Deviation	*t*	df	*p*	Cohen's *d*
Experimental	83.20	6.80	6.851	58	< .001	1.77 (Large)
Control	70.47	7.85				

The results in Table 4 confirm that the experimental group significantly outperformed the control group on the posttest ($t(58) = 6.851$, $p < .001$), with a large effect size ($d = 1.77$). These findings suggest that using ethnomathematical contexts in instruction substantially enhanced students' ability to express, justify, and represent mathematical ideas.

Discussion

The findings of this study underscore the significant impact of integrating ethnomathematics into mathematics instruction on enhancing students' mathematical communication skills. The substantial gain observed in the experimental group, as evidenced by a huge effect size (Cohen's $d = 1.97$), highlights the effectiveness of culturally contextualized instruction in fostering mathematical understanding and students' capacity to articulate their thinking. This result aligns with the study by Rizqi and Hawa (2023), who found that applying ethnomathematics-based contextual teaching and learning significantly improved the mathematical communication abilities of elementary students. Similarly, Salsanabila, Marsigit, and Mahmudi (2024) demonstrated that incorporating Purun weaving ethnomathematics into instruction enabled students to express mathematical ideas more clearly through culturally embedded representations. Additionally, Hasanah (2021) emphasized that ethnomathematics strengthens students' confidence and communication through familiar cultural patterns when integrated with effective learning models such as the 7E cycle. These findings are further supported by Rubel and McCloskey (2021), who argue that mathematics becomes more accessible and empowering when contextualized within learners' cultural and social realities. These studies affirm that ethnomathematics is not merely a supplementary tool but a transformative pedagogical approach that enriches discourse and promotes equity in mathematics education.

The control group also demonstrated statistically significant improvement, albeit with a smaller gain (Cohen's $d = 1.25$). This suggests that while conventional mathematics instruction can still develop students' communication skills to some extent, it lacks the contextual richness and cultural relevance that empower students to make personal connections with the content. Norton (2024) observed that

traditional methods often emphasize procedural fluency over conceptual understanding, resulting in improved scores but limited engagement and depth in student expression. Similarly, Palinussa, Molle, and Gaspersz (2021) argue that mathematics instruction detached from students' sociocultural environments tends to restrict meaningful communication and reasoning, especially in underserved or rural contexts. While such approaches may yield cognitive gains, they often fail to nurture students' capacity to relate mathematical ideas to real-life situations. Moreover, research by Alsmadi et al. (2023) highlights the importance of dialogic and collaborative strategies, elements often underrepresented in conventional instruction, critical in fostering communication, particularly when mathematical problems are situated within interactive and shared learning spaces. These findings reinforce that, despite some effectiveness, traditional teaching remains limited in fostering expressive competence, especially compared to culturally and contextually grounded pedagogies.

One critical observation lies in the role of meaningful contexts in enhancing students' mathematical understanding. In this study, students in the experimental group encountered problems involving familiar cultural artifacts, local measurement systems, and traditional practices, which made the tasks more relatable and meaningful. This contextual relevance allowed learners to construct mathematical meaning through multiple forms of representation—verbal, symbolic, and visual. According to Koskinen and Pitkäniemi (2022), meaningful learning in mathematics is significantly supported by instructional strategies that connect content to learners' lived experiences and promote conceptual engagement. Similarly, Polman, Hornstra, and Volman (2021) argue that learning becomes meaningful when students can interpret and apply mathematical ideas within contexts that resonate with their backgrounds and cognitive development. Supporting this, Harefa and Suastra (2024) emphasize that integrating local wisdom, such as *hombo batu* in Nias culture, provides authentic learning experiences and fosters students' capacity to communicate mathematics using culturally embedded concepts and representations. These findings affirm that culturally grounded and contextually rich problems enhance the depth and accessibility of students' mathematical learning.

Furthermore, ethnomathematics encourages active participation, collaboration, and discourse, all of which are fundamental for developing communication skills (O'Halloran, 1998; Steinbring, 2000). In contrast, the control group, operating under more traditional teacher-centered instruction, had fewer opportunities for student-led dialogue, which may have constrained their expressive growth despite statistical gains. The significant difference found in the independent sample t-test ($t(58) = 6.851$, $p < .001$, $d = 1.77$) between the two groups' posttest scores offers strong empirical support that culturally responsive pedagogy in mathematics is not only equitable but also instructionally superior in building expressive competence. These results echo calls from scholars like Abdulrahim and Orosco (2020), who advocate for culturally relevant mathematics teaching as a pathway toward inclusive and effective education. Despite these promising results, this study recognizes certain limitations. The sample was limited to two classes in a single school, which may affect the generalizability of the findings. Additionally, while the test captured improvements in students' ability to communicate mathematical ideas in writing, future research could incorporate classroom observations or interviews to gain deeper insights into verbal and social dimensions of communication. Overall, the discussion illustrates that ethnomathematics-based instruction is a powerful pedagogical strategy for enhancing students' mathematical communication. It validates students' cultural knowledge, facilitates conceptual understanding, and nurtures expressive competence—key components of high-quality mathematics learning in diverse classroom contexts.

Conclusion

This study concludes that integrating ethnomathematics into primary mathematics instruction significantly enhances students' mathematical communication skills. The experimental group, which engaged with culturally contextualized learning tasks, demonstrated a substantially greater

improvement than the control group, as indicated by a large effect size (Cohen's $d = 1.97$). Ethnomathematical instruction supports conceptual understanding and empowers students to express mathematical ideas using verbal, symbolic, and visual representations. These findings affirm that culturally responsive pedagogy contributes to more equitable and effective mathematics learning by validating students' cultural backgrounds and fostering expressive competence. While the results are promising, the study is limited in scope to two classrooms within a single school. Future research is recommended to involve a broader and more diverse sample, and to incorporate qualitative methods such as classroom observation or interviews to explore the social and verbal aspects of mathematical communication in greater depth.

Declarations

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Conflict of Interest	:	The authors declare that there is no conflict of interest regarding the publication of this paper.
Additional Information	:	Ethical clearance was obtained from the school principal and class teachers prior to data collection. Participation of students in this research was voluntary and based on informed consent, with full assurance of anonymity and confidentiality throughout the study.

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