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Integrating Balinese Cultural Ethnomathematics into Inclusive Mathematics Education to Improve Learning Outcomes

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Abstract
This classroom action research aimed to improve fifth-grade students' learning outcomes on fraction topics through the integration of Balinese ethnomathematics in inclusive mathematics learning. The study was conducted at SD Negeri 3 Petiga, Bali, involving 28 students, including two students with special educational needs (slow learner and autism spectrum). The research followed the Kemmis and McTaggart model and was carried out in two cycles. The intervention integrated Balinese cultural elements such as *endek* fabric motifs, *subak* irrigation systems, and *gebogan* traditional offerings as meaningful contexts for learning fractions. Inclusive approaches were applied through differentiated instruction, visual manipulatives, collaborative learning, and scaffolding techniques to accommodate students' diverse abilities and needs. Data were collected using pre- and post-tests, observation sheets, and documentation. The results indicated a significant improvement in student learning outcomes. In the pre-cycle, classical completeness was only 32.14% with a mean score of 62.4. After the first cycle, it increased to 67.86% (mean score 76.8), and in the second cycle it reached 89.29% (mean score 85.6). Students with special needs also demonstrated notable progress in conceptual understanding and active participation. The findings suggest that integrating ethnomathematics based on Balinese culture within an inclusive learning framework makes mathematics more meaningful, culturally relevant, and accessible to all students. This study contributes to the development of culturally responsive and inclusive mathematics education in primary schools.

Keyword: ethnomathematics, balinese culture, inclusive mathematics learning, fraction material, learning outcomes

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Introduction

Mathematics is one of the fundamental subjects in elementary education that plays a crucial role in developing students' logical thinking, problem-solving skills, and daily life competencies. However, many students still experience difficulties in learning mathematics, particularly in understanding fraction concepts. Fractions are considered one

of the most challenging topics for elementary students because they involve abstract concepts that are often presented without meaningful context (Rahmi & Mytra, 2025).

In the context of Bali, Indonesia, traditional mathematics learning tends to be teacher-centered and less connected to students' cultural background. This condition creates a gap between school mathematics and students' real-life experiences, resulting in low learning motivation and poor academic outcomes. To address this issue, ethnomathematics offers a promising approach by integrating local cultural elements into mathematics instruction, making learning more relevant and meaningful (D'Ambrósio & Knijnik, 2020; Suryandari et al., 2018). Ethnomathematics is the study of mathematical ideas embedded in cultural practices. In Balinese culture, rich mathematical concepts can be found in various traditions, such as geometric patterns in *endek* woven fabrics, proportional systems in *subak* irrigation, symmetrical designs in *gebogan* offerings, and spatial concepts in traditional Balinese architecture (Suryawan & Cahyani, 2024; Diputra et al., 2022). Integrating these cultural elements can bridge the gap between abstract mathematical concepts and students' everyday cultural experiences. Furthermore, inclusive education has become a national priority in Indonesia following the implementation of Permendikbud Number 70 of 2019 concerning inclusive education. However, the implementation of inclusive mathematics learning that combines local cultural wisdom remains very limited, especially in rural elementary schools. Most previous studies on ethnomathematics have focused on general students without specifically addressing the needs of students with diverse abilities, including those with special educational needs (Panglipur & Triayani, 2025; Newnham, 2021).

This classroom action research was conducted to fill this gap by integrating Balinese ethnomathematics into inclusive mathematics learning. The study aimed to improve learning outcomes on fraction material among fifth-grade students at SD Negeri 3 Petiga, Bali. Specifically, this research seeks to answer how the integration of Balinese ethnomathematics in an inclusive learning framework can enhance students' conceptual understanding, engagement, and academic achievement in fractions. The significance of this study lies in its contribution to the development of culturally responsive and inclusive mathematics education. It is expected to provide practical models for teachers in integrating local culture while accommodating student diversity, particularly in Bali and other regions with strong cultural identities.

Method

This study was classroom action research conducted using the Kemmis and McTaggart (1988) model which consisted of planning, action, observation, and reflection stages in each cycle (Khoiriyah & Husamah, 2018). The research was carried out in two cycles at SD Negeri 3 Petiga, Bali, from January to March 2026. The participants of this study were 28 fifth-grade students consisting of 15 males and 13 females. Among them, two students had special educational needs, namely one slow learner and one student with autism spectrum disorder.

The instruments used in this research included a learning outcome test on fraction material, observation sheets, documentation, and field notes. The test consisted of 10 items covering addition, subtraction, multiplication, and division of fractions and had been validated by mathematics education experts. The intervention integrated Balinese ethnomathematics into inclusive mathematics learning. Learning activities utilized local cultural contexts such as *endek* fabric motifs for equivalent fractions, *subak* irrigation systems for addition and subtraction of fractions, and *gebogan* offerings for multiplication and division of fractions. Inclusive strategies applied in this study included differentiated instruction, visual manipulatives, scaffolding, peer tutoring, and flexible grouping to accommodate the diverse learning needs of all students.

Data were collected through three stages: pre-cycle to determine the initial condition, Cycle I, and Cycle II. The fraction learning outcome test was administered before the intervention and at the end of each cycle (Khoiriyah & Husamah, 2018). Classroom observations were conducted by the researcher and a collaborator during every meeting. Qualitative data were obtained from observation sheets and field notes, while documentation was collected in the form of photographs of learning activities and student worksheets. Quantitative data from the tests were analyzed using descriptive statistics, including the calculation of mean scores and the percentage of classical completeness (with a minimum completeness criterion of 75). Meanwhile, qualitative data were analyzed using thematic analysis through data reduction, data presentation, and conclusion drawing. To ensure the trustworthiness of the findings, data triangulation from multiple sources (test results, observation, and documentation) was performed.

Result and Discussion

The implementation of Balinese ethnomathematics integrated with inclusive learning approaches successfully improved students' learning outcomes on fraction material. In the pre-cycle, students' average score was only 62.4, with classical completeness reaching merely 32.14% (9 out of 28 students). Most students had difficulty understanding equivalent fractions and performing fraction operations, while engagement was particularly low among students with special needs.

After Cycle I, there was a noticeable improvement with the average score increasing to 76.8 and classical completeness rising to 67.86% (19 students). In Cycle II, the results further improved significantly, reaching an average score of 85.6 and classical completeness of 89.29% (25 students). Both students with special needs also successfully met the minimum completeness criteria of 75.

Table 1. Improvement of Students' Learning Outcomes on Fraction Material

Description	Pre-cycle	Cycle I	Cycle II
Mean Score	62.4	76.8	85.6
Classical Completeness (%)	32.14	67.86	89.29
Number of Students Completed	9	19	25

The integration of Balinese cultural elements such as *endek* motifs, *subak* systems, and *gebogan* offerings made fraction concepts more concrete and meaningful. Students became more engaged because the learning was connected to their cultural daily lives. Inclusive strategies, including differentiated instruction and visual manipulatives, effectively accommodated the diverse needs of students. However, several challenges were encountered during the implementation (Onyishi & Sefotho, 2020; Schirmer et al., 2023). Time constraints were a major obstacle, as preparing culturally relevant materials required additional effort. Limited authentic cultural resources also posed difficulties, forcing the use of printed images and simplified replicas for some activities. In addition, classroom management in inclusive settings was challenging, particularly in balancing the needs of regular students and those with special educational needs. At the beginning of Cycle I, some students required intensive individual guidance, which occasionally slowed down the learning pace (Pritchett & Beatty, 2015; Bozkurt et al., 2020). Teachers' initial readiness in deeply integrating ethnomathematics with inclusive pedagogy was another limitation.

Despite these challenges, the obstacles were successfully minimized in Cycle II through better time management, improved teaching aids, and more structured student grouping. These findings indicate that although implementing culturally responsive and inclusive mathematics learning is highly beneficial, it demands careful planning, adequate resources, and continuous teacher reflection. The results of this study align with previous research on

ethnomathematics (Rosa et al., 2011) and inclusive education, confirming that culturally relevant teaching increases student motivation and learning outcomes (Anggraeni, Della Putri, 2021;Onyishi & Sefotho, 2020). The novelty of this research lies in its attempt to combine Balinese ethnomathematics with inclusive approaches in an elementary school setting, particularly for fraction material. This study contributes a practical model for teachers in Bali and other regions to create mathematics learning that is both culturally meaningful and equitable for all students.

Additional Classroom Observation Findings

Classroom observations revealed substantial improvements in student engagement and participation throughout the implementation of the ethnomathematics-based inclusive learning activities. During the pre-cycle phase, many students appeared hesitant when solving fraction problems and frequently relied on teacher explanations. Students often perceived fractions as abstract concepts that were disconnected from their daily experiences. In contrast, during Cycle I, students showed greater interest when fraction concepts were introduced through Balinese cultural contexts such as *endek* motifs and *subak* irrigation patterns. Students actively participated in group discussions and demonstrated curiosity by relating mathematical ideas to cultural practices familiar to them (Apriandi, 2023; Jones, 2022).

The observation data from Cycle II indicated further improvements in classroom interaction. Most students were able to explain fraction concepts using examples derived from Balinese culture and participated more confidently in collaborative activities. The use of visual representations and culturally relevant learning materials increased students' motivation and reduced mathematics anxiety. Observers noted that classroom discussions became more student-centered, with learners frequently exchanging ideas and supporting one another during problem-solving activities.

Progress of Students with Special Educational Needs

Particular progress was observed among the two students with special educational needs. The student identified as a slow learner initially experienced difficulty recognizing equivalent fractions and required continuous teacher assistance during the pre-cycle stage. However, after the implementation of visual manipulatives based on *endek* patterns and scaffolded learning activities, the student gradually demonstrated improved conceptual understanding and was able to complete fraction tasks with reduced support. The student's test score increased from 55 in the pre-cycle to 72 in Cycle I and 80 in Cycle II.

Similarly, the student with autism spectrum disorder showed significant progress in classroom participation. At the beginning of the study, the student tended to work independently and rarely engaged in group interactions. Through structured peer tutoring and clearly organized learning activities, the student became more involved in collaborative discussions and demonstrated greater confidence in presenting answers. The student's achievement score improved from 58 in the pre-cycle to 75 in Cycle I and 83 in Cycle II. These findings suggest that combining culturally relevant contexts with inclusive instructional strategies can effectively support diverse learners and promote equitable participation in mathematics classrooms (Salsabilah et al., 2022; Hasibuan & Hasanah, 2022).

Study Limitations

Despite the positive outcomes, several limitations should be acknowledged. First, this study was conducted in a single elementary school with a relatively small number of participants, including only two students with special educational needs. Therefore, the findings may not be generalized to all-inclusive educational settings. Second, the

intervention was implemented over only two action cycles, limiting the opportunity to investigate the long-term effects of ethnomathematics-based inclusive learning on students' mathematical achievement and cultural awareness. Third, the study focused exclusively on fraction material; therefore, further research is needed to examine the effectiveness of this approach in other mathematical topics and educational levels. Future studies involving larger samples, longer intervention periods, and diverse school contexts are recommended to strengthen the evidence regarding the effectiveness of culturally responsive inclusive mathematics education.

Conclusion

This classroom action research concluded that integrating Balinese ethnomathematics into inclusive mathematics learning effectively improved fifth-grade students' learning outcomes on fraction material at SD Negeri 3 Petiga. The average score increased from 62.4 to 85.6, and classical completeness rose significantly from 32.14% to 89.29% after two cycles. Students with special educational needs also demonstrated notable improvement in understanding and participation. The study confirms that contextualizing fraction concepts through Balinese cultural elements (*endek* motifs, *subak*, and *gebogan*) combined with inclusive strategies makes mathematics learning more meaningful and accessible to diverse learners. The findings also demonstrate that students with special educational needs benefited considerably from the integration of Balinese ethnomathematics and inclusive instructional strategies. Classroom observations indicated improvements in participation, communication, and conceptual understanding, suggesting that culturally responsive learning environments can support both academic achievement and social inclusion. This research contributes a practical model for culturally responsive and inclusive mathematics education in elementary schools, particularly in Bali. Future studies are recommended to examine the long-term impact of this approach and extend its application to other mathematics topics.

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