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The influence of Bingo games on learning outcomes of fraction arithmetic operations

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ABSTRACT
Mathematics learning in elementary schools continues to face challenges, including low student achievement, particularly in fraction operations, which are considered difficult due to their abstract nature and the use of conventional, monotonous teaching methods. This study aimed to examine the effectiveness of the Bingo game method in improving fifth-grade students' learning outcomes in fraction arithmetic at SDN Cawang 07 Pagi, Jakarta. Using a quantitative approach with a quasi-experimental posttest control group design, the study involved 60 fifth-grade students selected through purposive sampling. The research instrument was a validated and reliable learning outcome test. The treatment was delivered across four meetings, and data were analyzed using an independent t-test, complemented by effect-size analysis using Cohen's d. The results indicated that the experimental group taught using the Bingo method achieved a higher mean posttest score than the control group, with a high effect size. These findings demonstrate that interactive game-based learning methods, such as Bingo, are effective in fostering an active and enjoyable learning environment and in improving elementary students' mathematics learning outcomes, particularly in fraction arithmetic operations.

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ABSTRAK
Pembelajaran Matematika di sekolah dasar masih menghadapi tantangan rendahnya hasil belajar murid, khususnya pada materi operasi hitung pecahan yang dianggap sulit karena bersifat abstrak dan diajarkan dengan metode konvensional yang monoton. Tujuan penelitian ini adalah untuk mengkaji efektivitas metode permainan Bingo dalam meningkatkan hasil belajar operasi hitung pecahan pada murid kelas V SDN Cawang 07 Pagi, Jakarta. Penelitian ini menggunakan pendekatan kuantitatif dengan desain kuasi-eksperimen tipe posttest control group design. Subjek penelitian melibatkan 60 murid kelas V-A dan V-B SDN Cawang 07 Pagi yang dipilih dengan teknik purposive sampling. Instrumen penelitian berupa tes hasil belajar yang telah diuji validitas dan reliabilitasnya. Perlakuan diberikan selama empat pertemuan, kemudian data dianalisis menggunakan uji-t independen untuk membandingkan hasil belajar antara kelompok eksperimen dan kelompok kontrol. Selain itu, dilakukan perhitungan effect size dengan rumus Cohen's d untuk mengetahui besar pengaruh perlakuan. Hasil penelitian menunjukkan bahwa kelompok eksperimen yang belajar dengan metode Bingo memperoleh skor rata-rata posttest lebih tinggi dibandingkan kelompok kontrol, dengan nilai effect size berada pada kategori tinggi. Hal ini membuktikan metode pembelajaran berbasis permainan interaktif seperti Bingo terbukti efektif menciptakan suasana belajar yang aktif, menyenangkan, dan meningkatkan hasil belajar Matematika murid sekolah dasar, khususnya pada materi operasi hitung pecahan.
Kata Kunci: *hasil belajar; metode permainan Bingo; operasi hitung pecahan*

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INTRODUCTION

Mathematics at the elementary school level often still poses a challenge for students, especially in the topic of fraction operations, which are considered abstract and difficult to understand. At SDN Cawang 07 Pagi, Jakarta, observations conducted together with the class teacher showed that many fifth-grade students had not yet been able to meet the Kriteria Ketuntasan Minimal (KKM) in daily tests or midterm exams for fraction material. This situation is further exacerbated by the dominance of monotonous conventional teaching methods, such as lectures, which make the learning atmosphere less engaging, and students quickly become bored. (Setiyawan, 2018).

Game-based methods are effective in improving Mathematics learning outcomes. Theoretically, the effectiveness of game-based methods in learning is supported by constructivist learning theory, which emphasizes that students build knowledge through active experiences and social interactions, and by intrinsic motivation theory, which explains that enjoyable activities can increase student engagement and persistence in learning (Tamrin & Masykuri, 2024). In the context of Mathematics learning, games create a meaningful learning environment where students can experience abstract concepts through concrete manipulation and collaborative interaction. One game that can be applied in Mathematics learning is Bingo.

Mathematics Bingo games have been proven to improve students' understanding of integer operations by making the learning process more active and enjoyable. Previous research also shows that Mathematics Bingo games enhance the understanding of integer operations by making students more active and enthusiastic (Susanto & Fadlillah, 2024). Bingo is effective for addition and subtraction operations, helping students understand concepts in a fun way (Azizah, 2024). Bingo not only improves learning outcomes, but also student motivation (Karmani, 2021). In addition, Bingo enhances mixed arithmetic operation skills through hands-on practice (Nuraidah et al., 2023). However, most of these studies focus on integer operations or mixed calculations. In contrast, the application of Bingo to fraction operations has been rarely explored, especially among fifth-grade students in the context of elementary schools facing conventional learning challenges. The limitation of previous research lies in its narrow focus on integer operations and its failure to explore the unique characteristics of fraction learning, which require an understanding of part-whole concepts, visual representations, and operations more complex than integers. This study fills that gap by specifically testing the Bingo method on fraction material, using a quasi-experimental design to provide strong empirical evidence (Ramlah et al., 2024).

This indicates the need for learning innovations that can increase students' active engagement and facilitate the understanding of fraction concepts. One potential approach is the use of the Bingo game method, which is believed to create a more interactive and enjoyable learning atmosphere through group activities (Ashara A, 2020). Therefore, this study was conducted to test the effectiveness of the Bingo game method in improving the learning outcomes of fraction arithmetic operations in fifth-grade students at SDN Cawang 07 Pagi.

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Unlike previous studies that highlighted operations with whole numbers or mixed numbers, this research specifically explores the application of Bingo to fraction material, which is known to be complex for elementary school students. Theoretically, this study contributes to the development of Mathematics learning theory by providing an in-depth understanding of how game-based methods can be adapted for more abstract Mathematical concepts such as fractions. In practice, the findings of this study are expected to provide an alternative learning strategy that is applicable and easy for elementary school teachers to implement to improve the quality of Mathematics learning, especially for material that has so far been considered difficult by students. These findings are expected to enrich interactive learning strategies in elementary Mathematics education.

The problem in this study is the low learning outcomes in fraction arithmetic operations among fifth-grade students at SDN Cawang 07 Pagi, which is caused by the use of conventional teaching methods that are less engaging. Therefore, this study proposes the hypothesis that there is no significant effect of the Bingo game method on students' learning outcomes (H_0); and that there is a significant effect of the Bingo game method on students' learning outcomes (H_1).

This study aims to determine the effect of the Bingo game method on Mathematics learning outcomes, particularly in the topic of fraction operations. In addition, this study measures the effectiveness of the method in improving learning outcome scores and evaluates its practical impact through effect size analysis. Through the findings of this study, it is hoped that the Bingo game method can become an alternative interactive learning strategy applicable for elementary school teachers in enhancing conceptual understanding, learning motivation, and the quality of Mathematics learning in a sustainable manner. The broader implications of this study include contributions to the development of educational policies in promoting the implementation of innovative and interactive learning methods in elementary schools, as well as providing input for the development of a Mathematics curriculum that is more responsive to students' learning needs and characteristics.

LITERATURE REVIEW

Mathematics Learning Outcomes

Mathematics learning outcomes refer to changes in students' knowledge, skills, and attitudes resulting from participation in the learning process. Learning outcomes are the achievements of students measured through evaluations, such as test scores, which reflect mastery of the material (Anggraini, 2024; Ridha et al., 2025). In addition, learning outcomes are indicated by symbols or numbers as measures of learning success, covering the cognitive, affective, and psychomotor domains. In the context of fraction arithmetic operations, learning outcomes are measured by students' ability to correctly solve addition, subtraction, multiplication, and division problems involving fractions (Hikmah & Vioreza, 2023; Ulfah & Arifudin, 2021).

More specifically, learning outcomes in Mathematics on the topic of fractions not only include cognitive aspects in the form of calculation ability, but also conceptual understanding of the meaning of fractions as a representation of parts of a whole, the ability to convert between fraction forms, as well as the skill to apply calculation operation algorithms with the correct

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procedures (Sari et al., 2024). Optimal learning outcomes in the topic of fractions are marked by students' ability to identify types of fractions, equalize denominators, perform calculations systematically, and solve story problems involving everyday life contexts. Learning outcome indicators include students' enthusiasm in completing tasks and activeness in discussions, which are relevant to interactive approaches such as Bingo games (Masrohah et al., 2019; Putri et al., 2025). Lebih lanjut, hasil belajar yang tinggi dalam Matematika juga tercermin dari kemampuan murid dalam menjelaskan proses penyelesaian masalah, mengidentifikasi kesalahan dalam perhitungan, dan menerapkan konsep yang telah dipelajari dalam situasi baru.

Fraction Calculation Operation

Fraction arithmetic operations are among the core materials in the elementary school Mathematics curriculum, including addition, subtraction, multiplication, and division of fractions. Fractions are abstract and challenging because students must understand the concepts of denominators, simplification, and conversion in fraction form (Syukra et al., 2025). The complexity of learning fractions lies in several aspects: 1) Fractions have multiple representations (symbolic, visual, and verbal) that students must understand simultaneously; 2) Fraction operations have algorithms that differ from whole numbers, for example, in multiplying fractions it is not necessary to make the denominators the same, whereas in addition it is required; 3) Understanding the concept of place value and the magnitude of fractions, which often confuses students (Putri et al., 2025).

Fraction learning often faces obstacles, such as students' low understanding due to uninteresting teaching methods (Amir & Andong, 2022). Specific difficulties faced by students in fraction arithmetic include: errors in finding a common denominator in addition and subtraction, confusion in understanding why multiplying fractions results in a smaller number than the original, difficulty in the concept of dividing fractions by inverting the divisor, as well as errors in simplifying the final result (Nugroho et al., 2023). A common misconception is that students apply the rules of integer operations to fractions, such as adding the numerators with the numerators and the denominators with the denominators without first making the denominators the same.

Game-based approaches, such as Bingo, can overcome this obstacle by providing repeated practice in a fun format, making it easier for students to internalize concepts (Fernando et al., 2025). Bingo games are particularly effective for fraction material because they provide opportunities for intensive drill and practice without being boring, allow visualization and manipulation of fraction concepts through game cards, create a meaningful context in which fraction operations are used for a clear purpose (winning the game), and reduce Math anxiety that often hinders fraction learning (Pohan et al., 2023).

The Bingo Game Method in Mathematics Learning

The Bingo game method is a learning strategy that uses card games to create an interactive and enjoyable learning atmosphere (Rosyida et al., 2025). Bingo actively engages students by having them answer Math questions to complete card patterns, thereby enhancing understanding and retention of the material. Bingo is conducted in groups, where students

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compete to answer the teacher's questions to form a "Bingo" pattern on the card, which encourages creativity and engagement (Nguyen et al., 2024; Nuraidah et al., 2023). The advantages of this method include increased interest in learning, ease in memorizing material, and more dynamic student activities (Khadizah et al., 2024). However, the drawback is the potential for monotony if not well-designed and the reliance on the student's luck in answering questions (Islamiah et al., 2025). The basic principle of games in learning is to create an active, collaborative, and highly motivated learning environment. Games like Bingo utilize elements of competition and cooperation to increase students' interest in learning (Ibrahim et al., 2022). This game is designed with clear rules, such as answering questions to fill in a Bingo card, which encourages students to think quickly and accurately. The game also involves rules and targets that can be directed to reinforce counting skills in Mathematics learning (Agustina & Hidayati, 2024).

METHODS

This study uses a quantitative approach with a quasi-experimental design to examine the effect of the Bingo game method on Mathematics learning outcomes in the material of fraction operations for fifth-grade students at SDN Cawang 07 Pagi, Jakarta. The research design applied is a pretest-posttest control group design, which allows for comparison of learning outcomes between the experimental group and the control group before and after the treatment is given. The population of this study is all fifth-grade students, totaling 60 people, consisting of classes V-A and V-B. The sample determination used a total sampling technique, so all members of the population were included as the research sample.

Class V-A was chosen as the control group and class V-B as the experimental group, each consisting of 30 students, making the total sample 60 students through purposive selection based on the willingness of the class guardians and schedule. Then, random assignment was conducted to minimize bias. The research instrument consisted of an essay test with ten true-false questions validated by a Mathematics education expert to ensure content validity.

The research procedure consists of three stages, namely planning, which includes obtaining permits, preparing the Rencana Pelaksanaan Pembelajaran (RPP), modifying game media, and preparing instruments. The implementation is carried out over eight learning sessions using the Bingo method for the experimental group and the conventional method for the control group, along with evaluation through pretest and posttest administration to both groups, accompanied by observation of student involvement using a structured observation sheet. Data analysis begins with prerequisite tests, namely the normality test using the Kolmogorov-Smirnov test and the homogeneity test using the Levene test, followed by hypothesis testing using the t-test with a significance level of 0.05 to compare the average posttest scores between the experimental and control groups. In addition, the calculation of effect size is carried out using Cohen's d formula to measure the magnitude of the effect of the Bingo method, with the calculation of effect size carried out using Cohen's d formula to determine the magnitude of the effect of the Bingo method.

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RESULTS AND DISCUSSION

This research was conducted at SDN Cawang 07 Pagi, Jakarta, to analyze the effect of applying the Bingo game method on learning outcomes of fraction arithmetic operations in fifth-grade students. The research design was a pretest-posttest control group design with a sample of 60 students, comprising 30 in the experimental group and 30 in the control group. The experimental group received learning using the Bingo game method, while the control group was taught using conventional methods.

The Bingo method was modified by adapting the fraction arithmetic material into Bingo cards containing problems of fraction addition, subtraction, multiplication, and division, with the students divided into 5 groups, each consisting of 6 members,. The way to determine the winner is that the group that manages to arrange the card spelling B-I-N-G-O first is considered the winner.

Data were collected through a posttest essay consisting of ten questions with a maximum score of 50, to measure students' ability to solve fraction calculation operations. The descriptive statistics of the posttest scores for both groups are shown in **Table 1** below.

Table 1. Descriptive Statistics of Posttest Scores for the Experimental and Control Groups

No	Group	N	Mean	Std. Deviation	Min	Max
1	Experiment	30	40.00	2.90	34	47
2	Control		30	29.00	2.85	23

Source: Research 2025

Table 1 shows the descriptive statistical results of the posttest scores for the experimental group and the control group. The experimental group, consisting of 30 students, obtained an average score (mean) of 40.00 with a standard deviation of 2.90, a minimum score of 34, and a maximum score of 47. Meanwhile, the control group, which also consisted of 30 students, had an average score of 29.00 with a standard deviation of 2.85, a minimum score of 23, and a maximum score of 34. These results indicate that the experimental group's posttest scores were higher than those of the control group, suggesting that the treatment had a positive effect on students' learning outcomes.

Normality Test

A normality test was conducted to ensure that the posttest data in the experimental and control groups were normally distributed, as this is a requirement for performing parametric analysis. The normality test was carried out using the Kolmogorov-Smirnov test. The results of the normality test are shown in **Table 2** below.

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Table 2. Normality Test Results

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Post Test Eksperimen	.163	30	.040	.956	30	.244
Post Test Kontrol	.101	30	.200*	.972	30	.599

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Source: Research 2025

Based on Table 2, the Kolmogorov-Smirnov test results for the experimental group had a significance value of 0.244 (> 0.05) and for the control group 0.599 (> 0.05). Since the significance values for both groups are greater than α = 0.05, H0 is accepted, indicating that the data in both groups are normally distributed. Thus, the data meet one of the prerequisites for performing a parametric test, namely the t-test.

Normality testing was conducted to ensure that the posttest scores in the experimental group and the control group were normally distributed as a prerequisite for the use of parametric statistical analysis. The normality test was performed using the Kolmogorov-Smirnov test on the posttest scores of both groups. The analysis results indicated that the experimental group obtained a significance value of 0.244 and the control group 0.599, both of which are greater than the significance level α = 0.05. Thus, the null hypothesis (H_0) stating that the data are normally distributed can be accepted, so the research data meet the requirements to proceed to the t-test analysis stage.

Homogeneity Test

Homogeneity testing was conducted to ensure that the variance of posttest data between the experimental group and the control group was uniform. Homogeneity is a prerequisite before conducting parametric analysis using the t-test. The test was carried out using Levene's Test to determine whether the two groups have the same variance or not. The results of the homogeneity test are presented in **Table 3**.

Table 3. Homogeneity Test Results

Tests of Homogeneity of Variances

		Levene Statistic	df1	df2	Sig.
Hasil	Based on Mean	.145	1	58	.705
	Based on Median	.118	1	58	.733
	Based on Median and with adjusted df	.118	1	56.747	.733
	Based on trimmed mean	.148	1	58	.702

Source: Research 2025

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Based on the Homogeneity of Variance Test in **Table 3**, an F value of 0.145 and a significance of 0.705 were obtained. This significance value is greater than the significance level α = 0.05, so the null hypothesis (H_0), which states that the variance of the two groups is homogeneous, can be accepted. Thus, the data variance between the experimental and control groups is deemed uniform, allowing the analysis to proceed with an independent t-test.

T-test

An independent t-test was conducted to determine differences in average posttest scores between the experimental and control groups, and to test the hypothesis regarding the effect of the Bingo game method on learning outcomes in fraction arithmetic operations. The analysis was carried out using a t-test with the assumption of separated variance, considering that the sample size in both groups was the same, namely 30 students each. The calculation results showed a t-value of 15.84 with degrees of freedom (df) of 58 and a significance value (Sig. 2-tailed) of less than 0.001. This t-value is greater than the table t-value at a significance level of α = 0.05, which is 2.002, so the null hypothesis (H_0) is rejected and the alternative hypothesis (H_1) is accepted. Therefore, it can be concluded that the implementation of the Bingo game method has a significant effect on improving students' learning outcomes in fraction arithmetic operations.

Effect size test

Effect size testing was conducted to determine the magnitude of the practical impact of applying the Bingo game method on learning outcomes in fractional arithmetic operations, not only based on statistical significance but also on the strength of the treatment effect. The measurement of effect size in this study used Cohen's d formula, which was calculated by comparing the difference in average posttest scores of the experimental and control groups to the pooled standard deviation. The calculation of the pooled standard deviation resulted in a value of 2.826, obtained from the combination of the variances of the two groups. Furthermore, the Cohen's d value was calculated by dividing the difference in the average posttest scores of the two groups, which was 11.00, by the pooled standard deviation, resulting in a d value of 2.85. Based on Cohen's criteria, an effect size value ≥ 0.80 is categorized as very high, so it can be concluded that the Bingo game method has a very large practical effect on improving students' learning outcomes in fraction calculations. The calculation results are as follows:

$$\left[s_{pooled} = \sqrt{\frac{(30-1)8.41 + (30-1)8.12}{30+30}} = \sqrt{\frac{243.89 + 235.48}{60}} = \sqrt{7.987} \approx 2.826\right]\left[d = \frac{40.00 - 29.00}{2.826} = \frac{11.00}{2.826} \approx 2.85\right]$$

Based on the calculation of effect size using Cohen's d formula, the pooled standard deviation was obtained as 2.826. The difference in the average learning outcome scores between the treatment group and the comparison group was 11.00, resulting in a Cohen's d value of 2.85. This value falls into the very high category (≥ 0.80), indicating that the implementation of the Bingo game method has a very large practical effect on improving students' learning outcomes in fraction arithmetic operations.

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Discussion

The results of the calculation show a significant difference between the experimental and control groups. Therefore, it can be concluded that the implementation of the Bingo game method has a significant effect on improving learning outcomes in fraction arithmetic operations. In addition to statistical significance, the effect size analysis results show a Cohen's d value of 2.85, which falls into the very strong effect category. This value confirms that the Bingo game method is not only statistically effective but also has a very large practical impact on improving students' learning outcomes.

The findings of this study align with other research that confirms the effectiveness of game-based learning in improving Mathematics learning outcomes. Several studies indicate that Bingo games can enhance the understanding of Mathematical concepts through active and enjoyable learning activities (Azizah, 2024; Susanto & Fadlillah, 2024). Direct student involvement in the game process encourages more intense cognitive interaction, so that students not only memorize procedures but also understand the concepts being learned more deeply.

In addition to the cognitive aspect, game-based learning also has a positive impact on students' affective aspects. Previous research shows that using Bingo games can increase learning motivation, self-confidence, and students' positive attitudes toward learning Mathematics (Karmani, 2021; Nuraidah et al., 2023). This motivation is important for improving students' learning outcomes, one of which is by using the game method (Zafar et al., 2022). The integration of elements of healthy competition and cooperation in games encourages students to engage actively without excessive pressure, making the learning atmosphere more conducive and enjoyable.

However, upon closer examination, most previous research still focuses on integer operations or relatively simpler mixed arithmetic operations. Fraction operations have a higher level of cognitive complexity because they require understanding the relationships between fractions, finding common denominators, the simplification process, as well as the application of systematic steps in problem-solving (Syukra et al., 2025). This complexity often becomes a source of learning difficulties and misconceptions for students, especially when they directly apply integer rules to fraction operations (Nugroho et al., 2023).

The limitation of the material focus in previous research has resulted in minimal empirical evidence specifically examining the effectiveness of Bingo games on fraction calculation operations, particularly for elementary school students. In fact, fifth-grade students are at a stage of cognitive development transition that requires concrete and contextual learning strategies to help understand abstract concepts. Therefore, this study fills that gap by specifically testing the effect of the Bingo game method on fraction calculation using a quasi-experimental design complemented by effect-size analysis.

The research results show that the Bingo game method is effective in helping students understand fraction operations through structured, collaborative, and healthy-competitive learning activities. This game allows students to practice repeatedly in a meaningful context, thereby helping the internalization of complex fraction concepts. These findings expand on

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previous research results, which show that games can increase motivation and learning outcomes in Mathematics on number material (Rosyida et al., 2025; Wulandari et al., 2024).

Theoretically, the findings of this study are in line with the ARCS motivation theory, which emphasizes four main components in learning, namely attention, relevance, confidence, and satisfaction (Sudha et al., 2025). In implementing the Bingo method, students' attention is awakened through interactive game activities, relevance is reflected in questions that align with the learning material, confidence increases as students successfully complete challenges, and satisfaction is achieved through an enjoyable learning experience. Thus, the Bingo game method not only supports the achievement of cognitive learning outcomes but also sustainably strengthens students' learning motivation.

From a practical standpoint, the Bingo game method has an advantage because it is easy to implement and does not require high costs. The media used is relatively simple and can be adjusted to classroom conditions and student characteristics. This is in line with the view that a teacher's creativity in developing alternative learning methods is an important factor in improving the quality of teaching, especially in schools with limited facilities (Mea, 2024).

Overall, this study reinforces and expands previous research findings by demonstrating that the effectiveness of the Bingo game method is not limited to integer materials or simple operations, but is also relevant and has a significant impact on fraction arithmetic operations, which have a higher level of complexity. Thus, game-based learning can be used as an adaptive and contextual pedagogical strategy to improve the quality of Mathematics learning in elementary schools, especially for materials that have long been considered difficult and potentially cause student learning anxiety (Harizah & Rahmiati, 2025; Ramlah et al., 2024).

CONCLUSION

Based on the results of data analysis and discussion, it can be concluded that the use of the Bingo game method has a significant effect on improving elementary school students' Mathematics learning outcomes, particularly on the material of fraction arithmetic operations. The t-test results show a significant difference in average posttest scores between the experimental and control groups, with the experimental group that learned using the Bingo method obtaining higher scores. This finding is reinforced by the effect size value, which falls into the very high category, indicating that the application of the Bingo method has a strong practical impact on improving students' learning outcomes. The implementation of the Bingo game method has been proven effective in creating an active, interactive, and enjoyable learning environment, thereby encouraging optimal student engagement. Through learning-through-play activities, students find it easier to understand fraction concepts that were previously considered abstract and difficult. In addition, this method can increase motivation, self-confidence, and students' ability to solve Mathematics problems independently or collaboratively.

The Bingo game method can be used as an innovative learning strategy in teaching Mathematics at elementary schools. Teachers are expected to integrate this approach as a variation of conventional methods to create a more engaging and effective learning atmosphere. Nevertheless, variations in the design and implementation of the game need to

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be continuously developed so that students remain motivated and learning outcomes can be continuously improved.

AUTHOR'S NOTE

The author states that there is no conflict of interest related to the publication of this article. The author also affirms that the data, findings, and content of this article are free from plagiarism and are compiled based on the results of original research conducted with academic integrity.

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