Development of Mobile Game Application : "Saving Endangered Flora"

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Abstract: "Saving Endangered Flora" is an educational game for users to gain knowledge about endangered flora. Research on existing mobile games found issues related to poor interface design, limited content explanation about endangered flora, and sound problems. The main objective of the project is to design a mobile game-based learning which emphasis about endangered flora. Game Development Life Cycle (GDLC) model used as the methodology basis and Unity as the development tool. C# language is used to codes the game mechanisms. The design part is well-supported by Adobe Illustrator, which creates the assets of the mobile game. A total of 10 children participated in the Beta Testing. In terms of learning outcome acquisition, 80% of respondents agreed that they learn about endangered flora from this game, and 70% of respondents agreed that they know the reason for the decrease of endangered flora. Most of the respondents give positive feedback in interface design, game instructions and overall gameplay experience. Overall, this "Saving Endangered Flora" game had a good outcome and is well accepted by the target users.

Keywords: Endangered Flora, Mobile Game, Game-Based Learning

1. Introduction

Endangered flora refers to flora species threatened with extinction due to massive deforestation, illegal logging, human overpopulation, and climate change. However, human activities which accelerating environmental change cause an increase in temperature due to open burning. Public awareness is considered as one way to protect endangered flora [1]. Many printed and online campaigns are executed by the government authorities and non-government organisations to increase awareness among citizenship. However, the awareness among youth and children still needs to be widespread by implementing the latest technology as an indirect campaign method.

An educational game could play an important role in increasing their awareness and knowledge of endangered flora. It is characterised as a directions strategy that requires the learner to take an interest in competitive action with preset rules [2]. Research on existing similar mobile games through Google Play found out that there are many mobile games or applications related to endangered flora. Several

issues found in the current related mobile application are including poor user interface design, lack of appropriate content related to explaining endangered flora, and sound settings.

Therefore, this paper discussed the development of a mobile game named "Saving Endangered Flora". Mainly, the purpose of this project is to provide an alternative medium for users to learn about endangered flora while having fun. This "Saving Endangered Flora" implements game-based learning. Android mobile platform is used as the development platform, supported by Unity as the integrated development environment (IDE). The functionalities and acceptance of the "Saving Endangered Flora" mobile game were tested on the target users aged between 7 years old to 12 years old.

The interface design "Saving Endangered Flora" follows the metaphors of a local jungle's environment. The gameplay is characterised by the side-scrolling perspective that shows the movement of the game character as a scientist to the right and left of the screen. Users can click the start button to start the game. After the user started the game, a storyline is displayed on the screen. Then, the user can click the skip button to skip the storyline. The user needs to start from level 1, then the next level will be unlocked when the user completes the game. Instruction of the game will show on each level. The user needs to collect a certain number of endangered flora in a limited time to complete the game. A successful message will be popped up when the user completes the level, while a failed message will be popped up when the user failed to complete the game. Besides, a learning module will be popped up when the user meets with the scientist character. Matching Game and Quiz Game will be popped up during the user collect the endangered flora.

Section 2 would explain the related work that includes game-based learning, and a comparison of related mobile games. Section 3 would explain the Game Development Life Cycle (GDLC) model used in this project. Section 4 would explain the result of user acceptance level and section 5 would explain the conclusion of this project.

2. Related Work

This section would discuss the game-based learning, and comparison of related mobile games with the proposed mobile game.

2.1 Game-based Learning

Game-based learning is the use of current games or specially developed serious games to learn something or to achieve a specific learning outcome[3]. Learning is the result of playing games, which encourages critical thinking and problem-solving abilities. Game-based learning can include both digital and non-digital games, as well as simulations that provide learners with a hands-on experience with the topic. The benefit of game-based learning is that it allows users to experiment and get instant feedback about their behaviour. Furthermore, game-based learning can keep the attention of users for a long time because of immersive and interesting game settings. Therefore, game-based learning is considered an effective learning method.

On the other hand, the drawback of game-based learning is that it needs the involvement of a facilitator, such as a peer, instructor, or teacher, to appropriately facilitate game-based learning. As a result, the facilitator should be well on the game being used. Furthermore, game-based learning might encourage learners to shift their attention from learning to winning, especially if the rewards are more significant.

2.2 Comparison of Related Mobile Games

There are three existing mobile games chosen to be reviewed and compared in this section. The selected applications are Flora Study, Endangered Species Guess Game, and Plant Rescue. The comparison is based on various aspects such as developer, platform, languages, game style, strength, and weakness. The comparison is tabulated in Table 1.

Table 1: Comparison between mobile game

Title	Flora Study [4]		Endangered Species Guess Game [5]		Plant Rescue [6]		"Saving Endangered Flora"	
Icon								
Developer	-	Frendy	-	Family Group App	-	Neeraj Singh	-	Tan Siao Tian
Platform	-	Android	-	Android	-	Android	-	Android
Language	-	English	-	English	-	English	-	English
	-	РУССКИЙ (Russian)						
Game style	-	Simulation,	-	Trivia	-	Puzzle	-	Puzzle
	-	Action & Adventure					-	Educational
							-	Role-playing
Strength	-	Free to play	-	Free to play	-	Free to play	-	Free to play
	-	Provide tutorial	-	Provide a function for users to ask	-	Background can change	-	Contain endangered flora content
	-	Provide many options for user change setting			-	Has 2 modes for users to choose	-	Has storyline
Weakness	-	Lack of endangered flora contents	-	Lack of endangered flora contents	-	Lack of endangered flora contents	-	Only cover 6 levels in the game module
	-	The button is hard to see as the colour is white	-	Did not contains the main interface	-	The sound button turns off both the sound effects and the background music		
	-	Hard to play	-	Did not provide background music				

Based on the comparison of Table 1, the "Saving Endangered Flora" is an educational game with a combination of role-playing games and puzzle It can provide information about the endangered flora and a storyline. It is also supported by the Android platform and is free to play. Furthermore, the "Saving Endangered Flora" only consist of 6 levels.

3.   Methodology

Game Development Life Cycle (GDLC) model [7] acts as the methodology was used in this project to achieve the objective of this project. The GDLC model is including in 6 phases, which are the Initiation phase, Pre-production phase, Production phase, Testing phase, Beta phase and Release phase. The tasks of each phase are explained in sub-section 3.1 to 3.6.

3.1   Initiation Phases

The initiation phase is the first phase of the GDLC model. The first step in game development is to outline a rough idea of what kind of game will be created [7]. The problem statement, objective, and project scope have been determined in this phase. In the initiation phase, a "Saving Endangered Flora" mobile game was decided to develop. The target user of "Saving Endangered Flora" is the user between

the ages of 7 to 12 years old. The game style that has been chosen is a role-playing game, educational and puzzle.

3.2 Pre-production

Pre-production is a design phase in game development. This phase involves creating and reviewing the game design and prototyping the game [7]. In the pre-production phase, the user requirement analysis, concept art, storyboard, and flowchart were produced. The details are explained in sub-section 3.2.1 to 3.2.4.

3.2.1 User Analysis

The user analysis has been tabulated in Table 2 after conducting a questionnaire to the target users by using Google form.

Table 2: User analysis

Stakeholder Category	Role in product	Design implications	Actions Needed
General user	End-user of the system	Based on the questionnaire, • Can play at any time, and anywhere	• Develop game with offline mode. • Develop game with mobile-based on Android platform.
		• Prefer English version	• Develop a game in English Languages.
		• It is fun and easy to play	• Provide the storyline for the user. • Provide clear instruction. • Develop a simple game style.
		• Game with valuable contents	• Provide knowledge about endangered flora. • Provide awareness messages through the game.

According to Table 2, the data indicates that the "Saving Endangered Flora" should include valuable content and it is fun and easy to play. Besides, it is recommended to develop the "Saving Endangered Flora" in English. Lastly, the "Saving Endangered Flora" can play at any time and anywhere.

3.2.2 Requirement Analysis

In this section, the functional requirement and non-functional requirement are mentioned about "Saving Endangered Flora". The functional requirement and non-functional requirements have been tabulated in Table 3 and Table 4.

Table 3: Functional requirements

No	Functional Requirements
1	The mobile game should allow the user to adjust the volume of background music and sound effect.
2	The mobile game should allow the user to exit the game.

3	The mobile game should allow the user to return to the main interface.	
4	The mobile game should allow the user to access the setting interface	
5	The mobile game should allow the user to clear all the progress.	
6	The mobile game should allow the user to skip the storyline.	

Table 4: Non-functional requirements

No	Non-functional requirements	Description
1	Implementation	The mobile game should be able to access any android mobile-based platform.
2	Usability	The mobile game should be developed in the English Language. The button should be designed in light orange colour with a red border. The close button should be designed in red colour. The font type of the mobile game should be Sans serif.
3	Reliability	The mobile game should be accessible by the user at any time.
4	Performance	The response time of the mobile game should be within one second.
5	Security	The mobile game should allow the user to view the information in the mobile game only, cannot modify the data.

Table 4 shows the non-functional requirements for the "Saving Endangered Flora" can be classified into implementation, usability, reliability, performance, and security. The mobile game should include the stated requirements to ensure that it performs and function properly without any unexpected errors.

3.2.3 Flowchart

A flowchart is a structured graphic representation of a logical sequence, work or production process, flowchart, or similarly formalized structure. A flowchart aims to provide everyone with a common language or point of reference when it comes to a project or process. The flowchart of "Saving Endangered Flora" would be shown in Appendix A.

3.2.4 Storyboard

A storyboard is a guide or reference that can provide a more detailed image of how to develop a mobile game. Storyboarding is a great way to learn more about gameplay, mission progression, or bugs in a particular part. Therefore, the storyboard "Saving Endangered Flora" was designed for this purpose and is attached to Appendix B.

3.3 Production

In this phase, the game assets and source code are produced. The Adobe Illustrator was used to develop the graphic assets and Unity will be used to write the source code. The storyboards and flowchart deliverables from the previous phase were used to guide the preparation of the graphic resources and the development of "Saving Endangered Flora". The sub-section 3.3.1 to 3.3.2 would explain the script implemented in Unity.

3.3.1 Show and Hide Game Object

The feature of the show and hide Game Object is often used in Saving Endangered Flora. This feature makes some game objects invisible at the beginning of the game. If the user wants the game object to become visible, they need to click a specific button.

```
public class buttonFunction : MonoBehaviour
{
    public GameObject setMenu, infoMenu, exitMenu;
    // Start is called before the first frame update
    void Start()
    {
        setMenu.SetActive(false);
        infoMenu.SetActive(false);
        exitMenu.SetActive(false);
    }

    public void setButton()
    {
        setMenu.SetActive(true);
        infoMenu.SetActive(false);
        exitMenu.SetActive(false);
    }

    public void exitButton()
    {
        setMenu.SetActive(false);
        infoMenu.SetActive(false);
        exitMenu.SetActive(true);
    }

    public void infoButton()
    {
        setMenu.SetActive(false);
        infoMenu.SetActive(true);
        exitMenu.SetActive(false);
    }

    public void closeButton()
    {
        setMenu.SetActive(false);
        infoMenu.SetActive(false);
        exitMenu.SetActive(false);
    }
}
```

Figure 1: Script attached on scene_manager game object

Figure 1 shows the script of show and hide Game Object. There are 4 functions, namely setButton(), infoButton(), exitButton() and closeButton(). SetActive (false) is used to make the Game Object invisible, whereas SetActive (true) makes the Game Object visible.

3.3.2 Player controller

```
public void moveLeft()
{
    if(GetComponent<Animator>().GetCurrentAnimatorStateInfo (0).IsName("player_idle"))
    {
        GetComponent<Animator>().SetTrigger("jalan");
    }
    transform.localScale = new Vector3(-scaleX, transform.localScale.y, transform.localScale.z);
    transform.Translate (Vector3.left * speed * Time.fixedDeltaTime, Space.Self);
}

public void moveRight()
{
    if (GetComponent<Animator>().GetCurrentAnimatorStateInfo(0).IsName("player_idle"))
    {
        GetComponent<Animator>().SetTrigger("jalan");
    }
    transform.localScale = new Vector3(scaleX, transform.localScale.y, transform.localScale.z);
    transform.Translate (Vector3.right * speed * Time.fixedDeltaTime, Space.Self);
}

public void Jump()
{
    if(GetComponent<Rigidbody2D>().velocity.y == 0)
    {
        GetComponent<Rigidbody2D>().velocity = new Vector2(0, jumpForce);
        GetComponent<Animator>().SetTrigger("jumping");
    }
}

public void Stop()
{
    GetComponent<Animator>().SetTrigger("stop");
}
```

Figure 2: Code snippet of the player controller

Figure 2 shows the script for the player character's movement. This script consists of moveLeft (), moveRight (), Jump () and Stop () functions. This script is attached to the player character for moving and jumping.

3.4   Testing

An alpha testing would be conducted during the testing phase and done by internal testers. The main goal of alpha testing is to observe the "Saving Endangered Flora" prototypes developed in the previous phase and identify the game errors and bug fixes. This phase will help the game developers to know the actual outcome and expected outcome. The functionality of the button is being checked during the alpha testing. If any problems are found during alpha testing, improvements will be made to ensure that the buttons work as expected. The result of alpha testing would mention in below:

Table 5: Result of alpha testing based on button functionality in "Saving Endangered Flora".

Button	Expected Result	Actual Result	Corrective Action
Set Button	Display setting Game Object	Works well as expected.	Not needed.
Info Button	Display info Game Object	Works well as expected.	Not needed.
Exit Button	Display a confirmation message before the game is exited	Works well as expected.	Not needed.
Start Button	To start the game	Works well as expected.	Not needed.
Close Button	Hide the setting Game Object, info Game Object, and exit Game Object	Works well as expected.	Not needed.
YES Button	Exit the game	Works well as expected.	Not needed.
Pause button	Stop the video of the storyline	Works well as expected.	Not needed.
Play Button	Play the video of the storyline	Works well as expected.	Not needed.
Skip Button	Skip the storyline	Works well as expected.	Not needed.
OK Button	Hide instructions Game Object	Works well as expected.	Not needed.
Home Button	Navigate to the main interface	Works well as expected.	Not needed.
Level Selection Button	Navigate to the level selection interface	Works well as expected.	Not needed.
Next Button	Navigate to the next level	Works well as expected.	Not needed.
Repeat Button	Play again the game level	Works well as expected.	Not needed.
Restart Button	Display in the last scene and all progress is cleared.	Can display in the last scene, but it does not operate.	Make it display in the level selection interface.
Move Left Button	Control the character move to the left-hand side with walking animation.	Works well as expected.	Not needed.
Move Right Button	Control the character move to the right-hand side with walking animation	Works well as expected.	Not needed.
Jump Button	Control the character jump with jump animation	Works well as expected.	Not needed.

As shown in Table 5, the alpha test result based on the button function in "Saving Endangered Flora" shows an error. The error is that the restart button can be displayed in the last scene, but it does not work. Therefore, corrective actions have been taken to fix the errors found in the alpha testing.

3.5 Beta Version

Unlike alpha testing, beta testing is done by external testers. The beta testing involved target users who are aged between 7 to 12 years old. This was to identify any remaining bugs that were missed during alpha testing and to get comments and feedback on the game from external testers. The result of beta testing would explain in section 4.

3.6 Release Version

The release phase is the final phase of the GDLC model. After some well-defined planning and a lot of testing by developers and end-users, the game will be completed. If the game is free of errors and bugs it can be released to the market.

4. Results and Discussion

The user acceptance testing model used in this process is the technology acceptance model (TAM) and carry out to evaluate 3 variables, which are learning outcome acquisition, user acceptable level and functionality of "Saving Endangered Flora".

Table 6: Measured item based on technology acceptance model (TAM) [8]

Construct	Evaluation Variables	Measured Item
Perceived of Usefulness (PU)	Learning Outcome Acquisition	PU1: I learn what is the endangered flora from this game. PU2: I know the reason for the decrease in endangered flora.
Perceived Ease of Use (EU)	User Acceptable Level	EU1: I think the interface design of "Saving Endangered Flora" is beautiful. EU2: I think the game provides clear instruction. EU3: I enjoy playing the game as it is fun.
Attribute of Usability (AU)	Functionality	AU1: I can understand the function of each button in the game. AU2: I think everything about "Saving Endangered Flora" is good and error-free.

Beta testing is to get feedback from target users based on their experience when they are playing "Saving Endangered Flora". A set of questionnaires are prepared on Google Form. The automatically generated graphs and charts can make data analysis easier and more efficient without human error. The analysis of the beta testing is shown below:
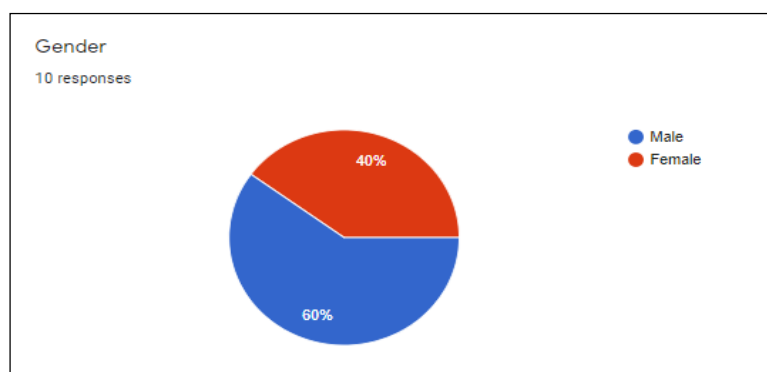

Figure 3: Analysis of gender

Figure 3 show the analysis of gender. A total of 10 children participated in the beta testing. There are 4 out of 10 respondents (40%) are girls and 6 of them (60%) are boys involved in the testing process.
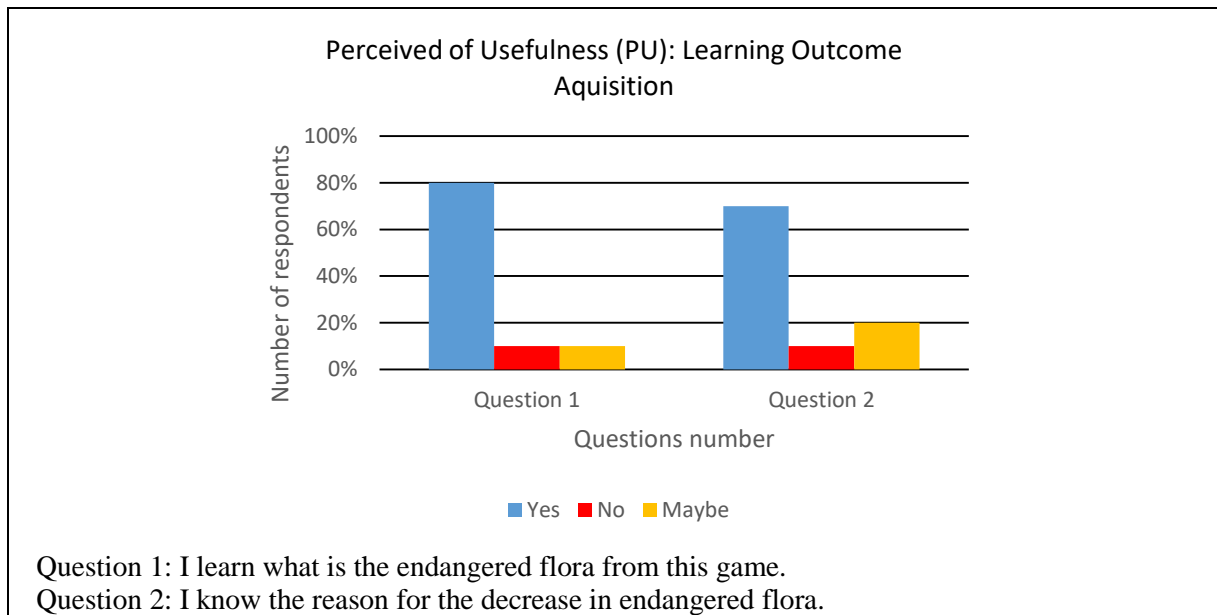
Figure 4: Analysis of learning outcome acquisition

Figure 4 shows the analysis of learning outcome acquisition. In response to question 1, 80% of respondents replied "Yes", 10% of respondents replied "No", and 10% of respondents replied, "Maybe". In response to question 2, 70% of respondents replied "Yes", 10% of respondents replied "No", and 20% of respondents replied, "Maybe". According to the findings, a large portion of the respondents gave a positive response, meaning that the "Saving Endangered Flora" had a good learning result.
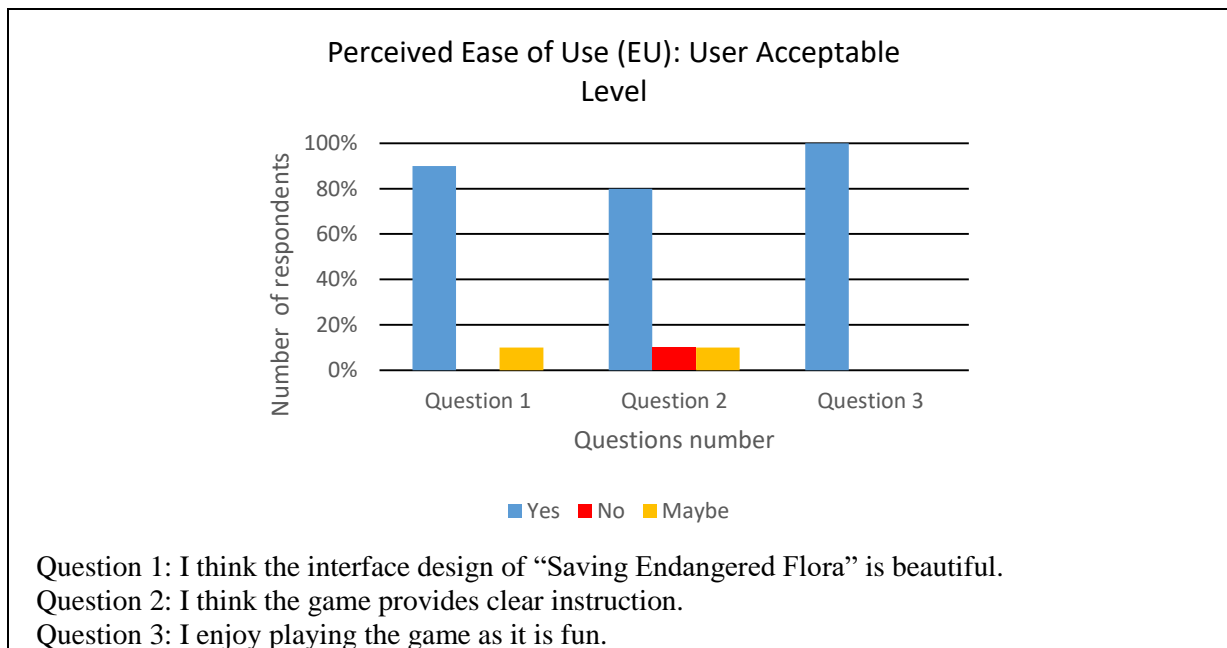
Figure 5: Analysis of user acceptable level

Figure 5 shows the analysis of the user acceptable level. In response to question 1, there are 90% of respondents replied "Yes", and 10% of respondents replied, "Maybe". No respondent replied "No". In response to question 2, 80% of respondents replied "Yes", 10% of respondents replied "No", and 10% of respondents replied, "Maybe". In response to question 3, all the respondents are replied "Yes" According to the findings, most of the respondents agreed that "Saving Endangered Flora" provides a beautiful interface, clear instructions, and enjoyed playing the game because it was fun.
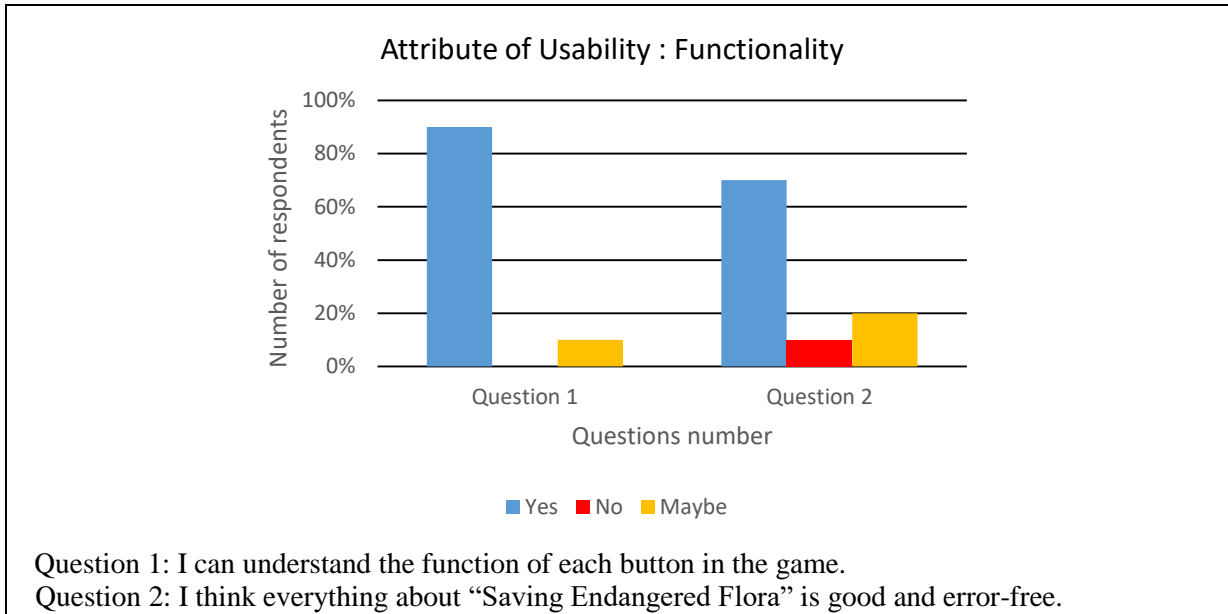
Question 1: I can understand the function of each button in the game.
Question 2: I think everything about "Saving Endangered Flora" is good and error-free.

Figure 6: Analysis of functionality

Figure 6 shows the analysis of functionality. In response to question 1, there are 90% of respondents replied "Yes", and 10% of respondents replied, "Maybe". No respondent replied "No". In response to question 2, 60% of respondents replied "Yes", 10% of respondents replied "No" and 20% of respondents replied, "Maybe". From this result, most of the respondents agreed that they can understand the function of each button and everything about "Saving Endangered Flora" is good and error-free.

5.   Conclusion

Several advantages are found in the "Saving Endangered Flora". Firstly, the "Saving Endangered Flora" provides information about endangered flora for the children to learn. Besides, "Saving Endangered Flora" was developed in simple English. Furthermore, the "Saving Endangered Flora" provides a storyline in the form of a video. Lastly, the "Saving Endangered Flora" provides a good game interface.

However, several limitations are also found on the "Saving Endangered Flora". The first limitation is "Saving Endangered Flora" has only 6 levels. Besides, "Saving Endangered Flora" only supports the Android platform. Lastly, the sound effects and animations used in "Saving Endangered Flora" are not enough.

Finally, some future works are suggested to enhance the "Saving Endangered Flora". The future work suggested is added more game levels to "Saving Endangered Flora" for children to learn. The next suggestion is to attempt to build "Saving Endangered Flora" for a different platform, such as iOS, and PC. The last suggestion is to add more sound effects and animation. For example, when time is running out, it makes an urgent sound effect to serve as a warning.
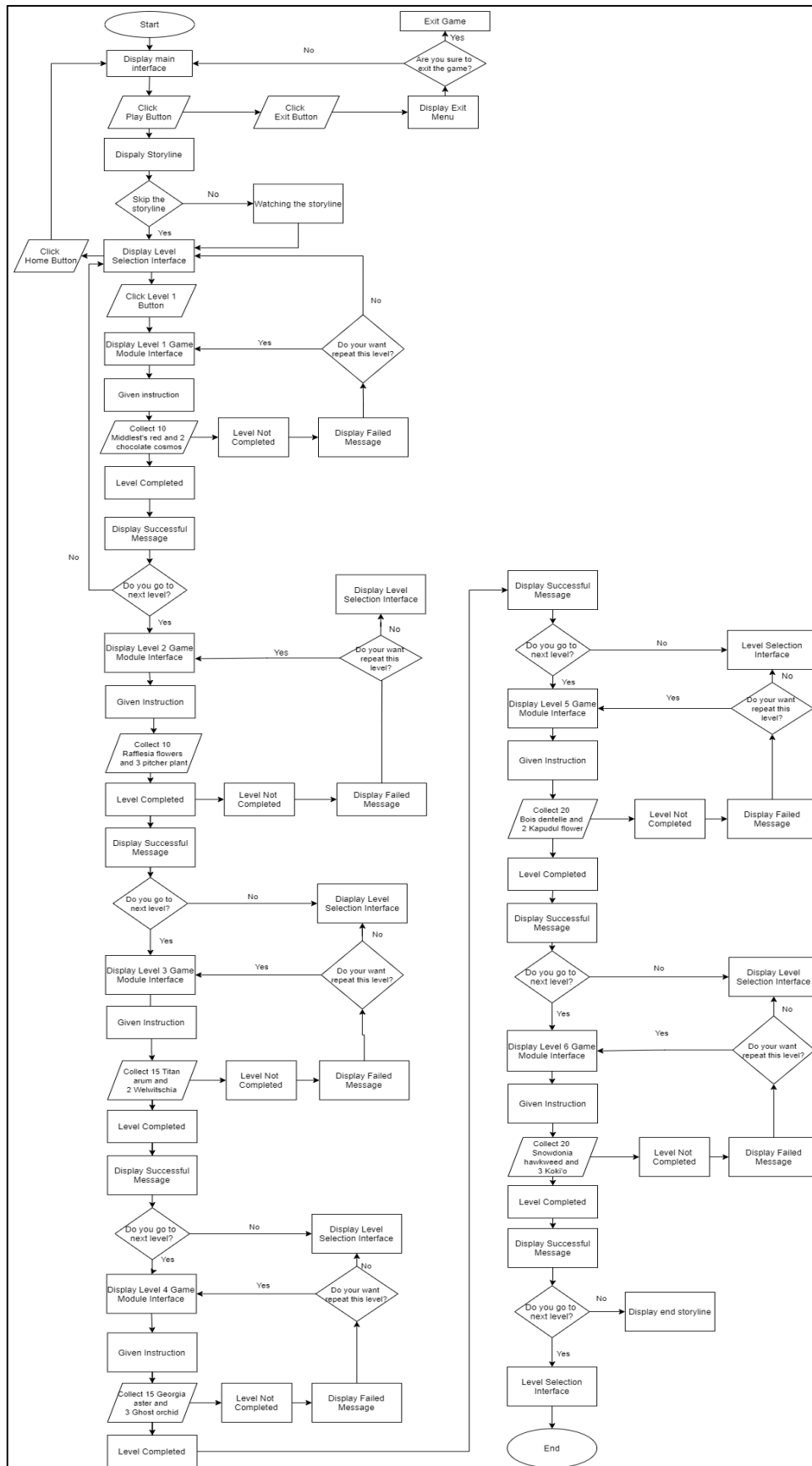
Acknowledgement

Appendix A

Figure 1: The Flowchart of "Saving Endangered Flora"

Appendix B

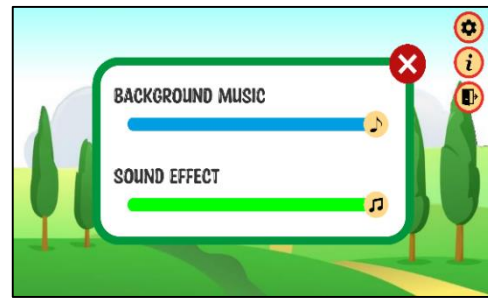**Figure 2: Main Interface**

Figure 3: Setting Interface
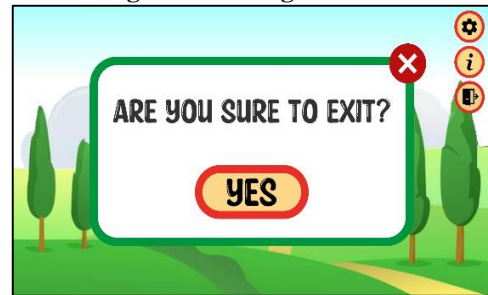

Figure 4: Information Interface

Figure 5: Exit Interface
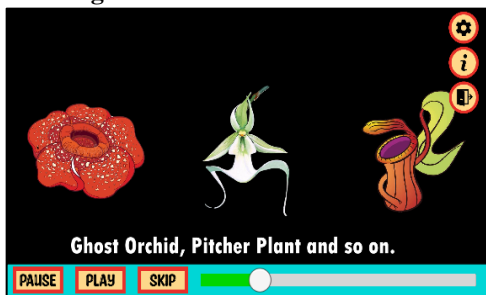

Figure 6: Storyline Interface
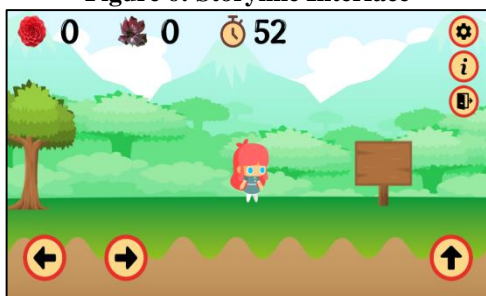

Figure 7: Level Selection Interface
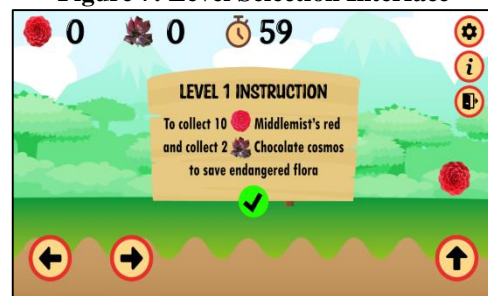

Figure 8: Game Module Interface

Figure 9: Instruction Interface

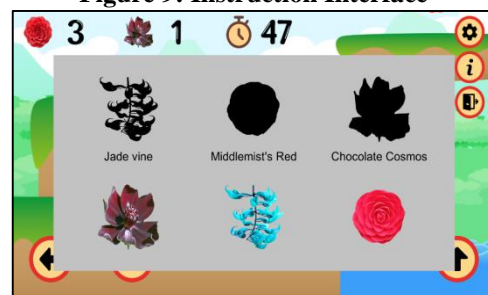**Figure 10: Learning Module Interface**

Figure 11: Matching Game Interface

Figure 12: Quiz Game Interface

Figure 13: Successful Message Interface

Figure 14: Failed Message Interface

Figure 15: End Storyline Interface

References

[1]   C. E. Vincenot, A. M. Collazo, K. Wallmo, and L. Koyama, "Public awareness and perceptual factors in the conservation of elusive species: The case of the endangered Ryukyu flying fox", Glob. Ecol. Conserv., vol. 3, pp. 526–540, Jan. 2015, doi: 10.1016/j.gecco.2015.02.005.

[2]   R. Trevino, C. Majcher, J. Rabin, T. Kent, Y. Maki, and T. Wingert, 'The Effectiveness of an Educational Game for Teaching Optometry Students Basic and Applied Science", PLoS One, pp. 1–14, May 2016, doi: 10.1371/journal.pone.0156389.

[3]   T. Laning, "Serious games, gamification and game-based learning: what's the difference?" Grendel Games. 30, Aug 2020. [Online] Available: https://grendelgames.com/serious-games-gamification-and-game-based-learning-whats-the-difference/ [Accessed Jul. 09, 2021].

[4]   Frendy, "Flora Study". Google Play. 30, Jul 2020. [Online]. Available: https://play.google.com/store/apps/details?id=com.frendygames.florastudy&hl=en [Accessed Nov. 21, 2020]

[5]   Family Group APP, "Endangered Species Guess Game". Google Play. 07, Jan 2019. [Online] Available:
https://play.google.com/store/apps/details?id=com.familygroup.endangeredspecies&hl=en [Accessed Nov. 21, 2020].

[6]   N. Singh, "Plant Rescue". Google Play. 13, Aug.2018. [Online] Available: https://play.google.com/store/apps/details?id=com.neerajpro.plantrescue&hl=en [Accessed Nov. 21, 2020].

[7]   R. Ramada and Y.Widyani, "Game development life cycle guidelines", ResearchGate pp. 95–100, Sep 2013, doi: 10.1109/ICACSIS.2013.6761558.

[8]   H. F. Mohd Latip, A. H. Omar, T. M. Jing, and A. Shahrom, "A Questionnaire-based Approach on Technology Acceptance Model for Integrated Multiple Ankle Technology Device on Patient Psychology", *Sains Humanika*, vol. 9, no. 3–2, Jul. 2017, doi: 10.11113/SH.V9N3-2.1267.