



Integrating physical and digital edugames to support elementary students' learning of integer multiplication: a classroom action research

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Abstract

Although game-based learning has been associated with mathematics achievement and engagement, evidence remains limited on how digital and non-digital games can be sequenced within a single primary-school intervention. This classroom action research documented changes in fifth-grade students' integer multiplication learning during an integrated sequence of mathematics domino cards, Wordwall, and Quizizz. Participants were 26 students at SD Negeri 9 Buntok, Central Kalimantan, Indonesia. The study comprised a pre-cycle and two action-reflection cycles. The instructional sequence was refined through reflection following each successive implementation cycle. Achievement tests, structured observations, brief motivation indicators, field notes, and documentation provided data analyzed descriptively across cycles. Mean achievement scores increased from 62.5 at pre-cycle to 74.2 in Cycle I and 84.6 in Cycle II. Mastery rates rose from 38.46% to 69.23% and 88.46%, respectively. Classroom observations indicated increasing participation, collaboration, and confidence across cycles. These findings describe improvements observed alongside the integrated edugame sequence in one classroom; they do not establish causal effects or compare the effectiveness of individual game formats. The study offers a practical example of sequencing tangible manipulation, digital practice, and gamified feedback through iterative classroom instruction. Further controlled studies are needed to assess transferability and effectiveness.

Keywords: Game-based learning; Integer multiplication; Digital and non-digital games; Elementary mathematics; Classroom action research

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INTRODUCTION

Fluency with multiplication is a foundational component of elementary mathematics because it supports later work with division, fractions, proportional reasoning, and algebraic thinking. Yet multiplication instruction can become overly procedural when students are expected to retrieve products without developing connections among repeated addition, patterns, representations, and contextual situations. In the source classroom, this problem was visible in low initial achievement and in students' tendency to rely on memorization rather than conceptual reasoning. Contemporary primary mathematics therefore requires instructional designs that combine conceptual access, purposeful practice, and sustained participation rather than



treating accuracy as the only learning target (Munawwarah et al., 2024; Yeh et al., 2019).

Game-based learning has become a prominent response to this instructional challenge. Meta-analytic and review evidence generally indicates that well-designed educational games can contribute to mathematics achievement, motivation, engagement, and positive learning experiences, although effects vary according to game type, instructional integration, duration, and learner characteristics (Hui & Mahmud, 2023; Pan et al., 2022; Tokac et al., 2019; Yu et al., 2021). A central implication of this literature is that a game does not improve learning merely because it is enjoyable. Its pedagogical value depends on how mathematical content, feedback, representation, challenge, and classroom interaction are embedded in the activity.

Digital game-based learning is especially visible in recent mathematics research. A systematic review focused specifically on primary mathematics identified digital game-based learning as a rapidly expanding field but also noted the need for more research that is sensitive to mathematics content, primary-school contexts, and the way games are integrated into instruction (Dan et al., 2024). A broader K–12 mathematics review similarly found substantial design diversity and emphasized the importance of connecting gameplay with intended mathematical processes rather than treating digital games as stand-alone add-ons (Hussein et al., 2022). Gamification research also indicates that feedback, points, progress indicators, badges, and leaderboards may influence engagement and motivation, but their effects depend on the instructional design as a whole (Mohammed et al., 2024; Sailer & Homner, 2020).

Platforms such as Quizizz and Wordwall operationalize several of these features in forms that are accessible to classroom teachers. Quizizz can provide immediate feedback, score visibility, pacing, and repeated practice, while Wordwall enables teachers to transform exercises into interactive matching, sorting, or game-like tasks. Research with elementary learners has reported motivational benefits from Quizizz-based assessment Quispe Ccoa et al., (2023), and Indonesian studies have documented the practical potential of Wordwall and other interactive digital media for elementary learning (Firdaus et al., 2024; Putri & Muzakki, 2022). These findings support digital tools as potentially useful components of mathematics instruction, but they do not resolve whether digital practice should replace or complement tangible mathematical activity.

Non-digital games and physical manipulatives remain pedagogically important in primary mathematics. Russo et al., (2024), in a systematic review of non-digital mathematical games, showed that such games can support mathematical learning when gameplay requires students to reason, represent, compare, calculate, or explain. Debrenti, (2024) directly compared digital and non-digital game-based experiences in primary mathematics and found that students enjoyed both formats while learning outcomes could differ between them. Her analysis also underscores a mismatch in the field: teachers frequently use tangible games and manipulatives, whereas research attention has often tilted toward digital games. Physical manipulatives can reduce the distance between an abstract symbol and a visible or touchable representation, while digital environments can add rapid feedback, variability, repetition, and motivational affordances (Byrne et al., 2023; Debrenti, 2024).

Indonesian elementary-education research reflects the same movement toward interactive and game-based learning. Fitriyadi & Wuryandani, (2021) reported that educational games can support higher-order learning processes in elementary settings. Primaestri et al., (2023) mapped the growing research trend on games in elementary learning, while Safitri et al., (2025) reviewed gamification approaches in elementary education and emphasized their potential for critical-thinking-oriented learning. More recently, Sugiarto & Ary, (2026) demonstrated the viability of a physically enacted educational game supplemented by quiz elements, and Firdaus et al., (2024) showed that interactive digital media can improve elementary students' conceptual understanding in mathematics. Collectively, these studies establish a strong rationale for interactive media, yet most still examine a single platform, a single game format, or a developed product as the main treatment.

The state of the art therefore points to a more specific gap. Existing literature has established

the potential of digital games, non-digital mathematical games, gamification elements, and interactive elementary media, but comparatively little classroom action research has examined a deliberately sequenced combination of tangible and digital games for one elementary mathematics topic. This gap is pedagogically important because the two formats may serve different functions. A tangible domino activity can foreground concrete matching, peer explanation, and visible mathematical relations; Wordwall can provide contextual and semi-visual practice; and Quizizz can provide rapid individual feedback and cumulative rehearsal. The novelty of the present study is not the claim that games are generally beneficial. Rather, it lies in examining an iterative instructional sequence that assigns complementary roles to a physical mathematics game and two digital platforms within successive action-reflection cycles.

This study focused on integer multiplication in a fifth-grade classroom at SD Negeri 9 Buntok, Central Kalimantan. The classroom problem was practical and clearly bounded: initial observations showed passive participation, low enthusiasm, frequent calculation errors, limited instructional media, and a mean pre-cycle score of 62.5, with only 38.46% of students meeting the school mastery criterion of 70. The study therefore asked how an integrated sequence of mathematics domino cards, Wordwall, and Quizizz could be implemented and how students' achievement and observed participation changed across the action-research cycles. The objective was to document instructional improvement within the studied class, not to estimate a population-level causal effect.

The state of the art therefore points to a more specific research gap. Previous studies have demonstrated the potential of digital game-based learning in mathematics education and non-digital mathematical games in primary classrooms (Russo et al., 2024). Beyond these separate approaches, investigated a hybrid physical-digital board game in elementary sustainability education, demonstrating that integrating physical and digital game elements is not inherently novel. However, these studies provide limited insight into how distinct physical and digital game formats can be deliberately sequenced and refined through classroom action-reflection cycles to address specific mathematical learning difficulties. This gap is pedagogically important because different game formats can serve complementary instructional functions. Mathematics domino cards can facilitate concrete matching, peer explanation, and recognition of mathematical relationships, Wordwall can support contextual and semi-visual practice, and Quizizz can provide immediate feedback and repeated practice. Accordingly, the contribution of the present study lies not in combining existing educational platforms, but in documenting the implementation and iterative refinement of a purposeful instructional sequence within fifth-grade integer multiplication lessons. Through classroom action research, the study provides context-specific descriptive evidence of changes in students' achievement and participation across successive cycles, without claiming causal effects or comparative superiority among the game formats.

Accordingly, this study treats novelty as an instructional-design contribution rather than a claim that domino cards, Wordwall, or Quizizz are new technologies. It examines how a concrete-to-digital sequence can be embedded in iterative classroom action research, how the sequence changes after reflection, and whether achievement improvement is accompanied by observable changes in participation and learning behavior. The study addresses three questions: (1) how can physical and digital edugames be integrated and refined across classroom-action cycles? (2) what pattern of change occurs in mean achievement and mastery? and (3) what classroom-process changes accompany the achievement trajectory? These questions provide a more focused basis for interpreting the intervention than a general comparison between game-based and conventional instruction.

METHODS

Research Design and Context

The study employed classroom action research (CAR) because the research problem concerned the improvement of ongoing classroom practice. The design followed an iterative sequence of planning, action, observation, and reflection. A pre-cycle established the initial condition, followed by two cycles. Cycle I was implemented in May 2026 and Cycle II in June 2026, within the broader research period of April–June 2026. The study was conducted during the second semester of the 2025/2026 academic year at SD Negeri 9 Buntok, Dusun Selatan District, Barito Selatan Regency, Central Kalimantan, Indonesia.

CAR was appropriate because each subsequent instructional decision was informed by evidence from the preceding stage. After Cycle I, the teacher and observer reviewed learning difficulties, classroom management, time allocation, students' familiarity with digital media, and the proportion of students reaching mastery. The Cycle II plan was then adjusted by strengthening concept review, increasing support for students who experienced difficulty, improving time management, and using the edugames more purposefully. This iterative logic is consistent with action research as a method for systematic improvement of educational practice (Madya,2021).

Participants and Sampling

The participants were the intact Grade V class consisting of 26 students, including 14 boys and 12 girls. The class was selected because initial classroom diagnosis showed heterogeneous mathematics performance and persistent difficulties with multiplication. No probabilistic sampling was used because CAR targeted the specific class in which the instructional problem occurred. The school mastery criterion for mathematics was 70, and the action was considered successful at the class level when at least 75% of students achieved a score of 70 or above.

The classroom context also informed the intervention design. Prior instruction relied largely on teacher explanation and routine exercises, and the use of interactive media was limited. The study therefore did not introduce a single technological tool as a replacement for teaching. Instead, it combined a tangible mathematics game with teacher-guided digital practice so that students could move between peer interaction, representations, contextual tasks, and individual feedback.

Intervention Sequence

The intervention consisted of five 3 × 35-minute meetings: one pre-cycle meeting, two meetings in Cycle I, and two meetings in Cycle II. Table 1 summarizes the sequence documented in the instructional plan. The sequence progressed from diagnosis to positive-integer multiplication, contextual problem solving, multiplication involving signs, and final consolidation. Physical and digital media were therefore assigned different instructional functions rather than being used simultaneously without structure.

Table 1. Sequence of the classroom action intervention

Stage	Meeting focus	Learning model	Main medium
Pre-cycle	Initial diagnosis of multiplication understanding	Direct instruction + diagnostic test	Written test
Cycle I-1	Concept of positive-integer multiplication	Discovery learning	Mathematics domino cards
Cycle I-2	Contextual buying-and-selling problems	Problem-based learning	Wordwall
Cycle II-1	Signs in integer multiplication, including negative integers	Discovery learning	Wordwall
Cycle II-2	Consolidation and final action evaluation	Contextual teaching and learning	Quizizz

The mathematics domino activity required students to connect problems with corresponding products while discussing choices within groups. Wordwall was used for interactive and contextualized practice, including buying-and-selling situations and later work on sign rules. Quizizz was used in the final cycle to support intensive practice and immediate feedback before the end-of-cycle evaluation. The teacher functioned as facilitator and provided additional guidance to students who encountered difficulty, particularly after Cycle I reflection.

The sequence was intentionally cumulative. The domino activity was used first to make multiplication relations visible and discussable in a small-group setting. Wordwall then shifted the same content toward repeated interactive practice, while Quizizz was placed later in the sequence to support rapid retrieval, immediate response information, and end-of-cycle consolidation. This design did not assume that one medium was inherently superior to another. Instead, each medium was used for a different instructional purpose within the same learning trajectory. The distinction is important because the intervention being evaluated was the orchestration of media, teacher explanation, guided practice, and reflection, not the isolated technical effect of a single application.

Instruments and Materials

Data were collected through achievement tests, structured observations, brief motivation indicators, field notes, and documentation. The achievement instrument contained six short-answer and constructed-response items intended to capture multiplication concepts, conversion to repeated addition, procedural calculation, and contextual problem solving. Scoring used item rubrics with full, partial, or incorrect-credit categories as appropriate. Achievement tests were administered before the action and at the end of each cycle.

Student activity was observed using a structured sheet covering activeness, participation in games, collaboration, enthusiasm, and task completion, rated on a four-point scale. Teacher implementation was also monitored across lesson opening, content mastery, use of edugames, classroom management, and closure. The research record additionally included two brief student motivation statements concerning enjoyment of learning with games and enthusiasm for mathematics. Because these motivation indicators were brief, the article treats them as supporting classroom evidence rather than as a psychometrically validated motivation scale.

Before classroom implementation, the instruments and lesson plan underwent expert review as part of the research preparation process. However, numeric content-validity coefficients and reliability coefficients were not reported in the source research record. Accordingly, no psychometric coefficient is claimed in this article. This limitation is important when interpreting observational and motivational evidence; the strongest quantitative evidence in the study is the repeated classroom achievement record and mastery proportion.

Data Analysis

Achievement data were analyzed descriptively using class means, the number of students reaching the KKM, and mastery percentages at the pre-cycle, Cycle I, and Cycle II stages. The change from one stage to the next was used as formative evidence for reflection and instructional adjustment. No inferential statistical test was used, and the design did not include a comparison group; therefore, the results are not interpreted as a population-level causal estimate.

Observation data were summarized by comparing qualitative classroom descriptors and four-level categories across stages. Field notes and documentation were used to contextualize why changes were observed, especially with respect to student participation, collaboration, confidence, use of digital media, and teacher adjustments after Cycle I. This descriptive integration of achievement and classroom-process evidence was appropriate to the improvement-oriented purpose of the CAR design.

Ethical Considerations

The research was carried out after school and research permission procedures had been completed. Student results are reported only in aggregate form and no personally identifying student information is presented. The original research documentation did not provide a formal institutional ethics approval number; therefore, no ethics approval number is claimed here. This reporting choice preserves transparency about the available research record.

RESULTS AND DISCUSSION

Results

Baseline Classroom Condition

The pre-cycle diagnosis confirmed both an achievement problem and a participation problem. Students were described as mostly passive, less enthusiastic, weak in conceptual understanding, prone to calculation errors, and exposed to limited instructional media. Only 10 of 26 students reached the KKM of 70. The class mean was 62.5 and mastery was 38.46%. These data established a sufficiently concrete instructional problem for action research: the intervention needed to improve not only practice opportunities but also how students interacted with multiplication ideas.

The baseline pattern also suggested why a multimodal sequence was appropriate. If the difficulty had been only insufficient exercise, a single digital quiz platform might have been adequate. Instead, students appeared to need a bridge from concrete relationships to contextual practice and repeated feedback. This consideration informed the use of domino cards first, followed by Wordwall and Quizizz in increasingly consolidative roles.

Cycle I: Initial Shift in Participation and Achievement

Cycle I produced an initial shift in classroom participation. Observation records described students as beginning to participate actively in discussion, showing enthusiasm during games, and collaborating well in groups. Their conceptual understanding and willingness to ask questions were still categorized as developing rather than fully strong. Students were able to use Wordwall and Quizizz, but some required guidance and the teacher identified limitations in time management and uneven understanding. These process observations were important because Cycle I was not treated as a final test of the intervention; it was used to identify where the instructional sequence required refinement.

Achievement improved concurrently. The class mean rose from 62.5 to 74.2, an increase of 11.7 points. The number of students reaching mastery rose from 10 to 18, and the mastery percentage increased from 38.46% to 69.23%. Although the direction of change was positive, the predefined class-level success criterion of at least 75% mastery had not yet been reached. The action therefore continued to Cycle II rather than treating the Cycle I gain as sufficient evidence of completion.

Cycle II: Refinement and Achievement of the Classroom Criterion

Cycle II incorporated the reflection from Cycle I. Concept explanations were strengthened, students experiencing difficulty received more intensive guidance, classroom time was managed more deliberately, and the use of digital media was made more targeted. Observation records then described very active discussion and question answering, high enthusiasm, stronger group cooperation, better confidence in asking and answering questions, and increasingly independent use of the digital media. Conceptual understanding was categorized as good, while several participation indicators were categorized as very good.

The Cycle II achievement record met the action-research success criterion. The class mean reached 84.6, an increase of 10.4 points from Cycle I and 22.1 points from the pre-cycle. Twenty-three of 26 students reached the KKM, corresponding to 88.46% mastery. Three students remained below the mastery threshold, indicating that the intervention improved the classroom-

level pattern without eliminating individual learning differences. Table 2 and Figure 1 summarize the achievement progression.

Table 2. Achievement progression across the action-research stages

Stage	Mean score	Students mastered	Students not mastered	Mastery (%)
Pre-cycle	62.5	10	16	38.46
Cycle I	74.2	18	8	69.23
Cycle II	84.6	23	3	88.46

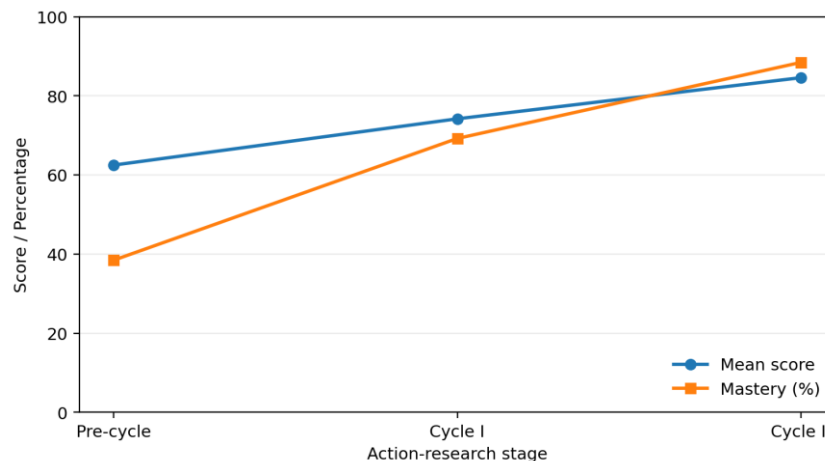


Figure 1. Mean achievement and mastery percentage across stages

Table 3. Observed classroom-process changes across stages

Dimension	Pre-cycle	Cycle I	Cycle II
Student activity	Mostly passive	Beginning to discuss actively	Very active in discussion and answering
Motivation/enthusiasm	Low enthusiasm	Enthusiastic during games	Highly enthusiastic across the lesson
Collaboration	Limited evidence	Good group collaboration	Stronger group collaboration
Conceptual understanding	Low	Developing	Most students understood the concept
Confidence to ask/answer	Low participation	Some students began to ask	Greater confidence to ask and answer
Digital-media use	Limited	Able to use Wordwall/Quizizz with support	Increasingly independent

Cross-Cycle Reflection and Instructional Refinement

Cycle I was informative because improvement occurred without yet satisfying the classroom success criterion. The mean score had increased to 74.2 and 18 of 26 students reached mastery, but the mastery percentage remained 69.23%, below the predetermined 75% criterion. Classroom reflection identified four practical barriers: several students still lacked confidence when responding, some continued to experience difficulty with larger multiplication tasks, game time was not yet managed optimally, and several students needed guidance when using digital media. These observations prevented the action research from ending after the first improvement and provided concrete targets for Cycle II.

The second cycle therefore represented a refinement of instruction rather than a simple repetition. The teacher strengthened explanations for concepts that remained unclear, provided more intensive guidance to students experiencing difficulty, organized game time more systematically, and used motivation and recognition to encourage participation. The learning tasks were also made more varied. The resulting improvement should therefore be interpreted as the outcome of an adaptive instructional package in which the edugames were combined with teacher diagnosis and responsive scaffolding. Table 4 summarizes how reflection evidence was translated into Cycle II action.

Table 4. Reflection evidence and instructional refinements from Cycle I to Cycle II

Cycle I evidence	Interpretation	Cycle II refinement	Cycle II evidence
Mastery reached 69.23% (18/26)	Class criterion had not yet been achieved	Strengthen concept explanation and targeted practice	Mastery reached 88.46% (23/26)
Some students were not confident when responding	Participation gains were uneven	Provide encouragement, recognition, and more opportunities to respond	Greater confidence in asking and answering
Difficulty remained on more demanding multiplication tasks	Conceptual support was still needed	Provide more intensive guidance and more varied exercises	Most students were described as understanding the concept
Game time was not yet optimal	Activity required tighter instructional pacing	Structure game time and transitions more explicitly	Classroom management was reported as improved
Some students needed support with digital media	Technology familiarity differed among students	Provide guided use and repeated exposure	Students were increasingly able to use media independently

The mastery counts provide another view of the same progression. Sixteen students were below the KKM at baseline, compared with eight after Cycle I and only three after Cycle II. Thus, the main change was not limited to a higher class mean; the number of students remaining below the school criterion also contracted substantially. Figure 2 visualizes this redistribution. Because the same class was followed across the cycles, the figure should be read as descriptive classroom evidence rather than as an estimate of a population effect.

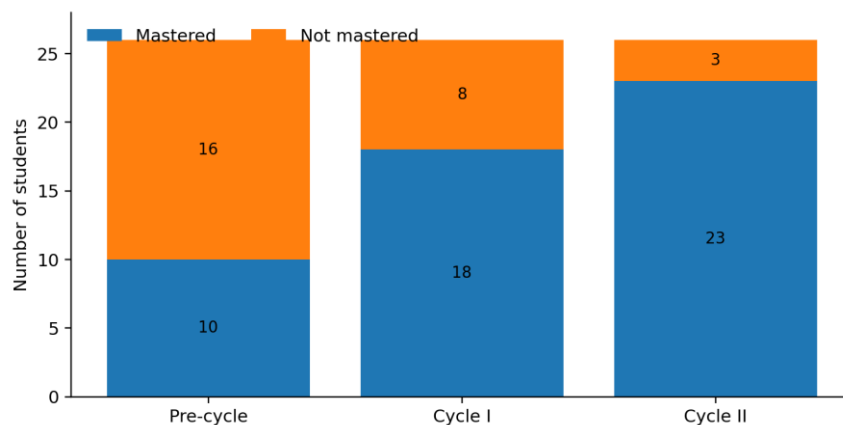


Figure 2. Students reaching and not reaching mastery across action-research stages

Instructional Functions within the Hybrid Edugame Sequence

A useful way to interpret the intervention is to separate the instructional functions assigned to each medium. The mathematics domino cards created a tangible matching task in which students had to connect multiplication expressions and products while discussing choices with peers. Wordwall provided a more dynamic practice environment in which items could be repeated and presented as challenges. Quizizz was positioned as a later-stage tool for individual retrieval, rapid feedback, and consolidation. The three media therefore differed in representational form, interaction pattern, and feedback speed.

This functional differentiation matters for elementary mathematics. Russo et al. (2024) noted that non-digital mathematical games can foster mathematical learning through social interaction, strategic reasoning, and accessible classroom participation. Digital game research, meanwhile, has repeatedly highlighted feedback, challenge, visible progress, and repeated practice as relevant mechanisms (Dan et al., 2024; Sailer & Homner, 2020). The present classroom sequence combined these affordances rather than asking one platform to perform every instructional task.

Table 5. Pedagogical function of each component in the hybrid edugame sequence

Component	Representational form	Primary student action	Instructional function	Observed role in this study
Mathematics domino cards	Physical/manipulative	Match expressions and products; discuss with peers	Concrete structuring and collaborative reasoning	Supported active discussion and conceptual engagement
Wordwall	Interactive digital	Practice through game-like tasks and repeated responses	Guided practice, variation, and immediate task engagement	Supported enthusiasm and repeated practice in Cycles I-II
Quizizz	Interactive digital assessment	Retrieve answers individually and respond to feedback	Consolidation, rapid feedback, and visible progress	Supported final practice and evaluation
Teacher reflection and scaffolding	Instructional mediation	Explain, guide, prompt, and reorganize tasks	Connect media use to diagnosed learning needs	Converted Cycle I barriers into Cycle II refinements

The resulting instructional logic is shown in Figure 3. The diagram emphasizes that the physical-to-digital order was embedded in a CAR feedback loop. Evaluation did not merely close the lesson; it generated evidence for the next instructional decision. This is a defining methodological feature of the study and helps distinguish the intervention from a one-shot use of a game application.

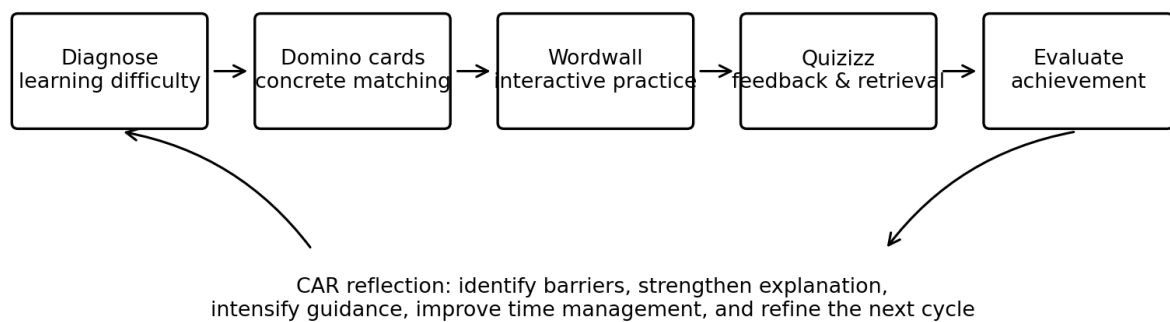


Figure 3. Hybrid edugame sequence embedded in the classroom-action reflection loop

Taken together, the results show two linked trajectories. The achievement trajectory moved upward across all stages, while the process trajectory moved from passivity and low enthusiasm toward more active discussion, stronger collaboration, greater confidence, and more independent media use. The convergence does not establish that engagement changes caused the score gains, but it strengthens the classroom interpretation because improvement was documented through more than one type of evidence.

Discussion

Why the Physical-to-Digital Sequence Matters

The central contribution of the findings is not simply that scores increased after games were introduced. The more informative pattern is that improvement occurred within a sequence in which different media performed different representational and motivational functions. The mathematics domino cards gave students a tangible structure for matching problems and products, negotiating answers with peers, and seeing multiplication relationships as objects of interaction rather than isolated written exercises. Wordwall then shifted practice toward interactive and contextual tasks, while Quizizz supported rapid individual rehearsal and feedback at the consolidation stage. This layered use of media is consistent with the argument that game-based learning is strongest when game mechanics are subordinated to mathematical meaning and instructional purpose (Debrenti, 2024; Pan et al., 2022).

The result aligns with current evidence that non-digital and digital games should not be treated as interchangeable. [Russo et al., \(2024\)](#) showed that non-digital mathematical games can promote learning when they embed substantive mathematical actions. [Debrenti, \(2024\)](#) similarly found that digital and non-digital formats can generate different outcomes even when students enjoy both. In the present classroom, the tangible domino phase was especially suited to peer explanation and visible problem-product relationships, whereas the digital phases provided speed, repetition, variety, and immediate response information. The pedagogical implication is therefore complementarity: teachers can select a medium according to the cognitive function needed at a particular point in learning rather than choosing technology because it is newer.

This interpretation is also compatible with [Bruner, \(1966\)](#) representational view of learning. The intervention moved from physical manipulation and action toward visually structured digital practice and then toward symbolic individual response. Although the classroom data cannot isolate the effect of each representation, the sequence offers a plausible instructional mechanism for helping students connect concrete activity with symbolic multiplication. Recent work on physical manipulatives likewise suggests that tangible materials are most useful when deliberately linked to the target concept rather than used as decoration ([Byrne et al., 2023](#)).

Achievement Gains as Iterative Classroom Evidence

The achievement trajectory was monotonic across the three stages: 62.5, 74.2, and 84.6. Mastery rose by 50 percentage points from the pre-cycle to Cycle II. This pattern is consistent with the broader literature indicating positive associations between game-based mathematics instruction and achievement ([Phu Loc et al., 2019](#); [Tokac et al., 2019](#)). It is also compatible with findings from digital mathematics studies showing that games can support achievement and interest when content is meaningfully integrated into gameplay ([Yeh et al., 2019](#)).

However, the design requires disciplined interpretation. The gain cannot be attributed exclusively to the edugame media because several instructional features changed simultaneously: the teacher revised explanations, increased guidance, improved time management, repeated and extended practice, and adjusted task difficulty after reflection. There was also no control group and no inferential statistical test. The appropriate claim is therefore that the integrated edugame sequence, embedded within iterative teacher adjustment, was associated with a substantial classroom improvement across cycles. This is a stronger scientific formulation than claiming general causal effectiveness from a single-class CAR design.

The Cycle I result is particularly informative in this respect. Despite an 11.7-point increase in the mean, mastery reached only 69.23%, below the action criterion. The decision to continue the intervention prevented a common weakness in classroom reports in which any positive change is immediately treated as success. The second cycle required pedagogical refinement, and the final 88.46% mastery was achieved after targeted support and more structured use of the media. In action-research terms, the improvement therefore reflects the combination of instructional innovation and reflective adaptation rather than a fixed treatment delivered unchanged.

Engagement, Feedback, and Motivation

The observed process data showed a parallel shift from passivity toward active discussion, collaboration, confidence, and independent media use. These observations are consistent with reviews showing that game-based mathematics learning frequently affects both cognitive and affective domains ([Hui & Mahmud, 2023](#); [Vankúš, 2021](#)). Gamification mechanisms can make progress visible and create short feedback cycles, which may encourage students to remain engaged with repetitive practice that would otherwise feel monotonous ([Sailer & Homner, 2020](#)). Quizizz-based research with elementary students has similarly reported increased motivation in assessment contexts ([Quispe Ccoa et al., 2023](#)).

The present results also support a more cautious account of motivation. Mohammed et al. (2024) found that gamified elementary environments can enhance cognitive and achievement motivation, yet their findings suggested that gains may arise from holistic design rather than from

one isolated element such as a badge or leaderboard. That distinction is relevant here. Students encountered not only scores and feedback but also peer interaction, novelty, tangible cards, contextual tasks, teacher scaffolding, and repeated opportunities for success. The article therefore avoids attributing motivation changes to a single game mechanic.

The motivation evidence in this study should also be weighted according to measurement quality. The classroom observation and two brief motivation statements were suitable for monitoring an action cycle, but they are not equivalent to a validated multidimensional motivation scale. Thus, the strongest conclusion is that observable enthusiasm and participation increased across cycles. A future controlled study should use a validated motivation instrument, report reliability, and distinguish intrinsic interest, task value, self-efficacy, and performance-oriented responses to gamification.

Convergence of Achievement, Process, and Reflection Evidence

The strongest feature of the evidence is the consistency among three data streams: achievement records, structured classroom observation, and cycle reflection. Achievement data showed the numerical progression in mean scores and mastery. Observation data documented changes in activity, enthusiasm, collaboration, confidence, conceptual understanding, and digital-media use. Reflection records then explained why Cycle II was modified. When these sources are read together, the study presents a coherent account of instructional change even though it does not provide the causal control of an experiment.

This distinction is important in evaluating classroom action research. A score increase alone can be misleading if the action is poorly documented or if the instructional process remains unchanged. Conversely, positive classroom impressions are insufficient if they are not accompanied by evidence of learning. Here, the class mean increased by 22.1 points and the proportion reaching mastery increased by 50 percentage points from baseline to Cycle II, while observations concurrently shifted from predominantly passive behavior toward active discussion and greater independence. The alignment between outcome and process evidence increases the internal plausibility of the classroom account, while still leaving alternative explanations open.

Table 7. Convergence of evidence across achievement, classroom process, and reflection

Evidence domain	Baseline / Cycle I evidence	Cycle II evidence	Interpretive value
Achievement	Mean 62.5 at baseline; 74.2 in Cycle I	Mean 84.6	Shows monotonic descriptive improvement
Mastery	10/26 at baseline; 18/26 in Cycle I	23/26 students	Shows fewer students remaining below KKM
Student activity	Mostly passive; began to discuss actively	Very active in discussion and answering	Supports a process shift toward participation
Motivation/enthusiasm	Low; enthusiastic during games in Cycle I	Highly enthusiastic across lessons	Suggests improved affective engagement, measured descriptively
Confidence and independence	Low participation; some digital guidance needed	Greater confidence and more independent media use	Indicates reduced participation and technology barriers
Teacher reflection	Identified conceptual, pacing, confidence, and media-use barriers	Refinements implemented and criterion reached	Shows how CAR evidence informed the next action

The convergent pattern is consistent with broader game-based learning research that treats learning outcomes as the product of interaction among game features, task design, feedback, and instructional support rather than the presence of a game label alone. [Tokac et al., \(2019\)](#) reported a positive overall effect of game-based learning on mathematics achievement, while [Sailer & Homner, \(2020\)](#) showed that gamification effects depend on how design elements shape learning processes. The present study adds a practice-level illustration of this principle: the digital tools were most productive when connected to concrete representation, teacher guidance, and structured reflection.

Positioning the Findings within Indonesian Elementary Education Research

The findings extend a growing Indonesian literature on interactive and game-based elementary learning. [Fitriyadi & Wuryandani, \(2021\)](#) showed that educational games can support

critical-thinking-oriented elementary learning, while [Primaestri et al., \(2023\)](#) documented increasing scholarly attention to games and self-regulated learning in elementary contexts. [Safitri et al., \(2025\)](#) likewise concluded that gamification is increasingly used to support active and higher-order learning in elementary education. These studies establish a broad local rationale for game-based pedagogy, but they do not specifically address the instructional sequencing of physical and digital media for integer multiplication.

The present study contributes at that narrower level. Its novelty can be stated in three parts. First, it integrates a physical mathematical manipulative game and two digital platforms rather than testing one game or application. Second, the media are sequenced according to instructional purpose: concrete matching, contextual interactive practice, sign-rule reinforcement, and final gamified consolidation. Third, the sequence is refined through CAR reflection, so the intervention is responsive to observed student difficulties rather than being implemented as a fixed product. This contribution is modest but defensible because it identifies a replicable instructional architecture rather than making an unsupported claim of a universally superior medium.

The results also complement Indonesian studies of interactive digital mathematics media. [Firdaus et al., \(2024\)](#) reported gains in elementary fraction understanding using an interactive e-module, illustrating the value of digital interactivity for conceptual mathematics learning. [Sugiarto & Ary, \(2026\)](#) integrated physical movement, game components, and quiz elements in an elementary learning medium, illustrating current interest in blended game forms. In this wider landscape, the present study adds classroom-based evidence from Central Kalimantan and from a multiplication topic, thereby broadening the contexts in which hybrid game-oriented designs have been documented.

Practical Implications

For classroom practice, the findings suggest that teachers do not need to choose between low-tech manipulatives and digital platforms. A more productive design question is what each medium should accomplish in the learning sequence. Physical cards can be used when students need to externalize mathematical relationships and discuss them with peers. Wordwall can support varied contextual or classification tasks, and Quizizz can support rapid rehearsal and feedback once the core idea has been established. This functional allocation also reduces the risk that digital gamification becomes detached from the mathematical concept.

The intervention further indicates that teacher reflection remains indispensable. Digital tools did not remove the need for diagnosis, explanation, differentiated support, and time management. The improvement from Cycle I to Cycle II occurred after the teacher responded to students who were still struggling and modified implementation. Schools seeking to adopt edugames should therefore frame them as components of instructional design and teacher professional judgment rather than as automatically effective technologies.

Study Limitations and Directions for Future Research

Several limitations constrain the conclusions. First, the study involved one intact class of 26 students in one school, so the results are context-specific. Second, CAR does not provide a counterfactual comparison; maturation, repeated practice, teacher adaptation, and increasing familiarity with the tasks may have contributed to improvement. Third, the intervention was brief, comprising five meetings in total, and no delayed retention test was conducted. Fourth, the observational and motivation instruments were designed for classroom monitoring and were not accompanied by reported reliability coefficients. Fifth, the design combined multiple media and pedagogical models, so it cannot estimate the independent contribution of domino cards, Wordwall, Quizizz, or any particular game mechanic.

Future research should therefore move from practice-based evidence to comparative testing. A quasi-experimental or cluster design could compare a hybrid physical-digital sequence with digital-only, non-digital-only, and conventional instruction. Studies should use validated measures of conceptual understanding, procedural fluency, mathematics motivation, and engagement; report effect sizes and uncertainty intervals; and include delayed post-tests.

Process data could also examine which students benefit most from each representation and whether the order of physical and digital activities matters. Such work would test the instructional mechanism suggested by the present CAR rather than merely replicate the overall score increase.

A further limitation concerns the granularity of the available data. The thesis reports aggregate means, mastery counts, and categorical observation descriptions, but it does not provide item-level response data, individual longitudinal score vectors, or a validated multi-item motivation scale. Consequently, the article cannot calculate effect sizes based on individual variability, analyze which multiplication subskills improved most, or test whether students with lower baseline achievement benefited differently from their peers. Future studies should preserve student-level pre/post data and use validated affective measures so that learning gains and motivational change can be examined with greater precision.

Future comparative research should also isolate the contribution of sequencing. A useful design would compare at least three conditions: a physical-manipulative-first hybrid sequence, a digital-only sequence, and regular instruction, while holding content, teaching time, and assessment constant. Such a design could test whether the concrete-to-digital progression itself offers an advantage or whether the observed classroom gains are primarily attributable to increased practice, teacher attention, or novelty. Replication across schools in different geographic and technological contexts would also clarify how feasible the hybrid model is when device access and internet stability vary.

CONCLUSION

The classroom action research documented a clear improvement in fifth-grade integer multiplication learning across a pre-cycle and two iterative cycles. The class mean increased from 62.5 to 74.2 and 84.6, while the proportion reaching the school mastery criterion rose from 38.46% to 69.23% and 88.46%. Classroom observations also indicated progressively stronger participation, collaboration, confidence, and independence in using the learning media. The most defensible contribution is the instructional sequence itself: mathematics domino cards were used for tangible conceptual interaction, Wordwall for contextual and interactive practice, and Quizizz for consolidated rehearsal and immediate feedback, with each cycle refined through teacher reflection. Because the study involved one class without a comparison group or inferential testing, the findings should not be generalized as proof of causal effectiveness. They nevertheless provide practice-based evidence that deliberately combining physical and digital edugames can be a viable architecture for iterative improvement in elementary mathematics. Controlled studies with stronger measurement and longer follow-up are needed to test the sequence more rigorously.

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