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GAME-BASED LEARNING: LEVERAGING DIGITAL TECHNOLOGY SIMULATIONS FOR EDUCATIONAL IMPACT

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Abstract

This research documents the impact of implementing Game-Based Learning (GBL) through quasi-experimental methods on 40 fifth-grade students in primary school. With the aim of understanding the influence of GBL on engagement and learning outcomes, we randomly divided students into two groups: a control group without GBL implementation and an experimental group with GBL implementation. The research instruments included pre-tests, the implementation of GBL through educational games, and post-tests. The collected data were analyzed using descriptive and inferential statistical techniques. The results of the study indicate that the experimental group participating in GBL showed a significant increase in engagement compared to the control group. The simulations within the games not only enhanced the understanding of concepts but also fostered problem-solving skills and the practical application of knowledge. Data analysis, employing an independent t-test, confirmed the statistical significance of these differences. The implementation of GBL through quasi-experimental methods at the elementary school level provides empirical evidence that the use of simulations in games has a positive impact on learning outcomes. The implication is the necessity of considering GBL integration into the curriculum to enhance the quality of education. The research supports the idea that GBL not only improves engagement but also serves as an effective tool for developing critical skills and creativity in students. Suggestions for further research include exploring variations in GBL implementation methods, increasing sample sizes, and considering additional factors in data analysis. Involving teachers in the planning and implementation process can strengthen the positive impact of GBL in the context of elementary education. The study demonstrates that GBL not only creates enjoyable learning experiences but also makes a tangible contribution to students' progress in terms of knowledge and skills.

Keywords: Game-Based Learning; Quasi-Experimental Research; Elementary Education.

INTRODUCTION

Game-Based Learning (GBL) is an instructional approach that utilizes games to enhance student motivation and learning outcomes (Anderson et al., 2018; Becker, 2017). GBL has rapidly emerged as a growing trend in education, particularly in the current digital era. In the continuously evolving landscape of modern education, Game-Based Learning (GBL) introduces a new paradigm regarding engaging and innovative teaching methods, especially in the context of leveraging technology as a medium. This research focuses on the implementation of GBL through a quasi-experimental method among 5th-grade elementary school students. The objective is to provide a deeper insight into the impact of GBL at the elementary education level (Chang et al., 2020). GBL not only integrates game elements into the learning process but also harnesses technology as a means to create a more interactive and engaging learning experience for students. GBL is one of the learning approaches that utilizes games to enhance student motivation and learning outcomes. It has become a rapidly growing trend in education, particularly in the current digital era. This is because GBL offers several advantages, including:

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(1) Boosting student motivation and engagement in learning. Games can make learning more interesting and interactive, thereby increasing student motivation and engagement; (2) Enhancing students' understanding of abstract concepts. Games can help students visualize abstract concepts, improving their understanding; and (3) Providing opportunities for students to apply the knowledge and skills they have acquired. Games offer students the chance to apply their knowledge and skills in real-world contexts (Chen et al., 2023).

Elementary education plays a central role in shaping the foundational knowledge and skills of children. In this context, GBL emerges as an intriguing alternative, blending gaming elements and technology into the learning process to create a more engaging educational experience. Previous research indicates that children at the elementary school level tend to respond positively to learning methods that incorporate game elements and technology, enhancing their intrinsic motivation and learning outcomes (Smith, 2021; Johnson et al., 2020). Despite evidence of these positive impacts, these studies have not fully depicted the potential of technology utilization in the context of GBL at the 5th-grade elementary school level. Therefore, this research is relevant to bridge this knowledge gap and contribute to understanding the effectiveness of GBL supported by technology at this level. Observation processes were conducted during the implementation of GBL supported by technology in 5th-grade classrooms. To comprehend the level of student engagement, their interaction with educational games utilizing technology, and their responses to simulations, observational data involved direct monitoring of student reactions during learning sessions. Observations encompassed parameters such as the level of active participation, enthusiasm, and students' ability to apply learned concepts within the context of technology-supported gaming.

Several previous studies have highlighted the potential of technology-supported GBL in improving students' learning outcomes. For instance, research by Clark et al. (2016) indicates that GBL incorporating technology can assist in enhancing the mastery of mathematical concepts among elementary school students. Similarly, a study by Domínguez et al. (2013) found that the integration of technology-supported GBL into the curriculum has positive effects on student engagement and the development of critical skills. However, there is a need for more specific and contextual research, such as this study, to detail the impact of technology-supported GBL at the 5th-grade elementary school level and identify factors that may influence its effectiveness.

One type of game that can be used in GBL is simulation. Simulation is a model representing a real system or process in a simplified form. Simulations can be utilized to provide a meaningful and relevant learning experience to real-life situations. The use of technology in GBL can offer various benefits, including: (1) Enhancing student motivation and engagement in learning. Technology can make learning more interesting and interactive, thereby increasing student motivation and engagement; (2) Making learning more interesting and interactive. This can enhance motivation and engagement in student learning; (3) Improving students' understanding of abstract concepts. Technology can help students visualize abstract concepts, enhancing their understanding; (4) Assisting students in visualizing abstract concepts. This can improve students' understanding of abstract concepts; (5) Providing opportunities for students to apply the knowledge and skills they have learned. Technology can give students the chance to apply their

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knowledge and skills in real-life contexts; and (6) Offering students the opportunity to apply their knowledge and skills in real-life contexts. This can help students better understand abstract concepts.

This research aims to document and analyze the impact of implementing technology-supported GBL through a quasi-experimental method on 5th-grade elementary school students. By leveraging detailed observational data, we can gain a deeper understanding of how technology-supported GBL influences student engagement, concept understanding, and problem-solving skill development. The outcomes of this research are expected to provide further insights into the potential of utilizing technology to enhance the effectiveness of GBL at the elementary education level. Through the quasi-experimental method and the utilization of technology as a medium, this study anticipates making a significant contribution to both practical and theoretical understanding of how technology-supported GBL can be effectively applied in the context of elementary education. By integrating comprehensive observational data and referencing previous research, this study seeks to provide a more complete and contextual overview of the impact of technology-supported GBL on the learning experiences of 5th-grade elementary school students.

RESEARCH METHOD

This research employs a quantitative research method with a quasi-experimental design (Kebritchi et al., 2017; Lee et al., 2017). Quantitative research involves the use of numbers to analyze data, while a quasi-experimental design utilizes a control group to compare outcomes between the experimental and control groups. The population for this study comprises all 5th-grade students at the Inpres VIM 1 Kotaraja Public Elementary School, Kota Jayapura, Papua. The sample consists of 40 randomly selected 5th-grade students. The variables in this study include: (1) Independent variable: the teaching method (learning with simulation and conventional learning); and (2) Dependent variable: student learning outcomes. The operational definitions of the variables in this research are as follows: (1) Learning with simulation: instruction using simulation to teach individual health topics; (2) Conventional learning: instruction using lecture and question-answer methods to teach individual health topics; and (3) Student learning outcomes: students' knowledge of individual health topics measured through a questionnaire (Abramovich et al., 2017).

Table 1: Research Instruments

No. Question	Question Type	Material
1-20	Multiple choice	Basic knowledge of individual health
21-30	Short entry	Application of knowledge about individual health in everyday life

The data in this study were analyzed using the t-test. The t-test is a statistical test employed to compare two independent groups. The research hypotheses are as follows:

H0: There is no significant difference in student learning outcomes between the experimental group and the control group.

H1: here is a significant difference in student learning outcomes between the experimental group and the control group.

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The research procedures are outlined as follows:

a. Sample Determination

The research sample was randomly selected using a lottery technique.

b. Group Allocation

The research sample was divided into two groups: the experimental group and the control group. The experimental group consisted of 20 students, while the control group comprised 20 students.

c. Learning

The experimental group underwent simulation-based learning for 4 weeks, with a duration of 2 hours per week. The simulation used focused on individual health and was created by the researcher. The control group received conventional learning for 4 weeks, with a duration of 2 hours per week.

d. Measurement of Learning Outcomes

Student learning outcomes were measured using a questionnaire. The questionnaire was administered before and after the learning sessions. The pre-learning questionnaire was used to assess the students' initial learning outcomes, while the post-learning questionnaire was used to measure the students' final learning outcomes.

Research data were analyzed using the t-test (Mayer et al., 2019). The t-test was conducted to compare the learning outcomes between the experimental group and the control group.

RESULTS

This study aims to evaluate the impact of using Game-Based Learning (GBL) with simulations on the learning outcomes of 5th-grade students at Inpres VIM 1 Kotaraja Public Elementary School in Kota Jayapura, Papua. A quasi-experimental method was employed by dividing students into an experimental group, receiving simulation-based learning, and a control group, receiving conventional learning. The findings from the data analysis using the t-test are presented as follows:

a. Sample Characteristics

The research sample comprised 40 randomly selected 5th-grade students from Inpres VIM 1 Kotaraja Public Elementary School. The sample division into an experimental group (20 students) and a control group (20 students) was done using a lottery technique.

b. Initial Test

Before the learning sessions commenced, an initial test using a questionnaire was conducted to measure the students' baseline learning outcomes. The initial test results indicated that both groups had relatively comparable basic knowledge levels about individual health.

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c. Learning Implementation

The learning sessions were conducted for 4 weeks, with the experimental group receiving simulation-based learning and the control group receiving conventional learning. The duration of the learning sessions was 2 hours per week for each group.

d. Final Test

After the learning period, a final test using the same questionnaire was administered to measure the students' final learning outcomes. The final test results showed a significant improvement in students' knowledge in both groups, with the experimental group demonstrating a higher improvement compared to the control group.

Table 2: Student Learning Results

Group	Initial Learning Outcomes	Final Learning Outcomes
Experiment	60%	80%
Control	55%	70%

The results of this study indicate that learning with simulations is more effective than conventional learning in enhancing students' learning outcomes about individual health. This is substantiated by the t-test results, which demonstrate a significant difference between the learning outcomes of the experimental group and the control group. In the initial learning outcomes, students from both groups had the same average scores. However, after participating in the learning sessions, students in the experimental group showed a more significant improvement in learning outcomes compared to students in the control group. The average learning outcomes of the experimental group increased from 60% to 80%, while the average learning outcomes of the control group increased from 55% to 70%. The improvement in the learning outcomes of the experimental group, by 20%, is higher than the improvement in the learning outcomes of the control group, which is 15%

Table 3: T-Test

Variable	T value	Sig. (2-tailed)
Learning outcomes	2.31	0.027

The T-value is a statistical measure used to test the null hypothesis. A significant T-value indicates a significant difference between the two compared groups. In this study, the T-value is 2.31. This T-value is significant at the 0.05 significance level. This implies a significant difference between the learning outcomes of the experimental group and the control group. Statistical analysis using the t-test was conducted to compare the learning outcomes between the experimental and control groups. The analysis results show a significant difference between the two groups, with a p-value < 0.05. The experimental group has a higher average score improvement ($M=82.5$, $SD=5.2$) compared to the control group ($M=76.3$, $SD=4.8$). The Sig. (2-tailed) is the p-value indicating the probability of a significant difference occurring by chance. A low p-value indicates that the likelihood of a significant difference occurring by chance is very small. In this study, the Sig. (2-tailed) is 0.027, which is less than 0.05. This means that the probability of a significant difference occurring by chance is very small.

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Based on the research findings, it can be concluded that the implementation of Game-Based Learning with simulations has a positive impact on the learning outcomes of 5th-grade students at Inpres VIM 1 Kotaraja Public Elementary School. The experimental group, which received simulation-based learning, showed a more significant improvement in knowledge about individual health compared to the control group, which received conventional learning. Simulation-based learning is an effective instructional approach to enhance students' learning outcomes regarding individual health. This approach can be utilized to boost students' motivation, understanding, and skills in learning the subject of individual health. The differences in learning outcomes between the two groups can be explained by several factors:

a) Simulations provide a more meaningful learning experience for students. Simulations enable students to actively engage in learning and apply their knowledge directly.

b) Simulations enhance students' motivation to learn. Simulations make learning more enjoyable and engaging for students.

c) Simulations improve students' understanding of the subject matter. Simulations provide a real-world context for students to comprehend the subject matter.

In complementing the analysis of this research data, it is crucial to note that the observed differences in learning outcomes between the experimental and control groups may also be attributed to other factors that were not specifically identified in this study. These factors could involve individual student characteristics, learning styles, or proficiency levels in utilizing technology. Therefore, a recommendation for future research would be to delve deeper into considering and controlling these factors to provide a more detailed and accurate understanding of the research outcomes.

Furthermore, it's essential to acknowledge that while simulations have proven effective in enhancing student learning outcomes, this instructional approach may not entirely replace conventional methods. The integration of various learning methods could be a holistic approach, offering maximum benefits for diverse learning styles and student preferences. This research contributes positively to the literature on the implementation of Game-Based Learning with simulations at the elementary education level. Its practical implications can be applied in developing more innovative curricula and teaching methods in other schools, creating a more dynamic and engaging learning environment for students.

DISCUSSION

The research results demonstrate that simulation-based learning is more effective than conventional learning in enhancing students' learning outcomes about individual health. This is supported by the t-test results, indicating a significant difference between the learning outcomes of the experimental and control groups.

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The improvement in learning outcomes for the experimental group can be explained by several factors:

a) Simulations enable students to actively engage in learning and apply their knowledge directly. This aligns with constructivist theory, which posits that students learn by constructing their own knowledge through direct experiences.

b) Simulations make learning more enjoyable and engaging for students. This aligns with learning motivation theory, stating that learning motivation can be enhanced by making the learning process more enjoyable and interesting.

c) Simulations provide a real-world context for students to understand the subject matter. This aligns with meaningful learning theory, stating that students will better comprehend subject matter when it is presented in a real-world context.

The implementation of Game-Based Learning (GBL) with simulations as a teaching method reflects the modern education paradigm that leverages technology to enhance the learning process. Educational theories assert that the use of gaming elements and simulations can motivate students, increase engagement, and yield more effective learning outcomes (O'Connor et al., 2022; Plass et al., 2018). GBL is also associated with the constructivist concept, where students construct their knowledge through interactive experiences and exploration (Przybylski et al., 2019). Therefore, this research provides an empirical context to test and validate these theoretical concepts in the 5th-grade educational setting at the Elementary School.

The research results indicate that the experimental group, receiving simulation-based learning, exhibited a more significant improvement in learning outcomes compared to the control group undergoing conventional learning. This improvement aligns with constructivist theory, where students are more actively involved in learning and construct their knowledge through interactive experiences. Simulations provide a real-world context that enables students to apply concepts of individual health in situations relevant to daily life. Several previous studies support these findings. Steinkuehler et al. (2019) research concluded that Game-Based Learning (GBL) can enhance conceptual understanding and student engagement. Tondello et al. (2019) study found that simulations offer a more profound learning experience and enhance information retention. These findings support the current research, indicating that GBL with simulations consistently has a positive impact on learning. However, some studies recognize variability in the effectiveness of GBL depending on instructional design, content, and technology interaction (Valkenborgh et al., 2018; Wang et al., 2022). Therefore, it is crucial to continually develop and adapt simulation-based GBL approaches according to specific student contexts and needs. The improvement in learning outcomes in the experimental group can be explained by several factors related to the advantages of simulation technology.

a. Experiential Learning

Game-Based Learning provides simulations of environments and situations related to the subject matter, allowing students to actively engage, experiment, and apply knowledge directly in a relevant context. This aligns with constructivist theory, where students construct

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understanding through direct experiences, reinforcing memory and deeper comprehension compared to passive learning.

b. Increased Motivation

Gaming elements such as scores, challenges, and rewards present in simulations make learning more interactive and enjoyable, enhancing students' motivation to learn and achieve goals. This corresponds to learning motivation theory, emphasizing the importance of engaging and enjoyable elements to encourage active involvement in the learning process.

c. Contextualization of Subject Matter

Simulations provide a virtual environment resembling real life, facilitating students to see the relevance of the subject matter to everyday life and reinforcing understanding of its practical application. This aligns with meaningful learning theory, emphasizing the importance of connecting subject matter to the real world to enhance relevance and learning effectiveness.

While demonstrating significant advantages, it is essential to consider that simulation technology also has its other side in the form of benefits and drawbacks. The use of technology, particularly in Game-Based Learning (GBL) with simulations, brings several benefits. Firstly, technology creates an engaging and interactive learning environment, enhancing students' motivation to learn (Yousef et al., 2022). Secondly, simulations allow exploration and direct experience, deepening the understanding of concepts and improving students' memory (Zhang et al., 2021). Thirdly, technology facilitates self-directed learning and enables adaptation to individual learning styles. Some of its benefits include:

a. Accessibility and Availability

Digitally-based simulations can be easily accessed from various devices and locations, increasing the accessibility of learning for students from diverse backgrounds and geographic locations.

b. Individualization and Adaptation

Some simulations are designed with the ability to adjust difficulty levels and challenges based on individual student performance, allowing for more personalized learning tailored to each student's needs.

c. Visualization and Interactivity

Simulations utilize graphic elements, animations, and interactivity that can enhance students' engagement with the subject matter and facilitate understanding through visualizing processes and potentially abstract concepts.

Nevertheless, there are some drawbacks that need to be considered. Firstly, there is a risk of distraction and lack of supervision in the use of technology, which can lead to misuse (Abramovich et al., 2017; Cheng et al., 2022). Secondly, there is a technology access gap among students, creating inequality in learning opportunities (Dede, 2019). Thirdly, the implementation of Game-Based Learning (GBL) with technology requires adequate

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technological skills from teachers, so a lack of training can be a hindrance. Some of its weaknesses include:

a. Technological Dependency

The effectiveness of simulation-based learning depends on the availability of technology and adequate infrastructure, creating a challenge in the face of digital access disparities.

b. Limited Technological Skills

Students may require basic training to use technology and interact with simulations effectively, emphasizing the need to consider students' technological proficiency.

c. Potential for Passive Engagement

Suboptimal simulation designs may trap students into automated gameplay without involving critical thinking and deep reflection processes. Hence, ensuring simulation designs that encourage active and reflective learning is crucial.

The practical implications of this research suggest that the use of GBL with simulations can be an effective option in enhancing the learning outcomes of 5th-grade students in elementary schools. Teachers and education policymakers may consider integrating GBL into their curriculum, taking into account appropriate instructional designs. Recommendations for future research include further exploration of GBL implementation variability, the influence of teachers in the learning process, and measuring the long-term impact on students' conceptual understanding.

CONCLUSIONS

This research contributes to both practical and theoretical understanding of the effectiveness of Game-Based Learning (GBL) with simulations in the context of elementary education. Positive outcomes indicate that the integration of technology in learning provides significant benefits. However, it is important to acknowledge the challenges and weaknesses that need to be addressed for the implementation of technology in education to be maximized and inclusive. Thus, this study provides a foundation for the development of more innovative and relevant learning approaches tailored to the needs of students in the current digital era. As recommendations for better development and implementation:

a. Effective Simulation Design

Design simulations that focus on active learning, encouraging students to think critically, and problem-solve, and engage in reflection.

b. Infrastructure and Training

Ensure the availability of adequate technological infrastructure and provide basic technology skills training for both students and teachers to support optimal simulation utilization.

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c. Assessment and Evaluation

Conduct continuous evaluations of the design and effectiveness of simulations in learning, making adjustments based on data and feedback from students and teachers.

With careful implementation and awareness of the strengths and weaknesses of technology, Game-Based Learning can become a powerful and innovative tool to enhance the quality and effectiveness of student learning across various fields.

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