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Effectiveness of ethnomathematics-based gasing in enhancing elementary students' multiplication mastery and mathematics learning motivation

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ABSTRACT

This study aimed to evaluate the feasibility and effectiveness of an ethnomathematics-based Gasing method for improving elementary students' multiplication mastery and mathematics learning motivation. A Design and Development approach using the 4D model was employed. Three experts assessed feasibility, while limited and field trials involved 10 and 30 third-grade students, respectively. Data were collected through validation sheets, pretest–posttest assessments, and motivation questionnaires and analyzed using descriptive statistics, N-Gain, and Pearson correlation. Results showed a feasibility score of 4.39. The limited trial yielded an N-Gain of 0.69 and motivation score of 3.63, while the field trial produced an N-Gain of 0.72 and motivation score of 3.54. Learning motivation was moderately correlated with improved multiplication mastery (r = 0.48). The findings demonstrate that ethnomathematics-based Gasing is a feasible and effective approach for strengthening multiplication mastery and fostering mathematics learning motivation among elementary students.

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Introduction

Mastery of basic multiplication concepts constitutes a fundamental component of mathematics learning in elementary education because it provides an essential foundation for understanding more advanced mathematical concepts, including division, fractions, ratios, measurement, and mathematical problem-solving (Suryandari, 2025). Effective multiplication instruction should therefore extend beyond the memorization of multiplication facts and promote students' conceptual understanding of repeated addition, equal grouping, numerical relationships, and connections among arithmetic operations (Johnson & Smith, 2023). Alongside conceptual mastery, learning motivation plays a critical role in determining students' engagement, persistence, willingness to employ diverse problem-solving strategies, and confidence when encountering mathematical challenges (Fitriani et al., 2025). Consequently, multiplication mastery and learning motivation represent interconnected cognitive and affective dimensions that should be developed simultaneously to establish meaningful and sustainable mathematics learning experiences.

Despite their importance, numeracy and mathematical conceptual understanding remain persistent challenges in Indonesian education. The 2022 Programme for International Student Assessment (PISA) reported that Indonesian students achieved a mathematics score of 366, substantially below the OECD average of 472 (OECD, 2023). Although PISA does not specifically assess elementary students' multiplication mastery, these findings highlight broader challenges concerning mathematical reasoning and the application of conceptual knowledge. Similar concerns are evident at the regional level, where the 2024 Education Report Card of Buton Regency indicated that 59.84% of elementary students had achieved or exceeded the minimum numeracy competency, whereas 40.16% remained below the expected standard. These conditions underscore the need to strengthen fundamental arithmetic competencies, particularly multiplication, because insufficient mastery of foundational concepts may constrain students' subsequent mathematical development.

These challenges are closely associated with instructional practices that continue to emphasize procedural explanations, textbook-based activities, and memorization rather than conceptual exploration and meaningful learning experiences (Ocsis et al., 2024; Putra et al., 2024; Sutrisno et al., 2023). Elementary students, who generally operate within the concrete operational stage, require tangible objects, visual representations, manipulative activities, and experiences connected to everyday situations to facilitate their transition toward abstract mathematical reasoning (Piaget, 1970). Monotonous instruction and limited opportunities for concrete exploration may consequently reduce students' engagement and mathematics learning motivation (Ariyanti et al., 2025; Davis et al., 2023; Rohimah & Anaya, 2024). This pedagogical concern is particularly relevant to the implementation of the Merdeka Curriculum, which emphasizes student-centered, contextual, and meaningful learning, although teachers continue to encounter challenges in designing instructional practices that effectively accommodate students' characteristics, needs, and learning experiences (Rahmawati & Yuliana, 2024).

The Gasing method (Gampang, Asyik, dan Menyenangkan, meaning Easy, Fun, and Enjoyable) provides a potential pedagogical response to these challenges by organizing mathematics learning through simple, gradual, active, and enjoyable stages. It facilitates students' progression from concrete experiences toward abstract representations and mental calculation, thereby supporting conceptual understanding rather than merely procedural accuracy (Hartono, 2021; Taylor & Robinson, 2023). However, meaningful mathematics learning also requires connections between mathematical concepts and students' sociocultural experiences. Ethnomathematics provides such a framework by situating mathematical ideas within cultural practices, traditional games, artifacts, community activities, and locally meaningful patterns (Rosa & Gavarrete, 2022). Culturally contextualized mathematics can make abstract concepts more familiar and meaningful while promoting student engagement and learning motivation (Mutiarani & Kurniawati, 2024). In Buton Regency, this potential is represented by the traditional congklak game known locally as kabhawa-bhawa, which involves grouping, distribution, repeated addition, and numerical patterns, as well as traditional woven textile motifs containing repetitive patterns and quantitative relationships relevant to mathematics learning (Sari et al., 2024; Hafsyim & Murlianti, 2025; Safitri et al., 2022).

Integrating the Gasing method with ethnomathematics may therefore provide complementary pedagogical advantages: Gasing offers structured progression from concrete activities to abstract and mental calculation, whereas ethnomathematics provides culturally meaningful contexts through which mathematical concepts can be explored. Nevertheless, previous studies have predominantly investigated the benefits of Gasing and ethnomathematics separately, leaving limited empirical evidence concerning their systematic integration for elementary multiplication instruction. In particular, research examining both the feasibility and effectiveness of an ethnomathematics-based Gasing method remains limited, especially when local Buton cultural resources such as kabhawa-bhawa and traditional woven textile motifs are incorporated into the instructional process. The research gap therefore lies not simply in applying culturally contextualized mathematics or the Gasing method independently, but in establishing an integrated instructional design capable of simultaneously addressing conceptual multiplication mastery and mathematics learning motivation.

Accordingly, the novelty of this study lies in the systematic integration of Gasing instructional stages with local ethnomathematical contexts within a unified learning design that simultaneously targets students' cognitive and motivational outcomes. Unlike approaches centered primarily on procedural multiplication practice, the proposed method incorporates culturally familiar experiences into concrete, abstract, and mental-calculation learning processes, thereby positioning local wisdom as an integral pedagogical resource rather than merely supplementary learning content. Based on this framework, this study aims to analyze the feasibility and effectiveness of an ethnomathematics-based Gasing method in improving elementary school students' mastery of basic multiplication concepts and mathematics learning motivation. Feasibility is evaluated through expert validation, whereas effectiveness is examined through improvements in multiplication mastery and students' learning motivation. The findings are expected to advance culturally responsive elementary mathematics instruction by providing an empirically grounded approach that is concrete, contextual, engaging, and rooted in local wisdom.

Method

Research Design

This study employed a Design and Development (D&D) approach using the 4D development model, comprising four sequential stages: Define, Design, Develop, and Disseminate (Thiagarajan et al., 1974; Ibrahim & Suardiman, 2021). This approach was selected because it provides a systematic framework for identifying instructional needs, designing and refining educational interventions, and evaluating their feasibility and effectiveness. The instructional product developed in this study was an ethnomathematics-based Gasing method for teaching basic multiplication. The method integrated the structured learning stages of Gasing with local cultural contexts to facilitate conceptual understanding and promote students' motivation toward mathematics learning.

Research Setting and Participants

The study was conducted in Buton Regency, Southeast Sulawesi Province, Indonesia, in December 2025. The developmental testing was implemented in two phases. The limited-scale trial was conducted at SD Negeri 34 Buton from December 8–10, 2025, involving 10 third-grade students purposively selected to represent high, moderate, and low academic achievement levels. Following product refinement, the field trial was conducted at SD Negeri 21 Buton with 30 third-grade students. In addition to student participants, three expert validators were involved in the development process, comprising two mathematics education experts and one learning motivation expert. The experts evaluated the feasibility of the developed instructional method and the appropriateness of the research instruments prior to field implementation.

Development Procedure

The development process followed the four stages of the 4D model. During the Define stage, needs analysis, student-characteristic analysis, task and concept analysis, identification of relevant local cultural resources, and formulation of learning objectives were conducted to establish the conceptual foundation of the instructional method. The Design stage focused on constructing the prototype of the ethnomathematics-based Gasing method, preparing research instruments, selecting appropriate instructional media, and organizing the structure and sequence of learning activities. During the Develop stage, the prototype underwent expert validation and revision before being implemented in the limited-scale trial. Feedback and empirical findings from this trial were subsequently used to refine the instructional product. Finally, the Disseminate stage involved field implementation, evaluation of the refined method, collection of feedback, and dissemination of the development outcomes. This iterative process ensured that revisions were informed by both expert judgment and empirical evidence obtained during implementation.

Research Instruments

Three primary instruments were employed. First, expert validation sheets were used to evaluate the feasibility of the instructional method and the appropriateness of the achievement test and learning motivation questionnaire. Second, students' multiplication concept mastery was assessed using pretest and posttest instruments consisting of eight open-ended questions, developed based on five indicators of conceptual mastery (Astuti & Lestari, 2020; Utami & Yuliana, 2023). Third, mathematics learning motivation was measured using a 10-item questionnaire representing five motivational indicators (Putra et al., 2022; Rahmawati & Hidayat, 2023; Sari & Wibowo, 2021). Responses were recorded on a four-point Likert scale accompanied by age-appropriate emoji representations to facilitate comprehension among elementary school students. Together, these instruments captured the feasibility of the developed method as well as students' cognitive and motivational outcomes.

Data Collection

Both qualitative and quantitative data were collected throughout the development and evaluation processes. Qualitative data were obtained through interviews, classroom observations, and written feedback from expert validators and were primarily used to identify weaknesses in the initial prototype and inform subsequent revisions. Quantitative data were obtained from expert validation scores, pretest and posttest assessments of multiplication concept mastery, and learning motivation questionnaire responses. The pretest was administered before implementation of the developed method, whereas the posttest and motivation questionnaire were administered following the instructional intervention. Data obtained from the limited-scale trial informed product refinement before implementation in the larger field trial.

Data Analysis

Qualitative data obtained from observations, interviews, and expert feedback were analyzed through data reduction, data display, and conclusion drawing (Miles et al., 2014). Quantitative data were initially analyzed using descriptive statistics to summarize expert validation scores, students' multiplication concept mastery, and learning motivation. Improvement in multiplication mastery from pretest to posttest was evaluated using the Normalized Gain (N-Gain):

$$N\text{-Gain} = \frac{\text{Posttest Score} - \text{Pretest Score}}{\text{Maximum Score} - \text{Pretest Score}}$$

N-Gain values were interpreted according to Hake (1999), with scores of ≥ 0.70 classified as high, 0.30–0.69 as moderate, and < 0.30 as low. In addition, the relationship between mathematics learning motivation and improvement in multiplication mastery was examined using the Pearson product–moment correlation, with students' N-Gain scores representing improvement in conceptual mastery. This analysis was used to determine the direction and magnitude of the association between learning motivation and gains in multiplication mastery following implementation of the ethnomathematics-based Gasing method.

Results and Discussions

Feasibility of the Gasing Method with an Ethnomathematics Approach

The expert validation results showed an overall mean score of 4.39, categorized as Feasible. Validator 1 assigned a score of 4.0 (Good) for the learning module, Validator 2 assigned a score of 5.0 (Very Good), and Validator 3 assigned a score of 4.57 (Very Good) for the learning motivation questionnaire. Based on the validators' suggestions, the module content was enriched with contextual examples derived from the local culture of Buton.

Table 1. Expert Validation Results

No.	Assessed Aspect	Validator 1	Validator 2	Validator 3	Mean
1	Feasibility of Module Content/Materials	4.0	5.0	–	4.5
2	Ethnomathematics Approach	4.0	5.0	–	4.5
3	GASING Method	4.0	5.0	–	4.5
4	Language and Readability	4.0	5.0	–	4.5
5	Learning Achievement Test Instrument	4.0	–	–	4.0
6	Learning Motivation Questionnaire	–	–	4.57	4.57
	Overall Mean				4.39 (Feasible)

Effectiveness of the Gasing Method in Improving Mastery of Basic Multiplication Concepts

The limited-scale trial (n = 10) produced a mean pretest score of 39.3 and a mean posttest score of 80.0, with a mean N-Gain of 0.69, categorized as Moderate. The field trial (n = 30) produced a mean pretest score of 52.0 and a mean posttest score of 85.6, with a mean N-Gain of 0.72, categorized as High. An improvement in effectiveness was observed following the revision.

Table 2. Distribution of N-Gain Categories in the Field Trial

Category	N-Gain	Number of Students	Percentage
High	≥ 0.7	16	53.3
Moderate	0.3 ≤ N-Gain < 0.7	10	33.3%
Low	< 0.3	4	13.3%
Total		30	100%
Mean N-Gain	0.72 (High)		

Effectiveness of the Gasing Method in Improving Mathematics Learning Motivation

The results of the learning motivation questionnaire in the field trial showed a mean score of 3.55, categorized as Very High. The indicator of desire and aspiration to succeed obtained the highest score (3.85).

Table 3. Results of the Learning Motivation Questionnaire by Indicator

No.	Indicator	Mean Score	Category
1	Desire and Aspiration to Succeed	3.85	Very High
2	Drive and Need for Learning	3.40	High
3	Engaging Learning Activities	3.62	Very High
4	Persistence in Completing Tasks	3.42	High
5	Perseverance in Facing Difficulties	3.48	High
	Mean	3.55	Very High

Correlation between Learning Motivation and Concept Mastery

The results of the Pearson correlation analysis showed a moderate positive relationship (r = 0.48) between learning motivation and improvement in conceptual mastery, as measured by N-Gain.

Table 4. Correlation between Learning Motivation and N-Gain

Variable	Mean	Correlation (r)	Interpretation
Learning Motivation	3.54	0.48	Moderate positive correlation
N-Gain	0,72		

The findings demonstrate that the ethnomathematics-based Gasing method achieved an overall expert-validation score of 4.39, indicating that the developed instructional approach was feasible for implementation in elementary mathematics learning. This result supports Sitompul (2025), who reported that integrating Gasing with ethnomathematics can produce a feasible instructional product following systematic expert evaluation, and reinforces the importance of expert validation in establishing instructional quality prior to classroom implementation (Hastuti et al., 2024). The involvement of two mathematics education experts and one learning motivation expert provided complementary perspectives on content, pedagogy, and affective measurement, reflecting the principle of triangulation proposed by Denzin (1978). The feasibility of the method was also reflected in its alignment with the self-instructional, self-contained, stand-alone, adaptive, and user-friendly principles of instructional material development (Prastowo, 2015). These characteristics were evident in students' ability to follow learning instructions independently, the completeness of multiplication content, the use of the module without supplementary materials, differentiated exercises and remedial activities, and positive teacher and student responses regarding usability. Importantly, the incorporation of congklak and woven textile motifs extended feasibility beyond technical usability by embedding mathematical learning within culturally meaningful experiences, thereby connecting instructional design with students' local cultural identity.

Regarding cognitive outcomes, the increase in mean N-Gain from 0.69 in the limited-scale trial to 0.72 in the field trial suggests that refinement following initial implementation strengthened the instructional quality of the developed method. This iterative improvement is consistent with the 4D development framework, in which empirical feedback and revision constitute essential mechanisms for optimizing an educational product (Thiagarajan et al., 1974). The observed improvement can also be interpreted through the instructional sequence of the Gasing method, which progressively moves students through concrete, abstract, and mental-calculation stages (Hartono, 2021). At the concrete stage, the traditional congklak (kabhawa-bhawa) game enabled multiplication to be represented through the physical grouping and distribution of objects, allowing students to experience multiplication as repeated addition rather than as an isolated symbolic procedure. Such experiences are consistent with Piaget's (1970) concrete operational framework and with the argument of Rohimah and Anaya (2024) that elementary mathematics instruction should provide concrete experiences before introducing symbolic representations. Thus, the improvement in multiplication mastery may reflect the pedagogical value of sequencing mathematical experiences from tangible manipulation toward increasingly abstract reasoning rather than relying primarily on memorization.

The transition from concrete manipulation to mathematical abstraction was further facilitated through the use of Wabula woven textile motifs. Students identified recurring visual patterns, determined the number of motifs and rows, and subsequently represented these relationships as multiplication expressions. This progression corresponds to Bruner's (1966) enactive, iconic, and symbolic modes of representation: manipulating congklak seeds provided an enactive experience, interpreting woven motifs provided an iconic representation, and constructing multiplication expressions represented symbolic reasoning. The mathematical and philosophical properties embedded within Wabula weaving further support its relevance as a culturally situated instructional resource (Asni, Alam, & Bahari, 2023; Hanapi, Usman, & Said, 2022). The subsequent mental-calculation stage strengthened this progression through additional practice time, strategy guidance, question cards, and mathematical games. Repeated practice is particularly important for developing fluency in mental calculation (Lestari & Rahayu, 2024; Wulandari & Prasetyo, 2025), while organizing multiplication patterns into meaningful units is consistent with Miller's (1956) concept of chunking. Moreover, the incorporation of game-based activities may support mathematical problem-solving while reducing the monotony associated with repetitive calculation practice (Anderson & Garcia, 2024). Collectively, these mechanisms indicate that the method connects cultural experience, visual representation, symbolic understanding, and computational fluency within a coherent learning sequence.

Beyond cognitive improvement, the field trial produced a mean mathematics learning motivation score of 3.55, categorized as very high, with all participating students classified within the high or very-high motivation categories. The strongest motivational dimension was students' desire and aspiration to succeed, suggesting that the instructional experience encouraged achievement-oriented engagement. This finding is consistent with

McClelland's (1987) theory of achievement motivation, which identifies the need for achievement as an important driver of goal-directed behavior. The learning design may have supported this motivation by providing repeated opportunities for successful performance through culturally familiar and progressively structured activities. Successful experiences in calculating congklak seeds and interpreting multiplication relationships in woven motifs may have reinforced students' perceptions of competence, an important psychological condition for intrinsic motivation according to Self-Determination Theory (Ryan & Deci, 2000). The high rating for engaging learning activities further supports this interpretation. By presenting mathematics through games and recognizable cultural practices, ethnomathematics can transform abstract mathematical content into experiences that are more familiar, meaningful, and enjoyable for elementary students, consistent with the findings of Mutiarani and Kurniawati (2024).

Nevertheless, the motivational findings also reveal dimensions requiring further pedagogical attention. Students recorded comparatively lower scores for drive and need for learning and for persistence in completing tasks, indicating that high overall enjoyment and achievement motivation did not necessarily translate into equally strong self-initiated learning behavior or perseverance. This distinction is important because sustainable mathematics learning requires students not only to enjoy instructional activities but also to remain engaged when tasks become demanding. Weiner's (1985) attribution theory provides one possible interpretation: students who perceive achievement as primarily dependent on external circumstances or task difficulty may exhibit less persistence than those who associate learning outcomes with controllable factors such as effort. Similarly, Rahmawati and Hidayat (2023) emphasize that persistence and resilience require continuous reinforcement and habituation. The moderate positive correlation between learning motivation and improvement in conceptual mastery ($r = 0.48$) further suggests that cognitive and motivational development are meaningfully associated, although the correlational result should not be interpreted as evidence of causality. This relationship is consistent with Sari and Wibowo (2021), Rahmawati and Hidayat (2023), and Schunk, Pintrich, and Meece (2008), who emphasize that motivation influences effort, persistence, strategy use, and engagement in learning. Future implementation should therefore complement enjoyable cultural activities with explicit strategies that promote questioning, perseverance, self-regulation, and constructive responses to learning difficulties.

Taken together, the findings provide practical and theoretical implications for culturally responsive elementary mathematics education. Practically, the ethnomathematics-based Gasing method offers a contextual instructional framework that teachers can adapt by integrating traditional games, artistic motifs, and other culturally relevant resources containing mathematical relationships. Positive responses from teachers and school principals during dissemination through the Gugus 1 Teacher Working Group (KKG) in Wabula District further indicate potential for broader classroom adaptation. Theoretically, the study extends previous research that has generally investigated Gasing and ethnomathematics separately (Syafriani et al., 2020; Prasetyo & Handayani, 2022) by demonstrating how their integration may provide complementary functions: Gasing structures progression toward computational fluency, whereas ethnomathematics situates mathematical concepts within culturally meaningful contexts. This integrated perspective contributes to the development of contextual and culturally grounded mathematics instruction (Hastuti et al., 2024; Sitompul, 2025) and is consistent with the Merdeka Curriculum emphasis on meaningful, student-centered, and locally relevant learning. Nevertheless, because the present field trial did not employ a comparison group, the observed gains should be interpreted as improvements following implementation rather than definitive causal effects. Further studies using larger and more diverse samples, comparison groups, and longer intervention periods are therefore warranted to establish the robustness, transferability, and sustained effectiveness of the approach.

Conclusions

This study concludes that the ethnomathematics-based Gasing method is a feasible instructional approach that shows promising effectiveness in improving elementary school students' multiplication mastery and mathematics learning motivation. The systematic integration of Gasing learning stages with local ethnomathematical contexts provides students with concrete, meaningful, and culturally relevant learning experiences that facilitate the transition from conceptual understanding to mathematical fluency while promoting active engagement and motivation. By connecting multiplication concepts with familiar cultural practices, the developed method addresses both cognitive and affective dimensions of elementary mathematics learning. These findings support the potential of ethnomathematics-based Gasing as a contextual and culturally responsive approach to multiplication instruction. Further research involving larger and more diverse samples, comparison groups, and longer implementation periods is recommended to establish its effectiveness and broader applicability across different elementary mathematics contexts.

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