The GASING Concrete-Abstract-Mental Computation Sequence: Learning Outcomes and Arithmetic Fluency in Elementary Mathematics

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Abstract
Mastery of basic arithmetic operations is foundational to elementary mathematics education, yet many students continue to struggle with both conceptual understanding and computational fluency. This study examined the effectiveness of the GASING method (*Gampang*, *Asyik*, dan *Menyenangkan* or Easy, Fun, and Enjoyable) in improving learning outcomes and arithmetic fluency among fourth-grade students in South Minahasa Regency, North Sulawesi, Indonesia. GASING employs a concrete-to-abstract-to-mental computation sequence built around critical points, integrating songs and games to promote engagement and automatization. A one-group pretest-posttest design was used, involving 64 students from 32 elementary schools who participated in a 15-day instructional program (November 25 to December 11, 2025) covering addition, multiplication, subtraction, and division. Overall mean scores improved significantly from 16.25 to 80.55 (N-Gain = 0.77, high category), with the Wilcoxon Signed-Rank Test confirming statistical significance ($Z = -6.964$, $p < 0.001$); all 64 students demonstrated improvement without exception. Division recorded the largest absolute gain (+66.87%) despite having the lowest baseline score, while computation speed converged to 1.12–1.29 minutes per item across all four operations, indicating a transition from procedural computation toward direct fact retrieval. These findings suggest that the GASING method was associated with substantial improvement in both conceptual mastery and arithmetic fluency simultaneously across all four basic arithmetic operations, supporting its potential as an evidence-based instructional approach for early mathematics education.

1. Introduction

Mastery of basic arithmetic operations, including addition, subtraction, multiplication, and division, constitutes the cornerstone of mathematics competence in elementary school. Without a solid command of these operations, students face serious obstacles in learning more complex mathematical content, as elementary arithmetic fluency underpins higher-order mathematical reasoning and problem-solving capacity (Fuchs et al., 2016; McNeil et al., 2025). Two dimensions are central to evaluating elementary mathematics learning: learning outcomes, reflecting the degree of students' conceptual and procedural mastery, and arithmetic fluency, defined as the ability to perform calculations quickly and accurately because mathematical facts have been fully automatized (McNeil et al., 2025). When fluency is low, students' working memory capacity is consumed by basic fact retrieval, leaving insufficient cognitive resources for more demanding mathematical tasks (Fuchs et al., 2016; National Mathematics Advisory Panel, 2008). In practice, Indonesia's performance on the Programme for International Student Assessment (PISA) illustrates the severity of this challenge: the country's mathematics score declined from 379 in 2018 to 366 in 2022, with only 18% of students reaching the minimum Level 2 proficiency, a trend that points to persistent weaknesses in conceptual grounding and procedural fluency at the foundational level (OECD, 2019, 2023; World Bank, 2020).

A primary contributor to low mathematics achievement in Indonesia is instruction that remains procedure-oriented, where students imitate steps without developing conceptual understanding (Rittle-Johnson, 2017; Star et al., 2015). Teachers frequently introduce multiplication and division through ready-made formulas, bypassing concept construction and leading to misconceptions and poor learning retention (Kusuma, Kusumah, Juandi, & Usdiyana, 2019). The cognitive literature consistently affirms that effective mathematics learning must follow a trajectory from concrete to abstract before automatization can be achieved: grounding instruction in physical and representational manipulatives significantly improves conceptual understanding, retention, and knowledge transfer compared to direct abstract instruction (Rittle-Johnson, Schneider, & Star, 2015). Furthermore, meta-analytic evidence involving over 11,000 participants confirms that whole-number calculation performance is significantly associated with working memory capacity, a capacity that develops optimally only after conceptual understanding is firmly established (Peng, Namkung, Barnes, & Sun, 2016).

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These findings collectively underscore the need for an instructional approach that deliberately sequences learning from concrete experience to abstract representation to automatized mental computation.

The GASING method (*Gampang*, *Asyik*, dan *Menyenangkan* or Easy, Fun, and Enjoyable), developed by Prof. Yohanes Surya, was designed to address these instructional challenges. The method organizes learning through three systematic stages, namely concrete, abstract, and *mencongak* (mental computation), built around identified critical points, ensuring students do not advance to formal symbols before conceptual understanding is established (Kusuma & Sulistiawati, 2014; Prahmana & Suwasti, 2014). Beyond the cognitive dimension, GASING explicitly addresses affective barriers: the *Gampang* principle builds confidence before complexity increases, *Asyik* fosters active hands-on engagement through songs and games, and *Menyenangkan* cultivates intrinsic motivation for sustained practice, conditions proven essential for long-term arithmetic fluency development (Koskinen & Pitkäniemi, 2022). Empirical studies have demonstrated GASING's effectiveness across multiple contexts. With respect to learning outcomes, Herawati (2018) found that third-grade students taught using GASING scored an average of 69.2 compared to 47.3 in the control group, representing a 46.3% advantage, while Hayati et al. (2024) reported a statistically significant improvement in problem-solving ability from 8.17 to 10.93 ($t = 6.315$, $p < 0.05$), and Yuliani et al. (2024) confirmed GASING's superiority for two-digit multiplication. With respect to arithmetic fluency, Kusuma and Sulistiawati (2014) documented a rise in mental subtraction mastery from 39.43% to substantially higher levels following GASING instruction, while Sariningsih et al. (2025) confirmed GASING's superiority through independent t-test analysis when the method was integrated with traditional games.

While these findings collectively affirm GASING's promise as an instructional approach, the existing evidence base remains incomplete in ways that limit its broader application. Most prior studies have focused on a single arithmetic operation, measured only academic scores without systematically evaluating arithmetic fluency, and were conducted within a single school or classroom, limiting the generalizability of findings (Kusuma et al., 2019; Sariningsih et al., 2025). Critically, computation speed as an indicator of arithmetic fluency has rarely been treated as a primary outcome variable and has not been measured through standardized timed procedures (Gilmore et al., 2025). Consequently, comprehensive evidence of GASING's effectiveness across all four basic operations simultaneously, assessed on both learning outcomes and arithmetic fluency, remains absent from the literature.

To fill this gap, this study aims to evaluate the effectiveness of the GASING method on both learning outcomes and computation speed across all four basic arithmetic operations among fourth-grade elementary school students. The study involved 64 students from 32 different schools using a one-group pretest-posttest design. Its novelty lies in three aspects: first, it tests GASING's effectiveness across all four operations within a single integrated program; second, it explicitly and simultaneously measures arithmetic fluency through both speed and accuracy dimensions; and third, by drawing participants from 32 different schools, it provides broader generalizability than prior single-school studies. Accordingly, two research questions guide this investigation: (1) Is the GASING method effective in improving learning outcomes in basic arithmetic operations among fourth-grade students? (2) Is the GASING method effective in improving computation speed as an indicator of arithmetic fluency?

2. Method

This study employed a quantitative within-subjects intervention design with a single-group pretest-posttest structure, conducted in South Minahasa Regency, North Sulawesi, Indonesia, from November 25 to December 11, 2025. The objective was to determine the effectiveness of the GASING method (*Gampang*, *Asyik*, dan *Menyenangkan* or Easy, Fun, and Enjoyable) in improving learning outcomes and arithmetic fluency among fourth-grade elementary school students, with treatment effectiveness determined by comparing each participant's scores before (O1) and after (O2) the intervention. This design was selected as an initial efficacy study appropriate for the exploratory implementation of GASING simultaneously across 32 schools, consistent with precedents in early-stage intervention research in elementary mathematics education (Hatten-Roberts, 2023; Hayati et al., 2024).

Participants consisted of 64 fourth-grade students (37 female, 27 male) from 32 different schools in South Minahasa Regency, distributed across four experimental classes of 16 students each, selected through purposive sampling based on schools' capacity to implement the structured 15-day program. The independent variable was the GASING instructional method, while the dependent variables were learning outcomes and arithmetic fluency, measured through mastery level and computation speed per arithmetic operation.

The intervention program, named BaKalKuBagi, was implemented over 15 days with two effective learning sessions per day (Session I and Session III), totaling approximately 30 effective sessions. Each session followed the three GASING stages: concrete, abstract, and *mencongak* (mental computation) (Kusuma & Sulistiawati, 2014; Prahmana & Suwasti, 2014). Each topic was organized around critical points, the minimal conceptual threshold required before any problem in that topic becomes solvable, operationalized through the *Gampang*

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principle. Songs during the concrete and abstract stages encoded concepts through rhythm and repetition (*Asyik*), while games at the end of each topic reinforced automatization and sustained motivation (*Menyenangkan*) (An, Capraro, & Tillman, 2013; Debrenti, 2024). The detailed intervention procedures for each topic are presented in Table 1.

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Table 1. Intervention Procedures of the BaKalKuBagi Program

Topic	Days	Materials	Concrete Stage	Abstract Stage	*Mencongak* (Mental Computation)	Songs	Games	Mastery Indicator
Addition	1-7 (~14 effective sessions)	Numbers 1-999 million; addition of 1-3 digit numbers; pairs of 10 strategy; multi-digit addition	Exploration of combining concepts using sticks, fingers, and place value cards (ones to hundred-thousands)	Discovery of addition patterns from largest place value; pairs of 10 strategy	Mental computation of addition orally and in writing without step-by-step procedures	*Orang Genius*; *Gasing Hore*; *Pasangan 10*; *Soalku Sangat Gampang*; *Tanya Jawab*; *Tekotek Kotek*; *Jeruk Jeruk*	*Amplop Nilai Tempat*; *Hompimpa*; *Suit Penjumlahan*; *Salam Gasing*; *Hujan Penjumlahan*; *Ular Naga Gasing*; *Timpuk Bilangan*	Posttest with minimum mastery score 60 (Day 7)
Multiplication	7-11 (~10 effective sessions)	Multiplication 1-10; 2-3 digit multiplication; special numbers; squares 1-60	Exploration of repeated addition concept using boxes, sticks, and place value cards (ones to hundreds)	Discovery of multiplication table patterns; special number multiplication strategies	Mental computation of multiplication orally and in writing including squares and special numbers	*Orang Genius*; *Gasing Hore*; *Gasing Dimana Kamu*; *Soalku Sangat Gampang*; *Tanya Jawab*; *Tekotek Kotek*; *Jeruk Jeruk*	*Suit Perkalian*; *Hompimpa*; *Papan Perkalian*; *Sedotan Maut*; *Si Buta dari Gua Hantu*; *Domino Perkalian*	Posttest with minimum mastery score 60 (Day 11)
Subtraction	11-13 (~6 effective sessions)	Subtraction below 10; 2-3 digit subtraction (with and without regrouping); alternative teens strategy; multi-digit subtraction	Exploration of taking-away concept using sticks, fingers, and place value cards (ones to hundreds)	Discovery of subtraction patterns from largest place value; alternative teens approach strategy	Mental computation of subtraction orally and in writing using teens approach	*Orang Genius*; *Gasing Hore*; *Pasangan 10*; *Gasing Dimana Kamu*; *Soalku Sangat Gampang*; *Tanya Jawab*; *Tekotek Kotek*; *Jeruk Jeruk*	*Hompimpa*; *Hujan Pengurangan*; *Tak Gendong Kemana-mana*	Posttest with minimum mastery score 60 (Day 13)
Division	13-15 (~6 effective sessions)	Division of numbers up to 100 and multi-digit numbers with 1-2 digit divisors	Exploration of equal distribution concept using boxes, sticks, and place value cards (ones to hundreds)	Discovery of division patterns based on multiplication tables; long division strategy	Mental computation of division orally and in writing based on multiplication table retrieval	*Orang Genius*; *Gasing Hore*; *Gasing Dimana Kamu*; *Soalku Sangat Gampang*; *Tanya Jawab*; *Tekotek Kotek*; *Jeruk Jeruk*	*Hompimpa*; *Hujan Pembagian*; *Engklek*; *Suit Pembagian*	Posttest with minimum mastery score 60 (Day 15)

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Two instruments were used. Topic-specific achievement tests were administered at the end of each instructional block (Addition Posttest Day 7, Multiplication Posttest Day 11, Subtraction Posttest Day 13, Division Posttest Day 15), each consisting of 10 items completed within 10 minutes. Arithmetic fluency was measured using mastery level, defined as the percentage of correct answers per operation, from which computation speed was derived using the formula: speed = 10 minutes divided by the number of correctly answered items, representing average time per correctly answered item (Gilmore et al., 2025; Royer et al., 1999).

Data were analyzed using descriptive statistics (mean, standard deviation, mastery percentage) and normalized gain (N-Gain) based on Hake's (1999) criteria. Normality was tested using the Shapiro-Wilk test, followed by a Paired Sample t-Test if normally distributed or the Wilcoxon Signed-Rank Test if not, at a significance level of 0.05 (Field, 2018). Arithmetic fluency improvement was analyzed descriptively by comparing mastery level and computation speed per operation between pretest and posttest.

3. Results and Discussion

3.1. Results

3.1.1. Learning Outcomes Across Four Basic Arithmetic Operations

The application of the GASING method demonstrated significant improvement in learning outcomes across all 64 participants. The overall mean pretest score was 16.25 (SD = 17.97), increasing to 80.55 (SD = 13.43) on the posttest, yielding an N-Gain of 0.77, classified as high category based on Hake's (1999) criteria. The Wilcoxon Signed-Rank Test confirmed statistical significance (Z = -6.964, p = 0.000), and Ranks data confirmed that all 64 participants improved without exception, with no participant showing decrease or stagnation. Complete descriptive statistics and inferential test results are presented in Table 2.

Table 2. Descriptive Statistics and Wilcoxon Test Results of BaKalKuBagi Learning Outcomes

Variable	Pretest M (SD)	Posttest M (SD)	N-Gain	Category	Z	p
BaKalKuBagi	16.25 (17.97)	80.55 (13.43)	0.77	High	−6.964	0.000
Addition	48.75 (25.79)	89.38 (11.94)	0.79	High	−6.972	0.000
Multiplication	24.38 (23.76)	82.50 (13.69)	0.77	High	−6.927	0.000
Subtraction	26.41 (20.42)	84.84 (13.80)	0.79	High	−6.935	0.000
Division	10.47 (11.74)	77.34 (15.35)	0.75	High	−6.999	0.000

Per-operation analysis revealed a consistent pattern of high improvement across all four operations, as shown in Figure 1. Addition and subtraction recorded the highest N-Gain (0.79), followed by multiplication (0.77) and division (0.75), all classified as high category. Notably, although division recorded the lowest N-Gain among the four operations, it demonstrated the largest absolute gain, rising from the lowest baseline score (10.47) to near mastery of 77.34 on the posttest.

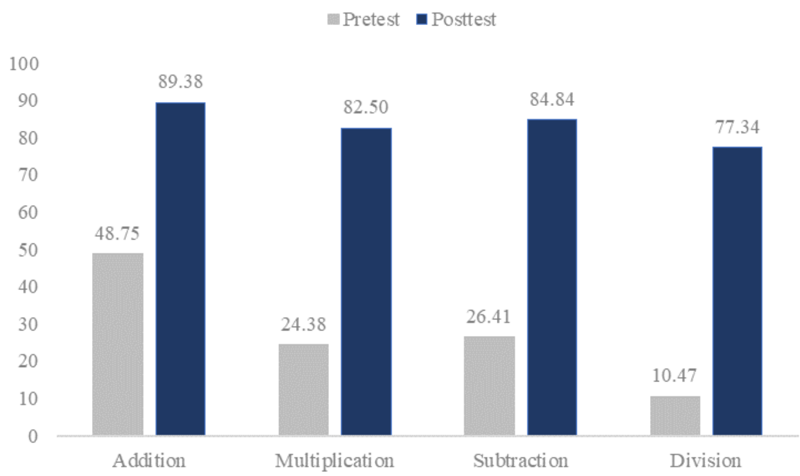

Figure 1. Comparison of Pretest and Posttest Mean Scores per Arithmetic Operation

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3.1.2. Arithmetic Fluency: Computation Speed and Accuracy

Computation speed and accuracy were analyzed descriptively based on per-operation test data (10 items, 10 minutes). Computation speed was calculated as the average time per correctly answered item (10 minutes divided by the number of correct answers), while accuracy was expressed as the percentage of correct answers per operation. Complete pretest and posttest comparisons are presented in Table 3.

Table 3. Computation Speed and Accuracy per Arithmetic Operation

Operation	Speed Pretest (min/item)	Speed Posttest (min/item)	Accuracy Pretest (%)	Accuracy Posttest (%)	Accuracy Gain (%)
Addition	2.05	1.12	48.75	89.38	+40.63
Multiplication	4.10	1.21	24.38	82.50	+58.12
Subtraction	3.79	1.18	26.41	84.84	+58.43
Division	9.52	1.29	10.47	77.34	+66.87

Prior to the intervention, computation speed varied considerably across operations, with division requiring the longest time per item (9.52 min/item), substantially higher than multiplication (4.10 min/item), subtraction (3.79 min/item), and addition (2.05 min/item), reflecting large disparities in initial mastery. Following the intervention, computation speed across all operations converged markedly to between 1.12 and 1.29 minutes per item, as illustrated in Figure 2.

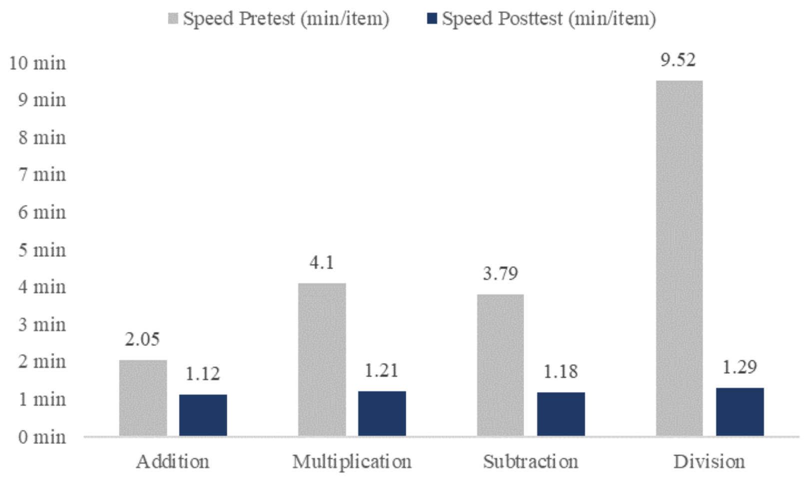

Figure 2. Comparison of Computation Speed per Arithmetic Operation (minutes/item)

From the accuracy dimension, the largest gain was recorded in division (+66.87 percentage points), followed by subtraction (+58.43), multiplication (+58.12), and addition (+40.63), consistent with the speed data showing that the operation with the lowest initial mastery demonstrated the largest improvement.

3.2. Discussion

3.2.1. Significant and Inclusive Improvement in Learning Outcomes

The findings suggest that the GASING method was associated with significant and inclusive improvement in basic arithmetic learning outcomes. The overall N-Gain of 0.77 indicates that the method brought participants substantially closer to the upper bound of achievable improvement from their starting points (Hake, 1999). More notably, all 64 participants improved without exception, extending prior GASING research by Herawati (2018), Hayati et al. (2024), and Sariningsih et al. (2025) which reported group-level effectiveness but did not document individual-level inclusivity. This study further provides preliminary evidence of GASING's effectiveness across all four basic operations simultaneously within a single integrated program.

This uniform effectiveness may be explained by three core principles operating in concert. The *Easy* (*Gampang*) principle ensures every participant reaches the critical conceptual threshold before advancing, making subsequent problems solvable regardless of difficulty (Kusuma & Sulistiawati, 2014; Prahmana & Suwasti, 2014b), consistent with meta-analytic evidence that concrete-based conceptual understanding significantly improves retention and transfer (Carbonneau, Marley, & Selig, 2013). The *Fun* (*Asyik*) principle reduces affective barriers through song-based learning, creating a flow state of full absorption that is intrinsically motivating (Cornett & Ganda, 2023; Csikszentmihalyi, 1990), which is consequential because mathematics anxiety demonstrably reduces working memory capacity and undermines arithmetic performance

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(Boz, 2024; McNeil et al., 2025). The *Enjoyable* (*Menyenangkan*) principle reinforces automatization through games as consolidation activities, sustaining motivation while strengthening long-term memory encoding (Debrenti, 2024; Hui & Mahmud, 2023). These principles collectively align with evidence that a positive and enjoyable classroom atmosphere is a core characteristic of effective mathematics learning (Koskinen & Pitkäniemi, 2022).

At the cognitive level, the concrete-abstract-mental computation sequence is consistent with frameworks emphasizing working memory efficiency. A meta-analysis by Peng et al. (2016) involving 11,224 participants found that whole-number calculations show a significant and moderate association with working memory capacity, and solid conceptual understanding built through the concrete phase may substantially reduce this cognitive load (Fuchs et al., 2016; McNeil et al., 2025). This principle converges with RME, which similarly emphasizes concrete-to-formal progression and has demonstrated a combined effect size of $g = 1.26$ ($p < 0.01$) in elementary mathematics achievement (Cahyaningsih & Nahdi, 2023; Gravemeijer, 1994), providing cross-approach validation of the concrete-abstract sequence as a fundamental instructional mechanism

3.2.2. Arithmetic Fluency: From Slow Computation Toward Direct Retrieval

The computation speed data provide preliminary evidence of a transition from slow procedural computation toward arithmetic automatization. Prior to the intervention, division required 9.52 minutes per item, far exceeding other operations, indicating possible reliance on slow algorithmic strategies that burdened working memory (Peng et al., 2016). Following the intervention, speed converged to 1.12 to 1.29 minutes per item across all operations, signaling a possible transition from procedural strategies toward direct retrieval identified by Royer et al. (1999) as the defining marker of genuine arithmetic fluency.

Division recorded the largest accuracy gain (+66.87 percentage points) alongside the most dramatic speed improvement, consistent with the finding by Peng et al. (2016) that whole-number calculations show significant association with working memory capacity. The GASING method may support this process through its concrete phase, where participants first understand division as a physically observable distribution process before advancing to abstract representations, potentially enabling the automated extraction process identified by Liu et al., (2024) in *PLoS ONE* whereby answers are extracted directly from long-term memory without conscious cognitive manipulation. This pattern of greatest gains among initially lowest-performing participants is consistent with the findings of Kusuma and Sulistiawati (2014).

The emphasis on mental computation as the final learning target in GASING directly corresponds to the international definition of arithmetic fluency (Gojak, 2014; McNeil et al., 2025; Royer et al., 1999). Higher automaticity requires progressively less working memory capacity, freeing cognitive resources for more complex tasks (Fuchs et al., 2016; McNeil et al., 2025; Yu, Ding, Zusho, Zhang, & Wang, 2023). The convergence of speed to 1.12 to 1.29 minutes per item is consistent with the possibility that participants achieved relatively uniform automatization across all four operations simultaneously, which is particularly significant given that literature indicates automatization across different operations typically develops at different rates and grade levels (Gilmore et al., 2025). Gilmore et al. (2025) confirmed that arithmetic fluency is validly assessed by integrating both accuracy and response time as complementary indicators, providing strong methodological support for the two-dimensional measurement approach employed in this study.

3.3. Implications

The findings of this study carry three practical implications for elementary mathematics instruction. First, the GASING method appears to effectively and simultaneously improve both learning outcomes and arithmetic fluency, making it a promising candidate for broader adoption in the Indonesian context given the country's persistently low PISA mathematics scores (OECD, 2023). Second, the concrete-abstract-mental computation sequence appears strategically effective for developing both conceptual mastery and computational automatization simultaneously, consistent with the NCTM principle that fluency must be built upon conceptual understanding rather than replacing it (National Council of Teachers of Mathematics, 2014, 2020). Third, the *Gampang*, *Asyik*, and *Menyenangkan* principles collectively appear to support inclusive outcomes across all participants, and therefore warrant equal attention alongside cognitive and procedural dimensions in elementary mathematics instructional design (Karnilah et al., 2024; Koskinen & Pitkäniemi, 2022). From a theoretical standpoint, this study extends the evidence base for the concrete-to-abstract learning trajectory and offers preliminary simultaneous evidence of GASING's effectiveness across all four basic arithmetic operations, contributing to a more comprehensive understanding of how structured engagement-based methods may support arithmetic automatization.

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3.4. Limitations

Several limitations of this study should be acknowledged. First, this study did not include a control group, which represents a significant methodological limitation. The within-subjects design means that observed improvements cannot be attributed exclusively to the GASING method with full causal certainty, as maturation, testing effects, or other concurrent factors cannot be completely ruled out. Second, although participants were drawn from 32 different schools, the purposive sampling strategy limits the generalizability of findings to other populations, grade levels, and regional contexts beyond South Minahasa Regency. Third, the 15-day program duration, while sufficient to demonstrate statistically significant improvement, does not allow conclusions about the long-term retention of learning outcomes or arithmetic fluency gains beyond the immediate posttest window. Future studies are encouraged to employ quasi-experimental or randomized controlled designs with delayed retention tests and broader sampling to strengthen the causal and generalizability claims of GASING research.

4. Conclusion

This study set out to evaluate the effectiveness of the GASING method in improving learning outcomes and arithmetic fluency across all four basic arithmetic operations among fourth-grade elementary school students in South Minahasa Regency, North Sulawesi, Indonesia. The results are consistent with both research questions, suggesting that the concrete-abstract-mental computation sequence supported by the *Gampang*, *Asyik*, and *Menyenangkan* principles appears to be a promising and inclusive instructional approach for elementary mathematics, with all 64 participants from 32 different schools improving without exception. These findings contribute preliminary evidence toward addressing the gap identified in the introduction, namely the absence of comprehensive evidence for GASING's potential effectiveness across all four basic operations simultaneously, measured on both learning outcomes and arithmetic fluency as complementary dimensions. Future research is recommended in three directions. First, studies employing quasi-experimental or randomized controlled designs with control groups are needed to strengthen causal inferences about GASING's effectiveness beyond what a within-subjects design can establish. Second, more precise measurement of arithmetic fluency using individually timed tests per item, as recommended by Royer et al. (1999) and Gilmore et al. (2025), would yield data more directly comparable with international fluency research. Third, given that division demonstrated the largest gain from the lowest baseline, future studies specifically examining the concrete-phase mechanisms of GASING for division, particularly in rural and remote educational contexts such as South Minahasa Regency where access to innovative instructional approaches remains limited, would contribute valuable theoretical and practical insights to both arithmetic fluency literature and elementary mathematics curriculum development in Indonesia.

Author Contributions

Jonatan Hasudungan Sihombing: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data curation, Writing - original draft, Writing - review and editing, Visualization, Supervision, Project administration, Funding acquisition. Mubiar Agustin: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data curation, Writing - original draft, Writing - review and editing, Visualization, Supervision, Project administration, Funding acquisition. Idat Muqodas: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data curation, Writing - original draft, Writing - review and editing, Visualization, Supervision, Project administration, Funding acquisition.

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Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/ or publication of this article.

Ethics and Consent Declarations

The research related to human use has been complied with all the relevant national regulations and institutional policies in accordance with the tenets of the Helsinki Declaration and has been approved by the authors' institutional review board or equivalent committee at Universitas Pendidikan Indonesia.

Data Availability

The data that support the findings of this study are available on request from the corresponding author, M.A. The data, which contain information that could compromise the privacy of research participants, are not publicly available due to certain restrictions.

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Declaration on AI Use

The authors declare that AI-assisted tools were used in the preparation of this manuscript to support language improvement, structural editing, and writing clarity under strict human oversight. All intellectual content, research ideas, data collection, analyses, and conclusions were conceived, directed, and verified by the authors. The authors take full responsibility for the integrity and accuracy of the work presented.

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