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The Use of the Drill Method with a Game-Based Learning Approach to Improve Mathematical Understanding and Foster Self-Confidence at Elementary School Level

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A B S T R A C T

This study addresses low mathematical understanding and self-confidence among elementary school students in mathematics learning. Conventional instructional methods often lack engagement and fail to effectively support students' motivation and conceptual development. This research examines the effectiveness of combining the drill method with a game-based learning (GBL) approach to improve students' mathematical understanding and self-confidence. A quasi-experimental design was employed involving sixth-grade students from two elementary schools. The findings reveal that students who learned through the drill method integrated with game-based learning demonstrated significantly higher levels of mathematical understanding and self-confidence compared to those taught through conventional methods. Improvements in both cognitive and affective dimensions were more evident in the experimental group. These results indicate that integrating drill practices with game-based learning creates a more engaging learning environment and effectively enhances students' comprehension and confidence in mathematics. The study highlights the potential of interactive learning approaches as an innovative strategy to strengthen mathematics learning at the elementary level.

1. Introduction

Education is an essential process aimed at developing students' character, competence, and critical thinking skills to enable them to adapt to the challenges of modern life. One of the key subjects that plays a strategic role in building logical and systematic thinking is mathematics. Mathematics learning in elementary schools serves as the foundation for developing reasoning, problem-solving, and creative thinking skills that support mastery of other disciplines (Putri et al., 2025). However, in reality, the mathematical understanding of elementary school students in Indonesia remains low. This aligns with the findings of Perdana and Isrokatun (2019), who stated that poor mathematical understanding often leads to misconceptions and errors in applying mathematical concepts in everyday contexts. Recent studies have further confirmed that students' difficulties in mathematics are not only related to cognitive factors but also to the limited application of varied instructional strategies (Gunawan et al., 2026).

Mathematics holds a central role in the development of students' cognitive abilities, logical reasoning, and problem-solving skills competencies that are essential not only for academic success but also for navigating real-life situations. At the elementary school level, mathematics is expected to serve as both a conceptual foundation and a medium for cultivating analytical thinking and creativity. Nevertheless, a growing body of research and evaluation reports consistently reveals that the mathematical understanding of elementary school students in Indonesia remains below expectations.

Many students struggle to interpret mathematical ideas, apply concepts to novel situations, and maintain confidence when confronted with mathematical tasks. According to Mustika et al. (2024), these challenges are often exacerbated by instructional practices that prioritize procedural knowledge over conceptual understanding. These difficulties suggest deeper issues in the learning process, particularly the dominance of conventional, teacher-centered methods that emphasize memorization and procedural routines over conceptual exploration. As a consequence, mathematics is often perceived by young learners as abstract, monotonous, and anxiety-inducing.

The challenge of low mathematical comprehension is strongly intertwined with the pedagogical approaches employed in the classroom. Traditional instruction tends to rely heavily on direct explanation accompanied by repetitive exercises, with limited opportunities for student interaction or contextualization. This approach is misaligned with contemporary learning theories, which advocate for student-centered, inquiry-rich, and experience-based environments. Rizqi et al. (2025) emphasize that meaningful learning occurs when students are actively involved in constructing their own understanding through exploration and collaboration. Without meaningful engagement, students find it difficult to internalize concepts or relate mathematics to everyday situations.

The affective dimension also plays a critical role: self-confidence has a substantial influence on students' willingness to participate, take risks, and persist through challenges. Students with low confidence often avoid tasks involving uncertainty, fear making mistakes, and withdraw from classroom discussions. Research by Kaharuddin and Tulak (2022) indicates that affective factors such as self-confidence and anxiety significantly affect students' mathematical performance. Considering that elementary school is a formative stage, it becomes increasingly important to design learning environments that foster curiosity, resilience, and self-belief alongside academic mastery.

In response to these concerns, educational scholars have long emphasized the need to modernize mathematics instruction through approaches that balance rigor with enjoyment. One method that continues to be relevant is the drill method, which focuses on repeated practice to consolidate procedural fluency and strengthen memory retention. While drill activities can indeed facilitate accuracy and automaticity, they are often criticized for their repetitive nature, which can diminish students' motivation over time. However, when implemented effectively, drill exercises can enhance students' mastery of basic skills, particularly when combined with motivational strategies (Utami et al., 2025). To address this limitation, drill-based activities must be redesigned in ways that retain their effectiveness while simultaneously enhancing engagement.

A promising way to achieve this is by integrating game-based learning (GBL) into drill practices. GBL incorporates elements commonly found in games competition, challenge, immediate feedback, rewards, and narrative frameworks to increase motivation and sustain attention. Prior studies have shown that GBL is capable of transforming abstract content into stimulating learning experiences. Kusumawati and Irwanto (2016), for instance, highlight that game elements can help students approach mathematical challenges more confidently by providing structured, meaningful tasks. Rahayu and Pujiastuti (2018) similarly explains that GBL environments tend to promote collaboration, persistence, and active engagement. Khayyirah et al. (2024) found that game-based learning not only improves cognitive outcomes but also fosters positive attitudes toward mathematics among elementary students. Moreover, Piaget's theory of cognitive development supports the use of play as a means for children to construct knowledge through interaction with their environment. This developmental perspective reinforces the suitability of GBL for elementary learners, who naturally learn through exploration and concrete experiences. A study by Astuti et al. (2025) demonstrated that interactive learning models, including game-based approaches, significantly enhance students' conceptual understanding and engagement in mathematics classrooms.

Although research has demonstrated the effectiveness of both the drill method and GBL when applied independently, few studies have examined the impact of combining the two approaches within a single instructional model. The integration of structured practice (drill) with playful engagement (GBL) presents an opportunity to create a balanced learning environment that nurtures both cognitive and affective growth. Students may be more willing to persist through repeated practice when it is embedded within a game format, and their confidence may increase as they experience success in competitive or collaborative game-based tasks. Evidence from Mutmainnah et al. (2025) suggests that hybrid instructional models combining traditional methods with innovative approaches can address multiple learning objectives simultaneously. This synergy suggests that a hybrid drill-GBL model could be particularly valuable for addressing weaknesses in elementary mathematics learning.

The relevance of this research also aligns with the direction of the Indonesian education system, especially within the framework of the Merdeka Curriculum. This curriculum encourages educators to adopt learning approaches that are meaningful, engaging, and centered on the development of student competencies. It also emphasizes the cultivation of positive character traits, including confidence, independence, and resilience components of the Profil Pelajar Pancasila. Research by Ardiana et al. (2025) emphasizes that student-centered approaches aligned with the Merdeka Curriculum framework promote both academic achievement and character development. Incorporating game-based elements into drill practices may not only improve cognitive skills but also support the growth of these affective qualities. Furthermore, from a practical standpoint, GBL does not necessarily require advanced digital tools. Teachers can adapt simple analog games, collaborative challenges, or low-cost digital activities according to the resources available in their schools. This adaptability makes the drill GBL model feasible for a wide range of classroom contexts.

The research gap addressed in this study centers on the lack of empirical investigations that examine the simultaneous effects of a drill GBL model on both mathematical understanding and self-confidence. Many previous studies have tended to focus on single outcomes, such as achievement or motivation, without exploring how instructional models influence cognitive and affective domains concurrently. In reality, these domains are closely interconnected: a student with strong conceptual understanding but low confidence may still avoid mathematics, while a student with high confidence but weak conceptual grounding may struggle to achieve long-term success. A comprehensive instructional model should therefore support the development of both skills and dispositions.

Based on the problems and research gap described above, this study is explicitly conducted to examine the effectiveness of integrating the drill method with game-based learning (GBL) in elementary mathematics instruction. Specifically, this research aims to: (1) determine the effect of the drill–GBL approach on students' mathematical understanding compared to conventional teaching methods; (2) analyze its effect on students' self-confidence in learning mathematics; and (3) evaluate the simultaneous impact of the drill–GBL model on both cognitive (mathematical understanding) and affective (self-confidence) outcomes. By clearly focusing on these objectives, this study seeks to provide empirical evidence on whether a hybrid drill–GBL instructional model can serve as an effective and balanced strategy to enhance both academic mastery and affective development in elementary mathematics learning.

2. Methodology

This study employed a quasi-experimental design to examine the effectiveness of integrating the drill method with game-based learning (GBL) in improving elementary school students' mathematical understanding and self-confidence. A non-equivalent control group pretest–posttest design was used, which is widely recognized as suitable for educational research conducted in natural classroom settings where random assignment is not feasible (Hasnunidah, 2017). This design enabled the measurement of changes in students' performance before and after the intervention, thereby providing a clearer understanding of the instructional impact.

The study was conducted in two public elementary schools located in Gatak District, Sukoharjo Regency. The participants consisted of sixth-grade students from two intact classes, with a total of 68 participants. One class (n = 34) was assigned as the experimental group, while the other (n = 34) served as the control group. Teacher training sessions were conducted prior to the intervention to ensure fidelity of implementation (Jazimah, 2020). The intervention in the experimental group involved the combination of the drill method and GBL elements. Drill activities were designed to reinforce students' procedural fluency, particularly in operations on fractions and integers. To make the drill activities more engaging, GBL components were incorporated in the form of game mechanics such as point accumulation, time challenges, group competitions, and immediate feedback. The games used were a mix of non-digital activities (math card challenges, board-based problem races, group puzzle competitions) and simple digital platforms that allowed quiz-based games (Hasanah & Himami, 2021). Instructional sessions lasted for four weeks, with two mathematics lessons per week, each lasting approximately 70 minutes. In contrast, the control group followed the school's regular instructional approach, which consisted mainly of teacher explanations, worksheets, and routine exercises.

Multiple research instruments were developed to gather data. Mathematical understanding was measured using a test composed of 20 multiple-choice and short-answer items that assessed conceptual and procedural knowledge. Self-confidence was measured through a Likert-scale questionnaire consisting of 25 items (Mahrani et al., 2022). An observation sheet was also used to record students' participation, enthusiasm, and interaction during the instructional sessions. Prior to implementation, all instruments underwent validation and reliability testing. Content validity was examined by three experts in mathematics education. Statistical validation using Aiken's V showed that all items met acceptable criteria for content validity (Candra & Kurniawan, 2020). Reliability testing using Cronbach's alpha yielded coefficients above 0.80, indicating strong internal consistency (Damayanti & Apriyanto, 2017).

Data collection took place in three stages: pretest, intervention, and posttest. Quantitative data analysis consisted of descriptive statistics, assumption testing (normality and homogeneity), and inferential analysis. Given that this study examined two related dependent variables simultaneously, Multivariate Analysis of Variance (MANOVA) was employed as the primary statistical technique (Tabachnick, Fidell, & Ullman, 2007; Field, 2024). When significant multivariate effects were identified, follow-up univariate analyses were conducted. Effect sizes were calculated using Cohen's d (Anggraeni et al., 2024), and normalized gain (N-Gain) analysis was applied to evaluate improvements from pretest to posttest. Ethical considerations were carefully observed throughout the research process. Permission was obtained from school principals and class teachers. Participation was voluntary, and students' data were anonymized to protect confidentiality. All research activities were conducted during regular school hours to minimize disruption to the instructional schedule.

3. Results and Discussion

Result

This section presents the quantitative findings of the study based on pretest–posttest scores, N-Gain analysis, and multivariate analysis (MANOVA) to examine the effectiveness of the drill–GBL instructional model compared to conventional instruction. The data were obtained from two groups of sixth-grade students, each consisting of 34 participants assigned to the experimental and control groups. The presentation of results follows a sequential structure, beginning with baseline measurements, followed by post-intervention outcomes, improvement indicators, and inferential statistical analysis. This systematic organization enables a comprehensive understanding of how the drill–GBL model influences both mathematical understanding and self-confidence compared to conventional teaching methods (Creswell & Creswell, 2018). Each subsection provides descriptive statistics accompanied by interpretive remarks to contextualize the numerical findings within the study's objectives.

a. Pretest Results for Mathematical Understanding and Self-Confidence

Before the intervention, both groups completed a pretest to measure their initial levels of mathematical understanding and self-confidence. This baseline assessment was essential to establish equivalence between the experimental and control groups prior to the instructional intervention. Pretest data serve as a reference point for evaluating the magnitude of change attributable to the treatment, thereby strengthening the internal validity of quasi-experimental designs (Dimitrov & Rumrill, 2003). The pretest was administered under standardized conditions in both schools, with identical time allocations and testing procedures to ensure comparability. Students were given clear instructions and sufficient time to complete all test items and questionnaire statements without feeling rushed. Descriptive statistics of the pretest results are presented in Table 1.

Table 1. Descriptive Statistics of Pretest Scores

Variable	Group	N	Mean	SD	Category
Mathematical Understanding	Experimental	34	58.00	8.12	Low
	Control	34	57.33	7.98	Low
Self-Confidence	Experimental	34	54.21	7.45	Low
	Control	34	53.87	7.68	Low

As shown in Table 1, the results indicate that the mean pretest scores for mathematical understanding were similar between the experimental (M = 58.00, SD = 8.12) and control groups (M = 57.33, SD = 7.98). Both groups were categorized at a low level of mathematical understanding, suggesting that students had not yet mastered the mathematical concepts and procedures targeted in the curriculum. A comparable pattern was also observed for the self-confidence variable, with the experimental group scoring 54.21 (SD = 7.45) and the control group scoring 53.87 (SD = 7.68), both categorized at a low level. The similarity in pretest scores across both variables indicates that the two groups were relatively equivalent at the outset of the study, which is a critical assumption in quasi-experimental research (Nasution, 2017). This baseline equivalence strengthens the validity of subsequent comparisons, as any observed differences in posttest scores can be attributed more confidently to the instructional intervention rather than to pre-existing group differences. The low initial scores in both groups also highlight the need for effective instructional strategies to improve students' mathematical competencies and affective dispositions.

b. Posttest Results for Mathematical Understanding and Self Confidence

After the four-week instructional intervention, both groups completed the posttest to assess their mathematical understanding and self-confidence following exposure to their respective instructional methods. The posttest was administered under the same standardized conditions as the pretest to ensure consistency and reliability of measurement. Students in both groups demonstrated improved performance compared to their pretest scores, although the magnitude of improvement differed substantially between the experimental and control groups. The posttest results provide critical evidence regarding the relative effectiveness of the drill–GBL model in promoting both cognitive and affective outcomes (Fraenkel et al., 2019). Descriptive statistics of the posttest scores are shown in Table 2.

Table 2. Descriptive Statistics of Posttest Scores

Variable	Group	N	Mean	SD	Category
Mathematical Understanding	Experimental	34	82.67	6.89	High
	Control	34	68.00	7.14	Moderate
Self-Confidence	Experimental	34	78.43	6.52	High
	Control	34	64.58	6.80	Moderate

As presented in Table 2, the posttest results show substantially higher mean scores in both variables for the experimental group compared to the control group. For mathematical understanding, the experimental group achieved a mean score of 82.67 (SD = 6.89), categorized as high, while the control group scored 68.00 (SD = 7.14), categorized as moderate. This difference of 14.67 points represents a considerable gap in mathematical achievement between the two instructional approaches. Similarly, for self-confidence, the experimental group scored 78.43 (SD = 6.52) compared to the control group's 64.58 (SD = 6.80), both measured on the same scale.

These findings suggest that the integration of drill method with game-based learning not only enhanced students' cognitive mastery but also fostered more positive affective outcomes (Huang et al., 2020). The experimental group's elevation to the "high" category in both variables indicates that the drill–GBL model successfully addressed the dual objectives of improving mathematical understanding and building self-confidence. The control group, while showing improvement from pretest levels, remained in the moderate category, suggesting that conventional instruction was less effective in promoting substantial gains in these outcomes.

c. N-Gain Results

To measure the magnitude of improvement from pretest to posttest, normalized gain (N-Gain) scores were calculated for both groups. N-Gain analysis is particularly valuable in educational research because it accounts for the ceiling effect by considering the maximum possible improvement each student could achieve based on their initial score (Hake, 1999). This standardized measure enables more accurate comparisons of learning gains across groups with different starting points. N-Gain values typically range from 0 to 1, with higher values indicating greater improvement. According to Hake (1999), N-Gain scores can be interpreted as follows: low gain ($g < 0.30$), medium gain ($0.30 \leq g < 0.70$), and high gain ($g \geq 0.70$). The calculation takes into account both the actual gain achieved and the potential gain available, providing a more nuanced understanding of instructional effectiveness. The N-Gain results are summarized in Table 3.

Table 3. N-Gain Scores

Variable	Group	Pretest Mean	Posttest Mean	N-Gain	Category
Mathematical Understanding	Experimental	58.00	82.67	0.59	Medium–High
	Control	57.33	68.00	0.25	Low
Self-Confidence	Experimental	54.21	78.43	0.53	Medium
	Control	53.87	64.58	0.19	Low

As indicated in Table 3, the N-Gain analysis reveals substantially higher improvement scores for the experimental group in both mathematical understanding ($g = 0.59$) and self-confidence ($g = 0.53$) compared to the control group ($g = 0.25$ and $g = 0.19$, respectively). The experimental group's N-Gain of 0.59 for mathematical understanding falls within the medium-to-high category, indicating that students achieved approximately 59% of the maximum possible improvement from their pretest scores. In contrast, the control group's N-Gain of 0.25 is categorized as low, suggesting that conventional instruction facilitated only modest gains relative to students' potential for improvement. A similar pattern emerged for self-confidence, where the experimental group achieved a medium gain ($g = 0.53$) while the control group showed low gain ($g = 0.19$). These N-Gain values provide strong evidence that the drill–GBL model was more effective than conventional instruction in promoting meaningful learning progress (Meltzer, 2002). The substantial difference in normalized gains between the two groups cannot be attributed to initial group differences, as both groups started with similar pretest scores.

d. MANOVA Results

Multivariate Analysis of Variance (MANOVA) was conducted to examine the simultaneous effects of the instructional model on mathematical understanding and self-confidence. MANOVA was chosen as the primary inferential technique because it allows researchers to test for group differences across multiple dependent variables while controlling for Type I error inflation that would occur if separate univariate tests were conducted (Tabachnick et al., 2007; Amri 2018). Prior to conducting MANOVA, assumptions of multivariate normality, homogeneity of variance-covariance matrices, and absence of multicollinearity were tested and confirmed. The MANOVA procedure generates several test statistics, including Wilks' Lambda, Pillai's Trace, Hotelling's Trace, and Roy's Largest Root, all of which assess the overall multivariate effect of the grouping variable on the set of dependent variables. The results are presented in Table 4.

Table 4. MANOVA Results

Analysis Type	Statistical Value	F	Sig.	Interpretation
Wilks' Lambda	0.412	11.874	0.000	Significant
Hotelling's Trace	1.443	11.874	0.000	The model shows significant influence
Pillai's Trace	0.588	11.874	0.000	The treatment produces differences
Roy's Largest Root	1.443	22.747	0.000	Very strong treatment effect

As shown in Table 4, the MANOVA results demonstrate a statistically significant multivariate effect of the instructional model on the combined dependent variables (Wilks' Lambda = 0.412, $F = 11.874$, $p < 0.001$). All four multivariate test statistics Wilks' Lambda, Pillai's Trace, Hotelling's Trace, and Roy's Largest Root yielded significance values below the conventional alpha level of 0.05, indicating robust and consistent evidence of group differences. The convergence of all four test statistics provides strong support for rejecting the null hypothesis that there are no differences between the experimental and control groups on the linear combination of mathematical understanding and self-confidence. The magnitude of the F-values, particularly Roy's Largest Root ($F = 22.747$), suggests that the drill–GBL intervention produced a substantial effect on student outcomes (Field, 2024). These results confirm that the drill–GBL instructional model had a significant simultaneous impact on both cognitive and affective dimensions of learning. The statistical significance of the multivariate test justified proceeding with follow-up univariate analyses to examine the specific effects on each dependent variable individually, although these detailed analyses are not presented in this table.

Discussion

The findings of this study demonstrate that combining the drill method with game-based learning (GBL) produces a significant impact on both mathematical understanding and self-confidence among elementary school students. The notable increase in posttest scores and the medium-to-high N-Gain values in the experimental group align with behaviorist principles, which emphasize repetition as a means to strengthen correct responses (Erlinda, 2016). However, drill activities in their conventional form often feel monotonous and may fail to maintain students' motivation. Embedding drill within a game-based structure addresses this limitation, supporting the argument of Fitriani and Maulana (2016) that intrinsic motivation is fostered when learning activities incorporate challenge, curiosity, and enjoyment. Recent evidence by Hasanah and Himami (2021) also confirms that game-supported drill activities improve computational accuracy and sustain attention more effectively than routine exercises.

The improvement in students' mathematical understanding is also in harmony with Grønmo et al. (2015) that children learn more effectively through concrete, interactive, and experiential activities. GBL naturally provides such an environment. Research by Rizqi et al. (2025) indicates that educational games help young learners build meaningful connections between conceptual ideas and procedural fluency. Similarly, Sulistiani (2016) reported that game-based mathematics activities enhance fifth-grade students' conceptual understanding of fractions. Hasanah et al. (2023) further emphasized that GBL strengthens long-term retention because students explore mathematical concepts through hands-on interaction rather than passive reception.

Self-confidence emerged as another important outcome of the intervention. Field's theory of self-efficacy (2024), positive belief in one's capabilities is shaped primarily by mastery experiences and constructive feedback. The GBL activities in this study provided frequent opportunities for students to succeed, observe their progress in real time, and receive immediate feedback. These learning conditions reinforce the findings of Mahrani et al. (2022), who reported that GBL environments reduce learners' fear of failure and encourage them to take academic risks. Nisa (2020) also found that mathematics games help diminish anxiety and increase students' willingness to attempt more challenging tasks.

From a sociocultural perspective, Noviyanti (2021) emphasized that learning occurs through social interaction and shared problem-solving. Game-based tasks naturally create such interactions especially when they involve collaborative or team-based challenges. This is supported by recent findings from Nuha (2024), who observed that collaborative games in mathematics classes foster both cognitive development and self-confidence due to peer support within the learning process. Similarly, Jazimah (2020) highlights that cooperative learning encourages persistence and engagement, which were also observed in the behavior of students during the intervention.

This study enriches the growing body of literature by showing that the drill and GBL approaches are not only effective individually but become more impactful when combined. Drill activities, often perceived as repetitive, become more appealing and meaningful when framed within game mechanics. Conversely, GBL becomes more academically oriented when it is anchored to the structured practice inherent in drill. This synergistic effect supports the arguments of Ardiana et al. (2025), who explain that games promote deep learning by allowing learners to experiment, make decisions, reflect on outcomes, and receive immediate feedback.

The MANOVA results, which revealed significant differences between the experimental and control groups on both outcome variables, strengthen the conclusion that the drill GBL model simultaneously enhances cognitive and affective learning. This dual impact reflects current educational perspectives that emphasize the integration of academic achievement and emotional readiness. As

Amri (2018) explains, early mathematical experiences play a crucial role in shaping long-term attitudes toward the subject. Therefore, improvements in both understanding and confidence at the elementary level are far-reaching and meaningful.

In practical terms, the model aligns well with the Merdeka Curriculum, which promotes active, student-centered, and differentiated learning. Its flexibility allowing the use of simple physical games or low-tech digital tools makes it suitable for diverse classroom contexts. Nuraeni et al. (2018) highlight that simple learning games support differentiated instruction effectively in both lower and upper elementary grades. This reinforces the feasibility of implementing the drill GBL model widely, even in schools with limited technological infrastructure. While the results of this study are promising, further investigations could extend its scope, such as examining the long-term sustainability of the gains or identifying which specific game elements exert the strongest influence on motivation and confidence. Qualitative studies may also provide richer insights into students' emotional experiences and their interactions during game-based activities.

Overall, the discussion highlights that the drill GBL model not only strengthens mathematical understanding but also cultivates self-confidence and positive attitudes toward mathematics. These dual outcomes are crucial for elementary learners, as early learning experiences greatly influence their future engagement with mathematics. Therefore, the drill GBL model stands out as a viable and innovative instructional alternative that addresses both the cognitive and affective needs of students simultaneously.

4. Conclusion

This study concludes that the integration of the drill method with game-based learning (GBL) is effective in improving both mathematical understanding and self-confidence among elementary school students. The findings demonstrate that students who learned through the drill–GBL model achieved significantly better learning outcomes than those who received conventional instruction, as evidenced by higher posttest scores, superior N-Gain values (0.59 vs 0.25 for mathematical understanding; 0.53 vs 0.19 for self-confidence), and statistically significant MANOVA results ($p < 0.001$). The drill–GBL model successfully provides a balanced learning environment by combining structured practice with engaging and interactive activities, demonstrating that mathematics instruction at the elementary level can be both rigorous and enjoyable when cognitive and affective aspects are developed simultaneously. From a practical perspective, the model offers flexibility and feasibility for diverse classroom contexts, as it can be implemented using either digital platforms or simple non-digital games, making it accessible to schools with varying levels of technological infrastructure and compatible with student-centered learning principles.

Despite its promising results, this study has limitations including the relatively short intervention period (four weeks), focus on sixth-grade students and specific mathematical topics (fractions and integers), and the quasi-experimental design's inherent constraints. Future research should conduct longitudinal studies to examine the durability of learning outcomes, expand the model's application to different grade levels and mathematical domains, and investigate which specific game elements exert the strongest influence on motivation and achievement. Additionally, qualitative investigations could provide deeper insights into students' affective experiences during game-based activities. Overall, this study provides empirical evidence that the drill–GBL model represents an effective and innovative instructional strategy that addresses critical cognitive and affective needs of young learners, offering a practical pathway for achieving both academic competence and character development in elementary mathematics education.

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