Emerging Information Science and Technology
Vol. 5, No. 2, (2024), pp. 60-65

The Influence of Developing an Understanding of Basic Programming Concepts Through Educational Games as A Learning Method for Elementary School Students.

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Abstract

Integrating engaging learning methods into the educational landscape has become increasingly crucial for enhancing student understanding and engagement. This study investigates the impact of educational games as a learning method for improving elementary school students' comprehension of basic programming concepts. The research hypothesizes that educational games can significantly enhance the understanding of programming concepts by making abstract ideas more tangible and engaging through interactive and enjoyable learning environments. Using a quasi-experimental design, the study involved two groups of elementary school students: the experimental group, which utilized an educational game designed for teaching introductory programming concepts, and the control group, which received traditional instruction. Both groups underwent assessments of their understanding of basic programming concepts before and after the intervention through standardized tests. The results demonstrated a statistically significant improvement in the scores of students in the experimental group compared to those in the control group. The findings of this study contribute to educational practices by illustrating how educational games can effectively support the introduction and teaching of programming at an early age within the elementary educational system.

Keywords: *educational games, programming education, elementary education, learning methods, quasi-experimental design*

1. Introduction

In today's digital era, understanding programming concepts has become an essential skill for the younger generation. As the initial stage in the formal education system, education at the elementary school level plays a crucial role in instilling the basics of this skill in students. Preparing for implementing changes is underway, where students will develop their computational thinking more broadly[1], [2]. Coding is a vital skill to master in the era of Industry 4.0 and must be taught early[2], [3]. Traditional teaching methods often do not convey abstract programming concepts to elementary students. A more interactive and engaging approach must be implemented to retain attention and enhance student understanding. Most people consider algorithms and programming difficult and tedious, so a particular method is needed to interest children[4], [5]. Educational games offer a more interactive and enjoyable learning approach. Through games, programming concepts can be taught in a more appealing format and more accessible for young students to understand. Introducing programming early can stimulate logical thinking, creativity, and problem-solving skills. Mastering coding skills early on provides a strong foundation for further technology learning. Educational games are structured activities where players make decisions through control over objects used in learning [6], [7]. Digitalization is transforming many aspects of life, and education must adapt to prepare students for a world increasingly dependent on technology. Shortly, many fields will require at least a basic understanding of computer science [8], [9]. There are many ways to introduce programming to children[10], [11]. Introducing programming concepts through educational games is a step toward education relevant to the times' needs. Given the importance of programming skills and the potential of educational games in education, this research aims to develop and evaluate the effectiveness of educational games for teaching introductory programming to elementary school students. The main goal is to assess how educational games can help students understand basic programming concepts and build strong foundational knowledge. Through this research, it is hoped that effective methods can be found to integrate programming into the elementary education curriculum and provide new insights into teaching technology to the younger generation. Educational games also have advantages over e-learning methods because they are easier to understand and more engaging for users[12]. In developing information and communication technology, games positively impact teachers in enhancing students' potential in a more engaging learning process [13].

According to various studies, children who learn coding at a very young age benefit from learning to assess situations critically, explore different perspectives, build creative solutions, and even develop cognitive abilities. Recent research shows that educational games are an effective tool in education, especially in building an understanding of basic programming concepts[14]. These games provide a fun, interactive environment that helps students quickly grasp abstract concepts. There is an increasing focus on teaching programming skills at the elementary school level. This is based on the understanding that programming skills are an essential competency in the digital era. Some studies demonstrate efforts to integrate programming instruction into the existing elementary school curriculum, combining educational games with other subjects to enrich learning. The use of educational games in education has been shown to increase student motivation and engagement. Studies show that games can facilitate more active and interactive learning, particularly for children. This state-of-the-art review includes recent developments in relevant fields. It provides context for research on developing an understanding of basic programming concepts through educational games for elementary students. These educational games serve as educational, independent, and free media for learning, enabling students to think creatively, innovatively, and productively in an enjoyable way [14], [15].

2. Method

Quasi-experimental design is a research approach that seeks to determine cause-and-effect relationships between variables within real-world settings [10]. Unlike true experimental designs, it does not rely on random assignment of participants to groups, often due to ethical considerations, practical constraints, or the natural characteristics of the study population. Instead, it employs alternative methods, such as pre-existing groups, matched groups, or interrupted time-series, to approximate the conditions of randomization. While this method offers valuable insights, it is generally more susceptible to biases and confounding factors, making careful design and analysis essential to ensure valid and reliable results. Here are the methods used to develop an educational game aimed at improving elementary students' understanding of basic programming concepts:

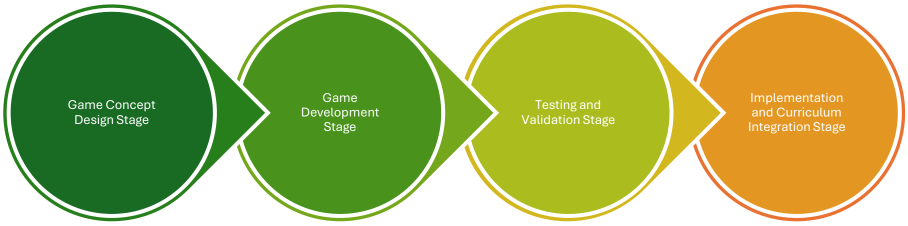

Game Concept Design Stage
Game Development Stage
Testing and Validation Stage
Implementation and Curriculum Integration Stage

Figure 1 Game Development Method

1. Game Concept Design Stage

Learning Objectives:

a. Define clear learning objectives. In this case, the main goal is to help students understand basic programming concepts such as logical flow, loops, conditions (if-else), and variables through interactive gameplay.

b. Ensure that the programming concepts taught are tailored to the comprehension level of elementary school students.

Target Audience:

This game is designed for elementary school students, ages 10-12, with no formal programming experience. Ensure that the game interface is child-friendly and easy to understand.

Game Type:

Choose a puzzle-based or problem-solving game where students must arrange programming commands to complete a task, such as guiding a character from the starting point to the endpoint.

Storyline:

Create a simple, engaging story, such as an adventure where the main character must navigate a maze using programming logic. This provides context for students to apply programming concepts practically.

2. Game Development Stage

Development Platform:

a. Use a game development platform such as Unity (with C#) or Scratch (for a simpler version). The choice depends on the target difficulty level and the availability of development resources.

b. Scratch is suitable for a more child-friendly, drag-and-drop-based game, while Unity is ideal for a game with more advanced visual elements.

Basic Programming in the Game:

a. Integrate concepts of sequences (command order), loops (repetition), and conditionals (branching) as part of the game's main missions.

b. For example, students must arrange commands for the character to move forward, turn right, or repeat instructions until the character reaches the goal.

Interactive Features:

a. Provide immediate feedback when students assemble correct or incorrect commands. For instance, if the command is correct, the character will move as instructed; if incorrect, an error message with hints will appear.

b. Add gradually increasing difficulty levels. Students start with basic levels and progress to more challenging ones as they advance in understanding programming concepts.

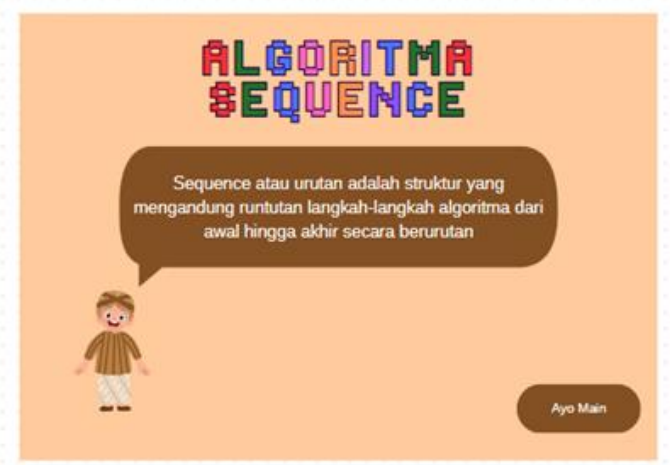
Use of Gamification Elements:

a. Offer rewards such as points, badges, or additional levels to enhance motivation and student engagement.

b. Implement a leaderboard system to encourage friendly competition among students.

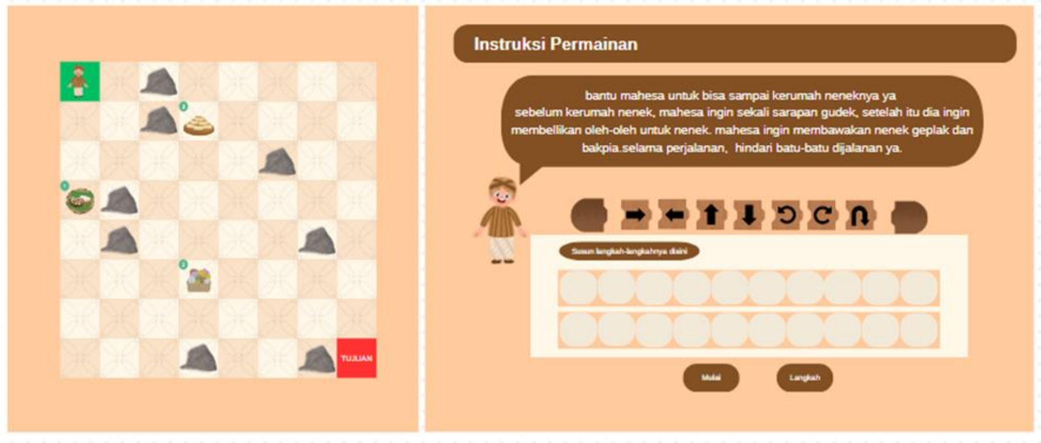
3. Result and discussion

The core concept of this research is to integrate game elements into programming education to attract students' interest and increase their engagement. This approach is designed so that students can learn while playing, making it easier to understand programming concepts. The research team successfully designed and developed an educational game targeted at elementary school students. The game is designed with varying difficulty levels, gradually allowing students to learn and develop fundamental programming skills.



Sequence atau urutan adalah struktur yang mengandung runtutan langkah-langkah algoritma dari awal hingga akhir secara berurutan

Figure 2 Programming Materials



bantu mahesa untuk bisa sampai kerumah neneknya ya
sebelum kerumah nenek, mahesa ingin sekali sarapan gudek, setelah itu dia ingin membellikan oleh-oleh untuk nenek. mahesa ingin membawakan nenek geplak dan bakpia.selama perjalanan, hindari batu-batu dijalanan ya.

Figure 3 Game Board

Below are the test results on students' understanding of fundamental programming concepts using the educational game:

Algorithm

We are testing objective to measure students' ability to understand and apply basic algorithms to solve problems in the game. Test Results show that 82% of students successfully designed and implemented simple algorithms to complete tasks in the game, and 18% struggled to break down problems into clear algorithmic steps.

Sequence

The testing objective is to evaluate students' understanding of the importance of instruction order in programming. Test Results: 88% of students understood the concept of sequence. They could logically arrange instructions to achieve goals in the game 12% of students required more practice to understand the impact of incorrect sequencing on the outcome.

Looping (Repetition)

They were testing objective to test students' ability to use looping structures to simplify repetitive tasks. Test Results: 75% of students could use loops to automate repetitive tasks in the game, and 25% had difficulty determining appropriate termination conditions for loops, resulting in loops running too long or not stopping.

Decomposition (Breaking Down)

We are testing objective to assess students' ability to break down complex problems into smaller, manageable parts. Test Results: 80% of students could effectively decompose problems into smaller tasks and solve them individually. 20% of students needed assistance identifying subproblems and linking them to the solution.

Branching (Conditionals)

We are testing objective to measure students' understanding of using conditional statements and branching to make decisions in the game. Test Results: 78% of students successfully applied if-else and other branching statements to make decisions in the game. 22% of students needed more practice determining the appropriate branching conditions.

Debugging (Error Detection)

We are testing objective to test students' ability to identify and fix errors in code. Test Results: 70% of students could independently identify and correct errors in the code, and 30% required guidance in recognizing common errors and effective debugging methods.

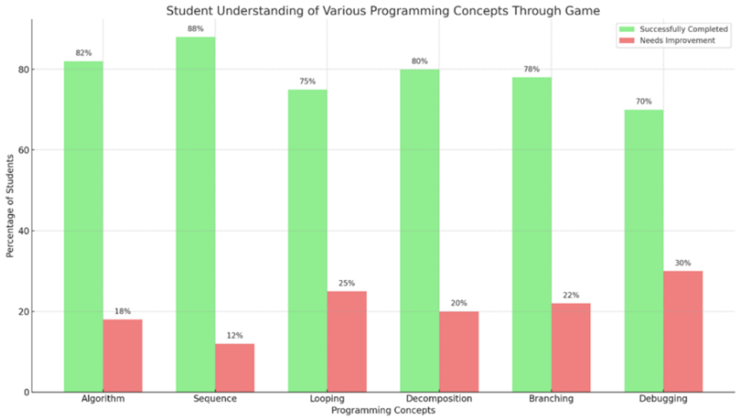


Figure 4 Test Results

4. Conclusion

This research shows that using educational games as a tool for programming learning can improve elementary students' understanding and engagement. Students can learn basic programming concepts more effectively with an interactive and enjoyable approach. The widespread implementation of this final product has the potential to impact programming education at the elementary level significantly. Furthermore, the study highlights the potential of integrating such tools into standard curricula to enhance student learning across various subjects. The study urges future research to explore the long-term impacts of educational games on learning outcomes and how these tools can be further integrated into the educational system.

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