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DEVELOPMENT OF ETHNOMATHEMATICS-BASED TEACHING MATERIALS USING KUE LUMPUR (MUD CAKE) ON FRACTION TOPICS TO IMPROVE NUMERACY AND SELF-EFFICACY OF FOURTH-GRADE STUDENTS

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ABSTRACT

Fourth-grade students in Indonesia consistently struggle with fraction concepts, while existing teaching materials fail to connect mathematics to students' cultural contexts. This study developed and evaluated ethnomathematics-based teaching materials using kue lumpur (a traditional Javanese mud cake) to improve numeracy and self-efficacy among Grade IV students. Employing the ADDIE development model, the materials were implemented with 20 students at SD Muhammadiyah 1-2 Taman Sidoarjo and evaluated against a 15-student comparison class receiving conventional instruction. Expert validation yielded very high scores across material (4.86), media (5.0), and practitioner (5.0) dimensions. Numeracy improved significantly, with mean scores rising from 42.10 (pretest) to 82.25 (posttest), corresponding to an N-Gain of 69.24% and a Wilcoxon test significance of $p = 0.000$. Student self-efficacy reached a class mean of 75.75%, with 90% achieving high or very high ratings. These findings indicate that ethnomathematics-based materials grounded in local cultural objects can substantially improve both numeracy competency and mathematical self-efficacy in elementary education.

Introduction

Indonesian students' numeracy performance remains a persistent concern. PISA 2022 recorded a mathematics score of 366 for Indonesian 15-year-olds, well below the OECD average of 472 (OECD, 2023), while data from the Asesmen Nasional Berbasis Komputer (ANBK) confirm that elementary students continue to struggle

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with foundational numeracy tasks, including conceptual understanding of rational numbers. Between 2018 and 2022, Indonesia's mathematics scores declined by 12 to 13 points(Anjelita & Supriyanto, 2024), underscoring the need for instructional interventions that address numeracy from the elementary level, particularly in fraction learning.

Fraction concepts are among the most cognitively demanding topics in elementary mathematics. Fourth-grade students transitioning from concrete to abstract thinking frequently struggle to conceptualize fractions, particularly when instruction relies solely on procedural explanations without concrete manipulatives or contextual support (Diputra et al., 2023). Classroom observations at SD Muhammadiyah 2 Taman confirmed that 75% of students in class IV-H experienced difficulties identifying, comparing, and determining equivalent fractions, primarily due to the absence of contextually meaningful materials. This points to a fundamental instructional design problem: students cannot build genuine conceptual understanding when mathematical content remains disconnected from their lived experience.

Conventional teaching materials at the elementary level present mathematics in abstract, decontextualized forms that are structurally unable to accommodate local cultural wisdom or regionally specific contexts (Sari et al., 2025), leaving instruction disconnected from students' social realities and diminishing motivation (Siregar et al., 2018). The underutilization of local cultural resources as authentic learning contexts, has allowed this instructional gap to persist for years (Aliyah & Atriyani, 2025). The repetitive and abstractly framed nature of current mathematics instruction has also been associated with declining academic performance and reduced enthusiasm for learning These systemic deficiencies in the instructional environment provide a compelling rationale for the development of culturally grounded, contextually rich teaching materials that can transform mathematics learning from a passive exercise into an active, meaningful experience. Addressing these structural gaps requires a paradigm shift toward learning that places students' cultural identities and everyday experiences at the center of the pedagogical process.

Self-efficacy an individual's belief in their capacity to execute actions required to achieve specific goals is a key predictor of mathematics engagement and performance (Bandura, 1997). Students with high self-efficacy persist through difficult tasks and recover from setbacks, while those with low self-efficacy disengage quickly (Schunk & Pajares, 2022). In mathematics, self-efficacy has been shown to predict achievement more strongly than prior knowledge alone, especially in fraction learning where conceptual demands are high (Munawaroh & Sholikhah, 2022). Teaching materials that create genuine success experiences are therefore essential to supporting both cognitive and affective learning goals.

Ethnomathematics integrates local cultural elements into formal mathematics instruction and has been recognized as an effective strategy for improving numeracy while strengthening cultural identity. The Merdeka Curriculum mandates contextualizing learning within local wisdom (Kemendikbudristek, 2022), creating an institutional basis for this approach. Empirical studies confirm that culturally grounded instruction improves numeracy outcomes by providing personally relevant contexts that support mathematical reasoning (Utami et al., 2026). Wiryanto, Franstito, et al. (2024) further showed that ethnomathematics-based teaching can simultaneously raise numeracy performance and foster positive mathematical dispositions among elementary students.

Kue lumpur, a traditional East Javanese mud cake, offers a culturally appropriate context for fraction instruction among students in the Surabaya metropolitan area. Its round shape provides a natural visual model for fractions, while its preparation involves measurement, proportion, and division that can be integrated into formal instruction (Nurmasari et al., 2023). Cultural familiarity with kue lumpur reduces affective barriers and increases student engagement in mathematics (Dahlan & Permatasari, 2018). Despite the potential of ethnomathematics-based materials and the relevance of local cultural objects like kue lumpur, no prior study has examined their combined effect on both numeracy and self-efficacy in a quasi-experimental design involving a comparison class. This study addresses that gap by developing, validating, and evaluating ADDIE-based teaching materials using kue lumpur as

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a culturally situated fraction learning context, with the explicit aim of improving Grade IV students' numeracy competencies and mathematical self-efficacy simultaneously.

Method

This study employed a Research and Development (R&D) design using the ADDIE model (Analysis, Design, Development, Implementation, Evaluation), integrated with a convergent parallel mixed-methods evaluation. The overall design is best characterized as mixed-methods R&D: the primary aim is instructional product development, while product effectiveness was assessed through a quasi-experimental comparison involving a treatment class (IV-H) and a comparison class (IV-A). The ADDIE framework was selected for its systematic and iterative structure, which integrates formative evaluation at each development stage to ensure alignment between instructional design and learning outcomes (Branch, 2009).In the analysis phase, need assessment was conducted through classroom observations, curriculum review, and student interviews to identify fraction learning difficulties. The design phase determined the module structure, student worksheets, assessment rubrics, and media plans grounded in Bruner's three-stage representation theory (enactive–iconic–symbolic). The development phase produced a mathematics module, website-based visual media, instructional videos, and physical kue lumpur manipulatives, all subjected to expert validation using a five-point rating scale. Following revision, the materials were implemented in one 2 × 35-minute session on February 10, 2026, using a Project-Based Learning model.

The study was conducted at SD Muhammadiyah 1-2 Taman Sidoarjo, East Java, selected due to documented numeracy deficiencies and institutional openness to instructional innovation. The treatment group comprised 20 students in class IV-H, selected through purposive sampling: IV-H was chosen because it exhibited the most pronounced fraction learning difficulties based on pre-study diagnostic assessment and teacher consultation. The comparison group consisted of 15 students in class IV-A, selected on the basis of comparable baseline numeracy scores and similar demographic characteristics, receiving conventional textbook-based instruction during the same period. Numeracy was measured with a five-item constructed-response test aligned with the Kemendikbudristek numeracy framework, assessing students' ability to formulate, apply, and interpret fraction concepts in context. Content validity was confirmed through expert review by two mathematics educators; the instrument achieved a Content Validity Ratio (CVR) of 1.0 across all items. Reliability was estimated using the Kuder–Richardson (KR-20) formula, yielding a coefficient of 0.78, indicating good internal consistency. Self-efficacy was measured using a validated 13-item Likert-scale questionnaire based on Bandura's theoretical framework; Cronbach's alpha for this instrument was 0.81. Due to non-normal distribution of posttest data confirmed by the Shapiro–Wilk test ($p < 0.05$), the Wilcoxon signed-ranks test was applied for pre-post hypothesis testing, and the Mann–Whitney U test was used for between-group comparison. Expert validity was assessed through structured rating forms; practicality was evaluated via learning implementation observation and teacher response questionnaires. The following table presents the complete description of the research design and data collection instruments.

Table 1. Research Design and Data Collection Instruments

Research Component	Description	Data Source	Instrument	Analysis
Validity	Expert assessment of material, media, and practicality dimensions	2 material experts, 1 media expert, 1 practitioner	Structured rating forms (scale 1-5)	Mean score and category conversion

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Research Component	Description	Data Source	Instrument	Analysis
Practicality	Ease of implementation in authentic classroom settings	Teacher and students of class IV-H	Observation sheets and response questionnaires	Percentage of implementation
Numeracy	Pre-post measurement of fraction numeracy competency	20 students, class IV-H, SD Muhammadiyah 2 Taman Sidoarjo	5-item constructed-response test (pretest and posttest)	N-Gain, Shapiro-Wilk, Wilcoxon test
Self-Efficacy	Students' confidence in learning fractions	20 students, class IV-H, post-implementation	13-item Likert-scale questionnaire (1-4)	Mean percentage and category distribution
Comparative Effectiveness	Comparison with conventional instruction class	15 students, class IV-A (control group)	Pretest and posttest scores	Mean gain and percentage comparison

Source: processed by researchers (2026)

Data analysis was conducted through a sequential integration of quantitative and qualitative procedures. Quantitative analysis of numeracy data began with normality testing using the Shapiro-Wilk test, which was appropriate given the small sample size of 20 students. Because the posttest data were not normally distributed (significance value of 0.001 versus the threshold of 0.05), the Wilcoxon signed-ranks test was selected as the non-parametric hypothesis test to evaluate the significance of pre-post differences in numeracy performance. The N-Gain formula was applied to calculate the relative magnitude of improvement from pretest to posttest, with gain categories defined as low for scores below 30 percent, moderate for scores between 30 and 70 percent, and high for scores above 70 percent. Self-efficacy data were analyzed by calculating the percentage of the total score for each student relative to the maximum possible score of 52, and students were then classified into five categories: very high (83 to 100 percent), high (65 to 82 percent), moderate (48 to 64 percent), low (30 to 47 percent), and very low (below 30 percent). Validity data were analyzed by computing the mean rating scores across all aspects for each validator, followed by conversion to verbal categories based on Astuti et al.,(2024)quality criteria. Qualitative data from observations and interviews were analyzed thematically to provide contextual explanation for quantitative findings, following the convergent parallel triangulation approach in which qualitative and quantitative data sets are analyzed independently and then integrated for comprehensive interpretation.

RESULT AND DISCUSSION

The results of this study are organized around the four research questions: (1) the process of developing ethnomathematics-based teaching materials using kue lumpur, (2) the feasibility of the materials in terms of validity, practicality, and effectiveness, (3) the improvement in students' numeracy skills, and (4) the status of students' self-efficacy following the implementation of the developed materials.

Development Process through the ADDIE Stages

The development of teaching materials proceeded systematically through the five stages of the ADDIE model. During the Analysis stage, classroom observations at the comparison class (IV-A) on October 20, 2025, revealed that only 5 out of 10 instructional steps were implemented satisfactorily, indicating significant gaps in the

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quality of conventional fraction instruction. Student interviews confirmed that conceptual understanding of equivalent fractions and fraction comparison remained particularly problematic, and that students responded positively to concrete, hands-on learning experiences. In the Design stage, the module structure was organized around Bruner's representational theory, beginning with enactive engagement through physical manipulation of kue lumpur, progressing to iconic representation through visual documentation, and culminating in symbolic representation through formal fraction notation. The Development stage produced four core instructional components: a mathematics teaching module, a website-based visual media platform containing historical information and interactive quizzes, instructional videos demonstrating kue lumpur preparation, and physical kue lumpur manipulatives for hands-on exploration. Following expert validation and revision, the Implementation stage was conducted with 20 students in class IV-H using a Project-Based Learning model, during which students created plasticine replicas of kue lumpur, performed fraction-related cutting activities, and participated in a simulated buying-and-selling scenario. The Evaluation stage culminated in the triangulated analysis of validity, practicality, and effectiveness data as presented in the following sections.

Validity of Teaching Materials

Table 2. Expert Validation Results for Teaching Materials

Instrument / Aspect	Expert 1 Score	Expert 2 Score	Mean Score	Category
Material Validity (overall)	4.75	4.98	4.86	Very Good
Content alignment with curriculum	5.00	5.00	5.00	Very Good
Accuracy of mathematical concepts	5.00	4.90	4.95	Very Good
Media Validity (visual design, technical quality)	5.00	-	5.00	Very Good
Practitioner Validity (implementability)	5.00	-	5.00	Very Good
Numeracy Test Instrument	5.00	4.80	4.90	Very Good
Self-Efficacy Questionnaire	5.00	5.00	5.00	Very Good

Source: processed by researchers (2026)

Table 2 presents the validity results for all instructional components evaluated during the Development stage. The material validity score of 4.86 out of 5.0 reflects expert consensus on the accuracy of mathematical content, the appropriateness of the ethnomathematical context, and the coherence of the instructional design with the Merdeka Curriculum. Both the media expert and the educational practitioner assigned maximum scores of 5.0, confirming that the visual design, technical quality, and implementability of the materials met the highest standards. All five instructional instruments, including the teaching module, numeracy test, self-efficacy questionnaire, observation sheet, and media platform, received validity scores in the very good category, establishing a strong foundation for the subsequent implementation phase.

Practicality and Numeracy Improvement Results

The implementation of the teaching materials in class IV-H was assessed through structured observation across three dimensions: the completeness of instructional step implementation, student learning behaviors, and teacher-student interaction quality. All three dimensions received a rating of very good, with all 10 planned instructional steps, all 5 student behavior indicators, and all 5 teacher-student interaction indicators fully realized

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during the session. This represents a dramatic improvement from the baseline observation in the comparison class, where only 5 out of 10 instructional steps were implemented.

Table 3. Pretest, Posttest, and N-Gain Scores for Numeracy in Class IV-H

Student	Pretest	Posttest	Gain	N-Gain (%)	Category
PD 1	42	90	48	82.76	High
PD 2	57	90	33	76.74	High
PD 3	55	83	28	62.22	Moderate
PD 4	53	83	30	63.83	Moderate
PD 5	50	88	38	76.00	High
PD 6	42	83	41	70.69	High
PD 7	42	82	40	68.97	Moderate
PD 8	32	83	51	75.00	High
PD 9	33	80	47	70.15	High
PD 10	42	90	48	82.76	High
PD 11	42	73	31	53.45	Moderate
PD 12	25	80	55	73.33	High
PD 13	52	83	31	64.58	Moderate
PD 14	33	83	50	74.63	High
PD 15	37	77	40	63.49	Moderate
PD 16	33	80	47	70.15	High
PD 17	40	80	40	66.67	Moderate
PD 18	42	57	15	25.86	Low
PD 19	42	90	48	82.76	High
PD 20	48	90	42	80.77	High
Mean	**42.10**	**82.25**	**40.15**	**69.24**	**Moderate**

Source: processed by researchers (2026)

Table 3 presents the complete numeracy score data for all 20 students in the implementation class. The mean pretest score of 42.10, corresponding to the 'sufficient' category, increased to 82.25 at posttest, classified as 'very good'. All 20 students experienced score increases without exception. The greatest individual gain was recorded by PD 12 (55 points), who entered the study with the lowest pretest score of 25. The mean N-Gain of 69.24% falls within the moderate category, with 12 students achieving high N-Gain scores above 70%, 7 students achieving moderate gains, and only one student falling in the low category. The following table presents the statistical test results confirming the significance of this improvement.

Table 4. Normality, Homogeneity, and Wilcoxon Test Results for Numeracy Data

Statistical Test	Statistic Value	Significance (p)	Decision	Interpretation
Shapiro-Wilk (Pretest)	0.950	0.371	$p > 0.05$	Normal distribution
Shapiro-Wilk (Posttest)	0.792	0.001	$p < 0.05$	Non-normal distribution

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Statistical Test	Statistic Value	Significance (p)	Decision	Interpretation
Levene's Test (Homogeneity)	0.557	0.460	p > 0.05	Homogeneous variance
Wilcoxon Signed-Ranks Test	Z = -3.923	0.000	p < 0.05	H0 rejected; significant improvement

Source: processed by researchers (2026)

The Wilcoxon test result (Z = -3.923, p = 0.000) provides definitive statistical evidence that the improvement in numeracy scores from pretest to posttest was highly significant. All 20 students showed positive ranks, meaning every student performed better on the posttest than the pretest, with no ties or negative ranks recorded. The comparison between the implementation class and the conventional class further confirms the superior effectiveness of the ethnomathematics-based approach, as shown in the following comparative analysis table.

Table 5. Comparative Numeracy Results: Implementation Class vs. Conventional Class

Class	Mean Pretest	Mean Posttest	Mean Gain	% Improvement
Conventional Class IV-A (n=15)	42.27	53.93	11.67	28%
Implementation Class IV-H (n=20)	42.10	82.25	40.15	95%
Difference	**0.17**	**28.32**	**28.48**	**67%**

Source: processed by researchers (2026)

Table 5 demonstrates that while both classes entered the study with nearly identical mean pretest scores (42.27 and 42.10 respectively), the implementation class achieved a posttest mean of 82.25, compared to only 53.93 in the conventional class. The percentage of improvement in the implementation class (95 percent) exceeded that of the conventional class (28 percent) by 67 percentage points, providing compelling evidence of the differential effectiveness of the developed teaching materials.

Self-Efficacy Results

Table 6. Distribution of Self-Efficacy Scores in Class IV-H Following Implementation

Score Range (%)	Category	Number of Students	Percentage	Cumulative %
83-100	Very High	5	25%	25%
65-82	High	13	65%	90%
48-64	Moderate	2	10%	100%
30-47	Low	0	0%	-
13-29	Very Low	0	0%	-
Total	-	**20**	**100%**	-

Source: processed by researchers (2026)

Table 6 presents the distribution of self-efficacy scores among the 20 implementation class students following the learning session. The mean self-efficacy score of 75.75% places the class in the high category. Ninety percent of students (18 out of 20) achieved either high or very high self-efficacy ratings, while no student fell into the low or very low categories. The highest individual score was recorded by PD 15 at 90%, and the lowest by PD 18 at 58%.

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Discussion

The systematic development of ethnomathematics-based teaching materials through the five ADDIE stages produced a structured, culturally grounded, and pedagogically coherent instructional product that addressed critical gaps in conventional fraction teaching. The analysis phase revealed that conventional instruction in the comparison class was characterized by the absence of concrete manipulatives, minimal contextual connection to students' daily lives, and low student engagement, mirroring patterns documented in prior research on elementary mathematics instruction in Indonesia (Sari et al., 2025). The decision to anchor the teaching materials in kue lumpur as an ethnomathematical context was validated by the analysis findings, which confirmed students' familiarity with and positive affective response to this locally significant food object. The design choices grounded in Bruner's representational theory ensured that the materials scaffolded learning through enactive, iconic, and symbolic stages, a sequence shown by research to be particularly effective for teaching abstract concepts such as fractions to students in the concrete operational stage (Puspita, 2023)The comprehensive validation process involving multiple expert types ensured that the materials met rigorous content, design, and implementability standards before deployment, consistent with best practices in instructional design for educational research (Diputra et al., 2023). The resulting teaching materials represent a synthesis of theoretical grounding, cultural authenticity, and practical pedagogical design that has rarely been achieved in prior ethnomathematics research focused on single cultural objects.

The very high validity scores obtained across all three categories of expert assessment confirm that the developed teaching materials meet the quality standards required for effective classroom use. The mean material validity score of 4.86 reflects expert judgment that the fraction content is accurately represented, pedagogically appropriate for fourth-grade students, and effectively integrated with the ethnomathematical context of kue lumpur (Astuti et al., 2024). The perfect scores of 5.0 assigned by the media expert and the educational practitioner indicate that the visual design, interactive features, and practical implementability of the materials surpass the threshold of excellence, a finding consistent with the rigorous iterative revision process that was applied in response to expert feedback (Adiningsih et al., 2023)The validity of all instructional instruments, including the numeracy test, self-efficacy questionnaire, and observation sheets, is particularly significant because it establishes the measurement quality of the study's outcome variables and ensures that improvements in scores reflect genuine learning gains rather than measurement artifact. This level of validation rigor is in accordance with the quality criteria framework proposed by (Astuti et al., 2024), which posits that instructional materials must satisfy the triple criteria of validity, practicality, and effectiveness to be considered of high educational quality. Prior ethnomathematics development studies have reported similarly high validity scores when materials were co-developed with domain experts and subjected to multiple rounds of revision (Dahlan & Permatasari, 2018). The achievement of very good ratings across all validation categories in the present study therefore represents a methodologically sound basis for attributing the observed learning gains to the quality of the instructional design.

The complete implementation of all planned instructional steps confirmed by observation data showing a perfect score of 10 out of 10 for learning step completion indicates that the developed materials are both theoretically sound and practically executable within a real classroom. By comparison, the conventional class (IV-A) completed only half of its planned instructional steps, suggesting a practical advantage of using structured, well-designed materials. Student learning behaviors in the treatment class received very good ratings across active participation, collaborative engagement, and confidence in communicating mathematical ideas, consistent with the view that culturally familiar contexts reduce affective barriers to mathematical engagement (Zainovi et al., 2025). Teacher response data confirmed that the materials were intuitive to use and well-matched to classroom needs. These practicality findings align with those of (Fatma & Samosir, 2023; Harahap & Fauzi, 2023)who reported that locally

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contextualized materials achieve high practicality ratings and are readily adopted without extensive prior training. These results are encouraging, though the single-session implementation limits claims about sustained usability.

The statistically significant improvement in numeracy scores, confirmed by the Wilcoxon test result of Z = -3.923 and a significance value of 0.000, provides compelling evidence that the ethnomathematics-based teaching materials effectively improved students' mathematical competencies in the domain of fractions. The increase in mean scores from 42.10 at pretest to 82.25 at posttest represents a gain of over 40 points, corresponding to a 95 percent improvement rate that substantially exceeds the 28 percent improvement recorded in the conventional class over the same period. The average N-Gain of 69.24%, while categorized as moderate rather than high, is nonetheless consistent with the results reported in comparable single-session intervention studies, where full mastery gains are rarely achieved within the constraints of limited instructional time (Brahmana & Suwanto, 2023)The fact that every single student in the implementation class showed improvement, including those who began with the lowest pretest scores, underscores the inclusive effectiveness of the cultural context in reducing learning disparities that are commonly observed in abstract mathematics instruction. This universality of impact across ability levels aligns with the theoretical claim that culturally relevant contexts reduce the cognitive load associated with abstract concept formation by providing accessible entry points for learners at all proficiency levels (Adiningsih et al., 2023)The 67-percentage-point difference in improvement rates between the two classes provides a robust comparative basis for concluding that the ethnomathematics-based approach is substantially more effective than conventional instruction for teaching fraction concepts to fourth-grade students.

The theoretical explanation for the observed numeracy gains is grounded in the alignment between the instructional design of the developed materials and established cognitive and constructivist learning theories. Bruner's representational theory was operationalized through a progression that began with students physically manipulating kue lumpur and plasticine replicas (enactive), proceeded to visual documentation and labeling of fraction representations on worksheets (iconic), and culminated in the formalization of fraction notation and problem-solving (symbolic). This sequence mirrors the conceptual bridging process described in constructivist accounts of fraction learning, wherein the connection between concrete experience and abstract symbol provides the scaffolding necessary for deep conceptual understanding rather than procedural imitation. The Project-Based Learning model further enhanced numeracy development by situating fraction concepts within an authentic task context, specifically the designing, making, and pricing of kue lumpur portions, which required students to apply fraction knowledge purposefully and communicatively. This approach is consistent with the numeracy framework of (Kemendikbudristek, 2021), which defines numeracy as the ability to formulate, apply, and interpret mathematical reasoning in real-life contexts, and with the findings of Mariana et al.,(2023)who demonstrated that contextually anchored problem-solving tasks produce superior numeracy outcomes compared to decontextualized computation exercises. The use of kue lumpur as the connecting cultural object was particularly effective in the Sidoarjo context, where students' familiarity with the food created immediate relevance and personal identification with the mathematical content being studied.

The high self-efficacy outcomes observed following the implementation session can be theoretically explained through (Bandura, 1997) four-source model of self-efficacy development, which identifies mastery experiences, vicarious learning, social persuasion, and physiological states as the primary mechanisms through which self-efficacy beliefs are formed and strengthened. The hands-on manipulation of kue lumpur, combined with collaborative group activities and classroom presentations, provided students with multiple authentic success experiences that serve as the most potent source of self-efficacy according to Bandura's framework. When students successfully divided kue lumpur into equal portions and correctly identified the resulting fractions, they accumulated evidence of their own mathematical competence that directly reinforced their belief in their ability to perform similar tasks in the future. The group-based learning structure also facilitated vicarious learning, as students observed their peers successfully completing fraction tasks and inferred from these observations that they too were capable of

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comparable performance (Zimmerman, 2000). The supportive and encouraging classroom atmosphere maintained by the teacher provided the social persuasion component, while the manageable level of task difficulty, carefully calibrated through the validation and design process, ensured that students experienced the positive emotional states associated with productive engagement rather than anxiety or frustration. The fact that 90 percent of students achieved high or very high self-efficacy ratings, with no student falling below the moderate category, suggests that the combined effect of these four sources was remarkably powerful and broad in its reach (Cahayaningsih et al., 2023)

The relationship between the observed improvements in numeracy and self-efficacy is consistent with the substantial body of research documenting a positive bidirectional association between these two constructs among elementary school students. Studies by Ningrum & Leonard, (2015) have established that self-efficacy contributes meaningfully to numeracy performance, with self-efficacy explaining between 20 and 51 percent of variance in numeracy outcomes among primary school students across diverse cultural contexts. In the present study, the concurrent development of both constructs through a single ethnomathematically grounded intervention suggests that culturally responsive teaching materials can serve as a dual-purpose pedagogical tool that simultaneously addresses cognitive skill development and affective competency building. Masitoh & Fitriyani, (2018)specifically identified the role of self-efficacy in sustaining students' persistence and critical thinking during numeracy challenges, a dynamic that appears to have been activated by the kue lumpur learning context in this study. The present findings extend this theoretical understanding by demonstrating that the positive self-efficacy environment created through ethnomathematical instruction not only boosts immediate motivation but also translates into measurable improvements in mathematical performance. This dual impact provides strong empirical justification for incorporating local cultural contexts into the design of mathematics teaching materials at the elementary level.

The limitations of this study are important to acknowledge in contextualizing the generalizability and scope of the reported findings. The research was conducted at a single school with only 20 students in the implementation class, a sample size that, while appropriate for a development study, does not allow the results to be generalized to all fourth-grade student populations in Indonesia or beyond the specific cultural context of East Java (Nur et al., 2025). The implementation was confined to a single session of 70 minutes, which is insufficient for observing the long-term retention of numeracy gains or the durability of self-efficacy improvements over time. The absence of a pretest for the self-efficacy questionnaire precluded the calculation of a quantitative self-efficacy gain score comparable to the N-Gain computed for numeracy, making it impossible to establish the precise magnitude of self-efficacy change attributable to the intervention. Furthermore, the cultural specificity of kue lumpur as an instructional context, while a pedagogical strength in the Sidoarjo context, may require contextual adaptation for implementation in other regions of Indonesia or in culturally different educational environments. Future research should address these limitations by conducting multi-site studies with larger and more diverse student samples, incorporating longitudinal follow-up measurements, designing matched pre-post self-efficacy assessments, and exploring the adaptation of ethnomathematical contexts from other regional food cultures to extend the reach of this instructional approach.

CONCLUSION

This study has demonstrated that ethnomathematics-based teaching materials developed using kue lumpur as a culturally situated context for fraction learning can significantly improve the numeracy competencies of fourth-grade elementary students. The materials developed through the five-stage ADDIE model achieved very high validity ratings from material experts, media experts, and educational practitioners, confirming their content accuracy, instructional coherence, and practical implementability. The numeracy improvement from a mean pretest score of 42.10 to a mean posttest score of 82.25, representing a 95 percent improvement rate and a statistically significant Wilcoxon result of $p = 0.000$, provides compelling evidence that the integration of local cultural wisdom into formal mathematics

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instruction can produce substantial learning gains that far exceed those achievable through conventional instructional approaches.

The finding that 90% of students achieved high or very high self-efficacy ratings following a single implementation session, with a class mean of 75.75%, indicates that ethnomathematics-based instruction can support positive academic self-belief alongside mathematical competence development. The kue lumpur context appeared effective in creating success experiences and fostering collaborative engagement, consistent with the broader literature on culturally situated learning. Together, these results support the value of locally grounded teaching materials as a promising approach to elementary mathematics education in Indonesia, although the limited sample size and single-session design suggest that broader and longer-term evaluations are needed before definitive conclusions can be drawn.

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