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Development of an Interactive Adventure Game for Enhancing Mathematical Learning in Second Grade Students

Hans Juwiantho[1]*, Ramadhan Daffa Ferdyatma[2], Liliana[3]
[1,2,3]Informatics, Petra Christian University, Indonesia
Hans.juwiantho@petra.ac.id

Abstract: Mathematics is a fundamental subject taught across all educational levels, particularly in primary schools, where it serves as a foundation for understanding technology and science. However, second-grade students often struggle with mathematics due to a lack of motivation, primarily caused by conventional teaching methods that fail to engage them effectively. According to educators, students prefer learning through real-life examples that help them better understand the material and information presented. To address these challenges, an educational game was developed to support second-grade mathematics in primary schools, aligning with Indonesia's latest curriculum, Merdeka Curriculum. The game covers key mathematical topics, including numbers recognition, comparisons, addition, subtraction, geometric shapes, spatial figures, and patterns. To increase student engagement and sustain their interest, the game incorporates an adventure genre where students complete mini-games as part of various missions throughout the gameplay. Testing was conducted by comparing the pre-test and post-test scores of second-grade students after playing the adventure game. Students took a pre-test before playing the game and a post-test afterwards. The test results demonstrated a significant improvement in understanding, with average scores increasing from 8.21 to 9.07, and the score range shifting from 5-10 to 7-10. This confirms that the use of the game is effective in enhancing students' comprehension of mathematics.

Keywords: Adventure game, Mini-Game Approach, Primary School Education

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A. INTRODUCTION

Mathematics plays a vital role in shaping students' cognitive development, particularly during the early years of primary education (Mulbar, 2015). In primary education, students begin to explore fundamental mathematical concepts such as basic arithmetic, comparison, geometry, and patterns, which serve as essential building blocks for their future academic growth. However, young learners often struggle to grasp these abstract concepts when delivered through traditional, text-heavy instructional methods. This can result in reduced motivation, lack of engagement, and ultimately, lower academic performance (Anggraeni et al., 2020).

In Indonesia, mathematics is taught from elementary to university level due to its significant contribution to critical thinking, reasoning, and everyday problem-solving (Sunzuma & Umbara, 2025). Given its crucial role in technological development, mathematical understanding should ideally begin from an early age. However, many elementary students, particularly those in second grade, face challenges in learning

mathematics. A lack of interest, motivation, and confidence often stems from conventional teaching methods that rely heavily on lectures and repetitive exercises. These traditional approaches tend to be monotonous and fail to create an engaging learning environment (Fadilla et al., 2021; Sari & Juandi, 2023). According to interviews with second-grade teachers, students show a preference for learning through real-life examples that help them visualize how the material applies in everyday contexts.

To address these challenges, educational games offer a promising alternative by providing an interactive and engaging learning experience (Cheung & Ng, 2021; Zeng et al., 2020). Adventure-based educational games, in particular, allow students to participate actively in problem-solving and exploration within a meaningful context (Chiang et al., 2019; Papadimitriou & Virvou, 2016). Through narrative elements, visual cues, and a mission-based structure, these games create an immersive environment that fosters curiosity and motivation. The integration of mini-games helps clarify specific learning objectives, delivers real-time feedback, and increases replayability—encouraging repeated practice and deeper conceptual understanding. Such features make game-based learning an effective method for supporting students in grasping abstract mathematical ideas in an enjoyable and meaningful way (Bado, 2022).

Educational games have been found to improve student engagement, promote problem-solving, and encourage active participation (Yu et al., 2021). Unlike conventional instruction, game-based learning allows students to learn at their own pace and in a context that feels meaningful and fun(Candra et al., 2024). Several studies have shown that integrating games into the classroom enhances learning outcomes and provides opportunities for exploration and experimentation, particularly in subjects that students typically find challenging, such as mathematics (Tokac et al., 2019; Vlachopoulos & Makri, 2017).

Several previous studies have highlighted the potential of educational games across various domains. Ghost Detective (Papadimitriou & Virvou, 2016) enhanced student interest in mathematics through an adventure game with adaptive and personalized features. Chiang et al. (Chiang et al., 2019) developed an interactive adventure game that successfully raised safety awareness among children. Math Adventure educational game using scenarios and missions in every stage (Kartika et al., 2019) improved fifth-grade students' motivation in learning mathematics. Moosa (Moosa et al., 2020) created a health-awareness game on diabetes that showed positive effects through pretesting and posttesting. Chen (Chen et al., 2021) demonstrated that integrating vocabulary practice within a visual novel led to better learning outcomes compared to games without such features.

This study differs from previous research by focusing on the development of an open-area adventure game specifically designed to support second-grade mathematics learning, aligned with Indonesia's latest national curriculum, Merdeka Curriculum. This curriculum promotes flexible, project-based learning and allows educators to tailor instruction based on student needs and interests. The game covers fundamental mathematical topics such as number recognition, comparison, addition, subtraction, geometric shapes, spatial figures, and patterns.

The primary aim of this study is to develop and evaluate the effectiveness of an educational adventure game in enhancing second-grade students' understanding of mathematics. The evaluation combines quantitative methods, including pretesting and posttesting score analysis. This game is expected to provide a fun yet effective learning alternative to help young learners grasp essential mathematical concepts.

B. METHOD

The application developed in this study is an adventure game designed as a mathematics learning tool for second-grade elementary school students. The game features six distinct mini-games, each created with unique designs and objectives based on different mathematical concepts aligned with the Curriculum Merdeka. In this game, the students take the role of Aji, a curious student who wonders how mathematics is applied in everyday life. One night, Aji falls asleep and wakes up in a mysterious world filled with math-related challenges. To return to the real world, he must complete various missions. Throughout his journey, Aji is assisted by unique creatures who guide him in solving these tasks. The game's progression follows a mission-based narrative reflecting the core competencies of second-grade mathematics defined in the curriculum.

Each mini-game is designed to strengthen specific mathematical skills and consists of six mini-games. The first mini-game focuses on placing value, where students must group numbers based on ones and tens by guiding the character toward the correct object. Correct answers are indicated with a check mark, and incorrect ones with a cross; the students must answer all questions correctly to complete the game. The second mini-game involves comparing the weight and size of two objects, requiring students to select the heavier or larger item. Success is achieved after answering two questions correctly, while incorrect answers lead to a restart level. The third mini-game is the addition and subtract mini-game, where students solve arithmetic problems by selecting the correct result from an addition or subtraction question, with right answers increasing the students' life count and wrong answers decreasing it. The fourth mini-game places the students in a shopkeeping scenario, where they must serve customers accurately, giving the customers the right amount of the item they need. The game is considered complete once a certain amount of money has been earned; otherwise, the students must repeat the game.

The fifth mini-game introduces the identification of 2D shapes. Students are given descriptive clues and must select the correct object that matches the shape described. The final mini-game involves recognizing patterns and sequences. Students identify the next item in a sequence based on the pattern shown. To finish the game, students are required to answer at least two questions correctly.

A pretest-posttest experimental method was conducted to evaluate the effectiveness of the game in enhancing students' understanding of mathematics. The testing procedure aligned with the mini-games' order to maintain coherence and prevent confusion. Students were first asked to complete a pretest before engaging with the game. They then played through the game following the designed sequence, after which they completed a post-test.

The pretest and posttest consisted of ten questions, and the tests were administered using Google Forms to simplify data collection and analysis.

C. RESULTS AND DISCUSSION

The game testing was conducted with 14 second-grade elementary school students. The students first completed a pretest, then played the game until the end, and afterward took a posttest. The participants consisted of students with varying learning profiles: 4 students who learn quickly, 4 students who take longer to understand, and 6 students with average comprehension skills. Both the pretest and posttest consisted of 10 questions, covering the following topics: 1. Numbers (2 questions), 2. Comparison (2 questions), 3. Arithmetic operations (2 questions), and 4. Geometry (4 questions). The same set of questions was used in both tests to allow for direct comparison.

The results of this study indicate a positive impact of the educational adventure game on students' understanding of mathematical concepts. After completing the interactive educational game, students achieved higher post-test scores compared to their initial pretest scores. On average, the students' scores improved from 8.21 to 9.07, and the score range, initially from 5 to 10, shifted to 7 to 10 based on the posttest and pretest results. Showing a clear enhancement in their grasp of the material.

Table 1. Pretest and posttest result

Testing	Average	Median	Range score
Pretest	8,21 / 10	8 / 10	5 – 10
Posttest	9,07 / 10	9 / 10	7 – 10

Throughout the gameplay, students were actively engaged with each mini-game, which was intentionally aligned with topics from the Merdeka Curriculum. For example, the first mini-game allows students to move around and try any number that appears on the ground, enabling students to visually understand the difference between ones and tens by placing the number in the correct place, as illustrated in Figure 1.
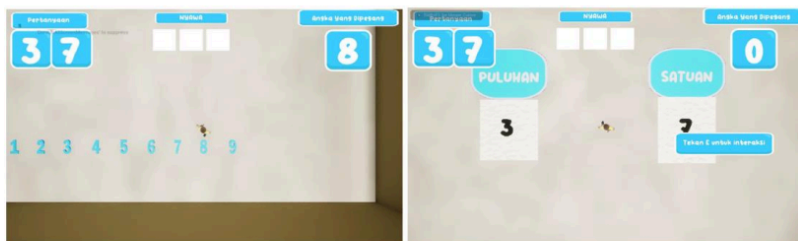

Figure 1. Mini-game placing ones and tens

Similarly, the mini-game on comparing object weight encouraged them to use logical reasoning to determine which item was larger or heavier. An example of the minigames can be seen in Figure 2. Every time a student gives a wrong answer, the game will give feedback in the form of a warning text that the answer is wrong and give an explanation about the right answer.

Figure 2. Mini-game comparing object weight or size

The arithmetic mini-game helped reinforce addition and subtraction skills before playing the next mini-game. Students need to understand addition and subtraction before trying the real-life demo of becoming a cashier who needs to calculate numbers. The next mini-game used a scenario in which the students practiced real-life application of math in the shopkeeping scenario, where they had to serve customers with accurate quantities. These interactive tasks allowed students to apply their knowledge in different contexts, enhancing both comprehension and confidence. For example, in Figure 3, the student needs to give the customer six milk cartons.

Figure 3. Mini-game real-life application of math

The fifth mini-game focuses on the identification of two-dimensional shapes. Students are presented with an image of a specific geometric shape, such as a square, triangle, or circle. Their task is to find and select the object within the game environment that matches the given shape. These objects are scattered throughout the area, requiring students to move around to scan and correctly identify the matching objects. This activity reinforces students' recognition of basic geometric forms and encourages them to apply their knowledge in a real-life visual environment setting. Through this interactive approach, students can better

understand and distinguish between different shapes in a more intuitive and enjoyable way. This mini-game can be seen in Figure 4.
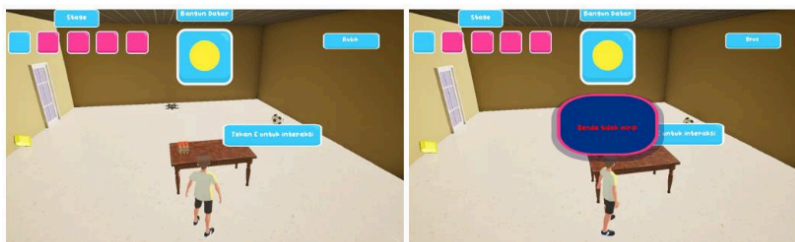

Figure 4. Mini-game matching shape

The final mini-game is designed to recognize patterns and sequences, an essential concept in early mathematics. In this stage, students are presented with shape elements arranged in a specific order. They analyze the pattern and determine the next correct item in the sequence. The game encourages logical thinking and attention to detail, as students must identify the sequence. To complete the mini-game, students must answer at least two questions correctly. This activity sharpens their pattern recognition skills and enhances their ability to predict and generalize, which are essential foundations for more advanced mathematical reasoning, as illustrated in Figure 5.
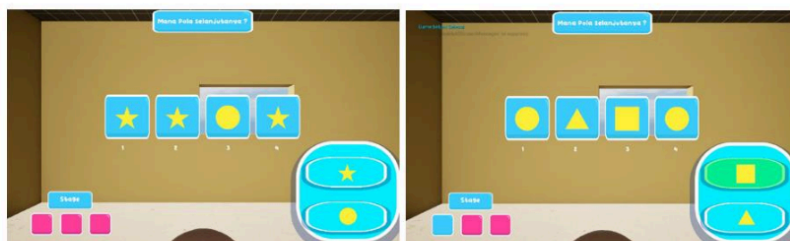

Figure 5. Mini-game of pattern and sequence

The students' responses and behavior during the sessions further reinforced the game's effectiveness. Many students expressed excitement while playing and showed clear signs of increased focus and motivation. Teachers who observed the session noted that students were more enthusiastic than usual and exhibited a strong willingness to complete each task. From a design perspective, the game's narrative structure helped maintain the students' interest. The storyline of Aji's journey through a dream world filled with math-based challenges created a meaningful context for learning. Visual cues, feedback mechanics, and mission

progression were carefully designed to keep students engaged and provide immediate understanding of their mistakes or successes.

These findings are consistent with previous research on game-based learning. Similar to the Ghost Detective game (Papadimitriou & Virvou, 2016) and other interactive educational games (Bado, 2022; Tokac et al., 2019) this study shows that a narrative-based, exploratory learning environment can significantly improve student engagement and learning outcomes. What sets this study apart is its focus on second-grade mathematics within the context of the Merdeka Curriculum, demonstrating how games can be tailored to meet curriculum goals while fostering enjoyment in learning.

Although the outcomes are promising, this study was conducted with a relatively small group of students and over a limited time period. Thus, while the results indicate short-term improvement in understanding, further research would be needed to assess long-term learning retention and scalability across different classrooms. Moreover, future development of the game could expand to include other topics within the grade level or offer adaptive difficulty to better meet individual learning needs. Despite these limitations, the findings highlight the potential of educational games as a valuable supplement to traditional mathematics instruction, especially for young learners. The combination of narrative-driven missions, interactive mini-games, and real-time feedback makes the learning experience more engaging and accessible, laying a strong foundation for deeper mathematical understanding.

D. CONCLUSIONS AND SUGGESTION

This study demonstrates the effectiveness of an educational adventure game in enhancing second-grade students' understanding of mathematical concepts. By combining narrative-driven gameplay, engaging mini-games, and curriculum-aligned content, the game succeeded in creating a meaningful and enjoyable learning experience. The results from the pretest and posttest show a noticeable improvement in students' performance, with increased engagement, motivation, and conceptual understanding observed during the gameplay sessions. The mini-games, each targeting specific mathematical topics, allowed students to practice understanding ones or tens, comparison value, arithmetic operations, geometric shapes, and pattern recognition in an interactive environment. The game's success in supporting learning suggests that digital game-based learning can complement traditional methods, particularly for young learners. Future work may include expanding the game to cover additional topics, increasing adaptability for different student profiles, and conducting broader trials to assess long-term effectiveness.

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