

7-Day Math: A Mobile Visual Novel Game for Mathematics Education

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Jennie Florensia, Alethea Suryadibrata^(✉)
Universitas Multimedia Nusantara, Tangerang, Indonesia
alethea@umn.ac.id

Abstract—Mathematics has much negative stigma in society caused by the delivery of less interactive learning materials that makes many people not interested in studying mathematics. Educational games can be an option to create interactive learning media. This study aimed to develop a mobile visual novel game for mathematics subjects, especially definite integral, to increase interest in learning mathematics. The visual novel emphasises interactivity by delivering a story inside a game. This research investigates the level of immersion and behavioural intention to use using the Hedonic-Motivation System Adoption Model (HMSAM). An evaluation was conducted using questionnaires with 46 students as respondents. The results showed that the game increased students' interest in learning mathematics. The students feel immersed when playing this game and desire to play again. This is indicated by the behavioural intention to use level of 84.28%, which states that students strongly agree that the game can increase the application's reusability. In addition, the game obtained 82.09% for immersion, showing that students strongly agree that the game can make the players get carried away.

Keywords—educational game, HMSAM, mobile app, visual novel

1 Introduction

Mathematics is used daily for simple tasks such as shopping or even more complex problems such as calculating the land area. Therefore, schools have made mathematics one of the mandatory subjects for students to learn. As a subject, mathematics requires high precision in order to gain an understanding of the subject. Students studying mathematics must be highly interested in the subject to increase their understanding. Interest can be divided into two types: an interest within the students themselves, either because of talent or hereditary factors and an interest that arises due to external factors influenced by the surrounding environment [1]. One influential external factor is the media portrayal of mathematics itself. Mathematics has a negative stigma in society as one of the subjects that is difficult and boring, and how its application is not used in everyday life (for intermediate-level mathematics).

This negative stigma can arise due to the way the material is delivered. Most schools focus on their students' study results rather than their understanding of the subject, contributing to students' low interest in mathematics [2]. To overcome the lack of interest in learning mathematics among students, one approach that can be done is by making the learning process more interactive. Using multimedia as a learning tool can help improve interactivity in the learning process. One of the multimedia forms that can be used for learning is educational games.

A game can be played with rules to achieve a specific goal. To achieve this goal, there will be challenges and prizes when players successfully pass the challenges. The game has multimedia concepts such as audio and visual. Delivering multimedia material is more effective because it can improve students' understanding of the learning materials [3].

With various genres, the game is trendy among students, especially children and adolescents. A visual novel is a game genre with multimedia concepts such as audio, images, and text. In addition, the interactivity between the user and the game is presented in the form of choices, where the user will be asked to choose one answer from several available answers [4]. This answer will affect the end of the games.

This research focuses on the development of “7-Day Math”, an Android-based visual novel game for mathematics education. This research evaluates the game using the Hedonic Motivation System Adoption Model (HMSAM) to measure users' behavioural intention to use and immersion towards the game. The interactivity and multimedia concepts applied are expected to increase students' interest in mathematics, which has a boring stigma in society. A study has shown that android-based teaching is highly feasible [5]. By implementing multimedia elements into students' learning process by using games as the learning tool, it is hoped to increase the interactivity in the learning process, which has an impact on increasing students' understanding of the material [6].

2 Methodology

This research follows the Multimedia Development Life Cycle (MDLC) for the development of “7-Day Math” [7]. MDLC consists of 6 phases: Concept, Design, Obtaining Content Material, Assembly, Testing, and Distribution. This methodology is used considering that games can be classified as multimedia applications.

2.1 Concept

In this phase, researchers gather information from previous studies regarding what material is problematic in mathematics. Li, Julaihi, and Eng [8] mentioned that integral calculus has a high failure rate and that improving students' calculus performance takes work. Researchers also found other studies from Ario and Asra [9] stating that integral is difficult for students. Dharsinni and Saleh [10] pointed out that Definite Integral is considered one of the most critical subjects in integral. As this material is taught for grade 11 and 12 students in the curriculum of the Senior High Program in Indonesia, the primary audience for the games is students from grades 11 and 12.

In finding the game genre, researchers gather some studies on learning games, especially visual novel games. Mamolo [11] developed digital interactive math comics (DI-MaC) with a love story / romantic comedy theme. Based on the evaluation results, DI-MaC can motivate students to learn the least learned learning competencies. Prasetyo and Kuswardani [12] use visual novel games to develop students' reading abilities. This study found that media, especially video games, have been used as an educational agent that helped bring innovation and interest in students to learn about the related subject. The visual novel is a game genre that presents interactive stories where players are usually given choices that will affect the storyline as they progress. The gameplay presented in the visual novel is simple, players only need to click to see the following dialogue, and there are also buttons such as fast forward and auto-play. With such gameplay, the experience of playing a visual novel is similar to reading a digital novel presented with pictures and audio [13]. Most visual novels use a point system that will determine the relationship between the player and the characters in the game. This point system is often found in visual novels in the romance genre, where players can date characters in it [14]. Visual novels have advantages in building the visual perception of the players. This is because the visual novel can provide visualisation of the player's imagination by using their sense of sight [15]. These advantages can help achieve the learning objectives, where visualisation is essential to learning and applying mathematics [16].

2.2 Design

This stage involves designing the visual novel game system, including the storyline and dialogue. In this game, the player has a role as a new math club member. There are five learning materials about definite integrals, and players can take practice each learning material after finishing the stories. The player will be faced with dialogue choices in the story, where the story will continue based on the choices made by the players. The choices also affect the character's affection value and response dialogue. The character's affection value will determine the game's ending.

2.3 Obtaining content material

After designing the game, researchers create the necessary asset requirements per the specifications described at the design stage. Since "7-Day Math" is a 2D game, researchers use 2D assets as sprites. The characters have 5-10 expressions. The sprites are made using Procreate and Clip Studio Paint. For the learning materials, a list of questions is collected for minigames to make learning more enjoyable.

2.4 Assembly

After all the required materials are gathered, researchers develop the game using Unity 2019.4.34f1 for the target platform Android.

2.5 Testing

The testing phase is carried out to test the features in the game, namely the quiz and the dialogue feature. In addition, testing was also carried out to check whether the story progression feature was running according to the player's progress.

2.6 Distribution

In the last phase, researchers distributed the game to the students in grades 11 and 12. The questionnaire was also conducted using the Hedonic Motivation System Adoption Model (HMSAM). HMSAM is a model that was adopted and built based on the Hedonic Motivation System (HMS) [17]. The questionnaire has seven main components that will be measured according to the focus on the HMSAM: control, joy, curiosity, perceived usefulness, perceived ease of use, immersion, and behavioural intention to use [18]. The questionnaire form was a 5-point Likert scale type.

Table 1. 5-point Likert Scale

| Score | Description |
|-------|-------------------|
| 1 | Strongly Disagree |
| 2 | Disagree |
| 3 | Neutral |
| 4 | Agree |
| 5 | Strongly Agree |

3 Results

"7-Day Math" is developed using Unity 2019.4.34f1 for the target platform Android. The game uses aspects of visual novels to deliver learning materials and stories for the player. The story part of the game consisted of dialogue sequences that players could read. There are seven chapters consisting of a prologue, five learning materials, and an epilogue. In the prologue, the player is introduced as a new math club member who wants to study mathematics for the Math Olympiads. The player meets two other characters, which helps the player in learning the materials. As the game progresses, some conflicts arise among the club members. In the gameplay, there are several buttons in the interface that players can interact with; the skip button, auto button, and log button.

The skip button is enabled when the player has read the story chapter. When clocked, the system will skip to the end of the dialogue sequence. The auto button is a switch button that enables or disables dialogue auto mode. The game will autoplay the dialogue sequence when the auto mode is activated. If the auto mode is off, the player must give input via touch to advance to the following dialogue sequence. The log button will provide the player with a popup box containing the history of the dialogue that the player has read within the chapter. Most of the chapters in the story will push the player to make choices related to the story. Depending on the player's selection, the response dialogue will be different. Figure 1 depicts the dialogue system from the game.

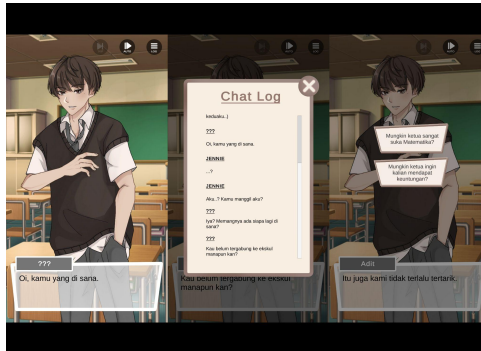


Fig. 1. Dialogue system in story mode

Players can choose which chapter to open stories. As players read more stories, the practice materials will be unlocked for the player to access. Figure 2 shows the story list.

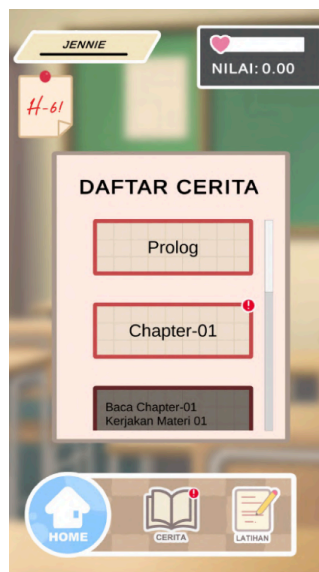


Fig. 2. Story list

In the practice part of the game, players will be given five random integral problems. Players can submit their answers after all the answers are filled in. For every correct answer, the player will be given 20 points. The highest point a player can earn is 100. If the player fails to score 70 on their first try, the next attempt on the same material will have the highest possible score of 70, even if the player answers all the problems correctly. After submitting the answer, there will be a button to display the solution to

the problem in the form of a popup window that is only visible if the player gives the correct answer. Figure 3 contains screenshots of the practice feature of the game.

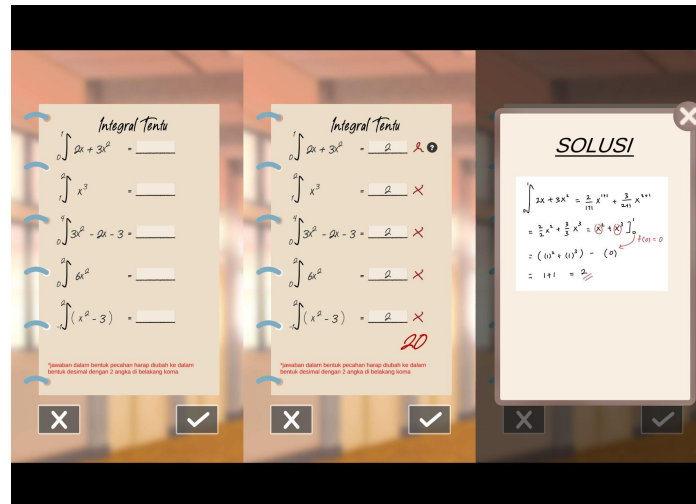


Fig. 3. Practice feature

4 Discussion

The game was evaluated by distributing the "7-Day Math" game download link along with a questionnaire link. The questionnaire was made using HMSAM to measure immersion and behavioural intention to use. The target respondents are senior high school students in grades 11 and 12. Forty-six students from 39 different high schools in Indonesia have filled out the questionnaire.

Based on Table 2, the game received positive feedback across all HMSAM components. Each component has an average value higher than 80%. Students strongly agree that the game has a straightforward user interface and is easy to understand. The results also show that the curiosity component gets the highest average percentage of 86.31%. This means that the students strongly agree that the storyline of this game made them curious. The average value for other components, such as joy and perceived usefulness, is 83.57% and 83.61%, respectively. The average value for behavioural intention to use is 84.28%. This means respondents strongly agree that they want to play the game again. The average value for control is 84.56%, and the average value for immersion is 82.09%. This means respondents strongly agree that they feel immersed in the game.

Table 2. Questionnaire result with HMSAM modelling

| No | Category | Average | Description |
|----|------------------------------|---------|----------------|
| 1 | Control | 84.56% | Strongly Agree |
| 2 | Perceived ease of use | 85.74% | Strongly Agree |
| 3 | Joy | 83.57% | Strongly Agree |
| 4 | Immersion | 82.09% | Strongly Agree |
| 5 | Curiosity | 86.31% | Strongly Agree |
| 6 | Perceived usefulness | 83.61% | Strongly Agree |
| 7 | Behavioural Intention to use | 84.28% | Strongly Agree |

5 Conclusion

Based on the research, it can be concluded that the visual novel educational game for definite integral titled “7-Day Math” has been successfully designed and developed. Evaluation has been conducted to measure users’ behavioural intention to use and the game's immersion. The game received positive feedback on all components in the HMSAM measurement model. The average value for all aspects is 84.31%. The results obtained show that the visual novel increases curiosity. Students agree that playing the game can increase their interest in learning mathematics. The students enjoyed playing and learning through this game. This can break the negative stigma on mathematics and eventually increase students' understanding of the material. Researchers also found that the students feel immersed when playing this game and desire to play again. This game is highly recommended for use by students in Indonesia in learning definite integrals.

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8 Authors

Jennie Florensia is a student at the Department of Informatics, Universitas Multimedia Nusantara, Indonesia. She has an interest in 2D and 3D game development (E-mail: jennie@student.umn.ac.id).

Alethea Suryadibrata is a lecturer at the Department of Informatics, Universitas Multimedia Nusantara, Indonesia. Her primary teaching and research interests include digital image processing, computer graphics and animation, applied artificial intelligence, machine learning and game. She has published several research articles in the International Journal of Advances in Soft Computing and its Applications; the International Journal of Interactive Mobile Technologies; the International Journal of Advanced Trends in Computer Science and Engineering; the Journal of Information and Communication Convergence Engineering; and International Journal of New Media Technology (E-mail: alethea@umn.ac.id).

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