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Comparing the Compassion-Based GASING Method and CPA Approach on Addition Learning Outcomes of Fourth-Grade Elementary Students

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Abstract

Low mathematics learning outcomes among elementary school students remain a persistent challenge in Indonesia, particularly in regions characterized by diverse socio-cultural backgrounds and limited instructional resources. This study investigated the comparative effectiveness of the compassion-integrated GASING method and the Concrete Pictorial Abstract (CPA) approach in enhancing mathematics achievement among fourth-grade elementary students in Nabire Regency, Papua. A quasi-experimental nonequivalent control group design was employed, with 125 students from six elementary schools comprising the analyzed sample, of whom 59 were assigned to the experimental group receiving the compassion-integrated GASING method and 66 to the control group receiving the CPA approach. Data were collected through a 20-item multiple-choice mathematics achievement test covering addition operations, validated through Pearson correlation analysis and demonstrating high reliability (Cronbach's Alpha = 0.871). The enactment of the compassion-integrated GASING method was assessed through structured observation checklists completed by classroom teachers at each session, yielding a mean implementation fidelity of 99.19%, compared to 97.22% for the CPA approach, with both classified as Very Good. Inferential analysis proceeded in two stages. The Wilcoxon Signed-Rank test revealed statistically significant within-group gains in both the experimental group ($Z = -6.689$, $p < .001$, $r = 0.871$) and the control group ($Z = -7.017$, $p < .001$, $r = 0.864$), with both effect sizes classified as large. The Mann-Whitney U test subsequently indicated no statistically significant between-group difference in posttest outcomes ($U = 1826.000$, $Z = -0.601$, $p = .548$, $r = 0.054$). These findings confirm that both approaches produced comparably equivalent and practically significant gains in mathematics learning outcomes. The high fidelity of compassion-based instruction observed across all sessions provides empirical support for the consistent enactment of the affective dimension of the intervention, though its direct impact on students' emotional outcomes warrants further investigation using validated affective instruments. These findings suggest that teachers in diverse and underserved elementary settings may confidently adopt either approach, with the compassion-integrated GASING method offering additional promise as a contextually responsive instructional model.

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INTRODUCTION

Mathematics learning in elementary school serves as a cornerstone for building students' logical reasoning, analytical thinking, and systematic problem-solving capacities. However, international assessments consistently document that mathematical proficiency remains a persistent challenge, particularly in developing countries. Data from the Programme for International Student Assessment (PISA) 2022 Result Factsheet for Indonesia reveal that only 18% of Indonesian students attained at least Level 2 proficiency in mathematics, markedly below the OECD average of 69%, while as many as 82% of Indonesian students were classified as low performers in mathematics, representing one of the highest proportions recorded across all participating countries (OECD, 2023). Furthermore, Indonesia's mean mathematics score of 366 points in 2022 not only fell substantially below the OECD average but also represented a decline from 2018, with overall results among the lowest ever recorded since Indonesia first participated in the PISA in 2001 (OECD, 2023). A systematic review by Wang et al. (2023), synthesizing findings from 156 peer-reviewed articles on PISA mathematics predictors, identified instructional quality and teacher support as among the most consistent determinants of students' mathematics achievement across countries, reinforcing that the quality of classroom instruction is a primary lever for improving learning outcomes. This is further corroborated by Liu et al. (2024), who demonstrated across ten countries using PISA 2012 and 2022 data that teacher support and disciplinary climate positively predict students' mathematics achievement, while also noting that these dimensions of instructional quality remain unevenly distributed across educational systems. This challenge is particularly salient in geographically remote and educationally underserved regions such as Nabire Regency in Papua, where limited access to quality instructional resources and diverse socio-cultural classroom compositions further compound the difficulties students face in achieving basic mathematical competence, thereby motivating the present study's examination of instructional approaches capable of more effectively supporting elementary students' mathematics learning outcomes in this context.

Despite the well-documented link between instructional quality and mathematics achievement, mathematics instruction in elementary school in many developing countries, including Indonesia, has historically prioritized procedural accuracy and rote memorization, affording comparatively little consideration to the quality and meaningfulness of students' overall learning experiences (OECD, 2023). Such narrow instructional orientations have been consistently associated with diminished student engagement and suboptimal learning outcomes. Hiller et al. (2022) established that both the quality of instructional delivery and students' academic experiences function as meaningful predictors of mathematical literacy at the elementary level, reinforcing that how mathematics is taught matters as much as what is taught. Furthermore, Quintero et al. (2022), in a longitudinal study, demonstrated that student engagement functions as an intermediary between instructional quality and academic performance, indicating that instructional approaches failing to sustain active participation are likely to produce limited cognitive gains. These findings collectively underscore that improving elementary students' mathematics learning outcomes requires moving beyond procedural instruction toward approaches that are both cognitively well-structured and genuinely responsive to students' learning needs.

In the Indonesian context, the challenge of improving mathematics learning outcomes at the elementary level is further compounded by the diversity of students' socio-cultural backgrounds and the variability in instructional quality across regions. Aprilia and Royanto (2020) found that affective and cognitive factors within mathematics learning among Indonesian elementary students are intricately interwoven, suggesting that instructional

approaches addressing both dimensions simultaneously are more likely to produce meaningful gains in achievement. This view is reinforced by Suren and Ali Kandemir (2020), who established through structural equation modeling that students' motivational orientation functions as a meaningful moderating factor in the relationship between their learning experiences and mathematics performance, indicating that the affective climate of instruction carries direct implications for cognitive outcomes. Taken together, these findings point to the necessity of developing instructional approaches capable of integrating cognitive rigor with responsiveness to students' learning experiences, a dual requirement that frames the rationale for the present study's examination of the compassion-integrated GASING method and the CPA approach as alternative instructional models for improving mathematics learning outcomes among fourth-grade elementary students in Nabire Regency.

One instructional approach that has gained prominence in Indonesia is the GASING method (*Gampang, Asyik, dan Menyenangkan*, meaning Easy, Enjoyable, and Fun). This method structures mathematics learning as a progressive journey from concrete manipulation toward abstract symbolic representation, with an emphasis on building genuine conceptual understanding. In practice, the GASING method resonates with conceptual learning frameworks that prioritize the construction of meaningful learning experiences. A bibliometric study conducted by Huan et al. (2022), covering 425 publications from 1968 to 2021, confirmed that concrete-to-abstract mathematics instruction has emerged as a well-established area of scholarly inquiry, with an increasingly diverse range of domains, including elementary school mathematics. Kim (2020) further affirmed that the concreteness fading strategy, a sequential instructional progression from concrete to abstract, constitutes a viable and sustainable pedagogical model for advancing conceptual understanding in mathematics classrooms. Nevertheless, a review of the existing empirical literature on the GASING method reveals that investigations have predominantly concentrated on cognitive and procedural outcomes. Kusuma and Sulistiawati (2014), in one of the foundational studies on GASING implementation, employed exclusively computational competence tests and teaching performance assessment as outcome measures, with no inclusion of affective instruments. Similarly, Nubatonic et al. (2023) examined GASING mathematics learning in an online setting and restricted their outcome measurement to pretest and posttest cognitive scores, with no assessment of student emotional or motivational responses to the instructional experience. This pattern of cognitive-only measurement across GASING studies stands in notable contrast to the method's own foundational philosophy, which explicitly foregrounds enjoyment and positive learning experience as core instructional values, thereby creating a substantive gap between the method's affective aspirations and the scope of its empirical examination to date.

Compassion-based teaching is characterized by empathy, heightened responsiveness to students' emotional states, and the deliberate cultivation of a learning environment that honors variation in student ability. Within mathematics education, this affective orientation carries particular relevance because the quality of the instructional climate has been consistently linked to students' learning outcomes. Jennings and Greenberg (2018) demonstrated that teacher social and emotional competence, including their capacity for empathic responsiveness, is associated with more positive classroom environments and stronger student academic outcomes, suggesting that the affective dimension of teaching extends beyond student well-being into the domain of cognitive achievement. This connection between effective instructional quality and mathematics learning outcomes is further supported by OECD (2023), which affirmed that classroom environments perceived as safe, supportive, and attentive to student well-being function as foundational

prerequisites for improving academic performance. At the level of students' own affective resources, Leppma and Darrah (2024) found that self-compassion and self-efficacy together serve as negative predictors of mathematics anxiety among students, suggesting that compassion-oriented learning conditions may support students in developing the psychological resources that sustain engagement and learning. While this evidence does not permit a direct causal claim linking compassion-based instruction to mathematics achievement, it provides a theoretically coherent basis for expecting that instructional design deliberately embedding compassion may contribute to improved learning outcomes by reducing barriers to engagement and fostering a more conducive cognitive learning environment.

On the other hand, the Concrete Pictorial Abstract (CPA) approach has accumulated a substantial body of empirical support and is widely regarded as an effective instructional framework in mathematics education. CPA facilitates the systematic construction of conceptual understanding through sequential engagement with concrete manipulatives, visual representations, and symbolic notation. A body of research has demonstrated that CPA effectively improves mathematics learning outcomes among elementary school students (Kim, 2020; Yurniwati et al., 2022). In Indonesia, Yuliyanto & Turmudi (2020) found that the CPA approach produced meaningful improvements in mathematics learning outcomes among elementary students with varied prior knowledge, with gains in academic confidence emerging as an accompanying benefit of the structured instructional progression. Moreover, Ding et al. (2024) affirmed that concreteness fading, referring to the sequential transition from concrete to abstract representations, represents an indispensable element of effective elementary mathematics instructional design, a view further supported by Meng et al. (2023), who found that teachers in high-performing educational systems consistently apply concreteness fading principles when linking multiple representations in elementary mathematics lessons.

Despite the growing body of evidence supporting both the GASING method and the CPA approach as effective instructional frameworks for elementary mathematics, several important gaps remain in the existing literature. First, empirical studies examining the GASING method have concentrated almost exclusively on cognitive and procedural outcomes in non-elementary or single-group settings, leaving its effectiveness at the fourth-grade elementary level in geographically remote and socio-culturally diverse contexts such as Nabire Regency largely unexplored. Second, while CPA has been extensively validated across various educational settings, direct comparative studies between CPA and the GASING method at the elementary level remain absent from the literature. Third, and most critically, no prior study has examined a configuration in which compassion values are deliberately integrated within the GASING method as a unified pedagogical model, nor has such an integrated approach been compared empirically against the CPA framework in terms of its effects on students' mathematics learning outcomes. The novelty of the present study therefore resides in three interconnected dimensions: the development and implementation of a compassion-integrated GASING model as a distinctive instructional configuration, its direct comparative examination against the well-established CPA approach, and the situating of this investigation within the specific socio-cultural and educational context of Nabire Regency, Papua, where evidence-based instructional guidance for elementary mathematics remains particularly limited. Guided by these gaps, the present study pursued the following objectives: (1) to analyze the improvement in mathematics learning outcomes of fourth-grade students taught using the compassion-integrated GASING method, (2) to analyze the improvement in mathematics learning outcomes of fourth-grade students taught using the CPA approach, and (3) to compare mathematics learning outcomes between the two instructional approaches among fourth-

grade elementary students in Nabire Regency. mathematics learning outcomes between the two instructional approaches among fourth-grade students in Nabire Regency.

METHODS

Research Design

This study adopted a quasi-experimental design structured around a nonequivalent control group. This design was deemed appropriate for comparing the effectiveness of two distinct instructional approaches within authentic classroom settings in the absence of full randomization (Creswell & Creswell, 2018).

Subject of Research or Population and Sample (Research Target)

The study drew its participants from fourth-grade students enrolled across six elementary schools in Nabire Regency. School selection was carried out using purposive sampling, with the criterion that only schools holding a "B" accreditation status were eligible for inclusion, ensuring a baseline level of institutional quality and comparability across sites. From the pool of eligible schools, six schools meeting this criterion were selected. Assignment of schools to the experimental and control conditions was subsequently conducted through random assignment, whereby three schools were randomly designated as the experimental group and the remaining three as the control group. Students in the experimental group received mathematics instruction delivered through the compassion-integrated GASING method, while those in the control group received instruction via the CPA approach. A total of 148 students initially participated, comprising 70 in the experimental group and 78 in the control group.

By the final data collection point, the analyzable sample had contracted to 59 students in the experimental group and 66 in the control group, yielding a total of 125 participants whose data were retained for analysis. The reduction in sample size was attributable to several factors, including student absenteeism on the day of posttest administration, illness during the posttest period, and cases in which students were present at the pretest but absent on one or more subsequent sessions, including the posttest, rendering their data incomplete for the purposes of pre-post comparison. In accordance with standard practice for handling incomplete data in quasi-experimental designs, analyses were conducted using a complete case approach, whereby only participants with complete pretest and posttest data were included in the final analyses (McCoy, 2017). It is acknowledged that this attrition, representing approximately 15.5% of the initial sample, carries a potential for selection bias if the students who were absent differed systematically from those who completed both assessments in terms of prior achievement or other relevant characteristics. However, given that the attrition was primarily attributable to incidental and health-related absences rather than to dissatisfaction with the instructional intervention and that the complete-case approach was applied consistently across both groups, the threat to internal validity is considered modest rather than substantial.

Instruments

The study employed two instruments: a mathematics achievement test and a teacher observation checklist. The primary research instrument was a mathematics achievement test targeting the cognitive domain, designed to measure students' learning outcomes on the topic of addition operations. The test was constructed based on a blueprint covering three cognitive levels according to Bloom's Taxonomy, namely remembering (C1), understanding (C2), and applying (C3), ensuring that the instrument assessed a range of cognitive processes rather than rote recall alone. All items were presented in multiple-choice format, with each item carrying a score of one point, yielding a maximum possible

score of 20. Prior to main administration, a pilot test was conducted with 26 students using an initial item pool of 30 questions. Item validity was assessed through Pearson correlation analysis, and 20 items that satisfied established validity criteria were retained for the final instrument. Reliability estimation using Cronbach's Alpha produced a coefficient of 0.871, consistent with standards for high reliability (Taber, 2018).

A teacher observation checklist served as the secondary instrument, designed to document the fidelity of compassion-based GASING method implementation across the three experimental schools. Classroom teachers at each experimental school assumed observer roles and used this checklist to systematically record the presence and quality of three core compassion-oriented behaviors demonstrated by the researcher during each instructional session: attentiveness to student difficulty, non-judgmental responses to student errors, and proactive accompaniment of students experiencing learning challenges. This observational instrument was employed to ensure that the compassion dimension of the intervention was enacted consistently and with sufficient fidelity across sites, thereby strengthening the interpretive validity of the study's findings regarding the compassion-integrated GASING method. It is acknowledged, however, that the absence of a standardized psychometric instrument for measuring students' affective outcomes constitutes a limitation of the present study, as it precludes a direct quantitative assessment of the extent to which the compassion-based instructional approach influenced students' emotional and motivational responses to mathematics learning.

Data Analysis Technique

Preliminary analysis involved normality testing via the Kolmogorov–Smirnov and Shapiro–Wilk procedures. Given that the distributional assumptions for normality were not consistently satisfied, inferential analyses were conducted using nonparametric statistical tests, specifically the Wilcoxon Signed-Rank test and the Mann–Whitney U test (Field, 2018).

Research Procedures

Figure 1 presents the overall research procedure implemented in this study. The study unfolded across three sequential phases: pretest administration, instructional intervention, and posttest administration. Regarding the measurement instruments, identical test items were used for both the pretest and posttest administrations. This decision was made on two methodological grounds. First, the use of identical items ensures complete standardization of measurement, guaranteeing that the difficulty level and the learning indicators assessed at both time points are fully equivalent so that any change in scores can be attributed purely to the effect of the instructional intervention rather than to differences in item quality or difficulty between the two administrations. Second, the use of identical items is a prerequisite for the accurate computation of gain scores, as valid pre-post comparisons require that the same construct be measured with the same instrument at both points in time. To mitigate the potential for practice effects arising from item familiarity, two precautionary measures were implemented. Students were not provided with answer keys or feedback on their pretest responses at any point prior to the posttest, ensuring that exposure to the items during the pretest did not confer an artificial advantage at posttest. Additionally, the test items were designed to assess higher-order cognitive processes at the application level (C3) alongside recall (C1) and comprehension (C2), meaning that students were required to engage in genuine reasoning and problem-solving rather than simple memorization of previously seen answers.

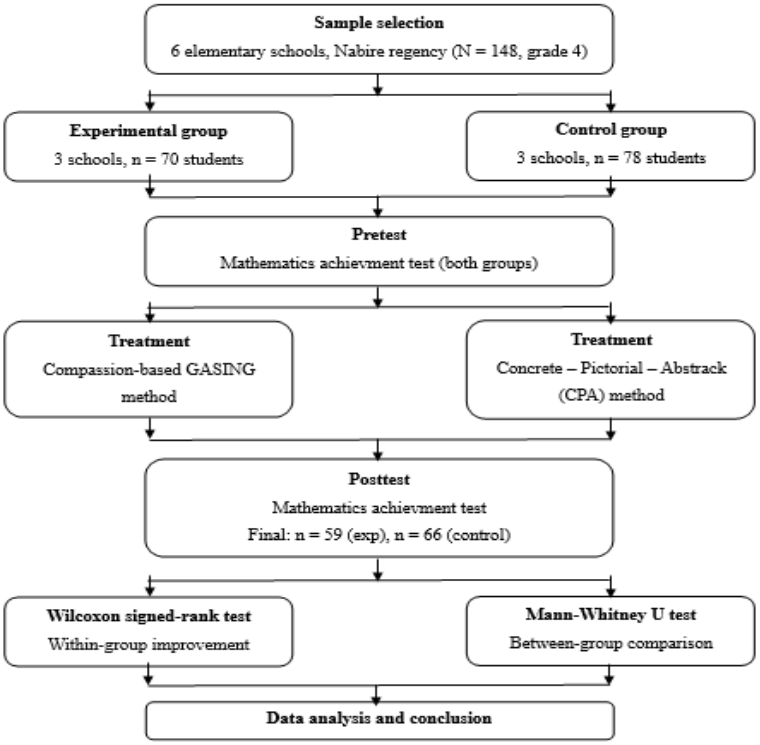

Figure 1 Research procedure

Instruction for the experimental group was delivered directly by the researcher at the three experimental schools, while classroom teachers assumed observer roles, using the structured observation checklist to document the fidelity with which the compassion-integrated GASING method was enacted across the three sites. This arrangement was instituted to safeguard consistency in how the compassion-integrated GASING method was enacted across sites. Instruction in the three control schools similarly proceeded through the structured concrete, pictorial, and abstract stages central to the CPA framework.

The implementation of the compassion-based GASING method in the experimental group followed three instructional phases. During the opening phase, an emotionally safe classroom climate was established by communicating to students that errors are a natural and expected dimension of learning and by establishing a shared classroom norm prohibiting ridicule of peers who had not yet grasped the material. During the core instructional phase, the progressive GASING sequence from concrete to abstract representation was implemented with three compassion-oriented teacher behaviors woven throughout: (1) attentiveness to student difficulty, reflected in active monitoring of signs of confusion or anxiety; (2) non-judgmental responses to student errors, whereby mistakes were addressed with patience and discretion to avoid public embarrassment; and (3) proactive accompaniment, wherein students encountering difficulty were approached and individually supported without waiting for them to seek assistance. During the closing phase, recognition was extended for student effort independent of outcome quality, and deliberate care was taken to ensure that no student departed the session carrying unresolved feelings of frustration from the day's learning experience.

RESULTS AND DISCUSSION

Descriptive analysis was carried out to characterize the initial and final mathematics learning outcomes of fourth-grade students in both the experimental and control groups across six elementary schools in Nabire Regency. Data were derived from pretest and posttest scores on a cognitive mathematics achievement measure covering the topic of addition operations. The analysis indicated that both groups registered improvements in learning outcomes over the course of the intervention. Descriptive statistics of mathematics learning outcomes are shown in Table 1.

Table 1 Descriptive statistics of mathematics learning outcomes

Group	N	Minimum	Maximum	Mean	SD
Pretest Experimental Group	59	0	55	28.90	15.84
Posttest Experimental Group	59	25	100	78.14	18.14
Pretest Control Group	66	0	85	34.47	22.47
Posttest Control Group	66	10	100	74.85	21.14

As shown in Table 1, the experimental group entered the study with a mean pretest score of 28.90, while the control group recorded a mean of 34.47. Although a descriptive difference of 5.57 points was observed between the two groups at baseline, a Mann-Whitney U test conducted on the pretest scores confirmed that this difference was not statistically significant ($U=1616.000$, $Z = -1.649$, $p = .099$), establishing that the two groups were comparable in terms of prior mathematics achievement before the instructional intervention commenced. The results of the Mann-Whitney U test for pre-test baseline equivalence are shown in Table 2.

Table 2 Mann-Whitney U test result for pretest baseline equivalence

Statistic	Value	Description
Mann–Whitney U	1,616,000	Not Significant
Z	-1.649	
Sig. (2-tailed)	0.099	

This baseline equivalence provides a sound statistical foundation for attributing subsequent posttest differences to the differential effects of the two instructional approaches. Following the instructional intervention, mean posttest scores rose to 78.14 in the experimental group and 74.85 in the control group, indicating that both groups registered meaningful improvements over the course of the study.

Fidelity of Implementation

Prior to reporting inferential test results, the fidelity of implementation of both instructional approaches was examined based on classroom observation data collected at each instructional session. For the experimental group, classroom teachers at each of the three experimental schools served as observers and documented the researcher's enactment of the compassion-integrated GASING method using a structured observation checklist across three meetings per school. For the control group, the same procedure was applied to document the implementation of the CPA approach across three meetings per school. Fidelity of implementation: The GASING method integrated with compassion is listed in Table 3.

Table 3 Fidelity of implementation: Compassion-integrated GASING method

No	School	Meeting	Total Score	Percentage (%)	Category
1	A	1	94	97.92	Very Good
2	A	2	96	100.00	Very Good
3	A	3	96	100.00	Very Good
4	B	1	93	96.88	Very Good
5	B	2	95	98.96	Very Good

No	School	Meeting	Total Score	Percentage (%)	Category
6	B	3	95	98.96	Very Good
7	C	1	96	100.00	Very Good
8	C	2	96	100.00	Very Good
9	C	3	96	100.00	Very Good
Mean			**95.22**	**99.19**	**Very Good**

Fidelity of implementation: The CPA approach is shown in Table 4.

Table 4 Fidelity of implementation: CPA approach

No	School	Meeting	Total Score	Percentage (%)	Category
1	A	1	88	91.67	Very Good
2	A	2	92	95.83	Very Good
3	A	3	93	96.88	Very Good
4	B	1	92	95.83	Very Good
5	B	2	92	95.83	Very Good
6	B	3	95	98.96	Very Good
7	C	1	96	100.00	Very Good
8	C	2	96	100.00	Very Good
9	C	3	96	100.00	Very Good
Mean			**93.33**	**97.22**	**Very Good**

As shown in Tables 3 and 4, both instructional approaches were implemented with consistently high fidelity across all nine sessions per group. The compassion-integrated GASING method achieved a mean implementation percentage of 99.19%, while the CPA approach achieved 97.22%, with all sessions falling within the Very Good category. These results indicate that both interventions were delivered with sufficient consistency and completeness to warrant confidence in attributing observed learning outcome changes to the instructional approaches themselves rather than to variability in implementation quality.

Prior to hypothesis testing, the distributional properties of the outcome data were examined using the Kolmogorov–Smirnov and Shapiro–Wilk tests. The results of the normality test are shown in Table 5.

Table 5 Normality test results

Data	N	Sig. Kolmogorov–Smirnov	Sig. Shapiro–Wilk
Pretest Experimental Group	59	0.001	0.001
Posttest Experimental Group	59	0.000	0.000
Pretest Control Group	66	0.001	0.001
Posttest Control Group	66	0.000	0.000

Normality test results indicated that all datasets produced significance values below 0.05, leading to the conclusion that the mathematics outcome data deviated from a normal distribution. Hypothesis testing, therefore, proceeded using nonparametric procedures, namely the Wilcoxon Signed-Rank test and the Mann–Whitney U test.

Within-group improvements were examined using the Wilcoxon Signed-Rank test, which compared pretest and posttest scores for each group. The results of the Wilcoxon test are shown in Table 6.

Table 6 Wilcoxon test results

Group	Z	Sig. (2-tailed)	Effect Size (r)	Description
Experimental Group (Compassion-Based GASING)	-6,689	< 0.001	0.871	Significant, Large Effect
Control Group (CPA)	-7,017	< 0.001	0.864	Significant, Large Effect

The Wilcoxon test results confirmed that statistically significant improvements in mathematics learning outcomes occurred within both the experimental and control groups. Effect sizes were calculated using the formula $r = \frac{Z}{\sqrt{n}}$, yielding r = 0.871 for the experimental group and r = 0.864 for the control group. Both values substantially exceed the threshold of 0.50 conventionally associated with large effects (Cohen, 1988), indicating that the practical significance of the gains produced by both instructional approaches was not merely statistically reliable but educationally substantial. These results establish that the compassion-integrated GASING method and the CPA approach each produced meaningful gains in mathematics achievement among fourth-grade elementary students in Nabire Regency.

Between-group differences in learning outcomes were subsequently examined using the Mann–Whitney U test. As established earlier, the two groups were statistically equivalent at pretest, supporting the appropriateness of posttest comparison as the primary basis for evaluating between-group differences in instructional effectiveness. The results of the Mann–Whitney test are shown in Table 7.

Table 7 Mann–Whitney test results

Statistic	Value	Description
Mann–Whitney U	1,826,000	
Z	-0.601	Not Significant
Sig. (2-tailed)	0.548	
Effect Size (r)	0.054	Trivial Effect

The Mann–Whitney test yielded a significance value of 0.548, which exceeds the 0.05 threshold, indicating that no statistically significant difference existed between the posttest mathematics learning outcomes of the two groups. The effect size of r = 0.054 falls below the threshold of 0.10 associated with even small effects (Cohen, 1988), confirming that the absence of the between-group difference was not merely a function of insufficient statistical power but reflects a genuinely trivial magnitude of difference in outcomes between the two instructional approaches. These results indicate that the compassion-integrated GASING method and the CPA approach produced comparably equivalent gains in mathematics learning outcomes among fourth-grade elementary students in Nabire Regency.

The findings of this study directly address three research objectives. With respect to the first objective, the Wilcoxon Signed-Rank test confirmed that the compassion-integrated GASING method produced a statistically significant improvement in mathematics learning outcomes among fourth-grade students in the experimental group ($Z = -6.689$, $p < .001$), with a large effect size of r = 0.871, indicating that the mean posttest score of 78.14 represented a substantial gain from the pretest mean of 28.90. With respect to the second objective, the CPA approach similarly produced a statistically significant improvement in the control group ($Z = -7.017$, $p < .001$, r = 0.864), with posttest scores rising from a mean of 34.47 to 74.85. With respect to the third objective, the Mann-Whitney U test revealed no statistically significant difference between the posttest outcomes of the two groups ($U = 1826.000$, $p = .548$, r = 0.054), confirming that the two instructional approaches produced comparably equivalent cognitive gains. These results collectively establish that both the compassion-integrated GASING method and the CPA approach are effective instructional frameworks for improving mathematics learning outcomes at the fourth-grade elementary level in Nabire Regency.

The large effect sizes observed within both groups are noteworthy and warrant contextual interpretation. The gains observed across both groups are consistent with prior scholarship affirming that structured, meaning-oriented mathematics instruction progressing from concrete to abstract representation has the capacity to advance students'

cognitive attainment (Carbonneau et al., 2020; Fyfe et al., 2022). More specifically, Iyamuremye and Burns (2025) demonstrated that CPA-based instruction produced substantial posttest improvements among students attending resource-constrained schools, reinforcing the generalizability of CPA's effectiveness across varied learning contexts, including those characterized by limited educational resources such as Nabire Regency. These findings are further consistent with Salingay and Tan (2018), who found that students exposed to CPA instruction demonstrated strong posttest performance and retention. The magnitude of gains observed in the present study, reflected in effect sizes exceeding 0.86 for both groups, suggests that both instructional approaches were not only statistically effective but also educationally meaningful in producing substantive improvements in students' addition operation competencies.

The absence of a statistically significant between-group difference, further confirmed by the trivial effect size of $r = 0.054$, suggests that the compassion-integrated GASING method and the CPA approach operate at comparably equivalent levels of cognitive effectiveness in the context of fourth-grade mathematics learning in Nabire Regency. This outcome is consistent with the perspective that the overall caliber of instructional design, encompassing the coherence of learning sequences, the degree of active student participation, and the fidelity of implementation, constitutes a primary determinant of mathematics learning achievement (Widjaja et al., 2020). Both approaches in the present study achieved high implementation fidelity, with mean percentages of 99.19% for the compassion-integrated GASING method and 97.22% for the CPA approach, suggesting that the quality of enactment was comparably high across both conditions and may have contributed to the equivalence of outcomes. In this regard, Listiani et al. (2025) cautioned that notwithstanding CPA's theoretical strengths, its practical implementation in elementary schools continues to encounter learning obstacles that must be addressed through instructional designs attuned to students' specific needs, a challenge that the structured fidelity monitoring in the present study sought to preemptively mitigate.

Although no statistically significant difference in cognitive outcomes was detected between the two groups, it is theoretically plausible that the compassion-integrated GASING approach carries distinct pedagogical advantages from an affective standpoint that were not directly captured by the cognitive measurement instrument employed in this study. This interpretive claim is advanced as a theoretical implication rather than an empirical finding, given that affective variables were not subjected to standardized quantitative assessment in the present study. The theoretical basis for this proposition rests on a body of evidence linking affective instructional climate to mathematics learning outcomes. Švecová (2024) documented a negative correlation between mathematics anxiety and problem-solving performance among elementary students, while Henschel and Roick (2017) demonstrated that both affective and cognitive expressions of mathematics anxiety were negatively associated with elementary students' mathematical performance. Radiusman et al. (2025) similarly found that mathematics anxiety impaired the performance of fifth-grade students in fraction operations. Taken together, these findings suggest that instructional designs capable of reducing anxiety-provoking conditions may carry indirect benefits for cognitive outcomes, even when such benefits are not directly measurable within a single study's design.

At the level of students' affective resources, Leppma & Darrah (2024) found that self-compassion and self-efficacy function as significant negative predictors of mathematics anxiety, suggesting that compassion-oriented learning conditions may support students in developing psychological resources that sustain engagement. Wangid et al. (2020), in the Indonesian elementary mathematics context, demonstrated that interventions prioritizing enjoyable and emotionally non-threatening learning experiences were effective in

alleviating mathematics anxiety, further underscoring the value of affective instructional approaches in elementary mathematics settings. The emotional support provided during instruction is equally critical: Li et al., (2023), through a longitudinal study, found that students' perceptions of teacher support were dynamically linked to mathematics engagement and reductions in anxiety. These findings collectively provide a theoretically coherent basis for expecting that the deliberate embedding of compassion within the GASING instructional framework may contribute to a more emotionally conducive learning environment, even if this contribution could not be directly quantified in the present study. Future research incorporating validated affective instruments would be necessary to empirically substantiate this theoretical proposition.

The equivalence of cognitive outcomes between the two approaches, situated within the specific context of Nabire Regency, also carries implications for understanding instructional effectiveness in geographically remote and socio-culturally diverse educational settings. The OECD (2023) has emphasized the imperative of embedding social and emotional dimensions within instructional practice as a prerequisite for equitable learning outcomes, particularly in contexts where students present diverse backgrounds and uneven prior achievement. The present findings suggest that both the compassion-integrated GASING method and the CPA approach are capable of delivering meaningful cognitive gains within such contexts, with the compassion-integrated model carrying additional theoretical potential for addressing the affective dimensions of learning that are particularly salient in heterogeneous classroom environments. Rather than supplanting the established cognitive architecture of the CPA approach, the compassion-integrated GASING method complements it with a humanistic orientation that, in contexts such as Nabire Regency where students' socio-cultural diversity places distinctive demands on instructional responsiveness, may offer a more contextually attuned pedagogical option. That the two approaches yielded comparable cognitive outcomes in this setting, rather than diverging significantly, may itself reflect the moderating influence of the high implementation fidelity maintained across both conditions, a finding that underscores the importance of consistent and well-monitored instructional delivery in determining learning outcomes across diverse educational contexts.

It is important to acknowledge several limitations that circumscribe the interpretive scope of these findings. The absence of standardized psychometric measurement of affective constructs such as mathematics anxiety and academic self-confidence means that the affective contribution of the compassion-integrated approach was inferred from theoretical literature rather than directly assessed, precluding definitive conclusions about its affective impact. Additionally, the confinement of the outcome measure to addition operations limits the generalizability of findings to broader mathematics learning outcomes. Future investigations are encouraged to incorporate validated affective instruments, extend the scope of mathematical content assessed, and employ more rigorous sampling designs to further examine the comparative effectiveness of compassion-integrated and CPA-based instruction across diverse elementary mathematics contexts.

CONCLUSION

This study investigated the comparative effectiveness of the compassion-integrated GASING method and the CPA approach in improving the mathematics learning outcomes of fourth-grade elementary students across six schools in Nabire Regency. Prior to drawing conclusions regarding comparative effectiveness, baseline equivalence between the experimental and control groups was verified through a Mann-Whitney U test on pretest scores, which confirmed no statistically significant difference between the two groups at

the outset of the study (U = 1616.000, Z = -1.649, p = .099). This baseline equivalence provides the necessary statistical foundation for the conclusions drawn below.

With respect to the first research objective, the compassion-integrated GASING method produced a statistically significant improvement in mathematics learning outcomes within the experimental group (Z = -6.689, p < .001), with mean scores rising from 28.90 at pretest to 78.14 at posttest, representing a gain of 49.24 points and a large effect size of r = 0.871. With respect to the second objective, the CPA approach similarly produced a statistically significant improvement within the control group (Z = -7.017, p < .001), with mean scores rising from 34.47 to 74.85, representing a gain of 40.38 points and a large effect size of r = 0.864. With respect to the third objective, no statistically significant difference was detected between the posttest outcomes of the two groups (U = 1826.000, Z = -0.601, p = .548), with a trivial effect size of r = 0.054, confirming that both instructional approaches produced comparably equivalent cognitive gains among fourth-grade elementary students in Nabire Regency.

While the cognitive outcomes of both approaches were statistically equivalent, it is theoretically plausible, though not empirically demonstrated in the present study, that the compassion-integrated GASING method carries supplementary pedagogical value from an affective standpoint. Given that affective variables such as mathematics anxiety and academic self-confidence were not directly measured using standardized instruments, any claim regarding the affective advantages of this approach must be understood as a theoretical implication grounded in existing literature rather than a direct finding of the present study. Future research incorporating psychometrically validated affective instruments would be necessary to empirically examine this proposition.

In practical terms, these findings afford teachers in Nabire Regency the latitude to select mathematics instructional approaches suited to the particular characteristics of their students and classroom contexts, with confidence that both the compassion-integrated GASING method and the CPA approach are capable of producing substantial and meaningful gains in elementary mathematics achievement. The high implementation fidelity achieved across both conditions, with mean percentages of 99.19% for the GASING method and 97.22% for the CPA approach, further suggests that consistent and well-monitored instructional delivery is a critical factor in realizing the cognitive benefits of either approach. The confluence of a rigorous cognitive framework with affective instructional dimensions represents a promising direction for developing mathematics learning that is oriented not only toward academic achievement but also toward the more comprehensive development of students as learners.

Several limitations of the present study warrant acknowledgment. First, affective constructs such as mathematics anxiety and academic self-confidence were not assessed using standardized psychometric instruments; consequently, the potential affective contribution of the compassion-integrated approach was inferred from theoretical literature and behavioral observation rather than direct quantitative measurement. Second, the outcome measure was restricted to addition operations, which limits the generalizability of findings to broader mathematics learning outcomes and other content domains. Third, the study was situated within the geographically and socio-culturally specific context of Nabire Regency in Papua, which may constrain the transferability of findings to other regions characterized by different educational conditions. Fourth, the attrition of the sample from 148 to 125 participants, attributable to absenteeism, illness, and incomplete posttest participation, may have introduced a degree of selection bias, notwithstanding the application of a complete case analysis framework and the finding that attrition was distributed across both groups.

Subsequent research is encouraged to examine the influence of compassion-centered pedagogical approaches on students' affective outcomes through more comprehensive measurement procedures, incorporating psychometrically validated instruments for constructs such as mathematics anxiety, academic self-efficacy, and learning engagement. Future studies would also benefit from broader and more heterogeneous research contexts, extended content coverage beyond a single arithmetic operation, larger and more representative samples obtained through probability sampling designs, and longitudinal follow-up to assess the durability of cognitive gains produced by both instructional approaches.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

AUTHOR CONTRIBUTIONS STATEMENT

Conceptualization, JKS; methodology, JKS; data collection, JKS; formal analysis, JKS; writing, preparation of the original draft, JKS; writing, review and editing, TM and RRS; supervision, TM and RRS. All authors have read and agreed to the published version of the manuscript.

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