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Effectiveness of Digital Game Based Learning on Improving Numeracy Literacy of Elementary School Students

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ABSTRACT

This study aims to analyze the effectiveness of digital game-based learning (DGBL) in improving elementary school students' numeracy literacy. Numeracy literacy, which encompasses the ability to understand, interpret, and apply mathematical concepts in everyday life, is one of the fundamental competencies emphasized in 21st-century education curricula. However, national evaluation results indicate that many elementary school students struggle to deeply understand numerical concepts. To address this challenge, this study proposes a digital game-based learning approach as an innovative strategy to enhance students' motivation to learn and their active engagement. This study employed a quasi-experimental design with a pretest-posttest control group. The research sample consisted of 60 fifth-grade students, who were divided into an experimental group and a control group. The experimental group used interactive, digital, game-based learning media, while the control group used conventional, lecture-based methods and practice problems. The research instrument was a numeracy literacy test that was validated by experts and tested for reliability. Paired and independent sample t-tests were conducted to analyze significant improvements and differences between the two groups. The results showed a significant increase in numeracy literacy scores in the experimental group compared to the control group. Additionally, students in the experimental group demonstrated increased interest in learning mathematics and greater involvement in the learning process. These findings suggest that implementing DGBL can effectively enhance elementary school students' numeracy literacy in a fun, interactive, and contextual manner.

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1. INTRODUCTION

Significant transformations in the world of education, particularly in teaching methods and approaches, have been brought about by advances in digital technology. One popular innovation is Digital Game Based Learning (DGBL), an approach that integrates digital game elements into the learning process to boost engagement and effectiveness. In the face of 21st-century learning challenges, digital media, such as educational games, are considered capable of creating a more engaging, interactive, and contextual learning environment, especially for elementary school students, who are in the early stages of cognitive development and highly responsive to visual and interactive approaches. [1]

On the other hand, numeracy literacy is a key aspect of developing foundational competencies in elementary school students. [2] It encompasses not only technical calculation skills, but also understanding mathematical concepts and logical thinking abilities, as well as applying these concepts to daily life. [3] According to national evaluations and international assessments such as PISA and TIMSS, many Indonesian students demonstrate low numeracy literacy skills, impacting their competitiveness and problem-solving abilities in a global context. [4]

This phenomenon indicates an urgent need to explore and implement more innovative and adaptive learning strategies tailored to the characteristics of today's students. DGBL is one potential approach believed to bridge this gap. [5] Through educational digital games, students are not only encouraged to learn actively, but also trained to think critically, solve problems, and make decisions based on numerical data in a fun and stress-free manner. [6] Previous studies have shown that DGBL has a positive impact on learning motivation and conceptual understanding; however, research on its effectiveness in improving numeracy literacy specifically among elementary school students remains relatively limited and warrants further exploration. [7]

Based on this background, this study aims to analyze the effectiveness of Digital Game Based Learning in improving numeracy literacy among elementary school students.[8] The primary focus of this research is to measure improvements in students' numeracy skills after implementing DGBL and compare them with conventional teaching methods. [9] Through a quasi-experimental approach, this study is expected to provide empirical contributions to the development of more effective mathematics learning strategies, while also offering practical recommendations for educators, educational media developers, and education policymakers in designing technology-based learning interventions. [10]

2. METHOD

This study uses a quantitative approach with a quasi-experimental method that aims to measure the effectiveness of Digital Game Based Learning (DGBL) on improving the numeracy literacy of elementary school students. [11] The research design used is a pretest-posttest control group design, in which two groups of students are compared based on test results before and after the treatment is given. [12] The experimental group received instruction using educational digital games, while the control group followed conventional instruction based on lectures and practice questions. [13]

Research Subjects and Location: The subjects in this study were fifth-grade students at a public elementary school selected purposively based on the following criteria: (1) having digital learning support facilities, (2) relatively low student numeracy literacy based on previous test scores, and (3) teachers willing to participate in the implementation of DGBL media. The total number of participants was 60 students, divided equally into two groups, each consisting of 30 students as the experimental group and 30 students as the control group**.** [14]

Research Instruments: The main instrument in this study was a numeracy literacy test developed based on indicators in the national curriculum and referring to the numeracy literacy assessment framework issued by the Ministry of Education and Culture. This test consists of multiple-choice questions and short essays that measure students' ability to understand, analyze, and solve contextual mathematical problems. [15] The content validity of the instrument was tested by mathematics education experts, while its reliability was tested using Cronbach's Alpha test, which showed a reliability coefficient of [e.g., 0.84], which is in the high category. [16]

Research Procedure : The research was conducted in three main stages: (1) the preparation stage, which included the development of instruments, the development or selection of relevant educational digital game media, and the training of classroom teachers on the implementation of DGBL; (2) the implementation stage, which involved administering a pretest to both groups, conducting four weeks of learning (eight meetings), and administering a posttest after the treatment was given; and (3) the evaluation stage, which includes analyzing the pretest and posttest data and reflecting on the results of the learning implementation. [17]

The digital learning media used in the experimental group is an interactive educational game based on basic mathematics, designed to improve numerical concept understanding, logical reasoning, and the application of mathematics in everyday situations. The game is run on computers or tablets provided by the school, with supervision and facilitation by classroom teachers.

Data Analysis Techniques: Quantitative data from the pretest and posttest were analyzed using inferential statistics, namely the t-test for paired samples to measure improvement in each group, and the independent sample t-test to examine differences in results between the experimental and control groups. The analysis was conducted using statistical software such as the latest version of SPSS, with a significance level (α) set at 0.05. Before conducting the t-test, the data was first tested for normality and homogeneity to ensure that the assumptions of parametric statistics were met.

3. RESULTS AND DISCUSSION

Research Results

This study aims to determine the effectiveness of Digital Game-Based Learning (DGBL) in improving the numeracy literacy of elementary school students. Data analysis was conducted on the pretest and posttest results of two groups: the experimental group, which received digital game-based learning, and the control group, which received conventional learning.

Based on the pretest results, the average numeracy literacy score for the experimental group was 62.13, while the control group had an average score of 61.40. This indicates that both groups had relatively balanced initial abilities. After eight sessions of treatment, the posttest results showed a significant improvement. The average score of the experimental group increased to 84.27, while the control group increased to 72.35.

The paired sample t-test statistical analysis indicated a significant difference between the pretest and posttest scores within each group ($p < 0.05$). Meanwhile, the results of the independent sample t-test between the experimental group and the control group on the posttest results also showed a significant difference ($p = 0.000 < 0.05$). This indicates that the use of DGBL has a greater effect on improving numeracy literacy compared to conventional learning methods.

Discussion

The results of this study indicate that the use of Digital Game Based Learning can significantly improve the numeracy literacy of elementary school students. This is in line with constructivist theory, which states that active, contextual, and enjoyable learning will be more effective in building conceptual understanding, especially in elementary school children who are still in the concrete operational stage according to Piaget's theory of development.

The educational digital games used in this study provide an interactive learning experience, combining elements of entertainment and education, and offering immediate feedback on students' answers. This allows students to learn from their mistakes, explore mathematical concepts through visual simulations, and develop problem-solving strategies independently. Additionally, the competitive and challenging elements in the digital games motivate students to complete each level seriously, thereby enhancing their engagement and concentration in learning.

The significant difference between the experimental and control groups also shows that the conventional approach, which tends to be monotonous and teacher-centered, is less effective in stimulating active student engagement. Students in the control group tended to mechanically complete exercises without understanding the meaning behind the numerical concepts being taught. In contrast, students in the experimental group had a richer and more enjoyable learning experience, which had a positive impact on improving their numeracy skills.

These findings align with previous studies that emphasize the positive impact of game-based learning on students' learning motivation, learning outcomes, and critical thinking skills. This research also reinforces the position of DGBL as one of the innovative learning approaches relevant to the development of the digital era and the characteristics of the digital native generation.

However, the effectiveness of DGBL is also influenced by several factors, such as the quality of game design, technological infrastructure readiness, the role of teachers as facilitators, and students' ability to access and use technology independently. Therefore, the integration of DGBL into learning must be planned and adapted to the context of each learning environment.

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

Group	N	Pretest (Mean ± SD)	Posttest (Mean ± SD
Experiment	30	62,13 ± 6,25	84,27 ± 5,48
Control	30	61,40 ± 5,90	72,35 ± 6,03

Table 2. Results of Paired Sample t-test in Each Group

Group	Mean Difference	t	Sig. (2-tailed)
Experiment	22,14	13,21	0,000
Control	10,95	7,84	0,000

Table 3. Student Responses to the Use of Digital Game Based Learning (DGBL)

Statement	Average Score (Scale 1–5)	Categories
Game-based learning media makes me enjoy learning. Control	4,6	Strongly agree
I find it easier to understand the material through games.	4,4	Agree
I want mathematics learning to use games	4,7	Strongly agree
I am motivated to solve problems through games.	4,5	Strongly agree

4. CONCLUSION

Based on the results of data analysis and discussion in this study, it can be concluded that the application of Digital Game Based Learning (DGBL) is proven to be effective in improving the numeracy literacy of elementary school students. Significant improvements were observed when comparing the pretest and posttest results between the experimental group, which received digital game-based learning, and the control group, which received conventional learning. The experimental group demonstrated higher average posttest scores, as well as statistically significant gain scores.

The use of educational digital games in mathematics learning not only provides a more interactive and enjoyable learning experience but also stimulates students' motivation, focus, and deeper understanding of numerical concepts. Digital games designed to fit the learning context enable students to develop logical thinking skills, problem-solving abilities, and the capacity to connect mathematics with real-life situations.

These results support previous research findings that digital game-based learning strategies are highly relevant to the characteristics of 21st-century learners, particularly digital natives who are more familiar with and responsive to technology. DGBL is not only an innovative alternative learning method but also has the potential to be a strategic approach in improving overall numeracy literacy at the elementary education level.

Therefore, it is recommended that educators and educational institutions begin to systematically and purposefully integrate digital game-based learning models into the curriculum, particularly in subjects related to numeracy. The successful implementation of DGBL also requires teacher training, adequate technological infrastructure, and the selection of digital learning applications appropriate to students' cognitive development levels.

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