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TICKET-PULLING GAME-BASED LEARNING AND FOURTH-GRADERS' MATHEMATICAL REASONING IN NUMBER AND FIGURAL PATTERNS

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Abstract

Mathematical reasoning is a core primary-school skill, but evidence on non-digital game-based learning (GBL) for it is still limited. This study examined whether a ticket-pulling GBL activity was associated with fourth graders' reasoning on number and figural patterns. A quasi-experimental nonequivalent control group design was used with two intact classes (29 students each) at a public elementary school in Purwakarta Regency. Over three sessions within about one month, the experimental class played the ticket game while the control class received teacher-led instruction. Reasoning was measured with an eight-item open-ended test (Cronbach's alpha = 0.822). Pre-test scores did not differ significantly between classes ($p = .818$). On the post-test, the experimental class ($M = 74.03$) outperformed the control class ($M = 65.86$), $t(56) = -4.223$, $p < .001$, Hedges' $g = 1.09$. Mean N-gain was 0.51 and 0.34, respectively, both in the medium category. These results suggest that the game was associated with greater improvement in reasoning. However, with one class per condition and no pre-test adjustment, causal interpretation and generalization are limited.

Keywords: Game-Based Learning, Mathematical Reasoning, Number Patterns, Figural Patterns, Elementary School Students.
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INTRODUCTION

Mathematics has great significance when it comes to development of the logical structured and analytical thinking skills of children in the course of their primary education (Bognar et al. 2025). Besides teaching the children how to perform calculations, mathematics plays a very important part in developing their ability to perceive how the things relate to each other and to use reasoning in solving problems (Hussein et al. 2022). Mathematical reasoning, which is a skill of perceiving relationships and patterns, formulating and justifying conjectures and drawing conclusions is one of the key competences that can help to develop such skills (Herbert & Williams, 2023; Valenta et al. 2024). One of the examples of mathematical reasoning in action is the reasoning that occurs while dealing with number and figural patterns, because in such activities children learn to perceive the rule according to which numbers or figures occur in a sequence, use the rule to determine what comes next and to justify their reasoning, rather than simply using the memorized algorithm (El Mouhayar, 2018). As the National Council of Teachers of Mathematics (2000) states, reasoning and proof belong to the five processes, which should govern school mathematics. According to the statement, students are supposed to consider reasoning as a very important part of mathematical activity, make and check conjectures and create and examine mathematical arguments. This opinion is confirmed by contemporary researches showing that logical thinking encourages learners to go beyond simple calculations, helps them to understand connections between concepts and gives an ability to give logical explanations of their way to solve the problem (Mukuka et al. 2020; Mahmud & Mohd Drus, 2023). The teaching of mathematics at the primary school level should be organized in such a way that it encourages active participation of the learners in the thinking process. (Datsogianni et al. 2020)

Though the significance is well-known, there is room for improvement in students' mathematical reasoning skills (Fitriyah et al. 2022). Additional evidence about this problem may be found through data obtained in large international assessments. The international assessment Trends in International Mathematics and Science Study (TIMSS) assesses the mathematical achievement of fourth- and eighth-graders in three areas of cognition: knowledge, application, and logical reasoning. It becomes obvious that there is a need for a pedagogical model that would foster active involvement of the learners while simultaneously ensuring the transmission of the deep understanding of the material. From the international studies, it is known that the level of mathematics achievement of the primary school students is lower than the world average level, especially in areas where the high-level reasoning skills are needed (Saleh et al. 2017). This indicates the fact that many students still have trouble with logical reasoning in math tasks (Marasabessy, 2021). One of the most common factors that cause this problem is an excessive use of teacher-centered instruction that makes the learners perform actions without really comprehending the principles (Sunzuma & Umbara, 2025). This means that there is a need to

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implement a pedagogical approach that would ensure active participation of students and deep understanding of the mathematical material (Bognar et al. 2025; Vale & Barbosa, 2023).

An alternative can be found in game-based learning (GBL), characterized by the incorporation of components of a game, such as rules, goals, and challenges, into the learning process. It does not consist in adding certain incentives like badges and points to an unchanged task (Manzano-León et al. 2021), as happens with gamification, or in the use of computer or video game technologies (Mubharokh et al. 2021; Setiawan & Soeharto, 2020) in the case of digital GBL. The activity discussed in the current study uses pieces of paper, thus constituting a low-tech example of game-based learning (GBL) similar to that used in traditional learning games in primary school mathematics (Asrial et al. 2020; Rosikhoh & Abdussakir, 2020; Russo et al. 2024). During the activity, each participant gets a piece of paper with either a number or a visual pattern-related task. They look at the sequence to recognize the underlying rule, generate and examine a rule for continuing the sequence, explain to their peers or teacher how and why the rule applies to the sequence, and come up with a conclusion based on the above activities. This entails the process of pattern recognition, conjecturing, reasoning, and concluding, which are the essential elements of mathematical thinking. Literature suggests that game-based learning (GBL) significantly improves the efficiency of instruction and mathematical thinking of primary school students (Dan et al., 2024; Himmawan & Juandi, 2023). Through the process of exploring, being challenged, and receiving feedback in the game-like environment, the students learn in a more meaningful and memorable way; moreover, GBL can also increase both engagement and mathematical knowledge and skills (Hui & Mahmud, 2023). In a game-based environment, exploration, challenge, and feedback create a more meaningful and memorable learning experience; besides, game-based learning (GBL) has the ability to improve both the engagement and mathematical knowledge and skills of the learners since GBL tasks require interaction, strategy, and exploration of different ways of coping with the challenge (Pan et al. 2022), as students acquire knowledge through structured, game-based tasks that require interaction, strategy, and the exploration of various approaches to overcoming a challenge (Gök & İnan, 2021). Besides, previous studies show that incorporating games into instruction can develop mathematical thinking, engagement, and mathematical concepts, especially in primary school students (Jensen & Skott, 2022).

Although some scholars have found that game-based learning (GBL) helps motivate students and improves their performance in mathematics learning (Hussein et al., 2022; Debrenti, 2024), few studies have addressed the effects of GBL on mathematical reasoning of primary school students (Polydoros & Antoniou, 2025). Furthermore, although reviews of literature on game-based learning have been primarily about digital games, little attention has been paid to non-digital games (Russo et al., 2024). Research concerning mathematical reasoning of fourth graders by means of physical card games is scarce as well. In order to fill this void, the current study explores a card game that is different from digital or app games and

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concerns reasoning with regard to number and figural patterns of fourth graders. This focus corresponds to the cognitive development expected of fourth graders, who are usually considered to be at the concrete-operational stage, when game-based activities help link abstract mathematical concepts to concrete, context-bound ones (Wang et al. 2022). Therefore, the research question posed within the framework of this study is: To what extent is a ticket-based GBL activity associated with mathematical reasoning skills of fourth-grade students concerning number and shape patterns? The purpose of the study is to explore the differences in progress made in mathematical reasoning skills by students who were involved in the game and students taught by means of conventional methods at the selected school. Based on the above, it was hypothesized that students who engaged in the ticket-based GBL activity would demonstrate better results in mathematical reasoning than students who studied traditionally.

METHODS

Research Design

In the current research, a quantitative methodology with a quasi-experimental design was used. The choice of a quasi-experimental design was dictated by the fact that the random allocation of participants into groups was not possible due to the use of naturally existing class groups in the context of the school environment (Gopalan et al. 2020). The design used included a non-equivalent control group design with both pre-tests and post-tests. In particular, one class served as the experimental group that received the treatment while another class worked as a control group (Denny et al., 2017). First, all participants took a pre-test to identify their initial level of mathematical reasoning and then took a post-test after implementing the treatment. The independent variable in the study included the instructional condition which can be either game-based learning with tickets or traditional instruction. The dependent variable was mathematical reasoning in the context of numerical and figural patterns. Mathematical reasoning is a term which means the ability of the learner to analyze logical connections between different mathematical concepts and make conjectures and conclusions in order to solve mathematical problems (Mata-Pereira & Da Ponte, 2017). Since there was only one intact class for each condition, the treatment effect was confounded with class effect. It means that the difference between two classes cannot be separated from the effect of teacher, schedule, classroom atmosphere, or peers' behavior.

Participants and Context

Fourth-grade students from one of the participating elementary schools in Purwakarta Regency comprised the population for this study. The target population excluded all elementary school students within Purwakarta Regency. A purposive sampling technique was used to select two intact classes (Campbell et al. 2020). based on the teacher's consent to participate and the student's previous experience of mathematics games. Each class teacher remained with their respective class throughout the study and implemented one of two conditions. The

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experimental and control groups consisted of 29 and 29 fourth grade students respectively for a final total of 58 students. The data was collected over approximately one month in the second semester of the 2025/2026 school year.

Instrument

Mathematical reasoning was evaluated by an open-ended test with eight questions related to numerical and figural patterns. This test served as both the pretest and the posttest.(Herbert & Williams, 2023) listed five indicators of logical reasoning, which are as follows: explaining math ideas, identifying patterns and relationships, planning solution steps, creating justifications for solutions, and drawing inferences. Originally, the assessment consisted of ten tasks meant for fourth graders regarding the assessment of their logical reasoning in numerical and figural patterns. The instrument was pilot-tested at a school that was different from the one in the main study. ANATES was utilized for item analysis to assess the quality of the items in the instrument. Following the item analysis, two items were removed. The instrument then contained eight items, and those eight were used in the main study to assess students' logical reasoning. Content validity was assessed through expert judgment. An elementary school teacher acted as the validator. The validator rated each test item according to how closely it was aligned to its associated indicator using a scale of 1 to 5. The rating was done in a 5 point scale where 1 means not aligned and 5 means highly aligned. Based on the validator's feedback, the instrument was deemed appropriate for the main study.

Table 1. Alignment of Mathematical Reasoning Indicators and Test Items

Indicator	Items	Pattern type	Task focus
Expressing mathematical ideas	Q1, Q2	Number, figural	Explain in your own words how the number sequence 5, 8, 12, 17, 23 is formed; explain how the number of stars increases (1, 3, 5), and state the next number.
Leveraging patterns and connections	Q3, Q4	Number, figural	Explain the relationship among 5, 10, 15, 20; explain how a given figural pattern develops.
Predicting solution pathways	Q5	Number	Give the next two terms of 6, 12, 18 and explain the reason.
Constructing mathematical justification	Q6	Number	Determine whether 77, 84, 91, 98, 105 is a sequence of multiples of 7.

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Indicator	Items	Pattern type	Task focus
Drawing logical conclusions	Q7, Q8	Number, figural	Formulate a conclusion regarding 4, 8, 12, and 16, and provide a justification for it; formulate a conclusion regarding the circle pattern (2, 6, 10 circles).

One of the test items (Question 6) reads: "Budi claims that the sequence 77, 84, 91, 98, 105 consists of multiples of 7. Prove whether his statement is correct." To answer fully, students needed to show that every number in the sequence follows from the previous one by adding 7 (or by applying the rules of multiplication), and then conclude that Budi was right. Responses were scored on a rubric from 0 to 4. A score of 4 meant a correct answer with a complete explanation or proof, and 3 meant a correct answer whose explanation was incomplete or missing. A score of 2 was given to partially correct answers and 1 to incorrect or irrelevant ones, while 0 meant the item was left blank (see Appendix 1). To check content validity, one validator, a teacher at a public elementary school, rated how well each item matched its indicator on a five-point scale, from 1 (not aligned) to 5 (highly aligned). The validator also commented on whether the instrument was suitable for field testing.

The initial instrument contained 10 items. It was piloted at a different school with students from the same grade level as the main study participants, and the responses were analyzed with ANATES. Two items showed no significant correlation with the total score, so they were removed, leaving eight items in the final instrument. The remaining items correlated significantly with the total score ($r = 0.615$-0.741), and the final instrument obtained a Cronbach's alpha of 0.822, which indicates acceptable internal consistency. Scoring the students' responses was time-consuming for the researcher. Because no second rater was available, interrater reliability could not be estimated, and this is acknowledged as a limitation of the study. Raw scores (0-32) were converted to a 0-100 scale by dividing each raw score by 32 and multiplying by 100. All means, effect sizes, and N-gain values reported in this study are based on the converted scores.

Procedure

The study began with developing and validating the instrument. After that, both the experimental class and the control class took part in three sessions each over a period of about one month, and every session ran for two lesson periods (70 minutes). In the first session, students took the pre-test and then moved on to the first unit of either the intervention or the comparison curriculum. The second session covered the second unit. The third session covered the final unit and ended with the post-test. Both tests were given within the regular class

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schedule, so no extra time was added. The two tests used the same instrument, and the researcher administered and supervised both of them personally, under the same conditions in the two classes.

Intervention and Comparison Condition

Students in the experimental class learned through a ticket-based game called "Pattern Ticket Pull" across the three sessions. The lessons followed the steps in the instructional module, and the 70 minutes included testing time in the first and third sessions. The first session dealt with numerical patterns, the second with figural patterns, and the third with a combination of both. In every session, students worked in groups of seven to eight, and each lesson moved through six phases.The lesson opened with the teacher introducing the game and telling students that they would learn the topic through a group activity. The teacher then showed several example patterns related to that day's topic and used guiding questions to help students work out the rule behind each sequence. Once the concept was clear, the teacher explained how the game would run. Each group would take turns drawing a ticket, discuss the task together, and write its answer on a worksheet, and the group with the most correct answers would be declared the winner. The tickets asked students to find the rule of a pattern, extend it, or spot the error in a given pattern. During the game itself, slips of paper containing sample tasks were pinned to the board. Groups came forward in turns, picked a slip, discussed it, and wrote down their answers. Members exchanged ideas until they agreed on the most accurate response, analyzed the patterns they had found, and gave short justifications. After the game, each group presented its findings and responded to questions and comments from the other groups. Wrong answers were corrected on the spot, and the teacher helped students identify the rules behind the patterns and connect them to everyday situations. The lesson closed with a reflection, in which students answered guiding questions about what they had learned, how they had recognized the patterns, and what difficulties they had met.

Together, these phases covered the five mathematical reasoning indicators examined in this study. Group discussions and presentations let students express mathematical ideas, while pattern analysis required them to use patterns and relationships. Extending patterns involved predicting solutions, and explaining their answers gave students practice in providing mathematical justifications. The consolidation phase, in turn, called for drawing logical conclusions.The control class studied the same three topics in three sessions of equal length and used the same student worksheets (LKPD). The difference was that the ticket game and other game-based activities were left out. Instruction instead followed a teacher-led sequence of explanation, worked examples, and practice. The teacher introduced the concept of patterns and solved several example problems on the blackboard. Students then did the exercises in their LKPD, either individually or in the same groups as the experimental class, but without the ticket game.

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Data Analysis

All data were processed in SPSS. To see whether the two classes started at a similar level, the pre-test scores were compared with an independent-samples t-test, and the post-test scores were compared in the same way. Normality was checked with the Shapiro-Wilk test and homogeneity of variances with Levene's test. Boxplots helped flag possible outliers, and each flagged score was then checked against the original answer sheets. N-gain scores (Hake, 1998) were calculated only to describe how much each class improved, not for hypothesis testing. Several limitations should be kept in mind. No pre-test-adjusted analysis such as ANCOVA was run, so the post-test comparison does not control for initial differences between the classes. In addition, each condition was represented by a single class, which means the treatment is confounded with class membership and classroom-level clustering could not be fully accounted for. For this reason, the student-level p-value should be read with caution and not taken as conclusive proof that the intervention alone produced the difference.

Ethical Considerations

The researcher's university gave permission to carry out the study, and the principal of the participating public elementary school (SDN) in Purwakarta Regency gave consent. Before collecting data, the researcher explained the study and its procedures directly to the classroom teacher. Because the participants were minors, the teacher also told their parents or legal guardians about the activities before the study began, although this notification was not recorded in writing. Written parental consent and student assent were not collected, since the activities were part of regular classroom instruction. Taking part carried no risk beyond that of ordinary lessons, and students' performance did not affect their report card grades. The study was not reviewed by a formal research ethics committee because the researcher's institution does not require one for classroom-based educational research of this kind. Students' identities were kept confidential, and the data were used only for research.

RESULTS AND DISCUSSION

This section reports the findings on the relationship between the Game-Based Learning (GBL) model and fourth graders' mathematical reasoning in number and figural patterns. The study used a Nonequivalent Control Group Design with two classes. The experimental class learned through a GBL ticket-pulling activity, while the control class received conventional instruction. A total of 58 fourth-grade students took part, 29 in each class, and each class completed three sessions within about one month. All students attended every session and completed both tests, so no data were excluded because of attrition, absence, or incomplete answers. All sessions were carried out according to the teaching module, although implementation fidelity was not formally documented. Before the treatment, a pre-test was given to check whether the two classes began from a similar baseline. The data were then

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examined for normality and homogeneity to confirm that the assumptions for the analysis were met. After that, an independent-samples t-test was run, followed by an N-gain analysis to gauge improvement in students' mathematical reasoning. Looking at the pre-test results first also gave a basis for interpreting the post-test comparison in light of students' starting ability. Table 2 compares the initial performance of the two groups based on their pre-test scores.

Table 2. Descriptive Statistics and Baseline Comparison of Pretest Scores

	Classes	N	Mean	Std. Deviation	t	df	Sig. (2-tailed)
Pre-Test Score	Control	29	48.45	8.301			
	Experiment	29	47.97	7.618			
	Equal variances assumed				0.231	56	.818
	Equal variances not assumed				0.231	55.593	.818

Note. Mean difference (Control − Experiment) = 0.48; Hedges' g = 0.06, 95% CI [−0.46, 0.58].

Before the intervention, the pre-test scores were compared with an independent-samples t-test to see how well students in the two classes could reason mathematically at the start. As Table 2 shows, the control class (M = 48.45, SD = 8.301) and the experimental class (M = 47.97, SD = 7.618) had very similar average scores. The equal-variances-assumed row gives t(56) = 0.231 with a two-tailed significance of .818, well above the 0.05 level. The standardized mean difference was small (g = 0.06), and its 95% confidence interval ran from −0.46 to 0.58. In other words, the two classes did not differ significantly in their initial mathematical reasoning. This result does not mean, however, that the groups were equivalent in every respect that matters. The post-test scores were compared with an independent-samples t-test rather than with a method that adjusts for pre-test performance, such as analysis of covariance (ANCOVA). A nonsignificant pre-test difference therefore cannot be taken as proof that all baseline differences were statistically controlled, and the post-test comparison in the next section should be read with students' initial scores in mind. Before moving on to hypothesis testing, we checked the assumptions of normality and homogeneity.

We first tested normality to find out whether the reasoning scores in each class were distributed closely enough to normal to justify parametric tests. Each group had 29 students, so the Shapiro-Wilk test served as the main check, since it is generally considered more suitable than the Kolmogorov-Smirnov test for small samples. The Kolmogorov-Smirnov statistic is still reported in Table 3 as supplementary information. As Table 3 shows, all significance values

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exceeded .05 (Shapiro-Wilk p = .108 to .344) for both the pre-test and post-test in each class, so the assumption of normality was met.

Table 3. Normality Test Results for Pretest and Posttest Scores

	Classes	Kolmogorov-Smirnov			Shapiro-Wilk		
		Statistic	Df	Sig.	Statistic	df	Sig.
Mathematical Reasoning	Pretest Control	.114	29	.200	.941	29	.108
	Posttest Control	.112	29	.200	.943	29	.121
	Pretest Experiment (GBL)	.116	29	.200	.954	29	.228
	Post-Test Experiment (GBL)	.102	29	.200	.961	29	.344

As Table 3 shows, the Shapiro-Wilk significance values for all four distributions were above .05. For the control class, p = .108 on the pre-test and p = .121 on the post-test, while for the experimental class, p = .228 and p = .344. The Kolmogorov-Smirnov results (all p = .200) pointed the same way. Because none of the tests gave evidence against normality, the four sets of scores were treated as approximately normal for the parametric analysis. Next, Levene's test was used to check whether the two classes had a comparable spread of scores. The results are presented in Table 4.

Table 4. Homogeneity Test Results for Posttest Scores

		Levene Statistic	df1	df2	Sig.
Mathematical reasoning	Based on Mean	0.614	1	56	.436

The mean-based row in Table 4 was not significant, F(1, 56) = 0.614, p = .436, so the variances of the two classes were treated as homogeneous. With normality and homogeneity both satisfied, an independent-samples t-test was used to compare the post-test reasoning scores of the two classes. Table 5 reports the results.

Table 5. Independent-Samples t-Test Results for Posttest Scores

Classes	N	Mean	Std. Deviation	Mean Difference	T	df	Sig. (2-tailed)	Hedges' g
Control	29	65.86	7.963		-4.223	56	<.001	1.09
Experiment	29	74.03	6.721	8.17				

The experimental class scored higher on the post-test (M = 74.03, SD = 6.72) than the control class (M = 65.86, SD = 7.96), a gap of 8.17 points. This difference was statistically significant, t(56) = −4.223, p < .001, and the effect was large (Hedges' g = 1.09). In practical terms, the experimental class finished about one standard deviation ahead of the control class on a 100-point scale. Students who learned through the ticket game therefore performed better on the post-test than students who received conventional instruction. This comparison has limits, though. It was not adjusted for pre-test scores and did not account for clustering at the classroom level. Because each condition was represented by only one class, the result should be

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read with caution and not taken as conclusive proof that the game-based intervention alone produced the difference. To see how much reasoning improved within each class, an N-gain analysis was carried out.

Table 6. presents the results.Table 6. N-Gain Results by Class

Classes	Mean N-Gain Score	Mean N-Gain Percent	Category Interpretation Effectiveness
Experiment	0.51	51%	Medium
Control	0.34	34%	Medium

Following the normalized gain classification, scores below 0.30 count as low, scores from 0.30 to below 0.70 as medium, and scores of 0.70 or higher as high. Both the experimental class (g = 0.51) and the control class (g = 0.34) fell in the medium category. Even so, the experimental class improved more, by about 17 percentage points. This suggests that the ticket-drawing game was associated with a larger improvement in mathematical reasoning than conventional teaching. The students in the experimental class also appeared more enthusiastic and participated more actively, which fits this pattern. Still, N-gain is better treated as supplementary descriptive evidence than as an independent measure of effectiveness, since the main comparison between the classes rests on the inferential test. The difference also suggests that the approach needs further testing and refinement before its contribution to students' reasoning can be firmly established.

Students in the experimental class, who took part in the ticket-drawing game, reached higher levels of mathematical reasoning in numerical and figural patterns than students in the control class. The results do not show that game-based learning alone caused this gap, however. The study was conducted at one school with a fairly small sample and a short intervention period, and the two classes may already have differed before the intervention. Even so, the findings agree with the view that game-based learning can make mathematics more meaningful than conventional instruction (Bado, 2022). During the activities, students identified patterns, predicted the next terms, compared strategies, and explained the reasoning behind their answers instead of simply receiving information from the teacher. Active participation, exploration, problem solving, and immediate feedback are central features of game-based learning, and they may have supported the reasoning measured on the post-test. Similar results have been reported in earlier studies linking game-based learning to deeper conceptual understanding (Alotaibi, 2024;Guan et al., 2024;Byusa et al., 2022).

Mathematical thinking is widely regarded as a core competency in mathematics education (National Council of Teachers of Mathematics, 2000). This study measured it through five indicators (Herbert & Williams, 2023): expressing mathematical ideas, identifying patterns and relationships, predicting possible solutions, providing explanations, and drawing logical conclusions. The ticket-drawing game gave students repeated chances to explore numerical and figural patterns, notice regularities, predict the next terms, and explain their answers. Instead of

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memorizing procedures, students were pushed to understand the structure behind each pattern, and recognizing such structures is an important part of inductive reasoning (Pásztor et al. 2022), Giving justifications and drawing logical conclusions are harder skills, though. They usually need continuous guidance from the teacher and cannot be fully developed in a single learning activity (Klang et al. 2021). A short game-based learning (GBL) intervention may therefore strengthen some indicators more than others, and it may work best as an entry point that is followed by structured classroom dialogue.

Piaget's theory offers one way to read the improvement. Fourth graders are generally in the concrete operational stage, in which abstract ideas are easier to grasp when they are tied to tangible activities (Sari & Darhim, 2020). The game created a concrete, low-pressure setting for exploring patterns, which may have helped students understand the material more broadly. This reading remains tentative, however, because the study neither assessed students' developmental stages nor collected direct evidence of this mechanism. Flow theory suggests a second explanation. Tasks that are neither too easy nor too hard tend to hold attention and encourage deeper thinking, and the graded difficulty of the pattern challenges may have come close to that balance for some students. In a review of GBL in primary mathematics. Lei et al. (2022) found that tasks matched to learners' ability were linked to stronger engagement than tasks seen as too easy or too difficult. Engagement was not measured directly in the present study, so this connection is inferred and not confirmed.

A third explanation concerns the collaborative format. Students solved problems together, which meant communicating their ideas, questioning one another's reasoning, and agreeing on a shared answer. Explaining and justifying their thinking to peers may help students refine it through feedback and organize their ideas more clearly (Klang et al. 2021). Research on collaborative learning also suggests that, under certain conditions, peer-based approaches can be more effective than direct teacher-led instruction (Siller & Ahmad, 2024). Cognitive readiness, task difficulty, and peer interaction may thus be plausible and interconnected explanations for the findings, although this study was not designed to test them directly.

These findings agree with earlier research pointing to the potential of GBL for promoting engagement, motivation, and conceptual understanding (Anggoro et al. 2025). Most of that work, however, has looked at general achievement or digital games. This study focused on mathematical reasoning in primary school and used a physical ticket-pulling game built around number and figural patterns, so it offers preliminary evidence in a less explored area. The 51% normalized gain of the experimental class should be read against its starting point. Both classes began with similar and fairly low pre-test averages (47.97 for the experimental class and 48.45 for the control class). After the intervention, the experimental class showed a numerically higher average gain than the control class over the same period. Karakoç et al. (2022) noted that digital GBL platforms with adaptive feedback may need longer implementation to produce larger gains, and Yuniarti et al. (2022), writing about Indonesian

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primary schools, reported that digital game-based media worked better with continuous use and suitable pedagogical support. Each class received only three sessions spread over about one month, so the limited amount of instruction may have restricted how much improvement could be observed. The 17-percentage-point difference in mean N-gain was not tested for statistical significance, so it should be treated as a descriptive finding and not as proof of a statistically confirmed advantage for GBL. What can be said is that, given the observed baseline and the implementation period, the experimental class showed a numerically greater average gain than the control class.

The physical ticket-pulling format also has practical features that may matter for schools with different levels of infrastructure. The game requires no devices or software, only simple classroom materials. Indonesian education also values active, context-based, and student-centered learning, and the activity reflects these qualities, since students solve problems directly, discuss strategies, and interpret patterns. The intervention was not compared against curriculum documents or specific indicators, so this is a context-based observation and not evidence that the activity is aligned with the curriculum. This study has several limitations. It involved one experimental class and one control class at a single school, with a fairly small sample, so the findings cannot be generalized widely. The classes were intact groups and students were not randomly assigned, which means the effect of the intervention cannot be separated from class membership. The teacher, the class schedule, or the makeup of the class may also have contributed to the difference, so firm causal conclusions are not possible. The analysis also did not account for the fact that students in the same class tend to resemble one another, which may have affected the accuracy of the group comparison. The intervention was short, consisting of three sessions per class spread over about one month, so its long-term effects remain unknown. How faithfully the intervention was delivered was not monitored in enough detail to confirm that it was consistent across sessions. The reasoning test was reviewed by one validator, piloted with 23 students, and scored by one rater, so agreement between raters could not be assessed. The test may also have covered the five reasoning indicators unevenly, especially justifying statements and drawing logical inferences. Prediction and justification were each measured by only one task on numerical patterns, and only three of the eight tasks involved figural patterns. Scores for individual indicators may therefore not be reliable enough to interpret separately. Given these limitations, the findings should be seen as preliminary. Future studies should involve more classes and schools, preferably with random assignment, so that the effect of game-based learning (GBL) can be separated from teacher, schedule, and student-group differences. They should also run the intervention for longer, monitor how consistently it is delivered, strengthen the validity and reliability evidence for the instrument, and use analyses that adjust for pre-test scores and for the grouping of students within classes. Applying GBL to other topics, such as fractions and basic geometry, would show whether the results hold beyond numerical and figural patterns.

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CONCLUSION

This study examined the use of a ticket-drawing game as a form of GBL and its association with the mathematical reasoning of fourth-grade students learning numerical and figural patterns. The experimental class obtained higher unadjusted post-test scores than the control class, and the mean normalized gains were 51% and 34%, both moderate under Hake's classification. These results suggest that the game-based activity was associated with a larger improvement in reasoning than conventional instruction for these students, at this school, and on these topics. Because the study used one class per condition at a single school, causal interpretation and generalization are limited. Future research should replicate the study across several classes and schools, run the intervention for longer, document implementation fidelity, use validated instruments, and apply analyses that adjust for baseline scores and account for clustering.

AUTHOR CONTRIBUTION

NCI conceptualized the study, developed the ticket-pulling game-based learning instruments, and led the data collection and analysis on students' mathematical reasoning; HEP guided the methodology, evaluated the conceptual framework for number and figural patterns, and revised the manuscript draft; while AN assisted in conducting the fourth-grade classroom implementation, documented learning interactions, and processed supporting descriptive data. All the writers, agreed to the final version of the paper and say there are no problems, with the way this study is being shared.

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