Educational Simulating Game “Plant the Tree” in Virtual Reality for Elementary Student

Endah Sudarmilah, Fildza Nur Sabrina

Abstract—The educational game is currently an alternative that aims to carry the concept of playing while learning for students. Advanced technology for education not potentially helps only for the deforestation problem but also for the education system such as using the educational game for teaching method. Many elementary school students still do not know about floras around them because most school does not focus on the flora topic in the environment. This research aims to build an educational game based on the Android VR using Unity 3D to introduce and build a sense of students caring on the environment. The benefit of VR is that the student will not feel bored with the offered concepts and make the absorption process of learning more effective. Using Game Development Life Cycle (GDLC) as the method consist of observation, data analysis, and questionnaire to find out the distance of the student’s insight of flora and will be used as the starting point of this game development. After the game was implemented in the Madrasah Ibtdia’yah Muhammadiyah (MIM) Gonilan involving a total of 32 students, the obtained results shown based on the System Usability Scale (SUS) calculation is 62. The results of this score indicate that the use of VR for education has not been fully effective due to various factors such as the hardware used or the mismatched software.

Index Terms—Android, Education, Environment, Game Development, Technology, Unity 3D, VR.

1 INTRODUCTION

A LONG with the development of the times, the utilization of IT (Information Technology) in a variety of areas has climbed to a higher level. Each individual indirectly claimed to always use IT in all activities of both professions as well as daily activities [1]. Including the field of education, according to Agus Mulyanto [2] the use of IT in this field allows students to learn as well as to add insight into the development of the nowadays technology. IT role in education is constantly undergoing development [3].

VR (Virtual Reality) technologies assessed for effective learning because it does not use the physical form (books) and can reduce the amount of use of natural resources [4]. VR is aimed to provide an experience of an artificial world and artificial reality [5]. This technology has now caught the attention of the general public because of its facilities and the benefits, in other words, the user can feel more realistic playing experience [6].

A simulation game is a genre of games that let players become a part of the game directly as a Main Character. Simulation games do not give excessive actions like Action Games, but rather to the controlling the given authority to the player [7]. Simulation Game is generally used for serious purposes of some special areas such as military, medical, industrial or transportation that is not earmarked for the public [8]–[10].

VR provides an experience that involves emotional and cognitive experience that will gives many advantages to education like immersive feeds and generates learning opportunities for education [11], [12]. Immersion is more popular than flow across academics and non-academics alike [13] because of its benefits for learning: VR can create far objects and physically virtual into something tangible, VR also avoids the student from the potentially harmful field and thanks to VR approaches [14]. As described above, the example of the implementation of VR for education is “Plant the tree” game. This is a VR-based simulation game implemented in Android platform because the ease of opensource that makes it easy for developers to make applications that are good for business applications, security, utilities and games [15]. Features and amenities such as provide players a new learning experience that will not make the student feel bored with the offered concepts, make the absorption process of learning more effective, and giving the value of appreciation for the environment to the students are the major points in the development of this game.

2 METHODS

This game is developed by using the method of GDLC (Game Development Life Cycle) which stages can be seen in Figure 1.

2.1 Initiation

The initiation step is the beginning of the creation of the concept or idea such as themes and genres, it takes several
tools in making the VR game shown in Table 1.

Components such as concept, genre, title and storyline based on GDD is shown in Table 2.

<table>
<thead>
<tr>
<th><strong>TABLE 1</strong></th>
<th><strong>TOOLS AND MATERIALS</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hardware</strong></td>
<td><strong>Software</strong></td>
</tr>
<tr>
<td>Lenovo Z40 Intel® Core™ i5-4210U CPU @1.70GHz 2.40 GHz</td>
<td>Unity 3D</td>
</tr>
<tr>
<td>VR BOX 2nd Generation</td>
<td>Corel Draw X8</td>
</tr>
<tr>
<td>Bluetooth VR Remote</td>
<td>Adobe Photoshop CC 2018</td>
</tr>
</tbody>
</table>

2.2 Pre-Production
Pre-production is where the output data from the initiation step is being developed and analyze, this step focusing on background design, character designing, object design and any other needs for the software.

2.2.1 Use Case and Activity Diagram
The use of use case and activity diagrams can produce a test case with better coverage [16]. The Use case and Diagram Activity of this game are shown in Figure 2 below.

<table>
<thead>
<tr>
<th><strong>TABLE 2</strong></th>
<th><strong>GAME ANALYSIS BASED ON GDD (CONTINUED)</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Game Flow Summary</td>
</tr>
<tr>
<td>1)</td>
<td>When opening the app game, the first appearing display is the main menu contains the menu UI, “PLAY”, “SETTING” &amp; “QUIT”.</td>
</tr>
<tr>
<td>2)</td>
<td>When the player select the “SETTINGS” menu, a pop-up menu of configuration contains the volume of the sound and music appears</td>
</tr>
<tr>
<td>3)</td>
<td>When the player choose the “QUIT” menu, then the game will be closed.</td>
</tr>
<tr>
<td>4)</td>
<td>When the player select “PLAY” menu, a pop-up menu containing the confirmation to play games will appear. When the player select “Yes”, then the game will begin at level 1.</td>
</tr>
<tr>
<td>5)</td>
<td>After the player goes into level 1, the first thing the player should do is looking for a NPC (Non-Playable Character) that exists there, and the NPC will tell about the place.</td>
</tr>
<tr>
<td>6)</td>
<td>The NPC will give the player a small mission in order to obtain the tools needed for planting.</td>
</tr>
<tr>
<td>7)</td>
<td>After the player successfully completes the mission, NPC will give the player watering can. And the player must find a suitable place to plant. Once the player has successfully planted a tree, a reward will appear containing exp point and drop items such as new plant seedlings before going to the next level.</td>
</tr>
</tbody>
</table>

| 7 | Look and Feel |
| This game will be customizing a children's imagination by using colors, assets, an attractive environment (bright colors) and does not have a heavy situation like a serious game. The visual style of the game is cel-shaded, a type of non-photorealistic rendering designed to make computer graphics 3-D look flat by using fewer colors than the shadow tint. |
2.2.2 Storyboard
A storyboard is a navigation and structure flowchart application diagram that illustrates the flow of the application [17]. The storyboard is shown in Table 3 below.

2.3 Production
This step discussed about the assets making, arrange game object, sound adding and coding process happens to make the game runs properly. After the development process which already described in part 2.2, mini-trial will start to identify errors and bugs.

2.3.1 Assets Making
Unity provides free assets for novice developers instead of creating 3D assets from scratch. Another software is Corel Draw and Adobe Photoshop to create the User Interface (UI) and other images such as Main Menu, Inventory, Reward, Dialogue, and Items.

2.3.2 Arrange Assets, Music and Sound Effects
As the genre is adventure-fantasy, exciting - fun music and sound are obtained from free music provider website that suits the student is required in order to make the player feel challenged. All assets and music are being organized into the desired game scene by drag and drop each object.

2.3.3 Coding Process
The programming language used C# because of its ease and flexibility compared to JS. The script added to the desired object, for example levitating ship, walking player, and NPC dialogue.

2.4 Testing
Blackbox testing is functional testing based on requirement and design specification of the games and aims to ensure the game flow already in accordance with the flowchart SUS used to determine the output from the prospective user after playing the game.

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**TABLE 3. STORYBOARD WIREFRAME (CONTINUED)**

<table>
<thead>
<tr>
<th>No</th>
<th>Figure</th>
<th>Description</th>
</tr>
</thead>
</table>
| 4. | ![Diagram](image1.png) | Item Acquired  
Player will receive items as the player clears the mini-game.  
NPC will guide to search the plantation area. |
| 5. | ![Diagram](image2.png) | Plant Info  
When the player clicks one of the available trees, plant info will show up. Click “CLOSE” to start planting the tree (the tree is automatically planted). |
| 6. | ![Diagram](image3.png) | Reward  
When the player cleared the game, the player will receive exp and seed reward to be used in the next level. |

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2.2.2 Storyboard

![Diagram](image4.png)

Table 3. Storyboard Wireframe (Continued)

<table>
<thead>
<tr>
<th>No</th>
<th>Figure</th>
<th>Description</th>
</tr>
</thead>
</table>
| 1. | ![Diagram](image5.png) | Main Menu  
BGM: menu.wav  
SFX: buttonclick.wav  
There are three buttons: Play, Settings and Quit.  
Background: Trees scenery |
| 2. | ![Diagram](image6.png) | Settings  
Consists of Music and sound effect setting.  
- Could be modified.  
- Save button to automatically save the setting. |
| 3. | ![Diagram](image7.png) | NPC  
NPC will guide the player to conquer tools by clearing mini-game |

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Fig. 2. (a) Game Use Case and (b) Diagram Activity
2.5 Beta Version
This stage involves external parties for testing and feedback systematically and procedurally to be reviewed by the developer and look for errors that can be fixed [18]. This stage will be followed by the alpha version before the official release.

2.6 Release
This step comes after checking of alpha and beta version where the final version of the completed and tested game ready to be officially released to the public.

3 RESULTS
The achieved results from this research are the VR based educational game on Android "Plant the Tree" which focused for elementary school students to enhance insight into trees as well as instilling a sense of concern for the environment. This game requiring three major hardware, there are VRBOX, VR Bluetooth Remote, and Android Smartphone.

3.1 User Interface

3.1.1 Main Menu
When the application opened, there will be Unity logo splash screen. The main menu consisting of three main buttons:

a) “Main” button, when the button clicked the confirmation window will pop out before the player could get into the game.

b) “Pengaturan” button, when this button is clicked, a window consisting music and SFX volume setting will pop up and saved.

c) “Keluar” button, to quit the game

3.1.2 Level Selection
In this menu, the player can choose the desired level to be played out of the three available levels with different biomes shown in Figure 4 below.

3.1.3 Game Play
After selecting a level, the player will go into the game. There are three stages in playing this game.

a) NPC Search
The first thing to do is seek the Non-Playable Character (NPC) before playing the mini-game. The NPC will give the player a mission to collect several items.

b) Mini Game
After the player given a mission by the NPC, the player must collect objects that are in the mini-game as shown in the Figure 6 below.

c) Planting Tree and Rewards
After receiving the items, the player must find a place to plant. The player could choose one out of three trees available. After successfully planting trees the player will level up and obtain a seedlings reward which will be used in the next level as shown in Figure 7 below.

This test is done to determine whether the application can run properly in accordance with its functions shown in the Figure 8 and the Table 4 below.

Fig. 3. The interface of the main menu buttons.

Fig. 4. Levels available in the game. When the player completes a level, a new level that was previously locked will be opened.

Fig. 5. NPC Search interface

Fig. 6. Mini-Game interface. After collecting all the items, the player will return to the biomes and talk to NPC to receive the reward item.

Fig. 7. Planting tree and reward interface

Fig. 8. Interface Implementation on a Smartphone
3.3 User Acceptance Rate Testing (Usability)

Prospective users are asked to fill out a questionnaire involving 5th grader of MIM Gonilan with a total of 32 students. The following is the SUS formula.

\[ x = \frac{\sum x}{n} \]

\[ x = \frac{\text{Average Score}}{\text{So}}, \]

\[ \Sigma x = \text{SUS Total Score} \]

\[ n = \text{Respondent Total} \]

**TABLE 4**

<table>
<thead>
<tr>
<th>No</th>
<th>Test Case</th>
<th>Input</th>
<th>Output</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Play button</td>
<td>Gaze click the “Main” button</td>
<td>Get into the game</td>
<td>Success</td>
</tr>
<tr>
<td>2</td>
<td>Quit button</td>
<td>Gaze click the “Kolam” button</td>
<td>Quit the game</td>
<td>Success</td>
</tr>
<tr>
<td>3</td>
<td>Settings button</td>
<td>Gaze click the “Pengaturan” button</td>
<td>Open settings containing music and SFX</td>
<td>Success</td>
</tr>
<tr>
<td>4</td>
<td>Level selection button</td>
<td>Gaze click the level selection on map scene</td>
<td>Open the desired level</td>
<td>Success</td>
</tr>
</tbody>
</table>

The System Usability Scale (SUS) formula is described in Table 5 below.

**TABLE 5**

<table>
<thead>
<tr>
<th>No</th>
<th>SUS Counting Score</th>
<th>Total SUS Score (Total * 2.5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5 2 4 1 2 3 2 3 4 2 26 65</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>4 4 4 1 4 4 4 4 4 1 54 85</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0 2 5 1 3 3 3 3 2 22 55</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>3 4 5 0 3 4 4 4 1 29 73</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>3 0 3 2 2 1 2 3 2 17 43</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>3 4 2 1 4 3 2 3 0 26 65</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>2 0 0 1 3 1 0 1 0 0 8 20</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>3 3 3 4 3 3 3 3 3 31 78</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>3 3 4 3 3 4 3 3 3 31 78</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>3 3 4 1 3 3 4 4 4 33 83</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>4 2 1 4 4 4 4 4 1 27 68</td>
<td></td>
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<tr>
<td>12</td>
<td>4 4 0 3 4 4 4 4 0 30 75</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>3 3 5 3 3 2 3 3 1 28 65</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>0 0 0 0 4 0 0 0 0 0 0 8 20</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>3 3 4 1 3 3 4 4 4 33 83</td>
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<td>3 2 1 2 2 3 3 4 1 24 60</td>
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<tr>
<td>19</td>
<td>1 1 1 1 1 1 1 1 1 17 43</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>0 1 3 2 4 1 4 3 1 22 55</td>
<td></td>
</tr>
</tbody>
</table>

Q7. I would imagine that most people would learn to use this system very quickly.

Q8. I found the system very cumbersome to use.

Q9. I felt very confident using the system.

Q10. I needed to learn a lot of thing before I could get going with this system.

After testing with a total of 32 students from MIM Gonilan, the results obtained from the use of the System Usability Scale (SUS) formula as shown in Figure 9 below.

![Fig. 9. SUS Score Graph](image)

4 CONCLUSION

It can be concluded that the making of the game “Plant the Tree” has been successfully completed but the purpose of this game designing is not fully achieved, this is caused by several factors such as some students complains of dizziness because they are unfamiliar with the virtual environment and lack of hardware specifications, proven by the conducted implementation in MIM Gonilan involving 32 students on 5th grade. The results of the SUS based calculation is 62, while a minimum score to be accepted is 71.4. Thus, this game arguably has not been good enough, neither is bad.

REFERENCES


