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GASING vs Deep Learning: Which Instructional Approach More Effectively Improves Primary Students' Understanding of Whole Numbers?

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Abstract: This study analyzes the comparative effectiveness of the GASING (Easy, Engaging, and Enjoyable) approach and the Deep Learning approach in improving the mathematics learning outcomes of elementary school students regarding whole number content. A quasi-experimental pretest-posttest design was employed with 18 students from two classes at a public elementary school in Siak Regency, Riau Province (Class A: Deep Learning, n = 9; Class B: GASING, n = 9). Data were collected using a 20-item validated multiple-choice achievement test (KR-20 = 0.78) and semi-structured interviews. Quantitative analysis included normalized N-Gain, paired-samples t-tests, the Mann-Whitney U test, and Cohen's d effect size. Results indicated that both approaches significantly improved learning outcomes. The Deep Learning approach yielded a medium N-Gain ($\langle g \rangle$ = 0.547, t = 6.874, p < 0.001), whereas the GASING approach yielded a high N-Gain ($\langle g \rangle$ = 0.827, t = 8.847, p < 0.001). Between-group comparison confirmed that the GASING approach was significantly more effective (U = 70.5, p = 0.009, Cohen's d = 1.57, indicating a very large effect). Interview data corroborated these findings, showing that Class B students demonstrated greater self-confidence and active engagement. Because whole number understanding serves as the foundation for subsequent mathematical concepts—such as arithmetic operations, fractions, and algebraic reasoning—mastering this content is critical for long-term mathematical development. Therefore, identifying instructional approaches like GASING that effectively support whole number mastery is essential for strengthening students' readiness for advanced mathematical concepts.

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Introduction

Mathematics serves not only as an academic subject but also as a tool for developing problem-solving skills applicable to daily life. The importance of early mathematics education has been substantiated by numerous studies in neuroscience and cognitive psychology. Evans (2015) found that early mathematics learning stimulates the development of brain regions responsible for decision-making and concentration. Children who actively engage in mathematics tend to exhibit superior cognitive development compared to those with limited exposure. These findings underscore the necessity of establishing a strong mathematical foundation at the elementary school level. International data further reinforce this urgency: the TIMSS 2019 results placed Indonesia below the international average in Grade 4 mathematics achievement, highlighting the critical need for improved instructional quality at the primary level (Mullis et al., 2020).

This aligns with the findings of Rahmalia and Safari (2024), who asserted that foundational mathematics education plays a pivotal role in developing children's critical thinking and problem-solving abilities. The process of learning mathematics compels children to practice logical reasoning, identify patterns, and systematically analyze problems skills that are transferable not only to other academic disciplines but also to real-world contexts. Consequently, deepening mathematical understanding extends beyond mastering computations or formulas; it constitutes the construction of a robust cognitive foundation for lifelong academic and practical needs. The author contends that investing in the effectiveness of mathematics teaching methods at the elementary level represents the most strategically impactful educational intervention, given its cumulative and foundational nature.

A fundamental issue identified by Hiebert and Grouws (2007) concerns the quality of instructional interactions in the classroom specifically, how teachers design learning experiences that cultivate conceptual understanding rather than mere procedural fluency. The dichotomy between relational and instrumental understanding, as formulated by Skemp (1976), remains highly relevant today: much of elementary mathematics instruction in Indonesia remains oriented toward procedural-mechanical approaches, producing students who are proficient in calculation yet deficient in deep conceptual understanding. This problem is particularly pronounced in the domain of whole numbers, which serves as the arithmetic prerequisite for all advanced mathematical content. When whole number understanding is constructed through rote memorization without adequate conceptualization, students fail to develop flexible number sense, which subsequently impairs their performance in subsequent topics (Van de Walle et al., 2019).

Efforts to identify optimal mathematics teaching methods have generated a rich body of empirical evidence. A meta-analysis by Carbonneau et al. (2013) of 55 experimental studies demonstrated that the use of concrete manipulatives yielded higher learning gains than instruction based solely on abstract symbols (effect size d = 0.57), while Verschaffel et al. (2020), in a systematic review published in ZDM Mathematics Education, confirmed the superiority of contextual approaches in building deep numerical understanding. Two pedagogical innovations particularly relevant to these findings are the GASING Approach and the Deep Learning Approach.

The effective mathematics learning principles outlined by NCTM (2014) emphasize the importance of building deep conceptual understanding prior to procedural fluency. The GASING (Gampang, Asyik, dan Menyenangkan Easy, Engaging, and Enjoyable) approach, developed by Surya (2011), operationalizes Bruner's (1966) enactive-iconic-symbolic representation model and Vygotsky's (1978) zone of proximal development through a structured sequence of concrete–abstract–mental arithmetic stages. Nasution and Surya (2021) reported that implementation of the GASING Approach in elementary schools consistently improved mathematics learning outcomes and students' self-confidence, particularly in basic number operations. Kurniawan (2018) further noted that the mental arithmetic (congak) stage in GASING has been demonstrated to effectively develop number sense and mental calculation ability foundational competencies for long-term mathematical proficiency.

The Deep Learning Approach, as conceptualized by Fullan, Quinn, and McEachen (2018) distinct from the term "deep learning" in artificial intelligence as well as from recent policy directives of the Indonesian Ministry of Education and Culture emphasizes profound student engagement through six global competencies (the 6Cs: character, citizenship, collaboration, communication, creativity, and critical thinking). Quinn et al. (2019) reported that this approach enhances intrinsic motivation and students' capacity for knowledge transfer. Mehta and Fine (2019), in an in-depth investigation, found that schools

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implementing Deep Learning produced students who were more capable of transferring and applying knowledge in novel situations.

Although both GASING and Deep Learning have been reported to improve mathematics learning outcomes, they are grounded in different pedagogical assumptions. GASING emphasizes structured conceptual development through concrete-to-abstract progression, whereas Deep Learning emphasizes student agency, inquiry, reflection, and knowledge transfer. Despite their growing adoption, empirical studies directly comparing these two approaches within the same instructional context remain extremely limited. Most previous studies have evaluated each approach independently, making it difficult for teachers to determine which approach is more appropriate for teaching foundational mathematical concepts such as whole numbers. This gap is particularly important because instructional effectiveness at the elementary level may differ substantially from that observed in secondary or higher education settings.

The present study was conducted at an elementary school in Siak Regency, Riau Province a school representative of public primary schools in Indonesian plantation regions. Preliminary observations revealed that mathematics instruction at the school was predominantly teacher-centered and procedurally oriented, with minimal conceptual exploration, resulting in limited deep understanding of number concepts among students. To date, studies that directly compare the effectiveness of the GASING Approach and the Deep Learning Approach within a single controlled experimental design on whole number content remain scarce; the majority of existing studies have been conducted in developed countries with substantially different sociocultural contexts and resource levels (Russo et al., 2021). This study aims to analyze the comparative effectiveness of the GASING (Easy, Engaging, and Enjoyable) Approach and the Deep Learning Approach in improving elementary school students' mastery of whole number concepts and mathematics learning outcomes. By directly comparing these two instructional approaches within the same educational context, this study seeks to address a gap in the literature regarding the most effective strategy for developing foundational number understanding in primary mathematics education. The novelty of this study lies in three aspects. First, it directly compares the GASING Approach and the Deep Learning Approach within a single quasi-experimental design, a comparison rarely reported in previous literature. Second, the study focuses specifically on whole number content, which constitutes a critical foundation for later mathematical learning. Third, the study integrates quantitative evidence (N-Gain, inferential statistics, and effect size) with qualitative interview findings to provide a more comprehensive understanding of instructional effectiveness in an authentic elementary school setting.

Research Method

This study employed a quasi-experimental design with a pretest-posttest control group structure (Creswell & Creswell, 2018; Sugiyono, 2019). Class A received the Deep Learning Approach treatment, while Class B received the GASING Approach treatment. The research design is presented in Table 1.

Table 1. Quasi-Experimental Pretest-Posttest Design

Group	Pretest	Treatment	Posttest
Class A (Deep Learning)	O_1	X_1	O_2
Class B (GASING)	O_3	X_2	O_4

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Note: O_1, O_3 = Pretest; O_2, O_4 = Posttest; X_1 = Deep Learning Approach; X_2 = GASING Approach

The research subjects consisted of 18 elementary school students from a school in Siak Regency, Riau Province, distributed across two classes: Class A (n = 9) and Class B (n = 9). Subjects were selected using purposive sampling. As the student count constituted the entire class population, the limited sample size reflects the actual classroom conditions at the school. The study was conducted during the second semester of the 2025/2026 academic year. All research procedures adhered to established ethical principles. Written permission was obtained from the school principal. Parents/guardians were provided with explanations of the study's objectives and procedures, and written informed consent was obtained. Individual student data were kept confidential through anonymous codes (S-A1 to S-A9 for Class A; S-B1 to S-B9 for Class B) throughout all reporting.

The study was conducted over 7 sessions organized into three main phases. The first phase pre-intervention (Sessions 1–2) involved orientation and an initial pretest (Session 1) and preliminary teacher and student interviews (Session 2). The second phase intervention (Sessions 3–6) comprised four sessions (2 × 35 minutes each) with differentiated treatments: Class A used the Deep Learning Approach through the Engage-Explore-Explain-Elaborate framework (Fullan et al., 2018), while Class B used the GASING Approach through the concrete → abstract → mental arithmetic stages (Surya, 2011). The third phase, post-intervention (Session 7) included the final posttest, post-intervention interviews, and data verification. Data collection instruments comprised two types. First, a 20-item multiple-choice mathematics achievement test, developed through three stages and yielding: a content validity value of 2.55/3 (Aiken, 1985), a KR-20 reliability coefficient of 0.78 (high reliability; Guilford, 1956), item discrimination indices ranging from 0.30 to 0.68, and item difficulty levels ranging from 0.32 to 0.71. Second, semi-structured interview guides for teachers (7 questions) and students (5 questions), analyzed through inductive thematic analysis (Creswell, 2014).

Prior to evaluating the effectiveness of the instructional interventions, an independent-samples t-test was conducted on the pretest scores to examine the equivalence of the two groups at baseline. The analysis indicated that there was no statistically significant difference between the initial mathematics achievement of Class A and Class B ($t(16) = 1.715$, $p = 0.106 > 0.05$). This result suggests that both groups possessed comparable prior knowledge and mathematical ability before the intervention, thereby supporting the validity of subsequent comparisons regarding the effects of the GASING and Deep Learning approaches.

Quantitative data analysis followed seven sequential procedures: (1) descriptive statistics; (2) Shapiro-Wilk normality test; (3) group equivalence testing via independent-samples t-test on pretest scores; (4) normalized N-Gain analysis (Hake, 1999); (5) paired-samples t-test for within-group significance of improvement; (6) Mann-Whitney test (Mann & Whitney, 1947) for between-group effectiveness comparison selected because the N-Gain distribution of Class A was non-normal (Shapiro-Wilk $p = 0.043$); and (7) Cohen’s d effect size.

Table 2. Categories of Normalized N-Gain (Hake, 1999)

N-Gain Value (⟨g⟩)	Category
$\langle g \rangle \geq 0.70$	High
$0.30 \leq \langle g \rangle < 0.70$	Medium

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N-Gain Value (⟨g⟩)	Category
⟨g⟩ < 0.30	Low

Results and Discussion

1) Descriptive Statistics

Table 3 summarizes the pretest and posttest results for both classes. Prior to intervention, Class A exhibited a higher pretest mean (M = 51.67; SD = 13.92) compared to Class B (M = 40.56; SD = 13.57). Following intervention, the posttest mean of Class B (M = 90.56; SD = 7.26) substantially exceeded that of Class A (M = 77.78; SD = 10.64). The Absolute Gain of Class B reached 50.00 points, nearly twice the Absolute Gain observed in Class A (26.11 points). Following the intervention, the posttest mean of Class B (M = 90.56; SD = 7.26) substantially exceeded that of Class A (M = 77.78; SD = 10.64). Furthermore, Class B demonstrated a considerably higher Absolute Gain (50.00 points) than Class A (26.11 points), indicating greater improvement in mathematics learning outcomes following the implementation of the GASING Approach. This comparison is visualized in Figure 1.

Table 3. Descriptive Statistics of Mathematics Learning Outcomes

Class	Test	Mean (M)	SD	Min	Max	Absolute Gain
Class A (Deep Learning)	Pretest	51.67	13.92	25	70	
	Posttest	77.78	10.64	65	95	26.11
Class B (GASING)	Pretest	40.56	13.57	20	60	
	Posttest	90.56	7.26	75	100	50.00

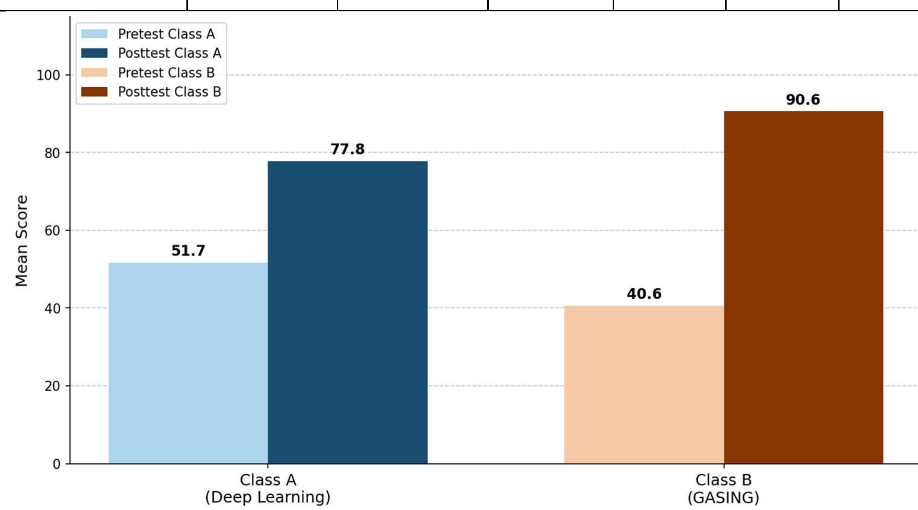

Figure 1. Comparison of Pretest and Posttest Mean Scores for Both Classes

2) Group Equivalence Test (Pretest)

Prior to evaluating treatment effectiveness, the initial equivalence of both groups was assessed using an independent-samples t-test on pretest scores. Results indicated no statistically significant difference between the pretest means of Class A (M = 51.67) and Class B (M = 40.56), with t(16) = 1.715; p = 0.106 (p > 0.05). Both groups were therefore considered statistically equivalent prior to the commencement of intervention.

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Table 4. Group Equivalence Test Results (Independent Samples t-test on Pretest)

Variable	M Class A	M Class B	t	df	Sig. (2-tailed)	Note
Pretest	51.67	40.56	1.715	16	0.106	Equivalent ✓

3) Normality Test

Table 5 indicates that the pretest and posttest data for both classes were normally distributed (all $p > 0.05$). However, the N-Gain data for Class A yielded $p = 0.043$ (< 0.05), indicating a non-normal distribution. This finding informed the selection of the Mann-Whitney test for the between-group effectiveness comparison.

Table 5. Shapiro-Wilk Normality Test Results

Data	W	p-value	Note
Pretest Class A	0.901	0.259	Normal ✓
Posttest Class A	0.850	0.075	Normal ✓
Pretest Class B	0.966	0.860	Normal ✓
Posttest Class B	0.894	0.218	Normal ✓
N-Gain Class A	0.828	0.043	Non-Normal ✗
N-Gain Class B	0.888	0.189	Normal ✓

4) Normalized N-Gain Analysis

Table 6 presents individual (anonymized) N-Gain values and class means. The mean N-Gain of Class B (GASING Approach) was 0.827, classified as High, while that of Class A (Deep Learning Approach) was 0.547, classified as Medium (Hake, 1999). Figures 2 and 3 visualize the N-Gain differences between classes, both overall and per student.

Table 6. Individual (Anonymized) Normalized N-Gain Values

No	Code (A)	Pre | Post (A)	N-Gain (A)	Code (B)	Pre | Post (B)	N-Gain (B)
1	S-A1	70 | 95	0.833	S-B1	20 | 90	0.875
2	S-A2	60 | 75	0.375	S-B2	30 | 95	0.929
3	S-A3	60 | 75	0.375	S-B3	40 | 85	0.750
4	S-A4	60 | 75	0.375	S-B4	50 | 75	0.500
5	S-A5	60 | 95	0.875	S-B5	55 | 95	0.889
6	S-A6	45 | 70	0.455	S-B6	45 | 90	0.818
7	S-A7	45 | 65	0.364	S-B7	25 | 95	0.933
8	S-A8	40 | 80	0.667	S-B8	40 | 100	1.000
9	S-A9	25 | 70	0.600	S-B9	60 | 90	0.750
	Mean	51.67 | 77.78	0.547 (Medium)	Mean	40.56 | 90.56	0.827 (High)

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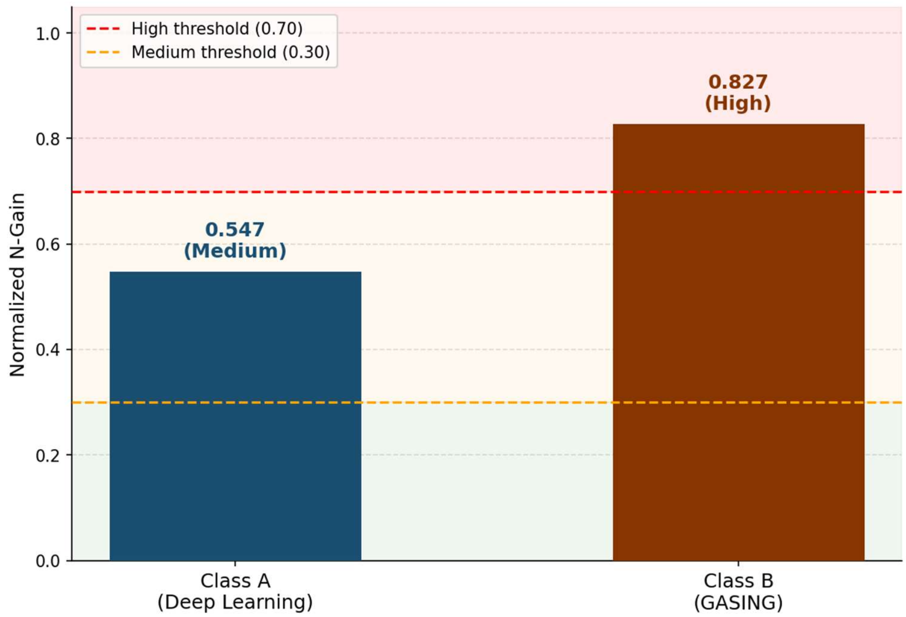

Figure 2. Comparison of Mean N-Gain: Class A (Deep Learning) vs. Class B (GASING)

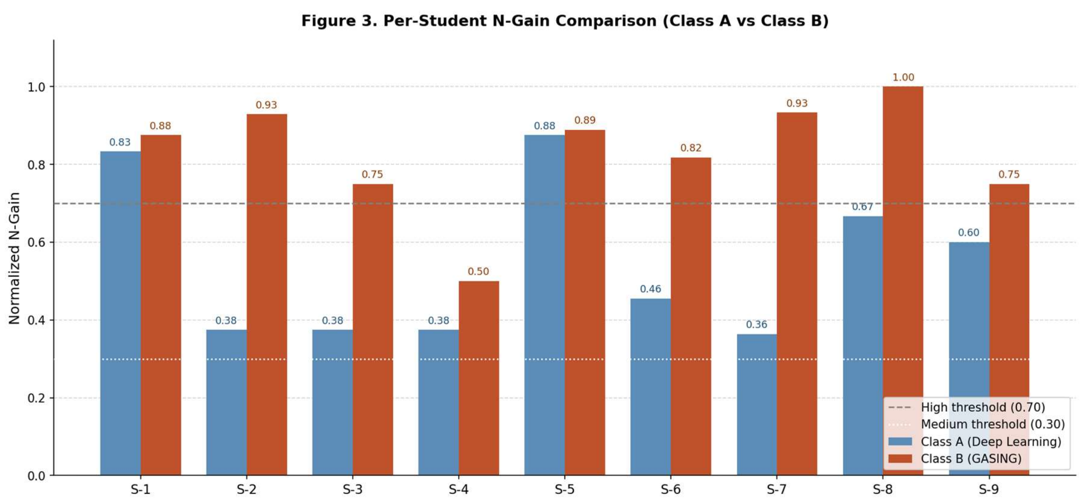

Figure 3. Per-Student N-Gain Comparison: Class A vs. Class B

5) Paired-Samples t-test (Within-Group Improvement)

Paired-samples t-test results confirmed that both classes experienced statistically significant improvements. Table 7 presents results in a complete SPSS-style format, including mean difference, standard deviation of differences, standard error mean, 95% confidence interval, t-value, degrees of freedom, and significance level.

Table 7. Paired-Samples t-test Results SPSS Format (Paired Samples Test)

Group (Post − Pre)	Mean Diff	Std. Dev	SE Mean	95% CI Lower	95% CI Upper	t	df	Sig. (2-tailed)
Class A (DL) Posttest−Pretest	26.111	11.396	3.799	17.352	34.871	6.874	8	0.000
Class B	50.000	16.956	5.652	36.967	63.033	8.847	8	0.000

Group (Post − Pre)	Mean Diff	Std. Dev	SE Mean	95% CI Lower	95% CI Upper	t	df	Sig. (2-tailed)
(GASING) Posttest−Pretest								

6) **Mann-Whitney Test and Effect Size**

Given the non-normal distribution of N-Gain scores in Class A, between-group effectiveness was compared using the Mann-Whitney test. Results ($U = 70.5$; $p = 0.009$) combined with a Cohen's d effect size of 1.57 (very large) unequivocally demonstrated that the GASING Approach was both statistically and practically superior.

Table 8. Mann-Whitney Test and Cohen's d Effect Size Results

Comparison	Mean Rank B	Mean Rank A	U	Sig. (2-tailed)	Cohen's d (Category)
N-Gain: Class B vs. Class A	12.28	6.72	70.5	0.009	1.57 (Very Large)

Note: Effect size categories small: d = 0.20–0.49; medium: d = 0.50–0.79; large: d = 0.80–1.29; very large: d ≥ 1.30 (Sawilowsky, 2009).

7) **Interview Data**

Semi-structured interviews were conducted with two classroom teachers and six students in Sessions 2 and 9. Inductive thematic analysis yielded four primary themes.

a) Theme 1 Engagement and Learning Motivation.
The Class B teacher reported a significant increase in active engagement: students competed enthusiastically in mental arithmetic exercises and displayed high levels of enthusiasm. The Class A teacher noted that group discussions proceeded effectively, although some students required an adaptation period for independent exploration.

b) Theme 2 Mathematics Self-Confidence.
Class B students demonstrated more consistent improvement in self-confidence, particularly in mental arithmetic. S-B7 (N-Gain = 0.933) reported being able to perform calculations mentally without the need to write out each step.

c) Theme 3 Teachers' Perceptions of Effectiveness.
The Class B teacher noted that the structured stages of GASING facilitated real-time monitoring of student understanding. The Class A teacher considered the Deep Learning Approach to have a positive impact on the depth of mathematical discussion and argumentation, though it required a longer adaptation period.

d) Theme 4 Implementation Challenges.
Both teachers identified time management as the primary challenge. The Class B teacher noted that the mental arithmetic stage required intensive repetition, while the Class A teacher reported that encouraging all students to actively engage in discussions necessitated more varied facilitation strategies.

Discussion

Recent evidence suggests that conceptual mathematics instruction supported by concrete representations significantly enhances number sense development and mathematical achievement among elementary learners (Fyfe et al., 2022). The finding that the Deep Learning Approach significantly improved learning outcomes ($t = 6.874$; $p < 0.001$; N-Gain = 0.547, Medium category) is consistent with Fullan et al. (2018), who argued that learning emphasizing deep conceptual exploration promotes more meaningful understanding. A

Medium N-Gain aligns with Nambiar et al. (2021), who found that initial implementation of Deep Learning in elementary schools produces moderate gains as students adapt to the paradigm of independent exploration. The author further argues that this outcome is influenced by students' cognitive readiness: as demonstrated by Piaget (1952), elementary school children in the concrete operational stage are not yet fully equipped for the level of abstraction and self-reflection this approach optimally demands. Studies have also demonstrated that inquiry-oriented and deeper learning pedagogies promote transferable understanding and long-term retention, although their effectiveness may depend on students' developmental readiness and prior knowledge (Darling-Hammond et al., 2021).

The GASING Approach produced highly significant improvements ($t = 8.847$; $p < 0.001$; N-Gain = 0.827, High category), even given Class B's lower initial ability. These results confirm Bruner's (1966) principle that learning progressing from enactive (concrete) to iconic to symbolic experience constructs robust understanding. The findings align with the meta-analysis by Carbonneau et al. (2013) and are corroborated by interview data reporting notable increases in students' self-confidence and active engagement. Boaler (2022) demonstrated that students' beliefs about their mathematical abilities termed "mathematical mindset" are shaped through positive and engaging learning experiences, as provided by the GASING Approach. Furthermore, the "Easy, Engaging, and Enjoyable" principles of GASING align with Deci and Ryan's (2000) Self-Determination Theory: intrinsic motivation arising from a sense of competence directly enhances learning quality.

The Mann-Whitney test results ($U = 70.5$; $p = 0.009$) and Cohen's $d = 1.57$ (very large) clearly demonstrate that the GASING Approach was more effective in this context. The author proposes that both approaches can be complementarily integrated: GASING to establish a concrete foundation, followed by the gradual application of Deep Learning to develop critical thinking and reflective competencies consistent with Vygotsky's (1978) principle of progressive scaffolding.

Several confounding factors warrant acknowledgment: (1) baseline ability differences between classes, although non-significant statistically; (2) teacher variables that were not experimentally controlled; (3) a very small sample size ($n = 9$) that limits statistical power and the stability of effect size estimates; and (4) a non-randomized design that constrains causal inference. Generalization of these findings to broader contexts should be approached with considerable caution.

Conclusion

This study demonstrates that both the GASING Approach and the Deep Learning Approach can improve elementary students' understanding of whole numbers. However, the GASING Approach appears to be more effective in supporting conceptual understanding, student engagement, and mathematical confidence within the context of this study. These findings highlight the importance of instructional approaches that align with the developmental characteristics of elementary learners and emphasize meaningful conceptual construction. Practically, the results suggest that GASING may serve as a strong foundation for mathematics instruction, while Deep Learning can be gradually integrated to foster higher-order thinking and reflective learning. Together, both approaches offer complementary contributions to strengthening mathematics learning in primary education.

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Recommendation

Future studies should employ larger and more diverse samples using randomized controlled designs to enhance the generalizability and causal validity of findings. In addition, longitudinal research is recommended to examine the sustainability of learning outcomes and retention effects over time. From a pedagogical perspective, it is advisable to develop an integrated instructional model that combines the structured, concrete foundation of the GASING approach with the higher-order cognitive engagement of the Deep Learning approach. Policymakers and curriculum developers are also encouraged to consider incorporating GASING-based strategies into elementary mathematics instruction, particularly in contexts with heterogeneous student abilities, while gradually embedding.

Based on the findings of this study, elementary school teachers are encouraged to prioritize conceptual understanding through concrete and engaging learning experiences when introducing whole number concepts. Teachers may adopt the GASING Approach during the initial stages of instruction to strengthen number sense, mental calculation ability, and student confidence. Once students demonstrate adequate conceptual mastery, elements of the Deep Learning Approach such as collaborative problem solving, reflection, and inquiry-based activities can be gradually incorporated to develop critical thinking and knowledge transfer. This sequential integration may provide a balanced pathway for achieving both foundational understanding and higher-order mathematical competencies.

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