

Enhancing Science Learning in Primary Schools: Development of Interactive Edu-Game Multimedia to Boost Student Motivation and Achievement

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ABSTRACT

The use of traditional learning media in elementary science education often fails to foster active participation or stimulate student motivation, leading to suboptimal learning outcomes. To address this, the development of interactive, game-based multimedia is proposed as a more engaging alternative. This study employed a Research and Development (R&D) approach using the ADDIE (Analysis, Design, Development, Implementation, Evaluation) model. The participants were second-grade students from an elementary school in Serang City. Data were collected through validity and practicality instruments, motivation questionnaires, learning outcomes tests, and observation sheets. The developed educational game-based interactive multimedia was validated by experts and deemed suitable for classroom use. Student feedback indicated high practicality, with 93% of learners responding positively. The multimedia tool significantly improved student motivation by 33.3% and science learning outcomes by 88%. The findings demonstrate that incorporating educational games into multimedia learning tools can effectively enhance both engagement and academic performance in elementary science education. The digital format aligns with current technological trends and meets learners' needs more effectively than traditional media. Educational game-based interactive multimedia is a valid, practical, and effective solution for improving student motivation and learning outcomes in elementary science education.

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1. INTRODUCTION

The rapid advancement of digital technology has significantly impacted various aspects of life, including education. One notable innovation in this field is the integration of interactive digital educational games, or edugames, into the learning process (Kale et al., 2021). Edugames are specifically

designed to merge educational content with game elements, creating a more engaging and interactive learning experience for students (Widjayatri et al., 2022; Safitri et al., 2022). Rooted in constructivist learning theory—as proposed by Piaget and Vygotsky—this approach supports the idea that students construct knowledge actively through experience and interaction with their environment (Mcleod, 2023). In this context, edugames provide an effective platform for learners to explore content, make decisions, and receive immediate feedback, all of which contribute to deeper understanding (Hidayat & Nur, 2022).

In the digital era, education increasingly requires the integration of technology to enhance the teaching and learning experience (Gupta, 2023). Interactive digital learning media such as edugames offer a dynamic and engaging alternative to traditional methods (Efe & Umdu Topsakal, 2024; Yeni Widiawati et al., 2022). Research has consistently shown that edugames can improve students' motivation, conceptual understanding, and academic achievement (Ruiz et al., 2021). According to the ARCS motivational model—comprising Attention, Relevance, Confidence, and Satisfaction—sustaining student motivation requires capturing interest, ensuring material relevance, building self-confidence, and fostering a sense of accomplishment (Chang, 2021). Interactive digital edugames address these elements effectively by presenting stimulating content, connecting lessons to real-life contexts, offering appropriately challenging tasks, and providing rewards such as points or level progression (Hong et al., 2021).

One of the main challenges in education in elementary schools is maintaining student motivation and involvement in the learning process (Justitia et al., 2021). Elementary school students tend to have short attention spans and prefer activities that are visual and interactive (Bernard et al., 2018). Therefore, innovative and interesting learning approaches are needed, such as digital edugames, to increase learning effectiveness (Tresnawati et al., 2020). Interactive digital educational games are games designed with educational purposes, which allow direct interaction between players (students) and learning content (Wang et al., 2023). Edugame offers a learning environment that can stimulate the mind, facilitate knowledge discovery, and strengthen student involvement in learning (Imanulhaq & Pratowo, 2022). From the research results above, there is a need for learning innovations that are relevant and have the potential to attract students in learning.

However, despite its great potential, the use of digital edugames in the context of formal education in elementary schools is still limited. Teachers in elementary schools often face difficulties in designing learning that utilizes technology, especially in effectively integrating game elements into learning materials. Therefore, research is needed that develops and tests the effectiveness of interactive digital edugame-based learning models that suit the characteristics of elementary school students. This research aims to develop an interactive digital edugame-based learning model in elementary schools and analyze its impact on student motivation and learning outcomes.

2. METHODS

This research uses the Research and Development (R&D) method (Mahmudin & Saprudin, 2023) with the ADDIE development model, which includes five stages: 1) Analysis: Analyzing learning needs, student characteristics, and the applicable curriculum. 2) Design: Designing a digital edugame that suits the subject matter and student needs. 3) Development: Developing a digital edugame based on the design that has been created. 4) Implementation: Implementing edugames in classroom learning. 5) Evaluation: Evaluate the effectiveness of edugames through learning outcomes and student motivation questionnaires. The development procedure is shown in the following image. (Ranuharja et al., 2021), (Dilaines et al., 2024).



Figure 1. ADDIE Development Model

The implementation of the ADDIE model takes place in five phases and needs to be carried out in a structured and sustainable manner. The ADDIE model, with each phase explained, looks like this: The first is the analysis phase. At this stage, the researcher will analyze the importance of developing educational game media with the aim of finding out the initial needs in developing educational game media. Next, at this stage, analysis is carried out which includes media analysis, curriculum analysis, and learning material analysis. The second stage is the design stage. The aim of this phase is to create a product design that is adapted to the results of the analysis carried out, or in the form of a first product (prototype). The third stage is the development stage. During this phase, there are several steps you need to take: a) Development of the Edu-Game media framework and design of tools created in the previous stage (assessed by experts), b) Evaluation of the Edu-Game media framework (assessed by experts), understand the field of media, material and language, games by experts who can provide criticism and suggestions for improving the preparation, and c) carry out revisions based on validation by experts on educational game media. Observations, suggestions and criticism from experts in the fields of media, materials and language. The fourth stage is the implementation stage. This is characterized by the use of educational game products that have been developed by instructors who understand media and are material experts, and who can be tested and tested on a small scale with research subjects.

The research subjects were 30 2nd grade elementary school students in Serang City. Data collection techniques include validation sheets, tests and questionnaires (Komarudin et al., 2022). Data collection instruments include learning outcomes tests consisting of multiple-choice questions and essays, learning motivation questionnaires consisting of intrinsic and extrinsic motivation, and observation sheets of student involvement in using interactive digital edugame-based learning media. Data analysis techniques using analysis of validity results from experts, the practicality of using learning media by looking at the active role of student involvement, and the effectiveness of developing interactive digital edugame-based learning in elementary schools in the form of analysis of improving student learning outcomes. The data analysis technique used refers to the following percentage formula.

$$\% \text{ score interpretation} = \frac{\sum \text{acquisition score}}{\sum \text{maximum score}} \times 100 \%$$

The results of the validity sheet questionnaire analysis are interpreted using the following criteria.

Table 1. Interpretation of Validity percentage

No	Interpretation	Percentage
1	Very Inadequate	0%-20%
2	Not Worth It	21%-40%
3	Decent Enough	41%-60%
4	Worthy	61%-80%
5	Very Worth It	81%-100%

The results of the analysis of the practicality sheet questionnaire are interpreted using the following criteria.

Table 2. Interpretation of the Practicality percentage

No	Interpretation	Percentage
1	Impractical	0%-54%
2	Less Practical	55%-59%
3	Quite Practical	60%-75%
4	Practical	76%-85%
5	Very Practical	86%-100%

3. FINDINGS AND DISCUSSION

This research uses the ADDIE method, which includes the stages of Analysis, Design, Development, Implementation and Evaluation. The following are the results and discussion of each stage in the development of interactive digital edugames for learning science and technology on animal introduction material in elementary schools.

3.1. Analysis

At the analysis stage, researchers conducted an assessment of students' needs, the characteristics of the science material regarding animal recognition, and the suitability of the 2nd grade elementary school curriculum. Based on the results of the analysis, several important points were found:

- a) Student Needs: Grade 2 elementary school students prefer learning that uses visualization and interactive activities. Conventional textual and verbal learning often does not attract their attention.
- b) Material Characteristics: Animal introduction materials have a lot of visual information (images and characteristics of animals), which is ideal for visualizing in the form of interactive games. Students can learn about habitats, physical characteristics, and animal food in a more fun way.
- c) Curriculum: The 2nd grade science curriculum covers the themes of animal recognition, including grouping animals based on habitat (land, water, air), type of food (herbivores, carnivores, omnivores), and distinctive physical characteristics.

These results indicate that students need an interactive and visual-based approach to facilitate understanding of the concept of animal recognition. Based on the needs analysis, the need to develop interactive digital edugame media is based on the need for media that supports student understanding




3.2. Design

At the design stage, interactive digital edugames are designed based on the results of the analysis. This stage includes designing the interface, game flow, and the types of activities integrated into the game. Some of the design elements created include:

- a) Visual Interface: Edugame is designed with a nature theme, using attractive and colorful animal images. Each animal is accompanied by an animation showing its habitat and living habits.
- b) Game Flow: Edugame is designed in the form of missions, where students have to complete several challenges to help the animals return to their suitable habitat. For example, students must group animals based on where they live or choose the right food for each animal.
- c) Interactive Features: Each game level provides interactive challenges related to animal recognition material. There are quizzes that provide immediate feedback, as well as a "star collection" feature that motivates students to complete levels correctly.
- d) Reinforcement: At the end of each level, students get additional information in the form of interesting facts about the animals being studied, so that learning does not only focus on gameplay but also on enriching knowledge.

After the analysis results, an edugame design was formulated involving: A visual interface that attracts students who like pictures and animations, a game level with the theme of grouping animals based on habitat, type of food and physical characteristics, and reward features (for example, stars or points).

Table 3. Animal Carrom Edugame Design Plans

Menu	Appearance	Short Description
Main View		The display that appears on the Edugame main page presents the name of the game, and there are options for Travel, game, sound effects, and exiting the game.
Next View		When choosing a game, there are 4 types of Animal Carrom Games, namely Land Animals, Water Animals, Air Animals and Animals of the Two Realms.
Animal Carrom Edugame Final View		The final display shows the shape of the Animal Carrom game with various types of Animals including land, Water, Air and Two Realms and one Master Coin as a coin shooter on the other coins alternately from each player..

3.3. Development

At the development stage, the planned design is realized in the form of a digital edugame application. This game was built using Blander software as a game development that supports high interactivity, which is then operated via an Android cellphone or computer. The development stage includes:

- a) Visual and Animation Content Creation: All animal images and animations are adapted to the real characteristics of these animals, so that students can learn with accurate visual representations.
- b) Game Coding: Edugame is developed with a programming language that allows the integration of interactive features, such as automatic scoring, animal grouping, as well as play in several levels of difficulty.
- c) Alpha Trial: Edugame is tested on a limited basis to ensure that all features work properly and there are no technical bugs. The development team also made adjustments based on feedback from initial testing.

Based on the results of the validation sheet, practicality results and student learning outcomes tests, the following data were obtained.

a. Validation Results

Next, the Edugames media was created and a design feasibility test was carried out through a questionnaire with three experts, namely a basic education materials expert, a media expert and a language expert. Evaluation includes appearance and content. The results of the expert validation questionnaire sheet are as follows.

Table 4. Expert validation results

Expert validation	Validation Results	Category
Materials Expert	93%	Very Worth It
Media Expert	89%	Very Worth It
Linguist	88%	Very Worth It

Based on the table above, it can be concluded that interactive multimedia learning based on education games is very suitable for use with several suggestions for revision. This multimedia can be used in learning because it can help students use the material contextually.

b. Practicality Results

This stage involves creating an edugame based on the design results, followed by an alpha trial on 10 students to see technical fluency and functionality. From the trial, it was found that 93% of students responded that the use of interactive learning multimedia based on educational games was very practical to use

c. Effectiveness Results of Student Learning Results

In the implementation stage, edugame was applied to 30 grade 2 elementary school students. The following is the data from the implementation of edugame based on pre-test and post-test to measure students' understanding of animal introduction material: Average pre-test score: 60, Average post-test score: 80. The graph below shows the increase in results student learning after using edugame.

Table 5. Student learning test results

Criteria	Pre-test scores	Post-test scores
Average	60	80
Highest	75	90
Lowest	45	65

Based on the results of an increase in the average value of 20 points, a 33.3% increase was obtained. The following graph shows the distribution of increases in student learning scores after using edugames:

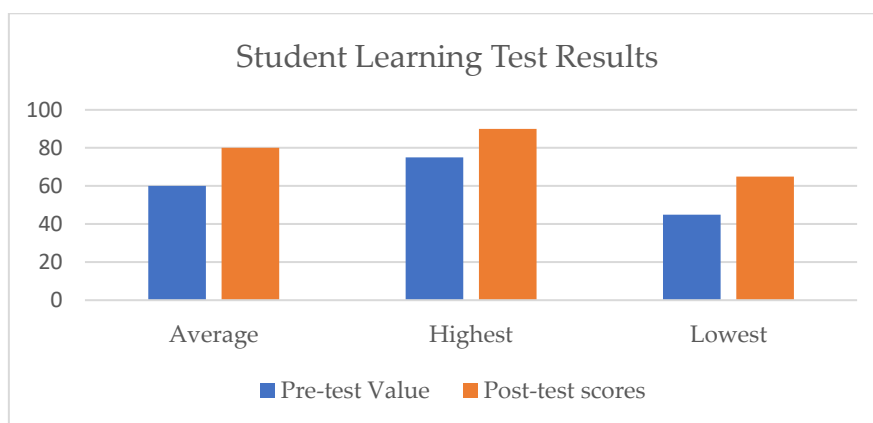


Figure 2. Graph of Student Learning Results Test

d. Results of the Effectiveness of Student Learning Motivation

In the implementation stage, edugame was applied to 30 grade 2 elementary school students. The following is data on student learning motivation results from the implementation of edugames based on pre-test and post-test to measure the increase in educational game-based interactive multimedia learning. Data on student learning motivation results are as follows

Table 6. Results of student learning motivation

Criteria	Pre-test scores	Post-test scores
Average	37	91
Highest	43	93
Lowest	47	87

Based on the table above, it can be seen that there is an increase in the average pre-test to post-test results of student learning motivation with interactive multimedia learning based on education games. The use of multimedia has an impact on increasing student learning motivation, both intrinsic and extrinsic motivation

3.4. Implementation

In the implementation stage, edugame was applied to 2nd-grade elementary school students in one of the elementary schools. The implementation process involves several steps:

- Teacher Training:** One of the main challenges is the lack of teachers' skills and knowledge in using digital technology, including interactive edugames, in the learning process. Not all teachers are used to using technology-based media, so the ability to integrate edugames with other learning methods can be limited. In addition, training related to digital learning technology may not yet be a priority in many schools. So teachers are given short training on how to use edugames and integrate them into daily learning. Teachers are also trained to monitor and evaluate student engagement during play. Then, not all schools have policies or programs that support the application of technology in learning.
- Learning Scenario:** Edugame is used as a learning aid in science learning about animal recognition. The teacher starts with a brief explanation of the material, then students are directed to play the edugame.
- Use of Edugames by Students:** During implementation, students played edugames in class using tablets provided by the school. Observations were made to see students' responses and how they interacted with the game.

The implementation of the edugame showed positive results in terms of student motivation, engagement, and understanding of the material. Most students demonstrated high enthusiasm while participating in the game, with 85% showing increased activity and involvement as they eagerly attempted to complete the challenges. They actively communicated and collaborated with their peers to determine the best strategies for completing each mission. In terms of content mastery, observations and quizzes embedded within the game revealed that students developed a stronger grasp of animal classification concepts. After playing the edugame, 90% of the students were able to accurately group animals based on their habitats and dietary categories, indicating a significant improvement in their understanding.

3.5. Evaluation

During the evaluation phase, two types of assessments were conducted: **formative** and **summative** evaluations.

a) Formative Evaluation

This evaluation took place during the development and alpha testing stages to ensure the content and functionality were appropriate and effective. As a result, several visual elements and user interactions were improved. Approximately 90% of expert feedback was incorporated into the final version of the edugame.

b) Summative Evaluation

The summative evaluation was conducted to measure the edugame's impact on student motivation and learning outcomes. Below are statistical findings based on a motivation questionnaire completed by 30 students after using the edugame:

- 88% of students reported feeling more motivated to learn after engaging with the edugame.
- 85% expressed increased interest in science topics.

Additionally, the following data were collected using a questionnaire based on the ARCS model (Attention, Relevance, Confidence, Satisfaction) to further assess student motivation.

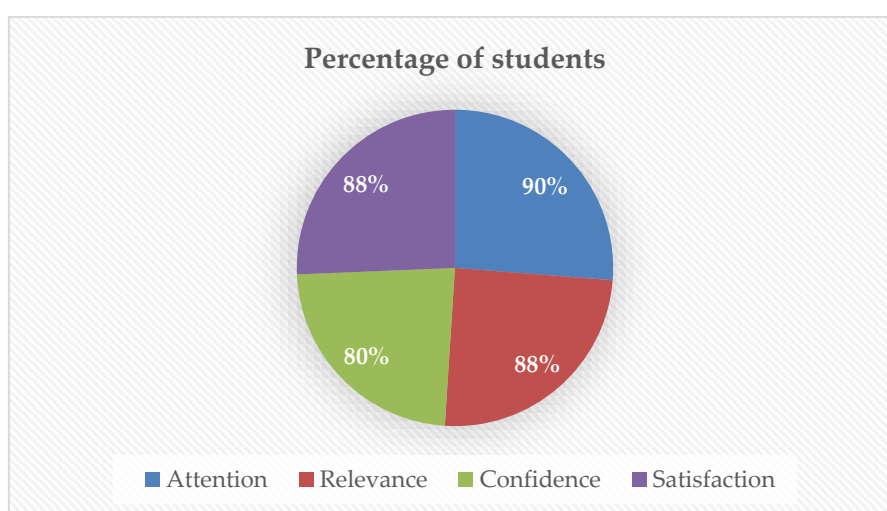


Figure 3. Percentage of students

Table 7. Results of student learning motivation

Aspect	Percentage of Students
Attention	90%
Relevance	85%
Confidence	80%
Satisfaction	88%
Total	85.75 %

Discussion

The findings of this study demonstrate that interactive digital edugames significantly improved student learning outcomes, with a 33.3% increase noted. This improvement can be attributed to the engaging visualizations and interactive features within the games, which helped students grasp scientific concepts in a more enjoyable and tangible manner. Furthermore, motivation among students increased substantially, with 88% reporting heightened enthusiasm for learning when using game-based digital media. The data suggest that technology-infused learning can address the boredom often associated with conventional instructional methods, especially for science content that typically requires visual and contextual support.

Incorporating edugames into the classroom provides an alternative method for presenting descriptive scientific content, making it more accessible and interactive for young learners. However, the study also identified several challenges in implementation, such as limited access to technological devices among students and insufficient teacher training in the effective use of digital media. These constraints must be addressed to fully realize the benefits of educational games in the learning environment.

During the development phase, formative evaluations were conducted through internal testing to assess functionality and usability. Feedback revealed that some features required refinement, particularly in user navigation and interface design. Adjustments were made based on this feedback to improve the intuitiveness and appeal of the edugame before its broader use. Following this, a summative evaluation assessed the edugame's overall effectiveness. Results showed a marked improvement in learning, as reflected in pre-test and post-test scores, which rose from an average of 60 to 80—an increase of 20 points. Motivation scores also supported the positive impact, with students expressing increased engagement due to the game's challenge-based and interactive elements.

Overall, the implementation of interactive digital edugames in science learning had a clear positive impact on both motivation and academic performance. These tools support independent learning and provide a concrete visualization of abstract concepts, making science more accessible and enjoyable for elementary students. The motivational design, incorporating elements of challenge and reward, further enhances student engagement. This aligns with the principles of constructivist learning theory, which emphasizes active exploration and student-centered interaction with learning materials.

Despite these benefits, successful implementation depends on systemic support. Schools must ensure the availability of adequate technological infrastructure and prioritize teacher training to integrate edugames into existing curricula. These findings align with prior research by Sudrajat et al. (2023), which also reported positive effects of digital media on elementary student learning outcomes. Similarly, Rati et al. (2024) confirmed the high validity and practicality of digital teaching materials, reinforcing the case for broader adoption.

When thoughtfully integrated into the national curriculum, edugames offer significant potential for enhancing elementary science education. As Patra et al. (2022) emphasized, alignment with core competencies (KI-KD), application in thematic learning, and incorporation into project-based and independent learning approaches can expand the utility of edugames across subjects. Continued school-level support, clear educational policies, and sustained teacher training are essential to maximizing the impact of these tools on the quality of learning in elementary schools.

4. CONCLUSION

This study concludes that the development of interactive digital edugames is effective in enhancing student motivation and improving learning outcomes in elementary science education. By offering an engaging, interactive environment, edugames successfully increase student attention and participation, making learning more enjoyable and impactful. These findings suggest that digital edugames can serve as innovative, alternative media to support the achievement of educational objectives at the primary level. However, this research is limited by its focus on cognitive outcomes within a single subject area and grade level, as well as the variability in students' access to technology and teachers' digital competencies. To maximize the potential of edugames, future development should ensure alignment with the national curriculum and consider the diverse characteristics of learners. Additionally, ongoing teacher training is essential to ensure effective integration of educational technology into classroom practice. Further research is recommended to explore the impact of edugames on non-cognitive skills, such as critical thinking, creativity, and student collaboration, across various subjects and educational contexts.

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Conflicts of Interest: Hopefully this research can be useful and become a reference regarding the development of interactive learning media for teachers, educational practitioners and stakeholders.

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