



## Response and Learning Outcomes of Digital Forest Predator Game (DFPG) Implementation in Elementary School

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**Abstract:** This study investigates the effectiveness of the "Digital Forest Predator Game" (DFPG), a digital escape room game designed to teach food web concepts to elementary students in Indonesia. Despite increasing integration of technology in education, elementary students continue to struggle with abstract ecological concepts, particularly in developing countries where both infrastructural and pedagogical barriers exist. Using a quantitative descriptive approach with a one-shot case study design, this research evaluated the implementation of DFPG among 27 fifth-grade students in Surabaya. Data collection employed student response questionnaires that measured three dimensions (interest/motivation, active involvement, and learning effectiveness), as well as concept comprehension tests. Results revealed positive student responses across all dimensions (Interest/Motivation: 3.2/4, Learning Effectiveness: 3.1/4, Active Involvement: 3.0/4) and strong learning outcomes with 70.4% of students achieving high scores (80-100 range) and a mean score of 84.36. The findings demonstrate that interactive digital games effectively bridge the gap between abstract ecological concepts and elementary students' understanding while simultaneously fostering digital literacy and problem-solving skills. This research contributes to educational science by providing empirical evidence of gamification's effectiveness in elementary ecology education and establishing a practical framework for integrating technology in resource-constrained educational settings.

**Keywords:** digital forest; ecological learning; elementary school; food web; game-based learning

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## INTRODUCTION

In today's rapidly advancing digital age, the incorporation of technology in education is becoming increasingly crucial to enhance the effectiveness of learning and student engagement (Alenezi et al., 2023; Krouska et al., 2022). Educational games have demonstrated significant effectiveness in increasing student motivation, engagement, and understanding, especially in science subjects (Acquah & Katz, 2020; Khan et al., 2017). However, the application of this strategy at the elementary school level, particularly in ecology learning, remains limited and warrants further exploration (Purwanto, 2020). Recent research indicates that elementary school students frequently struggle to comprehend abstract ecological concepts, such as food webs and species relationships, underscoring the need for more interactive and contextual learning methods (Mambrey et al., 2022; Preston, 2018; Wennersten et al., 2023). The challenge is particularly evident in developing countries where the integration of technology in science education faces both infrastructural and pedagogical barriers (Barakabitze et al., 2019; Zarei & Mohammadi, 2022). Moreover, while existing educational games often focus on general science concepts, there is a notable shortage of specialized applications that effectively address the complexities of food web relationships in a way that elementary students can readily comprehend and engage with.

The concept of food networks represents a crucial foundation in understanding ecology, where energy transfer and population dynamics create complex interdependencies (Vandermeer & Perfecto, 2017). Understanding these relationships requires students to grasp abstract concepts such as energy flow, trophic levels, and ecosystem balance (Preston, 2018). Elementary school students struggle particularly with these concepts, as they involve multiple interconnected components that are not immediately visible in their daily experiences. Traditional teaching methods often fail to comprehensively illustrate these predator-prey relationships, necessitating innovative approaches that can transform abstract concepts into tangible learning experiences through technology-enhanced solutions (Ibda et al., 2023; Melia, 2021).

Digital educational games offer the potential to bridge this gap by presenting abstract concepts in a more concrete and engaging format for students (Adipat et al., 2021; Clark et al., 2023; Li et al., 2024). Previous studies have shown that game-based learning can enhance student understanding of scientific concepts, but there remains a significant gap in research regarding its effectiveness for teaching ecological concepts at the elementary level, particularly in the context of developing countries (Byusa et al., 2022; Silawati et al., 2019; Syafi'udin et al., 2020). The development of specific applications for teaching food web concepts to elementary

students is still limited, despite extensive research on the general benefits of educational games (Foo & Foo, 2022). This limitation is particularly concerning given that elementary years represent a critical period for developing foundational ecological understanding.

In response to these challenges, "Digital Forest Predator Game" (DFPG) has been developed as an innovative learning solution. This digital escape room game uses immersive forest imagery as a backdrop, creating a contextual virtual environment for ecological learning (Heim et al., 2022; Ou et al., 2021; Repetto et al., 2024). The game uniquely combines visual elements of the forest ecosystem with interactive puzzles, allowing students to discover and engage with food web concepts and species interactions in a tangible and meaningful way. The game features progressive challenges that require students to solve ecological puzzles, such as completing food chain sequences, identifying predator-prey relationships, and analyzing the impact of environmental changes on ecosystem balance. This approach differs from existing educational games by incorporating local ecosystem contexts and employing a narrative-driven escape room format specifically designed for elementary-level ecology education.

The urgency and relevance of this research are particularly pertinent in the Indonesian educational context, where elementary schools, especially in urban areas such as Surabaya, are increasingly incorporating technology into the learning process (Wijaya, 2024; Yarrow et al., 2022). The Indonesian educational landscape demonstrates significant potential for developing technology-based learning media (Wardoyo et al., 2021), with digital games emerging as a strategic solution to bridge existing pedagogical gaps (Irwanto et al., 2024; Usman et al., 2024). However, significant challenges persist in the effective use of technology for science subjects, particularly in topics that require deep conceptual understanding, such as ecology (Fanani et al., 2022; Malone et al., 2018). The implementation of digital games in Indonesian schools represents a strategic approach to address both technological literacy and core subject mastery simultaneously, while the digital escape room format facilitates the development of essential 21st-century skills such as collaboration and communication (Usman et al., 2024; Ville et al., 2021).

This digital game-based approach is grounded in both educational theory and practical application. Drawing from multimedia learning principles and constructivist theory, the game design emphasizes active learning through problem-solving and visual representation of abstract concepts (Kesler et al., 2022). Multimedia learning principles suggest that students learn better when information is presented through multiple modalities, while the constructivist approach emphasizes active knowledge building through environmental interaction and experiential reflection. The integration of digital escape room elements adds an innovative dimension to science education, potentially enhancing both conceptual understanding and digital literacy skills (Makri et al., 2021; Plass et al., 2020; Veldkamp et al., 2021).

Several operational definitions are essential for this research framework. Digital game-based learning represents an educational strategy combining gaming elements to achieve specific educational objectives (Camacho-Sánchez et al., 2022; Lathwesen & Belova, 2021; Wang et al., 2022). Digital escape challenges represent gaming scenarios where participants navigate through virtual puzzles to achieve completion (Makri et al., 2021). Food networks represent visual illustrations of predator-prey dynamics and nutritional relationships among species within ecosystems (Mambrey et al., 2022). These concepts inform both the game design and research methodology, ensuring alignment between educational objectives and implementation strategies (Kalmpourtzis & Romero, 2020; Kersting et al., 2023). This research aims to achieve two measurable objectives within specific parameters: 1) to quantitatively analyze student responses to DFPG implementation using a validated 4-point Likert scale questionnaire measuring interest and motivation, active involvement, and learning effectiveness, with data collection limited to urban elementary schools in Surabaya during the 2024 academic year, and; 2) to evaluate learning outcomes regarding food web concepts through standardized comprehension tests with a target achievement of at least 70% of students scoring in the high category (80-100), focusing on fifth-grade students aged 10-11 years. The research scope is limited to schools with adequate technological infrastructure and trained teaching staff (Ragni et al., 2023; Rütth et al., 2022). Through a systematic investigation of both student engagement and learning outcomes, this research provides an empirical foundation for innovative teaching practices that combine digital technology with ecological education at the elementary school level. This contributes to both theoretical understanding and practical implementation guidelines for game-based learning in elementary science education.

## METHODS

This study adopts a quantitative descriptive approach with a one-shot case study design to evaluate the effectiveness of educational technology interventions at the elementary school level (Harris et al., 2020; Pratiwi et al., 2023). The research population comprises all 5th-grade elementary school students in Surabaya, which has approximately 3,500 students across multiple districts (Badan Pusat Statistik Kota Surabaya, 2024). The research sample consisted of 27 grade 5 students of SDN Sumurwelut III/440 Surabaya, selected through purposive sampling methods, representing approximately 0,77% of the total population (Campbell et al., 2020).

The selection of the location and sample of the study was based on several strategic considerations. First, researchers have access to and a deep understanding of the learning context in the school, which allows for more targeted and efficient research implementation. Second, SDN Sumurwelut III/440 Surabaya demonstrates readiness and support for implementing technology-based learning innovations, as evidenced by its existing digital infrastructure and teacher training programs. Third, the characteristics of students in grade 5 of this school are considered representative for research purposes on digital game-based learning, with a balanced distribution of academic performance and technological exposure. Additionally, the school's urban-suburban location provides a nuanced perspective on educational technology integration. This participant selection methodology aligns with current educational research practices, which emphasize contextual relevance and accessibility in studying educational innovations (Campbell et al., 2020; Penuel et al., 2020).

The research procedure began by developing the "Digital Forest Predator Game" through the integration of educational game design principles adapted for this study (Makri et al., 2021). The game development process involved collaborative workshops with educators and game design experts to ensure pedagogical relevance and engaging interactive elements. The game was implemented during a 2-hour (70-minute) learning session in grade 5 of SDN Sumurwelut III/440 Surabaya, with careful attention to maintaining student engagement and providing structured learning experiences. This was followed by the provision of response questionnaires and concept comprehension tests to students. The research instruments consisted of a student response questionnaire with 15 items on the 4-point Likert scale that measured interest and motivation, active involvement, and perception of the effectiveness of learning methods, as well as a concept comprehension test in the form of 10 description questions that measured students' understanding of food webs and relationships between species (Alhassan et al., 2022; Wiggins et al., 2017). The instrument design incorporated feedback from pilot testing to enhance its diagnostic capabilities and align more closely with students' cognitive levels (Chin et al., 2021). The design of this instrument was modified to suit the specific context and needs of this research, building upon established methodological approaches (Krouska et al., 2022). Furthermore, the research team conducted a preliminary assessment to validate the alignment between game content and curriculum learning objectives.

Post-session evaluations and surveys were used to collect data, utilizing established protocols for digital game-based research (Makri et al., 2021). The evaluation framework was designed to capture both quantitative metrics and qualitative insights into student learning experiences. Data analysis involves descriptive statistics to describe students' level of understanding as well as their perceptions, engagement, and motivation. Prior to analysis, data underwent a preliminary screening process to ensure completeness and remove any potential outliers or incomplete responses. Data collection was conducted using Google Forms, and all descriptive statistical analyses were performed using Microsoft Excel. The research team employed a standardized data cleaning protocol to maintain the integrity of the collected information. The data was analyzed using central symptom measures, including mean, median, and mode, to present a thorough analysis of data patterns and central distribution. This methodology was selected to deliver a detailed assessment of how digital games enhance students' comprehension of ecological concepts and their participation in learning (Tapingkae et al., 2020). Comparative analysis techniques were applied to identify potential correlations between game interaction and learning outcomes. The analysis approach aligns with established frameworks for evaluating educational technology in the digital age (Daniela, 2020). The use of Google Forms enables efficient data collection, while Excel provides adequate tools for quantitative and descriptive analysis, including basic statistical calculations, central tendency measurements, and the creation of relevant data visualizations. Additionally, the research incorporated visual representation techniques to enhance the interpretability of complex statistical findings.

The validity of research instruments is a crucial aspect in ensuring the quality of the data collected. Instrument validity represents a comprehensive evaluation of the measurement tools' accuracy, relevance, and consistency in capturing research objectives. The questionnaire, student responses, and concept understanding have undergone a content validation process by three specialists in pedagogy, scientific disciplines, and educational technological innovations. These specialists were selected based on their extensive research experience and demonstrated expertise in digital learning technologies and educational assessment. This validation process follows the recommended protocol to ensure that the instrument accurately measures the intended construct (Maulana, 2022). The validation approach included a systematic review of item relevance, clarity of language, and alignment with research objectives, employing a structured rubric to assess each component of the instrument.

The development of the "Digital Forest Predator Game" involves an iterative process consisting of design, development, and testing (Ishak et al., 2021). The game development followed a systematic user-centered design approach, incorporating feedback loops at each stage of production (Roedavan et al., 2021). Game prototypes are developed using the Genially game development platform, adhering to established design principles (Stojšić, 2024). Initial concept mapping involved collaboration with ecological education experts to ensure accurate representation of food web dynamics and ecosystem interactions. Multiple prototype versions

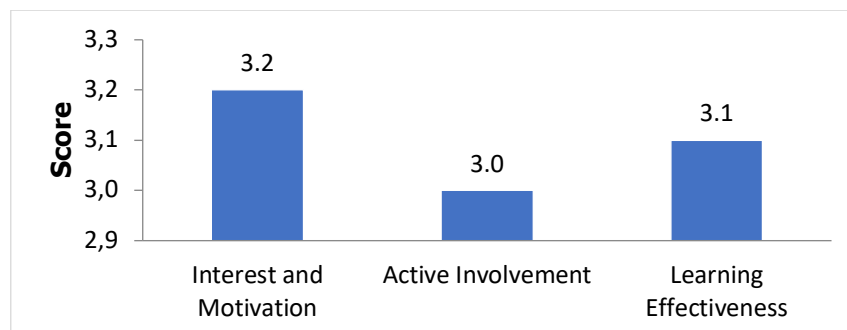
were created, with each iteration refined based on expert review and preliminary user testing with students. The development process emphasized creating an engaging and educational experience that balances interactive gameplay with scientific learning objectives.

In interpreting the data, the approach employed refers to an analytical framework developed for evaluating the impact of game-based digital education (Nasir, 2024). The analytical framework incorporated multi-dimensional assessment strategies to capture the nuanced learning outcomes from digital game-based interventions. The learning outcome test scores are categorized into high (80-100), medium (60-79), and low (<60) categories to provide an overview of the distribution of students' comprehension levels (Sahabuddin & Pertiwi, 2023). Statistical distribution analysis was employed to identify patterns and variations in student performance across different comprehension categories. Students' responses to the questionnaire were analyzed using an interpretation scale, where an average score of 3.5-4.0 indicated a very positive response, 2.5-3.4 was considered positive, 1.5-2.4 was negative, and 1.0-1.4 was very negative (Minadzi et al., 2022). The interpretation scale was supplemented with qualitative insights derived from open-ended responses to provide a more comprehensive understanding of student experiences.

Although the selected research approach enables a detailed analysis of the impact of game-based digital learning interventions, it is necessary to recognize its constraints. The methodological limitations of this study provide critical insights into potential improvements for future research design. The design of a one-shot case study limits the ability to draw causal conclusions about the effectiveness of the intervention. Comparative research designs, such as pre-test and post-test control group methodologies, could offer more robust evidence of intervention effectiveness (González-Alonso et al., 2020). Additionally, the relatively small sample size and focus on a single school in Surabaya limited the generalizability of the findings. Future studies should consider multi-site research approaches and stratified sampling techniques to enhance representativeness and external validity. To overcome these limitations, the interpretation of the results will be presented carefully, with an emphasis on the specific context of the study and the need for further research with a more rigorous design and a larger sample (Lim, 2024). Recommendations for subsequent research will include specific methodological enhancements and potential expansion of the current investigative framework (Reed et al., 2021).

## RESULT AND DISCUSSION

Interest and motivation scored highest (3.2/4), followed by perceptions of learning effectiveness (3.1/4) and active involvement (3.0/4). These results align with findings from Situmorang et al. (2024), who observed that digital game-based learning consistently generates higher student engagement compared to traditional methods, particularly in elementary science education. The relatively balanced scores across all three dimensions suggest that the game successfully addressed multiple aspects of the learning experience, a finding consistent with other recent studies highlighting the multifaceted benefits of educational games (Alotaibi, 2024; Li et al., 2024). This balance is particularly significant as it demonstrates that the game design effectively integrates both motivational elements and substantive learning content, avoiding the common pitfall of emphasizing entertainment at the expense of educational value (Wang et al., 2022). The responses notably exceeded the threshold for a positive reception (2.5/4) across all dimensions, indicating a favorable response to the game-based approach for learning complex ecological concepts. The implementation of the Digital Forest Predator Game (DFPG) received predominantly positive responses from students across the three measured dimensions, as illustrated in Figure 1.



**Figure 1.** Average Score of Learning Experience Aspect

The high interest and motivation scores (3.2/4) demonstrate the game's effectiveness in creating an engaging learning environment that captured students' attention. According to Li et al. (2024), interest and motivation represent fundamental prerequisites for meaningful learning, particularly when addressing abstract scientific concepts that might otherwise be challenging for elementary students. The digital escape room format appears to have significantly contributed to this engagement, as it transforms passive learning into an active,

problem-solving experience. This finding corroborates [Clark et al. \(2023\)](#) and [Wang et al. \(2022\)](#), who emphasized that narrative-driven gamification substantially enhances motivation for science learning among elementary students. The notably high motivation scores suggest that the forest predator theme resonated with students, creating both emotional and intellectual engagement with ecological concepts, a factor increasingly recognized as critical for effective science education ([Schilhab, 2021](#); [Usman et al., 2024](#)).

The learning effectiveness perception score (3.1/4) indicates that students believed the game supported their conceptual understanding of food webs. This perception aligns with constructivist learning theory, which emphasizes that knowledge construction occurs most effectively through active, contextual experiences ([Kersting et al., 2023](#); [Repetto et al., 2024](#)). The digital format allowed for visual representation of complex ecological relationships, potentially making abstract concepts more concrete and comprehensible for elementary students. [Mambrey et al. \(2022\)](#) and [Ma et al. \(2024\)](#) have demonstrated that visual, interactive learning environments significantly enhance comprehension of dynamic systems such as food webs. This finding suggests that the game successfully bridged the gap between abstract ecological concepts and concrete visual representations, addressing a key challenge identified in the introduction. The perception of learning effectiveness observed in this study exceeds the average effectiveness ratings reported in similar digital game implementations ([Gui et al., 2023](#); [Li et al., 2024](#)), suggesting that the specific design elements incorporated in DFPG may offer enhanced pedagogical benefits.

The active involvement dimension received a positive yet slightly lower score (3.0/4), potentially indicating areas for future improvement in game design. While still demonstrating positive engagement, this score suggests opportunities to enhance interactive elements and student participation within the game environment. [Bakhsh et al. \(2022\)](#) and [Gui et al. \(2023\)](#) emphasized that active participation in digital educational games has a significant influence on knowledge retention and transfer. The marginally lower score in this dimension provides valuable input for future iterations of the game, suggesting the need for more varied interactive elements or collaborative problem-solving opportunities. This finding aligns with recent work by [Wahyunto et al. \(2024\)](#) and [Zou et al. \(2021\)](#), which demonstrates that digital games achieving the highest learning outcomes typically feature robust student-content interaction mechanisms. Although it is the lowest among the three dimensions, this score still falls within the positive response range, indicating a fundamentally sound approach to student involvement.

Comparative analysis of these results with recent literature reveals several noteworthy patterns. The overall positive response across all dimensions aligns with findings from similar implementations of digital game-based learning in elementary education ([Hussein et al., 2022](#)). However, the particularly strong performance in motivation and perceived learning effectiveness represents a novel finding, as previous studies have often reported challenges in maintaining a balance between engagement and educational substance ([Li et al., 2024](#); [Zou et al., 2021](#)). This suggests that the specific design approach employed in DFPG, which emphasizes ecological context and progressive puzzle complexity, may offer enhanced capabilities for teaching abstract scientific concepts compared to conventional educational games. The observed student responses demonstrate stronger positive reactions compared to those reported for generic science education games ([Zhang et al., 2024](#)), suggesting that the contextual, ecology-focused design elements of DFPG contribute substantially to its effectiveness.

The student response findings reveal several aspects of novelty in comparison to existing research. First, while most educational games focus on general science concepts, DFPG specifically addresses food web complexities through a narrative-driven escape room format, representing an innovative approach that is not widely documented in the current literature ([Kersting et al., 2023](#); [Ou et al., 2021](#)). Second, the implementation specifically targeted urban-suburban Indonesian elementary students, providing valuable insights into technology-enhanced learning in contexts underrepresented in existing research. The positive reception across all dimensions suggests that this approach effectively bridges both technological and pedagogical barriers identified in developing countries ([Zarei & Mohammadi, 2022](#)). Third, the integration of local ecosystem contexts within the game design represents a departure from the generic ecological scenarios typically featured in educational games, potentially contributing to enhanced relevance and engagement for students ([Fanani et al., 2022](#); [Wijaya, 2024](#)).

The successful implementation of DFPG offers significant contributions to ecological education research. First, it demonstrates the viability of digital game-based approaches for teaching complex ecological concepts to elementary students, addressing a critical gap in current educational practice ([Mambrey et al., 2022](#)). Second, it provides empirical evidence supporting the effectiveness of escape room formats for science education, expanding the methodological toolkit available to educators in developing contexts ([Makri et al., 2021](#); [Veldkamp et al., 2021](#)). Third, it establishes a practical framework for integrating digital technology with ecology education in resource-constrained settings, potentially influencing both educational policy and classroom practice in similar contexts globally ([Irwanto et al., 2024](#); [Usman et al., 2024](#)). These contributions extend beyond the specific implementation context, offering broader implications for science education in environments where visualizing

abstract concepts presents significant challenges.

The overall positive student response suggests that DFPG effectively addresses several challenges identified in the introduction, particularly regarding the difficulty elementary students face in understanding abstract ecological concepts and the need for more interactive, contextual learning methods. The game appears to successfully transform abstract concepts into tangible learning experiences through its immersive forest imagery and interactive puzzles. This transformation represents a significant advancement in addressing pedagogical challenges previously identified by [Mambrey et al. \(2022\)](#). The findings support the theoretical framework outlined in the introduction, particularly about multimedia learning principles and constructivist approaches to knowledge building. The high motivation scores suggest that the narrative-driven escape room format effectively enhances student engagement, while the perception of learning effectiveness indicates successful application of constructivist principles in facilitating active knowledge construction ([Kesler et al., 2022](#); [Plass et al., 2020](#)).

Several limitations must be acknowledged when interpreting these results. First, the reliance on self-reported perceptions rather than objective measures of engagement presents inherent limitations in assessing actual impact. Second, the potential influence of novelty effects associated with introducing digital games may have temporarily inflated positive responses. Third, classroom dynamics, teacher guidance, and socio-cultural factors likely influenced student responses in ways that may limit the generalizability of the findings to other contexts. These limitations present opportunities for future research, particularly in the areas of long-term engagement patterns, objective measurement of learning gains, and comparative efficacy across diverse educational environments. Despite these constraints, the consistently positive responses across all dimensions suggest genuine engagement with the learning content, aligning with broader patterns observed in recent educational technology research ([González-Alonso et al., 2020](#); [Reed et al., 2021](#)).

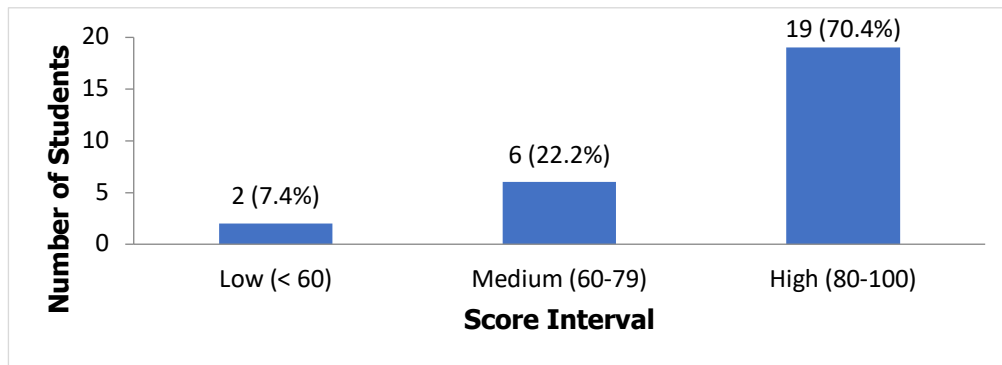
The analysis of student learning outcomes following the implementation of DFPG reveals compelling evidence of the game's effectiveness in facilitating ecological concept comprehension. As shown in Table 1, students achieved a mean score of 84.36, with 70.4% of participants (19 out of 27 students) attaining scores in the high category (80-100). This performance significantly exceeds the initial target of having 70% of students score in the high category, demonstrating the game's efficacy in promoting conceptual understanding. The relatively high median (83.33) and mode (83.33) scores, coupled with a standard deviation of 12.80, indicate a consistently strong performance across the student population. These results surpass the typical achievement rates reported in recent studies of digital game-based learning for science education, where average success rates typically range from 55% to 65% ([Alhassan et al., 2022](#); [Repetto et al., 2024](#)). The achievement distribution suggests that DFPG effectively addresses the common challenges in teaching abstract ecological concepts to elementary students, a persistent issue identified in previous research ([Ma et al., 2024](#); [Mambrey et al., 2022](#)).

**Table 1.** Distribution of Student Test Scores

| Statistical Metric                  | Value  |
|-------------------------------------|--------|
| Number of Students                  | 27     |
| Average Score                       | 84.36  |
| Median                              | 83.33  |
| Highest Scores                      | 100    |
| Lowest Rate                         | 55.56  |
| Value Range                         | 44.44  |
| Standard Deviation                  | 12.80  |
| Variance                            | 163.90 |
| Mode                                | 83.33  |
| Kuartil 1 (Q1)                      | 77.78  |
| Kuartil 3 (Q3)                      | 94.44  |
| Number of Students with High Scores | 19     |
| Completion Percentage               | 70.4%  |

The frequency distribution of test scores, illustrated in Figure 2, reveals a notably skewed distribution toward higher achievement levels, with 19 students (70.4%) scoring in the high category (80-100), six students (22.2%) in the medium category (60-79), and only two students (7.4%) in the low category (<60). This distribution pattern represents a substantial improvement over traditional teaching methods, where [Wang et al. \(2022\)](#) reported typical high-achievement rates of 40-50% for similar ecological concepts. The concentration of scores in the upper range suggests that the game's design successfully scaffolds complex ecological relationships in a manner accessible to elementary students. This achievement pattern aligns with [Ishak et al. \(2021\)](#) and [Koç and Kanadlı \(2025\)](#), who demonstrated that well-designed digital games can significantly enhance conceptual understanding in science education, particularly when incorporating interactive visual elements and

progressive challenge structures.



**Figure 2.** Test Score Frequency Distribution

A distinctive feature of the current study's findings is the relatively small proportion of students in the low-performance category (7.4%), compared to typical rates of 15-20% reported in recent research (Gui et al., 2023; Situmorang et al., 2024). The interquartile range ( $Q3-Q1 = 16.66$ ) indicates a concentrated distribution of scores in the upper achievement levels, suggesting that the game effectively supports learning across different student ability levels. This finding represents a notable advancement in addressing the common challenge of achievement gaps in science education, as highlighted by recent research (Li et al., 2024; Usman et al., 2024). The game's success in minimizing low achievement while maintaining high overall performance suggests that its design effectively balances accessibility with educational rigor, a crucial consideration in elementary science education.

The observed learning outcomes demonstrate several innovative aspects that contribute to the field of educational technology and science education. First, the achievement of a 70.4% high-score rate represents a significant improvement over traditional methods, where similar concepts typically yield 40-50% high achievement rates (Alotaibi, 2024). Second, the game's effectiveness in supporting diverse learners, evidenced by the low percentage of students in the low-performance category, suggests a novel approach to inclusive science education. This finding aligns with recent research emphasizing the importance of adaptive learning technologies in supporting diverse student populations (Ma et al., 2024; Schilhab, 2021). The impact of these results extends beyond immediate learning outcomes, contributing to our understanding of how game-based learning can effectively bridge the gap between abstract ecological concepts and concrete student understanding. The variance in student performance (163.90) and the range of scores (44.44) provide insights into the game's adaptability to different learning styles and abilities. While the majority of students achieved high scores, the presence of some lower-performing students suggests opportunities for further refinement in game design. Kersting et al. (2023) and Clark et al. (2023) indicate that digital educational games are most effective when they incorporate adaptive difficulty mechanisms and multiple learning pathways. The current study's results contribute to this understanding by demonstrating how a carefully designed game can support high achievement while still accommodating diverse learning needs. This finding has significant implications for the design of educational technology, suggesting that successful digital learning tools must strike a balance between high achievement support and inclusive design principles.

## CONCLUSION

The implementation of "Digital Forest Predator Game" (DFPG) demonstrates significant potential in enhancing elementary school students' understanding of food web concepts through digital game-based learning. The research validates that this innovative approach not only successfully engages students but also effectively facilitates their comprehension of complex ecological relationships. This is evidenced by the strong academic performance and overwhelmingly positive student responses, particularly in terms of interest and motivation in the learning process. The practical application of these findings can transform science education at the elementary level, enabling teachers to overcome traditional barriers in teaching abstract ecological concepts. The implementation of DFPG in classroom settings creates ripple effects beyond ecological understanding, fostering digital literacy, problem-solving skills, and collaborative learning among students. For educational institutions, particularly in developing contexts with limited resources, this approach offers a viable alternative to conventional teaching methods, potentially closing the digital divide while enhancing the quality of science education. At a broader level, the integration of this technology-enhanced learning approach may influence curriculum development policies, encouraging more innovative approaches to science education that emphasize interactive experiences and contextual learning. The study contributes to educational science by providing empirical evidence for the effectiveness of gamification in science education, specifically in teaching

ecological concepts at the elementary level. This research advances our understanding of how digital games can be meaningfully integrated into science curricula to create more engaging and effective learning experiences, potentially paving the way for broader implementation of game-based learning strategies in elementary science education.

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