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The Effectiveness of Digital-Based Traditional Games in Improving The Ability to Solve Numeracy Story Problems for Elementary School Students

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ABSTRACT

This study aimed to test the effectiveness of digital-based traditional games in improving third-grade elementary school students' ability to solve numeracy story problems. This study used a quantitative approach with a quasi-experimental, nonequivalent control group design. The participants were 40 third-grade students from SD Sukarajawetan II, who were divided into an experimental group of 20 students who received numeracy instruction using digital-based traditional games and a control group of 20 students who received conventional instruction. Data were collected through pretest and posttest instruments consisting of 20 essay questions that measured students' ability to understand the problem context, determine relevant operations, plan solution strategies, and perform calculations accurately. The data were analyzed using descriptive statistics, independent-samples and paired-samples *t*-tests, normalized gain (N-gain), and effect size (Cohen's *d*). The results showed that both groups had equivalent initial abilities; however, the experimental group showed significantly greater improvement than the control group. The experimental group achieved a higher mean posttest score and a moderate N-gain, whereas the control group showed a lower N-gain category. The effect size analysis revealed a large practical impact of the intervention. These findings suggest that digital-based traditional games are more effective than conventional methods in improving students' ability to solve numeracy story problems. The integration of local cultural games into the digital learning environment not only strengthens conceptual understanding but also increases student engagement and motivation in mathematics learning.

INTRODUCTION

Numeracy problems at the elementary school level, especially in solving story problems, are a challenge in the Indonesian education system (Arumsari et al., 2024; Hidayat et al., 2025; Maghfiroh & Wahyuningsih, 2024; Palayukan et al., 2025; Pratiwi et al., 2025; Pudjastuti et al., 2024; Syamsuddin et al., 2025). Numeracy story questions require students to not only master counting operations, but also the ability to read comprehension, identify relevant information, and translate verbal context into mathematical models. Research by Wijaya et al. (2022) revealed that 68% of grade III elementary school students have difficulty understanding the context of story problems, which has an impact on their low ability to determine the right solution strategy. This condition is exacerbated by conventional learning methods that tend to be monotonous and do not accommodate the learning styles of students aged 8-9 years who require a concrete and fun approach. These difficulties not only have an

impact on short-term academic achievement, but also on the foundation of students' mathematical abilities at the next level of education.

Various studies have shown the potential of game-based learning as a solution to improve student motivation and learning outcomes (Ahmed et al., 2022; Camacho-Sánchez et al., 2022; Jääskä et al., 2022; Maulida & Rahayu, 2022; Mikrouli et al., 2024; Nadeem et al., 2023; Pando Cerra et al., 2022). A meta-analysis study by Clark et al. (2016) on 69 studies found that educational games can increase learning outcomes by up to 20% compared to conventional methods, especially in STEM subjects. Meanwhile, research by Arief and Kusuma (2021) shows that gamification in numeracy learning can increase the involvement of elementary school students by up to 75%. Theoretically, this approach is in line with Piaget's theory of constructivism which emphasizes learning through active experience, as well as Ausubel's theory of meaningful learning which underlines the importance of context in the learning process. Educational games provide a learning environment that allows students to experiment, make mistakes, and learn through hands-on feedback without the pressure of formal evaluation.

On the other hand, traditional Indonesian games have educational values that have been tested for generations in developing children's cognitive, social, and motor skills. Games such as congklak, engklek, and gatrik implicitly teach basic mathematical concepts such as arithmetic, patterns, strategies, and logic. Ethnomathematical research by Rachmawati (2020) identified that the traditional game of congklak involves a minimum of 15 mathematical concepts, including addition, division, and optimization strategies. However, in this digital era, traditional games are increasingly marginalized and rarely played by the younger generation who are more familiar with gadgets. The integration of traditional games into digital formats has the potential to be a bridge that connects local wisdom with the demands of 21st century learning, while preserving the nation's cultural heritage.

Although research on educational games and traditional games has developed, studies that specifically examine the effectiveness of digital-based traditional games to improve the ability to solve numeracy problems at the elementary school level are still very limited. Most previous research such as those conducted by Prasetyo et al. (2023) focused on modern digital games without elements of local culture, while research on traditional games such as those conducted by Vuchkovski, et all (2023) still uses conventional approaches without digitization. This gap creates space for the development and testing of learning models that integrate three important elements: digitalization, local wisdom, and contextual numeracy learning (Hidayah, et all 2021). Furthermore, the majority of educational game research in Indonesia is still focused on secondary and higher education, so understanding its effectiveness at the elementary school level, especially grade III which is a transition period from concrete to semi-abstract learning, still requires more in-depth empirical studies.

The urgency of this research is even stronger considering that the Independent Curriculum, which has been implemented since 2022, emphasizes student-centered, contextual, and technology-based learning. The Ministry of Education, Culture, Research, and Technology (2023) has designated strengthening numeracy as one of the national priorities in Episode 15 of Merdeka Belajar. This research is significant because it can provide alternative concrete solutions for teachers in implementing effective, fun, and cultured numeracy learning (Udo Seino, Feb 10, 2022). Furthermore, this research has the

potential to contribute to the development of learning models that can be adapted in various regions by utilizing the richness of their respective local traditional games, thereby strengthening cultural identity in the context of national education.

The novelty or novelty of this research lies in three main aspects. First, this study develops an integration framework between traditional games, digitalization, and story-based numeracy learning that has not been widely explored in the literature. Second, this study specifically targets grade III elementary school students who are at a critical stage of cognitive development, namely the transition from the initial concrete operational stage to a more complex stage, where the understanding of stories begins to require higher abstraction skills. Third, this study not only measures the effectiveness of the cognitive aspect, but also considers the dimensions of motivation, engagement, and cultural preservation as holistic learning outcomes (Hayat et al, 2024). This multidimensional approach makes a theoretical contribution to the development of culturally and contextually based mathematics learning models in the digital age.

Based on the phenomena and gaps that have been described, this research aims to fill this gap by developing and testing the effectiveness of digital-based traditional games in improving the ability to solve numeracy story problems for grade III elementary school students. This research is expected to answer the fundamental question: how effective are traditional digital-based games developed in improving students' numeracy skills, especially in the context of solving story problems? This question is important to answer considering the investment of time, resources, and manpower required in the development of digital learning media must be based on strong empirical evidence of its effectiveness. The findings of this study are expected to provide practical recommendations for education stakeholders in designing more effective and contextual numeracy learning interventions.

METHOD

Research Type and Design

This research uses a quantitative approach with a quasi-experimental design using a nonequivalent control group design model. This design was chosen because the research was conducted in a natural classroom setting where full randomization of the research subjects is difficult considering that students have been distributed in classes that have been formed (Mann et all, 2022). This research involved two groups, namely the experimental group that received treatment in the form of numeracy learning using digital-based traditional games, and the control group that used conventional learning methods. Both groups were given a pretest before treatment and a posttest after treatment to measure the improvement in the ability to solve numeracy story problems. The design of this study allows researchers to identify a causal relationship between the use of digital-based traditional games and the improvement of students' numeracy skills, while controlling for disruptive variables that may affect the results of the study (Inafazri, S., & Formen, A., 2024).

Research Participants

The participants of this research were grade III students of SDN Sukarajawetan II with a total sample of 40 students, which were divided into 20 students in the experimental group and 20 students in the control group. The selection of grade III is based on the consideration that at this level students are in a transition period from the initial concrete operational stage

to a more complex stage in cognitive development (Piaget, 1952), so learning about numeracy stories is very crucial to strengthen the foundation of their mathematical understanding (Mutiah et all 2023).

The sampling technique used purposive sampling with the following inclusion criteria: (1) grade III elementary school students who actively participated in learning during the research semester, (2) had relatively equivalent initial numeracy skills based on the results of the pretest, (3) had never used traditional digital-based games in numeracy learning before, and (4) did not have clinically diagnosed special learning difficulties. The determination of experimental and control classes is carried out based on existing classes (intact groups) in schools to minimize disruption to the regular learning process. This research has obtained permission from the school and informed consent from parents/guardians of students before the implementation of the research, by ensuring that student participation is voluntary and can resign at any time without academic consequences.

Data Collection Instruments and Techniques

Data collection in this study used two main instruments designed to measure the effectiveness of digital-based traditional games on students' ability to solve numeracy story problems.

First, the ability test to solve numeracy story problems developed based on the basic competency indicators of the Independent Curriculum for grade III elementary schools (Wibowo, W. et all 2025). This test consists of 20 descriptive questions that measure four main aspects of ability: (a) understanding and identifying information in the context of the story question, (b) determining relevant calculation operations (addition, subtraction, multiplication, or division), (c) planning a systematic solution strategy, and (d) executing settlement procedures with appropriate accuracy. Each question item has a context of daily life that is relevant to the experiences of grade III students, such as shopping, playing, or activities at school, with difficulty levels varying from easy to difficult. This instrument was used as a pretest given to both groups before the intervention to measure students' initial abilities, and as a posttest given after eight weeks of treatment to measure students' improvement in abilities. Scoring was carried out using a holistic rubric with a score range of 0-100, where each question was assessed based on the accuracy of problem identification, strategy selection, completion process, and correctness of the final result (Tashtoush et all 2025). Although this instrument has not gone through a formal validation process by experts, this test was developed based on a grid that is adjusted to the learning outcomes of the Independent Curriculum and has been *reviewed* by experienced grade III teachers to ensure compatibility with the level of cognitive development of students (Karmini, et all 2024). For the purpose of publication and improvement of the quality of the instrument, validation of the construct and content by a panel of mathematics education experts as well as empirical trials to calculate the reliability of the instrument will be carried out as part of the improvement of this research.

Second, the learning implementation observation sheet was used to monitor the fidelity of the implementation of digital-based traditional games in the experimental group and the implementation of conventional learning in the control group (Barz et all 2023). This observation sheet contains aspects such as: (a) students' activities when interacting with games or learning materials, (b) the level of student involvement and participation in the

learning process, (c) students' interaction with digital media (for experimental groups), (d) students' ability to understand instructions and game rules, and (e) collaborative or competitive behaviors that arise during learning. Observations were made by researchers in each learning session using checklists and field notes to record important events that were not captured in the checklist. This observation data serves as supporting data to understand the learning process that occurs and provides context for the quantitative results obtained from the test.

In addition to the two main instruments, documentation in the form of photos of learning activities, screenshots of student interaction with games, results of student work on worksheets, and game application data logs were also collected as secondary data to enrich the interpretation of research results and provide visual evidence of the learning process taking place.

Research Procedure

The research was carried out for two months (eight weeks) at SDN Sukarajawetan II with systematic and structured stages. The preparation stage begins with coordination with the school, socialization to teachers and parents, and the provision of informed consent. The researchers also conducted a short training for classroom teachers who will facilitate learning in the experimental group to ensure they understand how to use digital-based traditional games and the learning objectives they want to achieve.

The first week a pretest was carried out for both groups simultaneously under the same conditions and time to ensure the equivalence of the initial ability measurement. The pretest was conducted in each classroom with a duration of 70 minutes (2 x 35 minutes), and supervision was carried out by researchers with classroom teachers to prevent cheating and ensure students worked independently.

The second to seventh weeks are the learning intervention period. The experimental group used traditional digital-based games to learn numeracy stories twice per week, with each session lasting 140 minutes (4 x 35 minutes or two hours of lessons). Learning is conducted in a school computer lab or classroom equipped with tablets/computers, where each student or student pair gets one device to play games. Each learning session begins with a brief explanation of the numeracy concept to be learned, followed by a game activity that has been designed with a gradual difficulty level (*scaffolding*), and ends with reflection and class discussion about the problem-solving strategies used. Meanwhile, the control group followed conventional numeracy learning with the same frequency and duration, using lecture, question and answer methods, and practice questions from textbooks, led by classroom teachers with *a teacher-centered* approach that is common in schools.

The eighth week was a *posttest* for both groups using the same instrument as the pretest (*parallel form*) to measure the improvement of the ability to solve numeracy story problems. *Posttest* is carried out with a procedure identical to the *pretest* to maintain measurement consistency. Throughout the research period, the researcher made observations at each learning session and documented the learning process that took place.

Technical Data Analysis

Data analysis in this study uses a combination of descriptive and inferential statistics to answer research questions about the effectiveness of digital-based traditional games in improving students' ability to solve numeracy story problems.

Descriptive Statistical Analysis is conducted to provide an overview of the research data. Descriptive statistics calculated include: (1) the mean (average) of pretest and posttest scores for each group, (2) standard deviation to measure score variability within each group, (3) minimum and maximum values to see the score range, and (4) gain score (the difference between posttest and pretest) for each student. This descriptive data is presented in the form of tables and graphs to facilitate interpretation and comparison between the experimental group and the control group.

Before conducting the hypothesis test, a prerequisite analysis test was first carried out which included: (1) a normality test using the Shapiro-Wilk test to test whether the pretest and posttest score data from the two groups were normally distributed, and (2) a variance homogeneity test using Levene's test to test whether the variance of the two groups was homogeneous (De Souza, R., Borges, E. 2023). This prerequisite test is important to ensure that the data meets parametric statistical assumptions before t-testing is performed. If the data do not meet the assumption of normality or homogeneity, the Mann-Whitney U non-parametric test will be used as an alternative.

Inferential Statistical Analysis uses independent samples t-test to test the difference in average posttest scores between the experimental group and the control group after being controlled with the initial ability (pretest). The hypotheses tested were: H_0: there was no significant difference between the ability to solve numeracy story problems in the experimental group and the control group; H_1: there was a significant difference between the ability to solve the numeracy story problems of the experimental group and the control group. The test was performed at a significance level of $\alpha = 0.05$, which means that the null hypothesis would be rejected if the p< value was 0.05. In addition to comparing posttest scores, paired samples t-tests were also conducted for each group to test whether there was a significant increase from pretest to posttest in each group.

The Normalized Gain (N-gain) calculation was performed to measure the effectiveness of increasing numeracy ability in each group using the formula Hake (1999):

N-gain = (Posttest Score - Pretest Score) / (Maximum Score - Pretest Score)

N-gain value Categorized As Next : Low if $g < 0.3$; moderate if $0.3 \leq g < 0.7$; and height if $g \geq 0.7$. N-gain give Information About how much large Potential Improvement who can achieved by each group, with Calculate Abilities Beginning Students . Comparison Average N-gain between Group Experiments and groups Control akan memberikan gambaran tentang efektivitas relatif dari kedua metode pembelajaran.

The Effect Size calculation (Cohen's d) was performed to measure the magnitude of the practical impact of interventions using digital-based traditional games, with the formula:

Cohen's d = ($Mean_1$ - $Mean_2$) / SD_pooled

where SD_pooled is the combined standard deviation of the two groups. Cohen's d values are categorized according to Cohen (1988): small (d = 0.2), medium (d = 0.5), and large (d = 0.8). Effect size is important to report because it provides information about the practical significance of the research findings, which is different from the statistical significance indicated by the p-value. A difference can be statistically significant but have a small effect size, or vice versa.

Qualitative Data Analysis from the observation results was carried out descriptively to complement the quantitative data. The observation data was analyzed by: (1) transcribing field notes and observation checklists, (2) identifying patterns of student learning behavior that emerged during learning, (3) categorizing findings based on the observed aspects, and (4) calculating the percentage of implementation of each aspect of learning to assess the fidelity of implementation. The results of the observational analysis are used to provide context and explanation for the quantitative results, such as why the experimental group showed higher improvement or what obstacles students experienced during learning.

All statistical analysis was carried out using SPSS software version 25 with a 95% confidence level. Data triangulation was carried out by comparing test results, observations, and documentation to strengthen the validity of findings and provide a comprehensive understanding of the effectiveness of digital-based traditional games in improving the ability to solve numeracy story problems for grade III elementary school students.

RESULT AND DISCUSSION

This study aims to investigate the effectiveness of digital traditional game-based learning in improving the ability of elementary school grade III students to solve numeracy story problems. The study involved 40 students from SDN Sukarajawetan II who were divided into two groups: the control group (Class 3A, n=20) that received conventional learning and the experimental group (Class 3B, n=20) that used traditional digital games. Data was collected through pretest and posttest, then analyzed using descriptive and inferential statistics. The results of the study are presented in four main sections: descriptive statistics, prerequisite tests, hypothesis tests, and effect size analysis.

Descriptive Statistics

Table 1 presents descriptive statistics for control groups and experiments on pretest, posttest, gain score, and normalized gain (N-Gain). Pretest scores showed that both groups had comparable initial abilities, with the control group obtaining an average of 53.25 (SD = 8.63) and the experimental group 54.00 (SD = 8.05). A small difference of 0.75 points suggests that the two groups were relatively equal at the initial condition.

Table 1. Descriptive Statistics

Group	Variable	N	Red	SD	Min	Max
Controls	Pretest	20	53.25	8.63	40	70
	Posttest	20	66.50	10.77	50	85
	Gain	20	13.25	6.42	5	25
	N-Gain (%)	20	29.64	14.81	9.09	55.56
Experimental	Pretest	20	54.00	8.05	40	70
	Posttest	20	82.00	11.05	60	95
	Gain	20	28.00	8.97	15	45
	N-Gain (%)	20	62.70	19.82	28.57	90.00

After the intervention, both groups showed improvement, but at significantly different rates. The average posttest of the control group increased to 66.50 (SD = 10.77), with a gain of 13.25 points and an N-Gain of 29.64%, which belongs to the low category according to the classification of Hake (1999). In contrast, the experimental group achieved an average posttest of 82.00 (SD = 11.05), with a gain of 28.00 points and an N-Gain of 62.70%, which

belongs to the medium category. The gain of the experimental group was more than double that of the control group, and the N-Gain percentage difference of 33.06 percentage points showed that traditional digital games were substantially more effective in maximizing students' learning potential. Higher standard deviation in posttest scores compared to pretest indicates variations in students' responses to learning methods.

The difference in improvement between the two groups reached 14.75 points, showing that learning using traditional digital games resulted in more than double the increase compared to conventional learning.

Hypothesis Test

Initial Ability Equivalency Test

Independent t-test results on pretest scores showed no significant difference between the control and experimental groups ($t = -0.289$; $p = 0.7742 > 0.05$). This ensures that both groups have equal initial abilities.

Increase Test in Group

The results of the paired t-test showed that: The control group experienced a significant improvement ($t = -9.234$; $p < 0.001$) with a gain of 13.25 points. The experimental group experienced a larger and significant increase ($t = -14.789$; $p < 0.001$) with a gain of 28.00 points.

The t-value in the experimental group was much greater than in the control group, indicating a stronger impact of the intervention.

Increase Test in Group

Independent t-test results on posttest scores showed very significant differences between the two groups ($t = -4.672$; $p = 0.0001 < 0.05$). The average of the experimental group (82.00) was 15.50 points higher than the control group (66.50).

Impact Size

To complete the results of statistical significance, the effect size was calculated using Cohen's d.

Table 2. Impact Size

Measure	Cohen's d	Interpretation
Posttest	1.420	Large
N-Gain	1.827	Large

Cohen's d value for posttest was 1,420 and for N-Gain was 1,827, both of which were in the large category according to Cohen's (1988) criteria. This value shows that the difference between the experimental and control groups is not only statistically significant but also practically meaningful. The value of d = 1,420 showed that the average student in the experimental group outperformed about 92% of the students in the control group.

This study shows that traditional digital game-based learning is significantly more effective than conventional learning in improving the ability to solve numeracy story problems for grade III students.

The experimental group showed more than twice the improvement compared to the control group. These findings are in line with various studies that support the effectiveness of

game-based learning in mathematics education. The integration of traditional games with digital technology provides an exciting combination of cultural proximity and technological engagement for students.

N-Gain's analysis showed that the experimental group was able to achieve almost 63% of its learning improvement potential, while the control group was only about 30%. This shows that traditional digital games are more optimal in maximizing students' learning potential.

From a constructivism perspective, digital games provide an active learning environment that allows students to build understanding through exploration and hands-on feedback. In addition, motivation theory suggests that the elements of play increase student engagement, sense of competence, and intrinsic motivation.

Although the control group also saw significant improvements, the results were still far below the experimental group. This shows that conventional methods are still effective, but less optimal in maximizing students' learning potential than game-based approaches.

Some of the limitations of this study include the limited sample size and the relatively short duration of the intervention. Further research with a randomized, longer-duration experimental design is needed to reinforce these findings.

Overall, the results of this study provide strong evidence that digital-based traditional games are an effective, culturally relevant, and have a great practical impact in improving the numeracy skills of elementary school students.

CONCLUSION

This study aimed to analyze the effectiveness of digital-based traditional game learning in improving Grade III elementary school students' ability to solve numeracy story problems. The low level of students' numeracy skills in understanding and solving story problems formed the basis for the need for more interactive and contextual learning innovations.

Through a quasi-experimental design involving 40 students divided into a control group and an experimental group, the study showed that both groups had comparable initial abilities. However, after the intervention, the experimental group that used digital-based traditional games demonstrated significantly greater improvement than the group that used conventional learning methods.

The results of the statistical analysis indicated that the difference in posttest scores between the two groups was statistically significant, with the effect size falling into the large category. This suggests that the use of digital-based traditional games not only produced a significant difference but also had a strong practical impact on improving students' numeracy skills.

These findings indicate that integrating traditional games into digital formats can enhance students' engagement, motivation, and conceptual understanding in solving mathematical story problems. Thus, digital-based traditional games can be recommended as an innovative, culturally relevant, and effective learning strategy for improving numeracy skills in primary schools.

However, this study has limitations, including a small sample size and a scope restricted to a single school. Therefore, further studies with larger samples and longer intervention periods are recommended to strengthen the generalizability of the findings.

Overall, digital-based traditional game learning proved to be effective and has strong potential for further development in primary mathematics education practices chools.

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