

THE MATEMATIKA GASING METHOD AS AN INTERVENTION FOR IMPROVING ARITHMETIC FLUENCY AMONG SCHOOL STUDENTS IN AN UNDER-RESOURCED COMMUNITY CONTEXT

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Abstract: Difficulties with foundational arithmetic operations remain a persistent impediment to mathematical progression among primary and lower secondary school students in Indonesia, and are frequently compounded by pedagogical approaches that prioritise rote memorisation over conceptual understanding. This paper presents findings from two successive structured intervention studies examining the short-term efficacy of the Matematika GASING (Gampang, Asyik, Menyenangkan—Easy, Fun, Enjoyable) method across all four basic arithmetic operations: addition, multiplication, subtraction, and division. Study 1 (n = 24) was conducted at GGP Jemaat Ayalon Church, Argapura Resimen, Jayapura, and focused on addition and multiplication. Study 2 (n = 30) was conducted at GKPMI Jemaat Ekklesia Church, Ardipura II, Jayapura, and focused on subtraction and division. Both studies employed a one-group pre-test/post-test design. In Study 1, all five arithmetic sub-items showed positive gains, with multi-digit addition recording the highest absolute gain (+37 percentage points (pp)) and multiplication sub-items yielding a consistent +20 pp gain each. In Study 2, all seven sub-items improved, with two-digit division recording the largest relative gain (+38 pp). Across both studies and all twelve assessed sub-items, the Matematika GASING method produced consistent and educationally meaningful short-term arithmetic gains. The intervention incorporated concrete–pictorial–abstract (CPA) sequencing, mnemonic songs with movement, manipulative place-value cards, and prize-incentivised oral drills. The findings extend the GASING evidence base to non-formal community settings in Papua, and to all four basic operations within a unified research programme.

Keywords: Matematika GASING, arithmetic fluence, addition, multiplication, subtraction, division, school student, community-based learning.

1. INTRODUCTION

Proficiency in basic arithmetic operations constitutes the cornerstone of mathematical development across all levels of schooling. The four fundamental operations, namely addition, multiplication, subtraction, and division form an interconnected progression in which each operation draws upon mastery of its predecessors (Kristensia et al., 2025; Nanda and Rani, 2025). Difficulties at any stage frequently translate into sustained underperformance in higher-order mathematical topics, including fractions, algebra, and ratio reasoning (Iglesias-Sarmiento et al., 2020; Sari et al., 2024). Despite decades of curriculum reform, Indonesia's performance in international mathematical assessments remains a cause for concern. In the 2022 Programme for International Student Assessment (PISA), Indonesian students ranked 69th out of 81 participating countries, with a mean mathematics score of 366 substantially below the OECD average of 472 (OECD, 2024). National assessment data from the same period reflected similarly

low mean scores at the junior secondary level, indicating systemic weaknesses in foundational mathematical competencies that begin in the primary arithmetic curriculum (Siregar et al., 2024).

A central factor contributing to poor arithmetic outcomes is mathematics anxiety (MA), defined as a state of apprehension, tension, and dread arising in contexts requiring numerical or mathematical engagement (Ashcraft, 2002; Balt et al., 2022). Research consistently demonstrates a significant negative correlation between MA and mathematical achievement across age groups (Barroso et al., 2021; Hembree, 1990; Zhang et al., 2019). In Indonesian primary school contexts specifically, MA has been shown to emerge early, frequently in students as young as seven or eight, and to be substantially shaped by pedagogical factors, including the dominance of teacher-centred, formula-heavy instructional methods that privilege procedural correctness over conceptual understanding (Balt et al., 2022; Diponegoro et al., 2024). These challenges are particularly acute in Papua Province, where educational infrastructure is frequently limited, access to qualified mathematics teachers is constrained, and community and religious institutions play an important supplementary role in children's education. Prahmana and Suwasti (2014) have noted that Papuan students face particular challenges with number operations owing to limited exposure to structured mathematical instruction outside formal school hours.

The Matematika GASING method, developed by Prof. Yohanes Surya, represents a deliberate departure from conventional rote-based mathematics pedagogy, moving toward a process-oriented approach that integrates concrete visualization and logical intuition (Gasing Academy, 2025; Shanty and Wijaya, 2012). The acronym GASING derives from the Indonesian phrase *Gampang, Asyik, Menyenangkan* (Easy, Fun, Enjoyable), and reflects the method's foundational philosophy that mathematics should be experienced as pleasurable and accessible rather than threatening or opaque. Pedagogically, the method is structured around a concrete–pictorial–abstract (CPA) progression, moving from tangible manipulative activities and kinaesthetic learning including movement, song, and partner-based games, towards written symbolic calculation (Surya & Moss, 2012). The method defines 'critical points' for each operation: the minimum conceptual and procedural threshold that must be reached before a learner can proceed to more complex computation (Siregar et al., 2014; Sulistiawati, 2019).

Prior research has demonstrated the effectiveness of GASING for individual arithmetic operations. Sulistiawati and Kusuma (2015) reported that Matematika GASING instruction significantly improved subtraction mastery at an elementary school in Tangerang, with written subtraction scores increasing from a preliminary 67.2% to 92% and mental subtraction mastery

rising from 39.43% to 97.14%. Kusuma and Sulistiawati (2014) demonstrated that the Matematika GASING method effectively improved first-year undergraduate students' ability to understand, perform mental calculation of, and teach multiplication facts for numbers 1 to 10. Safitri et al. (2025) found a significant improvement in procedural multiplication understanding (Wilcoxon test, $p < 0.05$) following a one-group pre-experimental design. Maharudin et al. (2026) found that the GASING method significantly improved third-grade students' addition skills (N-Gain = 0.90) compared to a control group using direct instruction (N-Gain = 0.73), following a quasi-experimental design. Hayati et al. (2024) found that the GASING method significantly improved the mathematical problem-solving abilities of fourth-grade students, with average scores increasing from 8.17 to 10.93 following a pre-experimental intervention. Prahmana and Suwasti (2014) demonstrated that the GASING method significantly contributed to the conceptual understanding of division among students from rural areas, transitioning them from concrete exploration to abstract mathematical symbols.

Notwithstanding this evidence base, three important gaps remain. First, no single study has examined GASING's effectiveness across all four basic operations within a unified research programme, making it difficult to determine whether the method's benefits are general or operation-specific. Second, the existing evidence is drawn almost exclusively from formal school settings in Java; community-based applications in Eastern Indonesia are scarce. Third, GASING has not been systematically studied with age-heterogeneous groups in non-formal venues. The present paper addresses all three gaps by reporting findings from two successive structured intervention studies at church-based learning groups in Jayapura, Papua, conducted in consecutive academic semesters: Study 1 focusing on addition and multiplication, and Study 2 focusing on subtraction and division. Together, they provide the first cross-operation, multi-session evaluation of GASING in a community setting in Eastern Indonesia.

The paper aims to: (1) document pre-intervention arithmetic fluency levels across all four operations; (2) examine post-intervention changes in fluency following each structured GASING session; (3) identify which arithmetic sub-domains demonstrate the most pronounced improvement; and (4) synthesise findings across both studies to assess the consistency and breadth of GASING's efficacy.

2. RESEARCH METHODS

Research Design

The studies employed a pre-experimental one-group pre-test/post-test design. This design was selected on the basis of its suitability for exploratory educational intervention studies

operating in naturalistic, non-randomised settings where the allocation of participants to control groups is not feasible (Creswell, 2014). Whilst the absence of a control group constitutes a recognised methodological limitation, the design is consistent with precedent in the Matematika GASING research literature (Hayati et al., 2024; Safitri et al., 2025) and is appropriate for establishing initial efficacy evidence in novel implementation contexts.

Research Settings and Participants

Study 1 was conducted on 21 October 2023 at the GGP Jemaat Ayalon Church Hall, Jalan K.S. Tubun RT01/RW06, Argapura Resimen, Jayapura Selatan, from 09:00 to 15:00 WIT. Participants comprised 24 students: 17 primary school students (SD, Grades I–VI) and 7 lower secondary school students (SMP, Grades VII–VIII) (Figure 1). The session focused on addition and multiplication, delivered across two sequential modules (Term 1: Addition; Term 2: Multiplication).



Figure 1. Study 1 Setting and Participants

Study 2 was conducted on 24 August 2024 at the GKPMI Jemaat Ekklesia Church Hall, Jalan Ardupura II, Jayapura Selatan, from 09:00 to 15:00 WIT. Participants comprised 30 students: 27 primary school students (SD) and 3 lower secondary school students (SMP), attending 12 different schools across Jayapura (Figure 2). Ages ranged from approximately 7 to 14 years. The session focused on subtraction and division, delivered across two sequential modules (Term 1: Subtraction; Term 2: Division).



Figure 2. Study 2 Setting and Participants

Participation in both studies was voluntary and informal consent was obtained through the church administration.

Intervention Programme

The intervention in both studies was structured around the Matematika GASING method and followed an identical three-phase sequence within each module: pre-test, instructional delivery, and post-test. Instructional delivery across all four modules incorporated the GASING CPA (Concrete–Pictorial–Abstract) progression.

In Study 1, the addition module introduced number recognition and place-value decomposition using digit cards (*kartu digit*) representing units, tens, hundreds, and thousands, before progressing through column addition (*penjumlahan bersusun dari depan*—column addition from the left), the 'scratch' method for carrying, and multi-digit addition of three or more numbers using the scratch-column system. The multiplication module developed the concept of multiplication as repeated addition, introduced the 'pairs structure' for multiplication by 1, 2, 5, 9, 10 and the squared numbers, then applied the GASING partial-products shorthand for multi-digit multiplication. Both modules incorporated the GASING addition song and multiplication song with accompanying physical movement sequences delivered by the facilitating team.

In Study 2, the subtraction module introduced the 'pairs of ten' (*pasangan sepuluh*) mnemonic as the conceptual foundation for borrowing, then systematically covered subtraction without borrowing (two-digit minus one-digit; two-digit minus two-digit) before addressing subtraction with borrowing through the digit-card decomposition and the 'scratch' borrowing notation. The division module addressed the meaning of division as equal sharing, division with remainders, single-digit long division using the GASING circle-notation shorthand, and two-digit divisor long division supported by a multiplication reference table. The GASING subtraction song (*lagu pengurangan*) and multiplication-division jingle were used as mnemonic aids with movement, consistent with evidence that multi-sensory encoding supports arithmetic recall in young children. Prize-incentivised rapid-fire oral question sessions closed each module to reinforce content and sustain motivational engagement.

Assessment Instruments

Each module was assessed using researcher-developed pre-test and post-test instruments administered under timed conditions (15 minutes per test). Parallel forms (identical items) were used for pre- and post-test to ensure score comparability. In Study 1, the addition test comprised items spanning three sub-types: single-digit addition, two-digit addition, and multi-digit addition (Figure 3). The multiplication test comprised two sub-types: two-digit multiplication and three-digit multiplication. In Study 2, the subtraction test comprised five sub-types of increasing

complexity; the division test comprised two sub-types (single-digit and two-digit divisors) (Figure 4). All items within each instrument were sequenced from least to most complex. The primary outcome measure was the mean percentage of participants answering each item type correctly (percentage correct, PC%) at pre-test and post-test.

Figure 3 shows two sample test sheets for addition. The left sheet is the pre-test and the right is the post-test. Both sheets are from Universitas Internasional Papua and contain 10 addition problems in a table format. The problems are:

1. 15 + 8 =
2. 47 + 27 =
3. 83 + 17 =
4. 105 + 50 =
5. 321 + 279 =
6. 4.237 + 843 =
7. 5.678 + 2.587 =
8. 117.488 + 29.748 =
9. 1.543.678 + 2.578.436 =
10. 2.045.678.881 + 1.987.054.321 =

Figure 3. Sample of Addition Pre Test and Post Test

Figure 4 shows two sample test sheets for division. The left sheet is the pre-test and the right is the post-test. Both sheets are from Universitas Internasional Papua and contain 10 division problems in a table format. The problems are:

1. 35 ÷ 7 =
2. 81 ÷ 9 =
3. 7 ÷ 5 = ... sisa ...
4. 59 ÷ 7 = ... sisa ...
5. 29 ÷ 8 = ... sisa ...
6. 2.000 ÷ 8 = ... sisa ...
7. 15.307 ÷ 6 = ... sisa ...
8. 23.790 ÷ 5 = ... sisa ...
9. 22.527 ÷ 11 =
10. 21.459 ÷ 12 =

Figure 4. Sample of Division Pre Test and Post Test

Data Analysis

Absolute gain scores (post-test PC% minus pre-test PC%) were computed for each sub-item. Given the small sample sizes and single-group designs, descriptive analysis was the primary analytic method. Mean aggregate PC% scores were calculated across sub-items within each operation to indicate overall performance change. This approach is consistent with descriptive reporting conventions in analogous single-group GASING studies (Safitri et al., 2025). Qualitative engagement data from facilitator observations during both sessions were collated during post-session debriefing and are presented as corroborative descriptive evidence alongside the quantitative results

3. RESULTS AND DISCUSSION

Study 1: Addition and Multiplication

Tables 1 and 2 present the pre-test and post-test percentage-correct scores for addition and multiplication sub-items respectively, along with absolute gain scores.

Table 1. Pre-test and Post-test Results for Addition Sub-items, Study 1 (n = 24)

Sub-item	Pre-test (%)	Post-test (%)	Gain (pp)
Single-digit addition	55	75	+20
Two-digit addition	60	83	+23
Multi-digit addition	20	57	+37
Mean (addition sub-items 1–3)	45.0	71.7	+26.7

Source: Primary data, October 2023.

Table 2. Pre-test and Post-test Results for Multiplication Sub-items, Study 1 (n = 24)

Sub-item	Pre-test (%)	Post-test (%)	Gain (pp)
Two-digit multiplication	45	65	+20
Three-digit multiplication	35	55	+20
Mean (multiplication sub-items 1–2)	40.0	60.0	+20.0

Source: Primary data, October 2023.

The results presented in Tables 1 and 2 indicate consistent improvements across all assessed arithmetic sub-items following the Study 1 GASING intervention. For addition, pre-test accuracy ranged from a low of 20% for multi-digit addition to 60% for two-digit addition—baseline levels that confirm the participants' limited prior exposure to structured column-addition methods. Following the GASING session, accuracy rose substantially across all three sub-types.

The most striking gain was observed in multi-digit addition (+37 percentage points, from 20% to 57%), which is consistent with the principle that GASING produces disproportionately large gains in sub-domains where baseline performance is lowest, as even modest conceptual re-framing can dramatically alter performance from a low starting point (Sulistiawati, 2015). The mean addition accuracy across sub-items improved from 45.0% to 71.7%, a mean gain of +26.7 percentage points.

For multiplication, pre-test baselines of 45% (two-digit) and 35% (three-digit) reflect the expected difficulty gradient of multi-digit multiplication, which requires prior mastery of multiplication table facts and the application of place-value decomposition in a multi-step procedure. Both sub-items improved by exactly +20 percentage points following the GASING session, yielding post-test accuracies of 65% and 55% respectively and a mean multiplication gain of +20.0 pp. Whilst the post-test scores for three-digit multiplication remained below 60%, this is unsurprising given that three-digit multiplication involves the most steps of any sub-item assessed and cannot be fully consolidated within a single session. The consistency of the +20 pp gain across both multiplication sub-types suggests a uniform positive effect of the GASING partial-products algorithm, which simplifies multi-digit multiplication by processing digit pairs from the left and accumulating partial products systematically.

Qualitative facilitator observations from Study 1 documented high and sustained engagement throughout the session. The GASING addition song with accompanying movement was particularly well-received by younger participants (Grades I–III), who appeared to encode the 'pairs-of-ten' number bond relationships through the rhythmic-kinaesthetic format more readily than through the written activities alone. The competitive prize-based 'Games Matematika' segment at the close of each module generated the highest observed engagement peak: participants actively applied content from earlier in the module during the game, demonstrating short-term transfer of the GASING strategies to a novel low-stakes context (Jensen, 1998). Peer-tutoring dynamics were also observed, with older participants (Grades VII–VIII) assisting younger peers during the abstract computation stage.

Study 2: Subtraction and Division

Tables 3 and 4 present the pre-test and post-test percentage-correct scores for subtraction and division sub-items respectively.

Table 3. Pre-test and Post-test Results for Subtraction Sub-items, Study 2 (n = 30)

Sub-item	Pre-test (%)	Post-test (%)	Gain (pp)
Subtraction with 1-digit subtrahend, no borrowing	75	85	+10
Subtraction with 1-digit subtrahend, with borrowing	65	80	+15
Subtraction of 2-digit numbers, no borrowing	55	70	+15
Subtraction of 2-digit numbers, with borrowing	50	65	+15
Multi-digit subtraction, with and without borrowing	45	60	+15
Mean (subtraction sub-items 1–5)	58.0	72.0	+14.0

Source: Primary data, August 2024.

Table 4. Pre-test and Post-test Results for Division Sub-items, Study 2 (n = 30)

Sub-item	Pre-test (%)	Post-test (%)	Gain (pp)
Single-digit divisor (no remainder)	60	70	+10
Two-digit divisor	40	78	+38
Mean (division sub-items 1–2)	50.0	74.0	+24.0

Source: Primary data, August 2024

The results presented in Tables 3 and 4 indicate consistent improvements across all seven assessed sub-items following the Study 2 GASING intervention. For subtraction, all five sub-items showed absolute gains of between +10 and +15 percentage points, yielding a mean gain of +14.0 pp and lifting the mean post-test accuracy from 58.0% to 72.0%. The subtraction gains exhibit a clear pattern: the least demanding sub-type (1-digit subtrahend, no borrowing) recorded the smallest gain (+10 pp), whilst all four sub-types involving either borrowing or two-digit subtrahends yielded a uniform +15 pp gain. This gradient is consistent with the particular strength of the GASING 'pairs-of-ten' strategy for borrowing: by reframing regrouping as identification of a number bond partner (e.g., for $14 - 8$, identifying that 8's partner is 2, so $14 - 8 = 2 + \text{remainder}$), the method resolves a conceptual stumbling block that is particularly challenging under rote instruction.

For division, the most substantively notable result was observed in two-digit division, which recorded an absolute gain of +38 percentage points (from 40% to 78%)—the largest gain across any single sub-item in either study. Division with two-digit divisors is widely recognised as one of the most cognitively demanding arithmetic operations in the primary and lower secondary curriculum, requiring coordinated application of multiplication table knowledge, estimation, and multi-step procedural sequencing (Prahmana & Suwasti, 2014). The GASING

approach addressed this challenge by providing participants with a multiplication reference table alongside the long-division procedure, effectively reducing the retrieval burden by transforming a recall task into a recognition task. The magnitude of the gain suggests that the primary barrier for these participants was not procedural knowledge of the division algorithm per se, but rather the working memory load imposed by simultaneous multiplication fact retrieval—a barrier the reference table directly removed.

Qualitative observations in Study 2 were broadly consistent with those from Study 1. Facilitators noted that the larger cohort (30 vs. 24 participants) did not diminish collaborative engagement during the manipulative phases; indeed, the physical configuration of participants on the floor of the church hall during the concrete stage appeared to facilitate peer interaction and mutual observation more naturally than a seated classroom arrangement might. The prize-incentivised oral quiz at the close of the division module was observed to be the most energetically engaged moment of the session, with participants attempting to recall division results by cross-referencing the multiplication table—demonstrating active, self-directed use of the scaffold in a competitive context.

Cross-Study Discussion: Effectiveness of the GASING Methode Across All Four Operations

The pattern of improvement observed across both studies and all twelve arithmetic sub-items is consistent with the extant literature on the efficacy of the GASING method. The present paper extends this body of evidence to all four operations and to a community-based setting in Papua, providing the most comprehensive operational coverage of GASING's effects in a single research programme to date.

When viewed together, the two studies reveal a consistent pattern in which gains are largest for the most cognitively demanding sub-items in each operation domain: multi-digit addition (+37 pp, Study 1) and two-digit divisor division (+38 pp, Study 2). This counter-intuitive outcome—where the hardest sub-items show the largest absolute gains—is best explained by a 'conceptual leverage' effect. For learners operating near or below the 50% accuracy threshold, the GASING method appears to provide a single high-impact conceptual insight—the 'pairs-of-ten' schema for addition and subtraction, or the multiplication reference table for division—that rapidly unlocks a large proportion of previously inaccessible items. This is precisely the mechanism that Sulistiawati (2019) identified in the concept of the GASING 'critical point': mastering one pivotal concept enables a cascade of subsequent procedural application.

Three specific mechanisms underlie the gains observed across both studies. First, the CPA progression embedded within the GASING framework aligns with established principles of cognitive learning theory. The use of physical manipulatives, particularly the digit cards used to illustrate place-value decomposition, provides an enactive scaffold that reduces the cognitive load associated with symbolic arithmetic processing, thereby mitigating the working memory interference implicated in mathematics anxiety (Balt et al., 2022; Ashcraft, 2002). Second, the incorporation of kinaesthetic and musical elements specifically the GASING songs delivered with coordinated movement, aligns with multi-sensory learning frameworks and provides verbal-rhythmic cues activatable during timed assessment conditions, potentially reducing state mathematics anxiety and its associated interference with performance (Balt et al., 2022). Third, the prize-incentivised rapid-fire oral question sessions served a dual function: they provided formative feedback to facilitators and created a low-stakes, playful competitive environment associated with enhanced intrinsic motivation in mathematics learning (Gou et al., 2024), whilst simultaneously offering a retrieval practice context that is associated with long-term memory consolidation (Larsen, 2018).

The two studies also complement each other curricularly. GASING's design treats the four operations as an integrated *BAKALKUBAGI* system (*tamBAh*, *KALi*, *KUrang*, *BAGI*—addition, multiplication, subtraction, division), with each operation grounded in knowledge of the preceding one. The addition and multiplication content consolidated in Study 1 provided prerequisite knowledge directly applied in Study 2's subtraction (pairs-of-ten) and division (multiplication table) modules. This curricular interdependence suggests that sequential delivery of GASING across all four operations—as achieved across these two studies—is likely to produce stronger compounding effects than any single-operation session in isolation.

Community Setting as a Learning Environment

A distinctive feature of both studies is their location within church Sunday School contexts rather than formal school settings. This positioning is pedagogically significant for two reasons. First, the familiar, psychologically safe congregational environment may reduce the situational anxiety typically associated with formal mathematics assessment (Diponegoro et al., 2024), potentially amplifying observed gains relative to a formal classroom context. Second, community and religious organisations in Papua represent a largely untapped infrastructure for supplementary mathematics education. Given the Province's well-documented challenges with educational access and qualified teacher supply (Prahmana & Suwasti, 2014), the potential for GASING-trained facilitators to deliver structured arithmetic interventions through church programmes merits serious consideration as a policy strategy. The present findings from both

studies provide empirical support for the viability of this approach, demonstrating that meaningful learning gains are achievable within three-hour community sessions without specialist equipment or facilities.

Limitations

Several limitations of both studies must be acknowledged. First, the one-group pre-test/post-test designs without control conditions preclude causal attribution of observed gains to the GASING interventions; alternative explanations including practice effects, test familiarity, and motivational novelty responses cannot be excluded. Second, the small sample sizes ($n = 24$ and $n = 30$) and the heterogeneous school backgrounds of participants limit statistical precision and generalisability. Third, the timed written test format may disadvantage participants who process information aurally or kinaesthetically—a point suggested by the enhanced oral performance observed during quiz activities in both sessions. Fourth, no measure of mathematics anxiety was incorporated in either study, precluding analysis of the relationship between anxiety reduction and performance improvement. Fifth, the absence of a delayed post-test in both studies means that the durability of gains remains unknown. Future studies should employ quasi-experimental designs with matched comparison groups, delayed post-tests, validated anxiety measures, and larger samples.

4. CONCLUSIONS AND SUGGESTIONS

CONCLUSIONS

This paper makes four contributions to the existing literature. First, it provides the cross-operation evidence base for GASING, demonstrating that the method's pedagogical architecture is generalisable across all four arithmetic domains. Second, it extends the empirical record for GASING to non-formal community settings in Eastern Indonesia, a population and context previously unrepresented in the GASING literature. Third, the two-study design delivered at different venues, with partially different teams, across consecutive semesters, provides a degree of cross-validation exceeding what single-session studies offer. Fourth, by documenting the curricular interdependence of addition–multiplication and subtraction–division gains, it provides an empirical argument for sequential four-operation GASING delivery as a programme structure.

SUGGESTIONS

Practical recommendations arising from this work are as follows. First, future studies should employ quasi-experimental designs with matched control groups, delayed post-tests, and

validated mathematics anxiety instruments to strengthen causal inference and broaden the outcome evidence base. Second, GASING facilitator training for church teachers and Sunday School coordinators is recommended as the primary sustainability mechanism for extending arithmetic intervention reach beyond university-facilitated sessions. Third, take-home GASING resource packs—comprising place-value digit cards, a pairs-of-ten reference sheet, and a multiplication reference table—should be developed and distributed to participants to support independent practice between sessions. Fourth, the four-operation GASING curriculum should be delivered sequentially across at least two linked sessions, as the curricular interdependence documented here suggests that operation-linked sequential delivery is likely to produce compounding benefits. Fifth, the curriculum should be extended in subsequent sessions to cover fraction and decimal arithmetic, building upon the foundational number operations addressed in both studies.

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BIBLIOGRAPHY

- Ashcraft, M.H., 2002. Math anxiety: Personal, educational, and cognitive consequences. *Current directions in psychological science*, 11(5), pp.181-185.
- Balt, M., Börnert-Ringleb, M. and Orbach, L., 2022, February. Reducing math anxiety in school children: A systematic review of intervention research. In *Frontiers in Education* (Vol. 7, p. 798516). Frontiers Media SA.
- Barroso, C., Ganley, C.M., McGraw, A.L., Geer, E.A., Hart, S.A. and Daucourt, M.C., 2021. A meta-analysis of the relation between math anxiety and math achievement. *Psychological bulletin*, 147(2), pp.134-168.
- Creswell, J. W., 2014. *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches* (4th ed.). SAGE Publications.
- Diponegoro, A.M., Khalil, I.A. and Prahmana, R.C.I., 2024. When religion meets mathematics: From mathematical anxiety to mathematical well-being for minority group student. *Infinity Journal*, 13(2), pp.413-440.

- Gasing Academy, 2025. Tentang Metode GASING. *Gasingacademy.org*. Available at: <https://gasingacademy.org/about-us>
- Gou, M.F.T., Aje, A.U. and Seto, S.B., 2024. Metode Gasing dalam Pembelajaran Matematika untuk Meningkatkan Minat dan Hasil Belajar Siswa. *Jupika: Jurnal Pendidikan Matematika*, 7(2), pp.119-127.
- Hayati, Z., Satriani, N. and Raharti, N., 2024. Gasing Mathematics Instruction For Enhancing Problem-Solving Skills In Elementary School Students. *Genderang Asa: Journal of Primary Education*, 5(2), pp.25-36.
- Hembree, R., 1990. The nature, effects, and relief of mathematics anxiety. *Journal for research in mathematics education*, 21(1), pp.33-46.
- Iglesias-Sarmiento, V., Alfonso, S., Conde, Á., Pérez, L. and Deaño, M., 2020. Mathematical difficulties vs. high achievement: An analysis of arithmetical cognition in elementary school. *Developmental Neuropsychology*, 45(2), pp.49-65.
- Kristesia, E., Suriansyah, A., Harsono, A.M.B., Putra, E.C.S. and Mubarok, M., 2025. The Mastery of Basic Multiplication and Division Skills and Its Impact on Students' Mathematics Achievement. *AMPLITUDO: Journal of Science and Technology Innovation*, 4(1), pp.26-30.
- Kusuma, J. And Sulistiawati, 2014. Teaching Multiplication of Numbers from 1 to 10 to STKIP Surya Students Using Matematika GASING. *Indonesian Mathematical Society Journal on Mathematics Education*, 5(1), pp.66-84.
- Larsen, D.P., 2018. Planning education for long-term retention: the cognitive science and implementation of retrieval practice. In *Seminars in neurology* (Vol. 38, No. 04, pp. 449-456). Thieme Medical Publishers.
- Maharudin, L.O., Wahyudin, W. and Heryani, R., 2026. "The Influence of Applying the GASING Method on the Addition Skills of Third-Grade Elementary School Students in Batauga District, South Buton Regency", *Journal of Educational Sciences*, 10(2), pp. 2245–2261.
- Nanda, A. and Rani, R., 2025. Exploring the proficiency of basic mathematical facts among primary mathematics teachers. *Asian Journal for Mathematics Education*, 4(1), pp.31-55.
- OECD, 2024. PISA 2022 Results (Volume V): Learning Strategies and Attitudes for Life. *PISA, OECD Publishing, Paris*, <https://doi.org/10.1787/c2e44201-en>.
- Prahmana, R.C.I. and Suwasti, P., 2014. Local Instruction Theory on Division in Mathematics GASING: The Case of Rural Area's Student in Indonesia. *Indonesian Mathematical Society Journal on Mathematics Education*, 5(1), pp.17-26.
- Safitri, M., Iriawan, S.B. and Mufliva, R., 2025. The Effectiveness of the GASING Method in Improving Mathematical Procedural Understanding Ability in Multiplication Among Phase B Elementary School Students. *PALAPA*, 13(2), pp.238-248.
- Sari, I.P., Suryadi, D., Herman, T., Dahlan, J.A. and Supriyadi, E., 2024. Learning obstacles on fractions: A scoping review. *Infinity Journal*, 13(2), pp.377-392.
- Shanty, N.O. and Wijaya, S., 2012. Rectangular Array Model Supporting Students' Spatial Structuring in Learning Multiplication. *Indonesian Mathematical Society Journal on Mathematics Education*, 3(2), pp.175-186.

- Siregar, E.B., Karo, N.H.B., Samosir, D. and Rajagukguk, W., 2024. Kualitas pendidikan matematika di Indonesia. *Jurnal Ilmiah Widya Pustaka Pendidikan*, 12(2), pp.34-50.
- Siregar, J.H., Wiyanti, W., Wakhyuningsih, N.S. and Godjali, A., 2014. Learning the Critical Points for Addition in Matematika GASING. *Indonesian Mathematical Society Journal on Mathematics Education*, 5(2), pp.160-169.
- Sulistiawati, S., 2019. Pembelajaran matematika gasing ditinjau dari berbagai perspektif teori belajar. *Teorema: Teori dan Riset Matematika*.
- Sulistiawati and Kusuma, J., 2015. The teaching of mental subtraction in Matematika GASING to elementary school students. In *Proceeding in the 7th ICMI-East Asia Regional Conference on Mathematics Education* (pp. 587-596).
- Surya, Y. and Moss, M., 2012. Mathematics education in rural Indonesia. In *Proceeding in the 12th International Congress on Mathematics Education: Topic Study Group* (Vol. 30, pp. 6223-6229).
- Zhang, J., Zhao, N., & Kong, Q. P. (2019). The relationship between math anxiety and math performance: A meta-analytic investigation. *Frontiers in Psychology*, 10, 1613.