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Designing a Learning Game for Elementary School Students in Learning Mathematics using a Mobile Platform

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Abstract

Education is an important aspect in forming the potential of the young generation where the use of mobile platforms has become an integral part of everyday life. Over time, gadgets have become an access to learning besides books. Therefore, the increasingly complex development of the technological world encourages individuals to be able to apply technology in all their activities. Mathematics learning at elementary school level is often faced with challenges to make the learning process more fun and interactive. A common problem among students in Indonesia is that mathematics is considered a difficult subject. Monotonous learning reduces students' interest in learning. Therefore, designing learning games for elementary school students, especially in mathematics learning, can be an innovative solution to improve the quality and attractiveness of learning with interactive learning media. This research aims to create a game that allows students to learn more effectively which focuses on game development using the Game Development Life Cycle (GDLC) development model. This research produces a translation game from mathematics book learning material with the theme "Counting Numbers Up to 10,000" using the Unity 3D game engine which functions well and the application of the Game Development Life Cycle (GDLC) method also functions well.

Keywords: *Android Games, Game Development Life Cycle (GDLC), Elementary School, Mathematics.*

1 Introduction

Education is an important aspect in forming the potential of the younger generation. In the current era of information technology, the use of mobile platforms has become an integral part of everyday life. As time goes by, gadgets have become an access to learning besides books [1]. Therefore, the increasingly complex development of the technological world encourages individuals to be able to apply technology in all their activities [2]. In 21st century education, digital games have been identified as a potential tool for enhancing learning that allows people to train themselves as thinkers and provides an adequate environment to improve the necessary skills. Depending on the type, games can also stimulate players to formulate tactics, use 'guessing' techniques, and commit to a planned strategy [3].

Mathematics learning at elementary school level is often faced with challenges to make the learning process more fun and interactive. A common problem among students in Indonesia is that mathematics is considered a difficult subject [4][5][6]. Mathematics can be defined as the ability to develop thinking skills and students are required to have basic concepts of numeracy skills because it will help them understand and solve problems [7]. Mathematics learning at elementary school level is often faced with challenges to make the learning process more fun and interactive. Monotonous learning reduces students' interest in learning [8]. Therefore, designing learning games for elementary school students, especially in mathematics learning, can be an innovative solution to improve the quality and attractiveness of learning with interactive learning media [9].

Through mobile platforms, learning accessibility can be increased, allowing students to learn anytime and anywhere, according to their individual rhythm. By designing math learning games that fit the elementary school curriculum, we can create a learning experience that is both fun and immersive. In this context, designing mathematics learning games for elementary school students on mobile platforms is not only a technological breakthrough, but also a significant step towards more

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effective and enjoyable learning [10]. The hope is that this game can be a fun and useful partner in the educational journey of elementary school students in mastering mathematical concepts. This research aims to create a game that allows students to learn more effectively with learning material from grade IV elementary school mathematics books with the theme "Counter Numbers Up to 10,000". This research focuses on game development using the Game Development Life Cycle (GDLC) development model.

2 Literature Review

Research conducted by [11] in 2020 with the title "Primary School Children's Numeracy Educational Game Using Mobile-Based RPG Maker". In this research, the game was created using the Game Development Life Cycle method with the RPG Maker MV application which produces new, more interesting learning media so that children do not always get bored with learning that only relies on books. The results of the test involving 20 respondents showed that the feasibility of the resulting software had a success percentage with a total average of 93.29%, so it can be concluded that the percentage value obtained shows that the overall software quality is on a Very Good scale.

Furthermore, research was carried out by [5] in 2023 with the title "Designing an Arithmetic in Space Educational Game as a Mathematics Learning Media for Basic Counting Operations for Elementary School Students". In this research, the game was created using Construct 2 and is only based on Android with positive integer counting operations as material. Using the MDLC development method, this game was created with the aim of educating about simple arithmetic operations aimed at elementary school students, especially in grades 1 and 2 with the hope that it can become an interactive and interesting learning medium for elementary school students.

Furthermore, research was conducted by [12] in 2021 with the title "Introductory Educational Game and Learning to Count for Grade 1 Elementary School Students". In this research, the game was created using the Construct 2 application which has several features, such as displaying material in the form of images and videos in the form of learning to count from numbers 1 to 10, as well as counting games using drag and drop. The results of user perception of the game were 94.25% with an indicator in the "Very Good" category, which shows that this educational game can be used as an alternative in learning numeracy material in mathematics.

Furthermore, research will be carried out by [13] in 2022 with the title "Designing an Android-Based Elementary School Level Mathematics Learning Educational Game Using the Development of the Luther Model". In this research, the game was created using Construct 2 software, with the Luther model method with the aim of increasing students' interest and understanding of basic mathematical concepts, especially arithmetic operations and facilitating their understanding of the concept of arithmetic operations in an interactive and fun way.

Based on the literature review, good mathematics learning methods are further developed to increase students' interest in learning. Because now the curriculum uses a book with a thematic theme, this research will discuss the Design of Learning Games for Elementary School Students in Learning Mathematics Using a Mobile Platform which produces translated games from mathematics book learning material with the theme "Counting Numbers Up to 10,000" using the Unity 3D game engine.

3 Research Method

This research uses the Game Development Life Cycle (GDLC) development model. GDLC is a process for analyzing and developing games [14][15] which consists of six phases, namely concept development/concept prototyping, pre-production, production, testing, beta testing, and release.

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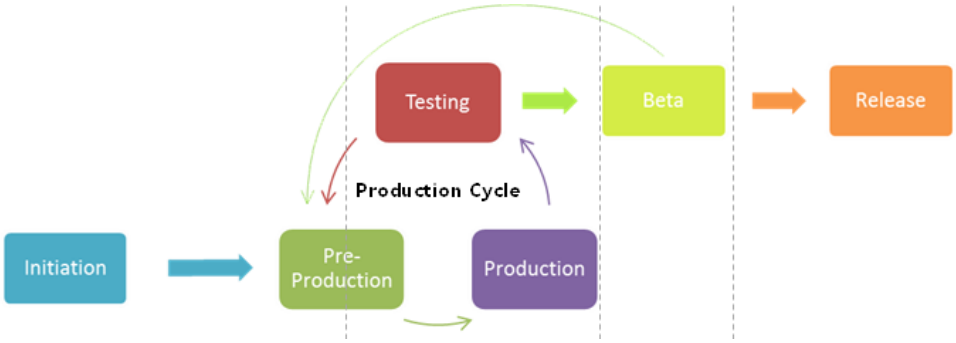

Figure 1. Model Game Development Life Cycle (GDLC)

Figure 1 above illustrates the flow of the Game Development Life Cycle (GDLC) development model. Of the six phases, there will be three main processes: Initialization Process, which consists of concept and design; Production Process, which consists of Pre-Production, Production, and Testing and Release [16][17].

A. Initiation
At this stage the researcher will create a concept for the game that will be built, including an analysis that includes the game scenario, characters, in-game plot, target players, game platform, and game engine and will produce a game concept and a simple description of the game [18].

B. Pre-Production
The Pre-production stage is one of the most important steps in the production process. The prototyping process includes developing and reviewing game designs as well as creating game prototypes. Game design focuses on defining the game genre, gameplay, storyline, characters, challenges, fun factor, technical aspects, and supporting documentation in the Game Design Document (GDD) [19].

C. Production
The Production phase is an internal process centered around asset initiation, code generation, and integration of the two elements. The prototype associated with this phase is formal detailing and refinement. Game design, prototyping and other pre-production elements are all discussed here Therefore, this time the author's focus is to focus the design on collecting data, designing the game, creating game rules, creating assets for player characters or enemies, trees, player food in the game, and other aspects to be part of the game description. This task involves creating assets, programming them, and integrating them with source code [20].

D. Testing
At the internal and external testing stage, it is carried out to verify the use of the designed game [21].
1. Alpha Testing: After production, this testing is carried out by checking whether there are still bugs and whether there is the possibility of reducing or even adding features.
2. Beta Testing: After the game is created, researchers will carry out external testing to test the game's acceptability and to detect various errors [22]. Beta is outside the production cycle, but if the results of this testing have the potential to still contain errors, the researcher will repeat the production cycle.

E. Release
The release phase is the final stage in game development [23]. The application is ready to be released to all users at this release stage. The release phase results in documentation, maintenance planning, and expansion of the game.

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4 Results and Analysis

This research aims to create a game that allows students to learn more effectively which focuses on game development using the Game Development Life Cycle (GDLC) development model. The following stages were carried out in this research:

4. 1 Initiation

This research produces an adventure genre game with the aim of changing mathematics learning to be more interesting. The material used is taken from the class IV mathematics book issued by the ministry and can be downloaded on the ministry of education and culture website. The first stage starts from the initiation stage to produce initial information for game development, such as what platform the game is being developed for, target users, genre, and the purpose of the game.

Table 1. Data Initiation

No.	Component	Results
1	Game Name	Mathematics Learning Game Class IV
2	Target	Elementary School Students Class IV
3	Device	Android
4	Genre	Adventure
5	Purpose	Creating learning innovations

Table 1 is the results of the initiation stage, namely the results in the form of the game name, target game users, devices used, game genre, and the purpose of developing this game. The results of the initiation are used for the next steps which will become a reference in game development.

4. 2 Pre-Production

The second stage, pre-production, will produce the assets used in game development. This stage produces assets in the form of characters, environments, and gameplay that will be created.

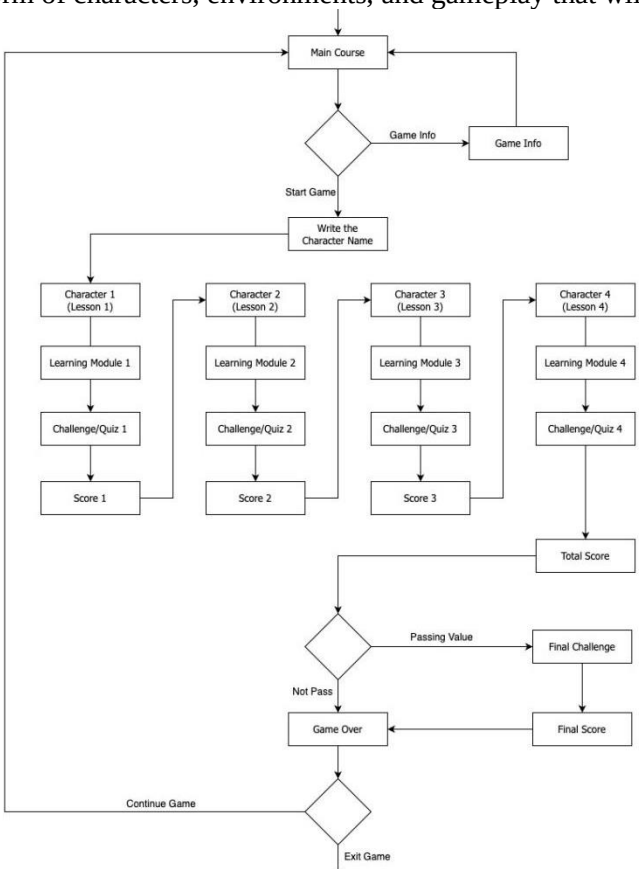

Figure 2. Flowchart Game

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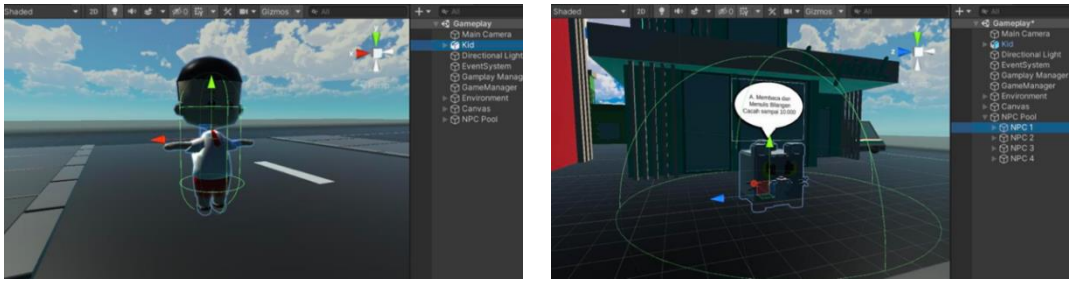
Figure 2 depicts the flow of the game that will be developed. From the flow above it can be seen that there will be a main menu consisting of the start game and game info. Game info will display information from the game, and start game functions to start the game. When you start, the initial process is to create a character name, followed by the player being able to start the game by choosing which NPC to talk to. When talking to the NPC there will be an explanation about the learning, followed by starting a challenge/quiz according to the learning and the results of the challenge/quiz will get a grade. Scores will be collected down to the last NPC, and the total score will determine whether the game will continue to the final challenge or the game ends. The final challenge will produce a final score which can be used as a grade by the teacher.



(a) (b)

Figure 3. Character Design (a), NPC Design (b)

Figure 3 depicts the formation of characters and NPCs in the game that will be developed, which are made according to the users to make the game more interesting. There are 4 NPCs designed, including: for chapter 1 players can get points by completing challenges/quizzes (if the player successfully answers the quiz, then they will get 10 points from each question) and so on until the last NPC and if the player is successful in getting points according to the provisions, then it will proceed to the final challenge stage.

(a) (b)

Figure 4. Environment Game Design (a) (b)

Figure 4 illustrates the formation of the environmental design in the game that will be developed by adjusting the background to the characters that have been created previously. Next, create a storyboard which is a visualization of the ideas of the application that will be built so that it can convey story ideas and game flow.

Figure 5. Gameplay

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Figure 5 above illustrates the gameplay of this game. The game mechanism consists of: learning materials, challenges/quizzes and grades. Points are earned by completing each challenge/quiz on each NPC. Each NPC has different learning materials and challenges/quizzes according to the learning material to get grades.

Figure 6. Challenge/Quiz

Figure 6 illustrates how users receive quiz challenges in the form of questions taken from the Class IV Mathematics book according to the lessons they will study.

4. 3 Production

The next stage is Production, where each asset and storyboard that have been developed at the pre-production stage will be prepared. The result at this stage is a game that is ready to be tested.

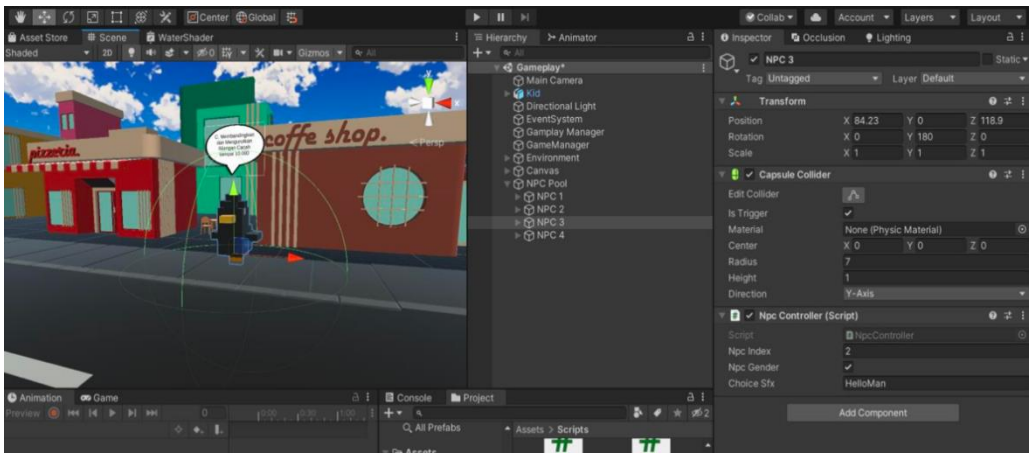

Figure 7. Game Code Generation

Figure 7 below illustrates the game creation process which consists of preparing each asset and the storyboard that was developed in the previous stage.

4. 4 Testing

The next stage is testing, aimed at ensuring the game is ready and successful in the development stage.

Table 2. Game Test Results

No.	Scenario	Expected Output Results	Test Results Yes	Test Results No	Remarks
1	Displays the Initial Game Display	Did the game successfully display the menu as planned?	✓		Game successfully displays the menu as expected
2	Displays Game Information	Does the game successfully display the game information menu?	✓		Game successfully displays game information as expected

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3	Running the Story	Does the game run as expected?	✓	Game managed to go according to previous plan
4	Running Challenges/Quiz	Did the challenge/quiz go as expected?	✓	Game successfully displays challenges/quizzes as expected
5	Running Results	Are the results of the game successfully displayed?	✓	Game successfully displays points and values as expected
6	Game Over	Is the end game scenario as expected?	✓	Game over was successful as expected

Table 2 displays the results of testing the game without encountering any problems and the game complies with what was planned.

5 Conclusion

This research produces a translation game from mathematics book learning material with the theme "Counting Numbers Up to 10,000" using the Unity 3D game engine which functions well and the application of the Game Development Life Cycle (GDLC) method also functions well. By designing a mobile game, it is hoped that it can provide a solution to increase students' interest in learning and the results obtained from creation to successful testing. In future research, additional teaching materials can be added that include all the material in the book, so that the games developed can be released to the public for use in the learning process.

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