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Development of The Last Glacier Mobile Game

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Abstract: Global warming is a worldwide issue observed since the development of the pre-industrial period. This issue affected climate change and increased the temperature of the planet, which continue to affect a series of global issues such as the decrement in the glacier. However, these issues can be controlled and reduced by people who start to learn and be eco-friendly. For instance, answer the question prepared in Level 2, what human activities turn the Earth sick and the question prepared in Level 3, which activities cannot preserve the Earth. Hence, The Last Glacier mobile game delivers knowledge to the youngster from seven years old and above using the gamification approach. Game Development Life Cycle (GDLC) is used to develop The Last Glacier Mobile Game. This application is developed using Unity and Blender and release in Android based. The application is tested by alpha testing and beta testing. By calculated with System Usability Scale (SUS), it has gained positive feedbacks from the target users. 40% of respondents very satisfied with the game, 56.67% of respondents satisfied with the functionality, and 56.67% of respondents satisfied with the performance of the proposed application. In conclusion, the users can learn the effect, activities that cause global warming and the way to preserve the glacier through a gamification approach.

Keywords: The Last Glacier Mobile Game, Game Development Life Cycle (GDLC), Global Warming

1. Introduction

Global warming issue is becoming more critical day by day. The earth is getting warmer, and the temperature increases about 0.8 degrees Celsius over the past 100 years [1]. Global warming happened is mostly due to human activities such as deforestation that carry out these days. This issue will cause the floating ice to melt moreover affected the sea level increase. As the ice melting continuously is in the future, the cities below 30 feet would be underwater. However, prevention is better than before. Thus, the objectives of this project are to design the content of The Last Glacier mobile game by using a gamification approach, develop the game in 2D and 3D environment for Android platform and test the mobile game to the children and teenagers from the age of seven and above by using alpha testing and beta testing.

The Last Glacier Mobile Game is an adventure game with single-player mode and develops in Android based and in English for the players. The project is applied a gamification approach to create The Last Glacier Mobile Game. The gamification approach can be determined as the use of elements and design of games that are not related to the game scenarios [2]. Some of the examples of the element are correct answer and wrong answer message, congratulations message and difficulty levels. The

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gamified learning will attract the users more willing to gain knowledge and improve their interest in learning through the educational game that exists with good design and use of gamification approach.

The game develops with Unity 3D and Blender. Moreover, 3D attractive character is the main character of the game. The game prepares with a storyline and tutorial to guide players play the game. They learn to rescue nature by carrying out some missions at different places successfully. Players can control the movement of the character by using a virtual joystick. Moreover, they can view their character in the third person omniscient. The proposed game attaches with comfortable background, and background music is inserted to help users relax. An easy play mode also designed to provide an effortless environment to users while playing the game.

In addition, the Related work of the proposed application will be discussed in the next section including, background of the case study, gamification approach and comparison of existing application. In Section 3, Game Development Life Cycle (GDLC) as the methodology is applied in the proposed application and studied. The application testing results and discussions are illustrated in Section 4. Last but not least, the overall important content, fulfill objective, limitations and improvements are summed up in Section 5.

2. Related Work

2.1 Background of Case Study

In these few years, global warming had become more serious since the development of the industrial in the last century. Based on the scientist of National Snow and Ice Data Centre (NSIDC), the Arctic sea ice coverage in 2020 is the second-lowest in the 42 years of records. There is only 3.74 million square kilometers are observed in the Arctic [3]. In the past four decades, the Arctic sea ice has lost about two-thirds of its original volume. The melting water fuse with the sea leads to the increment of sea level. This will cause to lose the land-based glaciers and ice helves. Therefore, people should take decisive actions from now to stop global warming through the preservation of nature.

The creation of The Last Glacier Mobile Game is to share the knowledge to preserve the planet, if everyone had noticed the changing of the climate and made a big change. Then, the future environment may be a happy ending instead of a bad ending.

2.2 Gamification approach

There are three levels provided to the users. Each level has a storyline and a tutorial to guide the users to play the game. In Level 1, the users need to challenge a mini running game from the destroyed glacier to the ice breaker. In Level 2, the users explore the map and answer the question about the cause of global warming to the Earth. The correct or wrong message will appear after users answer the question, either true or false. The correct message will show the correct answer message if users answer correctly. However, the wrong message will show to the users if they answer wrong. The next level provides the users to explore the map and answer the question that about the method to preserve the glacier in the world. Same with Level 2, the pop message will appear either user choose correct or wrong solutions that can help to reduce the worsening of the Arctic's environmental issue. Through the exploration in the map, users can feel the body as its territory in the Arctic.

The combination of education and gamification approach has become a new disruptive innovation that supports the users to play and learn at the same time [4]. This situation is killing two birds with one stone to the users. The gamified learning will attract the users more willing to gain knowledge and improve their interest in learning through the educational game that exists with good design and use of gamification approach. As a result, the proper gamification approach that applies in the game will increase the attractiveness of the game to the user.

2.3 Comparison of related application

The features and characteristics of the three mobile applications, Frog on Ice [5], Ice Age Scrat's Nutty Adventure [6] and Artie's World: An Adventure into the Arctic! [7] are compared with The Last Glacier Mobile Game. The comparison result is tabulated in Table 1.

Table 1: Comparison of related application

Element	Frog on Ice	Ice Age Scrat's Nutty Adventure	Artie's World: An Adventure into the Arctic!	The Last Glacier Mobile Game
Content	-Challenge with five bad characters to reign the paramount and defeat the wicked Ice Wizard's plans -Gather coins to exchange items in shop -Graphical response	-Find back the property by collect four legendary Crystal Nuts that decentralized across the land such as icicle, geysers and burning lava -Provide power boost to help the game character jump higher, grab heavier objects and search the Crystal Nuts -Graphical response	-Explore the environment of the Arctic and draw the animals that meet in the map -Drawing feature with a handy dot-to-dot system is provided -Learn and pronounce the name of animals and object in the map -Graphical and audio response	-Learn the knowledge, effect, cause and way to preserve of global warming through storyline and questions that insert in game levels -Each level are start from different storylines -Collect coins to purchase items in shop -Graphical and audio response
Strength	-Booster item can purchase in shop -Free of charge -Instruction is show clearly -Multiple sound effect	-3D content provide attentiveness -Button is consistent in placement and style -Multiple sound effect	-Clear pronounce of the name and objects in the map -Smooth drawing feature provided -Button is consistent in placement and style -Instruction is show clearly -Multiple sound effect	-Free of charge -Button is consistent in placement and style -Tutorial is show clearly -Shop item purchase as hint to answer the questions -Comfort background music
Weakness	-Complication of level -Movement of the main character is lag and undetectable -Button is inconsistent in placement and	-Graphic of stone is glitchy when jump on the stone -Sound effect will disappear sometime -Need to purchase -Instruction is not show clearly -No background	-In-app purchase for whole package -2D animals cannot provide realistic	-Only cover 3 levels -No random questions updated -Shop's items is less -No unlock features

Table 1: (continued)

Element	Frog on Ice	Ice Age Scrat's Nutty Adventure	Artie's World: An Adventure into the Arctic!	The Last Glacier Mobile Game

	Style	music		
Module	-Game	-Game	-Learn and Game	-Game and Learn
Platform	-Android	-TV mode, tabletop mode and handheld mode.	-iOS	-Android
System Requirement	-Minimum Android 2.3.3	-Minimum Windows 10/8/7	-Minimum iOS 7.0	-Minimum Android 4.4
Language	-English	-English (interface with full audio) -French (interface) -Italian (interface) -German (interface) -Spanish (interface)	-Multiple Language (English, Danish, Dutch, French, German, Italian, Japanese, Korean, Norwegian Bokmål, Portuguese, Russian, Simplified Chinese, Spanish, Swedish, Traditional Chinese and Turkish)	-English

Based on Table 1, the comparison of the four applications is tabulated and discussed included content, strength, weakness, module, platform, system requirements and language.

3. Methodology

Game Development Life Cycle (GDLC) was applied to develop The Last Glacier Mobile Game [8]. The presence of the Game Development Life Cycle (GDLC) was needed to guide the development process of the game process smoothly. Figure 1 shows the phases in GDLC.

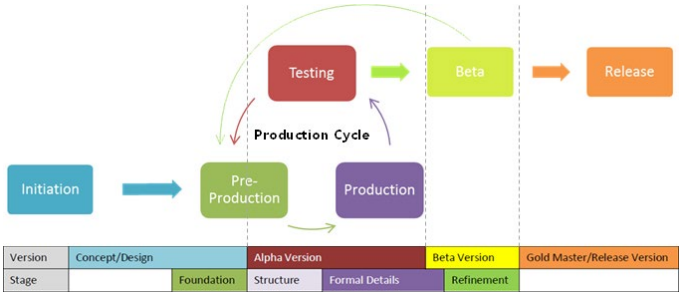


Figure 1: Phases of Game Development Life Cycle (GDLC) [8]

According to Figure 1, there were 6 phases to achieve the project's goal, initiation phase, pre-production phase, production phase, testing, beta testing, and release phase.

3.1 Initiation Phase

In the initiation phase, a brainstorming process was carried out to create a rough idea for the project. Firstly, the game was designed as an adventure game in Android mobile based. The main character and the game world were designed in 3D, but some components like the word are to apply the 2D technique. The player can visit the map by controlling the character with a virtual joystick and viewed the world with a third-person view. A Gantt Chart was created to confirm the development process completed on time. The flowchart and navigational structure were designed. Furthermore, a storyboard and a storyline also created before starting to develop the game.

3.2 Pre-production Phase

This phase was mainly to create the game design before starting to develop the real game. The game concept, characters, mechanics, fun factor, monetization technique were designed and decided in this stage [9]. First of all, the functional requirements and non-functional requirements of the systems were stated to confirm the function and non-function of the system does. For the functional requirement, it included the execution process of The Last Glacier Mobile Game and the information of the proposed game that must contain. The functional requirements are tabulated in Table 2.

Table 2: Functional Requirement

Functional Requirement	Description
User Interaction Module	- The virtual joystick should provide to the users to control the character. - The system should support the users an input button to select the answer.
Autonomous System Activities	- In first level, the time should count down automatically and users need to run away from the melting glacier to the ice breaker. - There will be pop messages neither the users answer correct or wrong. - The title of the mission will be fixed on the top middle of the screen to remind users. - A storyline will be attached before starts the game which to introduce the scene to users.
Game Module	- The system should provide three game modules to users. - The first level is about the melting ice in the Arctic. The users need to run away from the melting glacier. - The second level is asking the users to answer the question about the actions that cause global warming. - The third level asks the users to answer the question about the method to preserve the Earth.

The functional requirement of the proposed game shows in Table 2. The functional requirements were distributed into three parts, User Interaction Module, which was the interaction of the game with the users, Autonomous System Activities that meant it was automatically generated by the system and the Game Module, which illustrated the content of the levels of the proposed system. The non-functional requirement explained that The Last Glacier Mobile Game performance and the limitations of the mobile game. The non-functional requirements are tabulated in Table 3.

Table 3: Non-functional requirement

Non-functional Requirement	Description
Performance	- The proposed mobile game should in offline. - The game should be accessed at any time.
Implementation	- The mobile game should operate on any Android device.

Table 3: (continued)

Non-functional Requirement	Description
Cultural	- The mobile game should use simple a English language. - The content of the mobile game should be reliable with the global warming effect and method to preserve the Earth.

User Interface	-	The system should support text, buttons, graphics, animation and audio.

Table 3 displays the non-functional requirement of the proposed mobile game. The non-functional requirements were distributed into five parts, Performance, which was the overall performance of the system, Implementation which operated in an Android device, Culture that meant the language and the content of the proposed game, User Interface of the proposed game and the Security of the mobile game. Next, the integration of source code and game assets started in this stage. Software like Unity 3D was used to create 3D props based on the game design. Adobe Photoshop CS6 was used to create the buttons and graphics of the game. Figure 2 showed the main menu of The Last Glacier mobile application.

Figure 2: Main menu of The Last Glacier mobile game

Figure 2 indicates the main menu of The Last Glacier mobile game. Besides, Unity 3D was applied to create the game's 3D environment with some of the assets from the asset library of Unity 3D. In Unity, the generation of source code also completed. The production phase was the core phase of the game. Figure 3 displays the code snippet of single function prototype.

ChangeScene.cs

Miscellaneous Files

```
1   using System.Collections;
2   using System.Collections.Generic;
3   using UnityEngine;
4   using UnityEngine.SceneManagement;
5
6   public class ChangeScene : MonoBehaviour
7   {
8       public string SceneName;
9       // Start is called before the first frame update
10      void Start()
11      {
12
13      }
14
15      // Update is called once per frame
16      void Update()
17      {
18
19      }
20
21      public void ChangeSceneByName()
22      {
23          SceneManager.LoadScene(SceneName);
24      }
25  }
```

Figure 3: Code snippet of single function prototype

Figure 3 shows the code segmentation of Load Scene by using the UnityEngine.SceneManagement to carry out the scene switching.

3.3 Production Phase

In this phase, the implantation phase of The Last Glacier Mobile Application was started. Several features such as the development of graphics, development of the 3D asset, Exit Function, Count Down

Timer, and Appear and Disappear Panel were discussed in the continue subsection. Figure 4 displays the development of graphics by using Adobe Photoshop CS6.

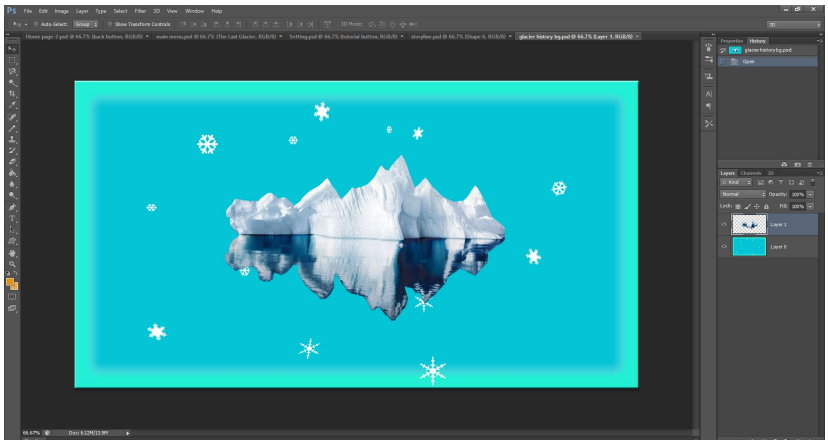


Figure 4: Historical Background Interface of The Last Glacier mobile game

Figure 4 displays the historical background of The Last Glacier mobile game. The interface was created in a simple and clean method to make the users feel comfortable while playing the game. Furthermore, the graphics were applied in the proposed system. Table 4 tabulates some user interfaces captured from the application.

Table 4: User Interface

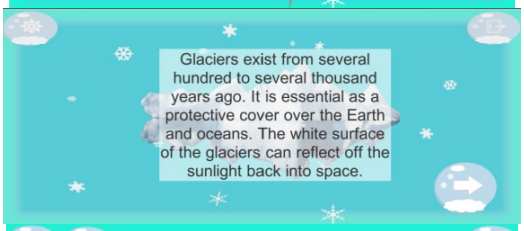
Scene	User Interface
Home Interface	
Storyline Interface	
Select Level Interface	

Table 4: (continued)

Scene	User Interface

Game Level 1	
Game Level 2	

Table 4 tabulates the important scenes of The Last Glacier mobile game. Figure 5 displays the development of a glacier, which was high usage and occurrence rate on the map using Unity 3D.

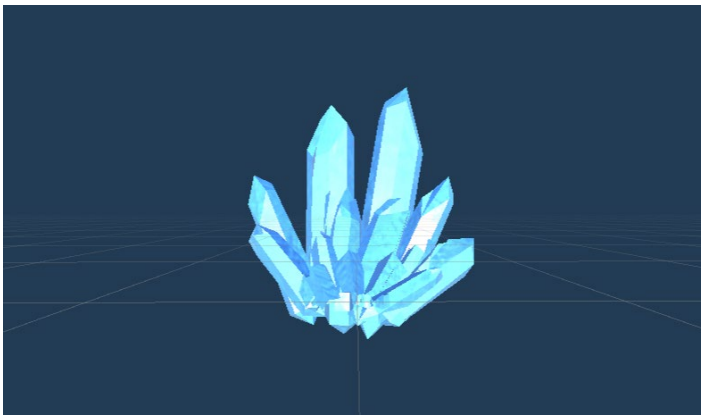


Figure 5: Glacier created by Unity 3D

Figure 5 shows the creation of the glacier that frequently utilized in the environment of the proposed mobile game. Figure 6 displays the Exit Panel that pop out after press the Exit button.

Figure 6: Exit Panel that pop out after press Exit button

The Exit panel of The Last Glacier mobile game is shown in Figure 6. The Exit button appeared in every scene, which supports the users to quit the game freely. The users clicked on the True button on the left inside in the Exit panel when the users decided to quit the application. Figure 7 displays the Count Down Timer that applied in Level 1.

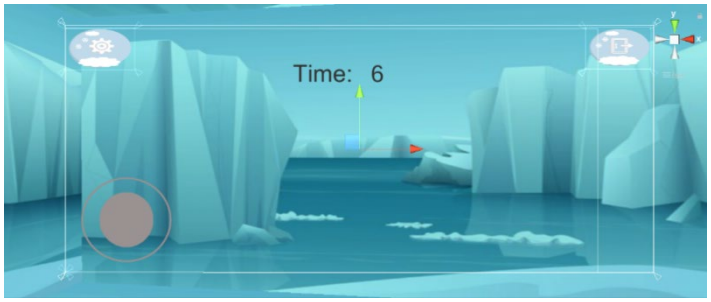
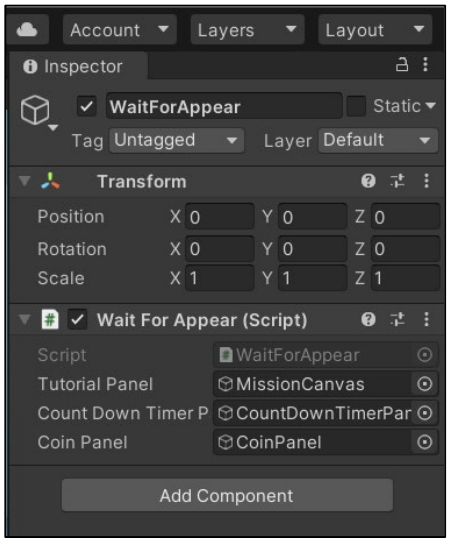
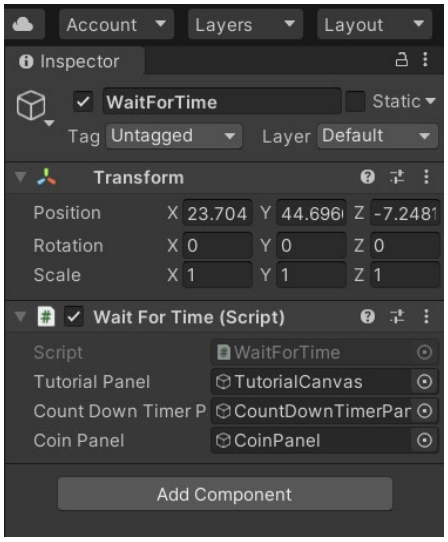


Figure 7: Count down timer

Count Down Timer was used to show the users the time taken they need to finish Level 1. Appear and Disappear Panel were utilized in the Tutorial Canvas, Count Down Timer Panel, Coin Panel and Mission Canvas. This function worked as autonomous when the time reached. The panels or canvases popped out or hid through the implementation of the coding. Figure 8 shows the insertion of the panels and canvases in the Unity inspector.



Insertion of Mission Canvas, Count Down Timer Panel and Coin Panel



Insertion of Tutorial Panel, Count Down Timer Panel and Coin Panel

Figure 8: Insertion of the panels and canvases in the inspector

3.4 Testing Phase

In this section, the testing phase was carried out for the proposed mobile game. The alpha testing was carried out in this section which tested the application by the developer. The results of alpha testing were discussed in this subtopic. The functionality and effectiveness of the application were tested by the developer. The object that tested by alpha testing was the functionality of the buttons. If errors were found, corrective actions should be carried out to advance the application. Table 5 tabulates the expected result, actual result and any corrective actions based on the functionality and effectiveness of the buttons. Thirteen buttons were implemented and tested by the developer in the game during the alpha testing phase.

Table 5: Results of alpha testing

Testing	Expected Result	Actual Result	Corrective Action

Play button	Navigates to glacier history.	Works well as expected.	Not required.
Home button	Navigates to Select Level Interface.	Works well as expected.	Not required.
Setting button	Navigates to Setting Panel.	Works well as expected.	Not required.
Back button	Backs to the previous page.	Works well as expected.	Not required.
Next button	Proceeds to the next page.	Works well as expected.	Not required.
Replay button	Restarts the game.	Works well as expected.	Not required.
Exit button	Quits the game.	Works well as expected.	Not required.
Shop button	Navigates to Shop Interface.	Works well as expected.	Not required.
Tutorial button	Shows the tutorial panel.	Works well as expected.	Not required.
Purchase button	Buys item.	Works well as expected.	Not required.
Level 1 button	Navigate to Level 1.	Works well as expected.	Not required.
Level 2 button	Navigate to Level 2.	Works well as expected.	Not required.
Level 3 button	Navigate to Level 3.	Works well as expected.	Not required.

Table 5 is tabulating the results of alpha testing against the buttons applied in the proposed application. All of the buttons were functioned well and reached the actual expectations after carried out alpha testing by the developer. Therefore, there were no corrective actions needed.

3.5 Beta Testing

In this subtopic, beta testing was carried out with the cooperation of the target users. This testing needed to get feedback from the target users. This action helped to improve and advance the mobile game. A Google form was prepared with ten questions by the developer. The questionnaire was distributed to ten respondents include males and females who were seven years old and above. User Manual also created to ease the users to understand the play mode of the proposed application. Figure 9 displays the pie chart of gender for the ten respondents who participated in the beta testing of The Last Glacier mobile game.

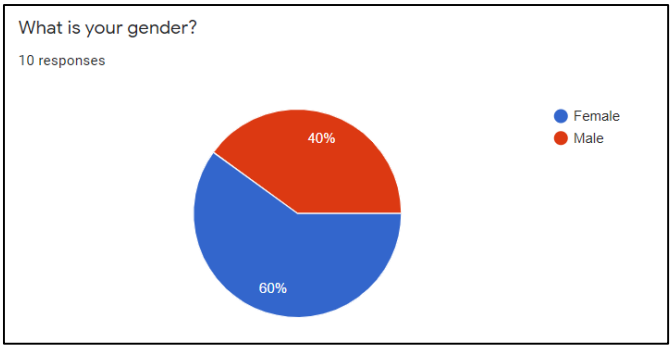


Figure 9: Gender of respondent

Figure 9 showed the analysis of gender that joined in the beta testing of the proposed application. According to the pie chart, four male respondents (40%) and six female respondents (60%) had accompanied the beta testing of The Last Glacier mobile game.

3.6 Release Phase

In this phase, the proposed application, The Last Glacier mobile game, exported and built for Android platforms from Unity. Figure 10 displayed the process of building the Android version of The Last Glacier mobile game. Figure 10 illustrates the process of building the proposed application from Unity. It built for Android based smartphones.

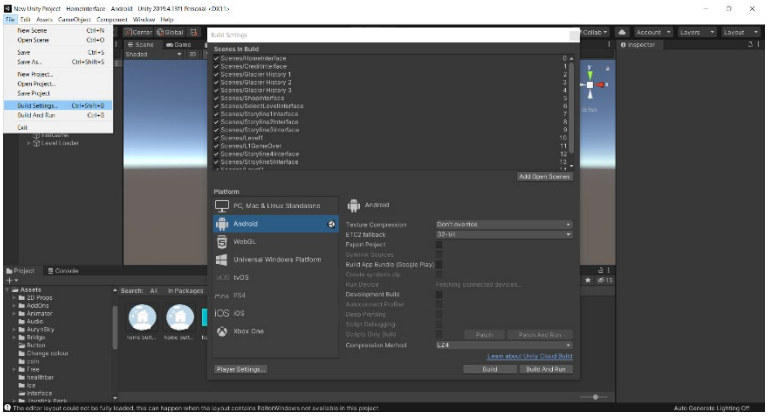


Figure 10: Process of building the Android version of The Last Glacier mobile game

4. Results and Discussion

4.1 Application Testing Results

In this subtopic, the testing result of beta testing was analyzed. All of the respondents had completed the entire application when they carried out the beta testing. The questionnaire was arranged into three components which are User Acceptance Test, Level of Functionality Test and Level of Performance Test. Each of the components occupied three questions, respectively. Figure 11 displays the analysis of the User Acceptance Test.

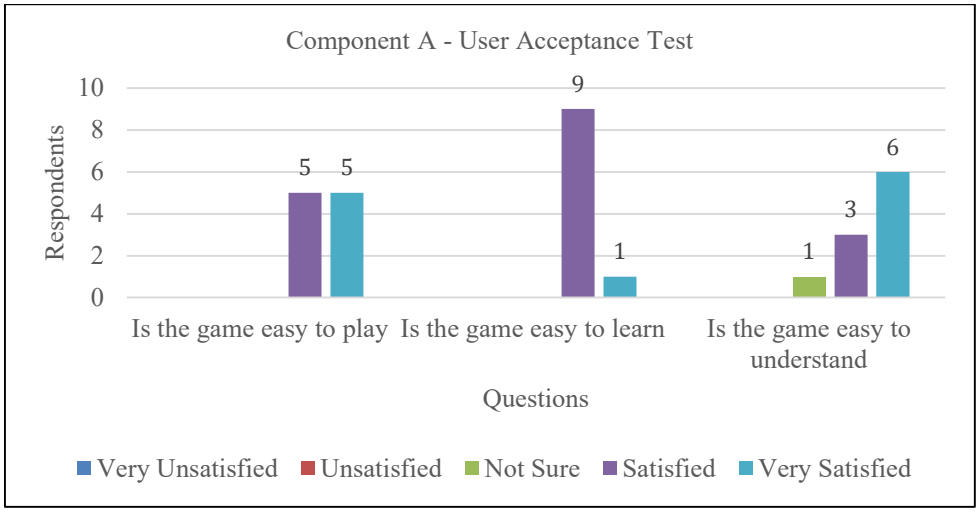


Figure 11: User Acceptance Test

From Figure 11, five respondents (50%) stated satisfied, and five respondents responded very satisfied (50%) for question 1, Is the Game is easy to play. While in question 2, Is the game easy to learn, nine respondents (90%) stated that The Last Glacier mobile game is easy to learn. Moreover, there is one respondent who (10%) stated very satisfied that the proposed application is easy to learn. Question 3 asked the respondents about the delivery of the understanding of the game. One respondent (10%) stated that not sure about the understanding of the game. However, three respondents (30%) and six respondents (60%) responded they were satisfied and very satisfied with the understanding of the

game, respectively. The application can be improved to deliver more understandable information to the users.

Besides, System Usability Scale (SUS) was utilized for to evaluate the User Acceptance Test of The Last Glacier mobile game. SUS had been chosen due to its effective and quick method to evaluate the usability of the proposed system. It provided an overall usability assessment measurement that included effectiveness, efficiency and satisfaction [9]. Through SUS, the result of the User Acceptance Test of the proposed game was evaluated and recorded with a list. The questions and results collected from the User Acceptance Test tabulate in Table 6.

Table 6: List of User Acceptance Test

Question	Very Unsatisfied	Unsatisfied	Not Sure	Satisfied	Very Satisfied	Result
Is the game easy to play	0/10	0/10	0/10	5/10	5/10	Fully Satisfied
Is the game easy to learn	0/10	0/10	0/10	9/10	1/10	Fully Satisfied
Is the game easy to understand	0/10	0/10	1/10	3/10	6/10	Mostly Satisfied

Table 6 illustrated the list of the User Acceptance Test of the proposed mobile game. Each question was recorded and analyzed with different results. By applying the evaluation method, SUS, a positive result was evaluated from the respondents. 40% of respondents were felt very satisfied with the game.

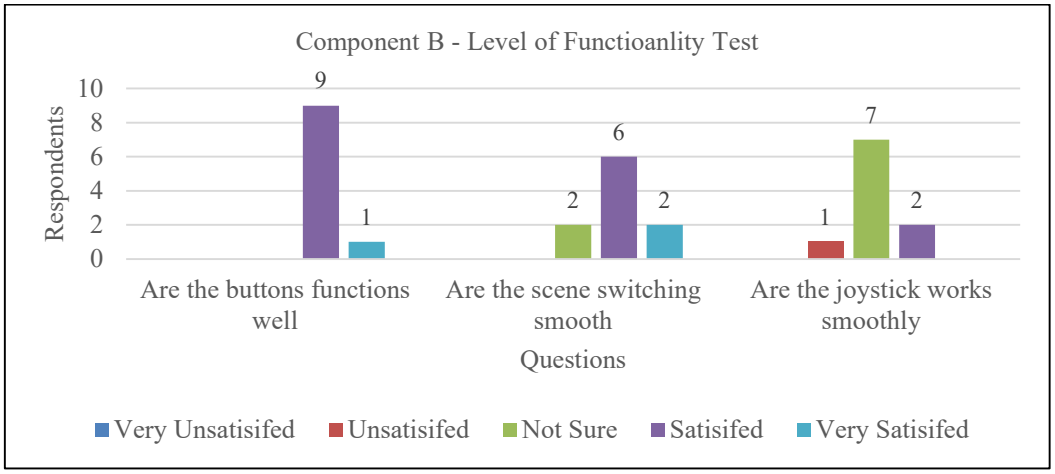


Figure 12: Level of Functionality Test

Figure 12 displayed the analysis of the Level of Functionality Test in a bar graph. There are nine respondents (90%) satisfied, and one respondent (10%) stated he or she is very satisfied with the function of the buttons, respectively. Next, two of the respondents (20%) stated that they were not sure about the smoothness of the scene switching. Meanwhile, scene switching should be improved in the future. There were six respondents (60%) who were satisfied with the smoothness of scene switching. In addition, two respondents (20%) were very satisfied with the smoothness of the scene switching. Question 3 asked about the feedback on the smoothness of the joystick. One of the male respondents (10%) was not satisfied with the smoothness of the joystick. Other than that, seven respondents (70%) felt unsure about the joystick's smoothness and out of six female respondents, four female respondents responded to it. This is because they did not always play adventure game. So, they could not determine whether it was their operational issue or the joystick smoothness issue when they controlled the main

character. From the responses, the smoothness of the joystick should be improved as the future work. However, two female respondents (20%) felt that they were satisfied with the smoothness of the joystick utilized in the game.

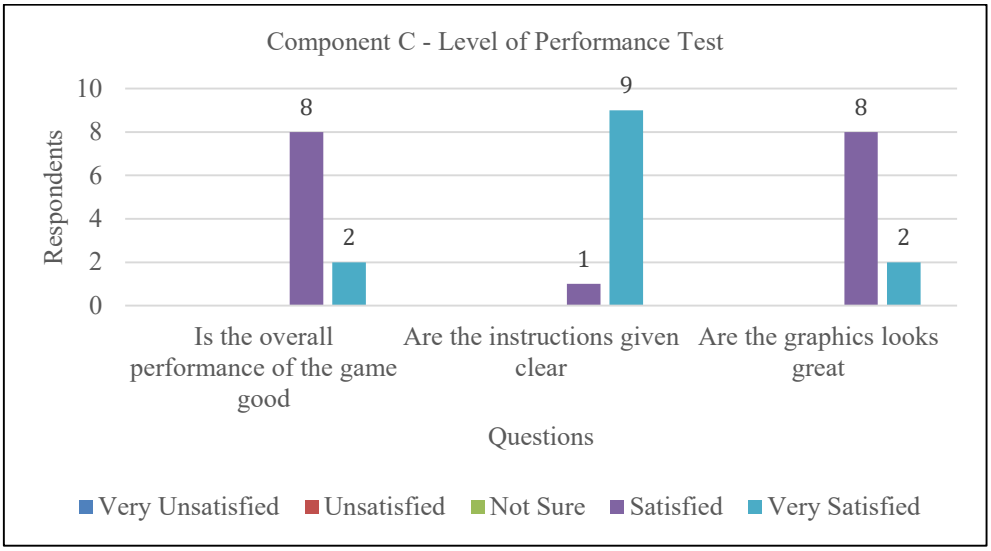


Figure 13: Level of Performance Test

Figure 13 demonstrates the bar graph of the Level of Performance Test. Question 1 asked about the overall performance of the application to the target users. Eight respondents (80%) replied that they are satisfied with the performance of the proposed application. Two respondents (20%) responded that they are very satisfied with the overall performance of the application. Question 2 asked about the instructions is delivered in a clear situation or not. There is one respondent (10%) felt satisfied, and nine respondents (90%) felt very satisfied with the clear instructions provided by the developer. For the last question, eight respondents (80%) felt satisfied with the graphics of The Last Glacier mobile game. At the same time, two respondents (20%) felt very satisfied with the graphics of the proposed application.

5. Conclusion

To share the knowledge of the effect, cause and solutions of global warming, The Last Glacier Mobile Game is designed and developed for the target user from the age of seven and above. According to the Game Development Life Cycle (GDLC), the proposed project is completed until the release phase. The prototype of the proposed mobile game is created as reference to the analysis and design. Following to the development of the application is completed with the C# scripting algorithms. Several functions such as Exit Function, Count Down Timer and Appear and Disappear Panel are described in the production phase of the methodology. Alpha testing and beta testing are completed by the developer and the involvement of target users, respectively. The feedback from the users is gathered by Google Form, and the analysis of the questionnaires is completed with System Usability Scale (SUS). By evaluating with SUS, 40% of respondents very satisfied with the game, 56.67% of respondents satisfied with the functionality, and 56.67% of respondents satisfied with the performance of the proposed application.

This application has gained positive feedbacks from the target users during the testing phase. All the three objectives of this proposed mobile game are achieved, and the advantages have such as deliver glacier knowledge to the users with the storyline and the functionality of the proposed game are well supported. Moreover, some limitations such as no unlock level feature and fewer levels are provided to the users have been discussed. Last but not least, there are several improvements such as support unlock level feature and more levels of The Last Glacier mobile game for the future works to advance this application and hope it exists better performance in the future.

Acknowledgement

The authors would like to thank the Faculty of Computer Science and Information Technology, Universiti Tun Hussein Onn Malaysia for its support and encouragement throughout the process of conducting this study.

Appendix A

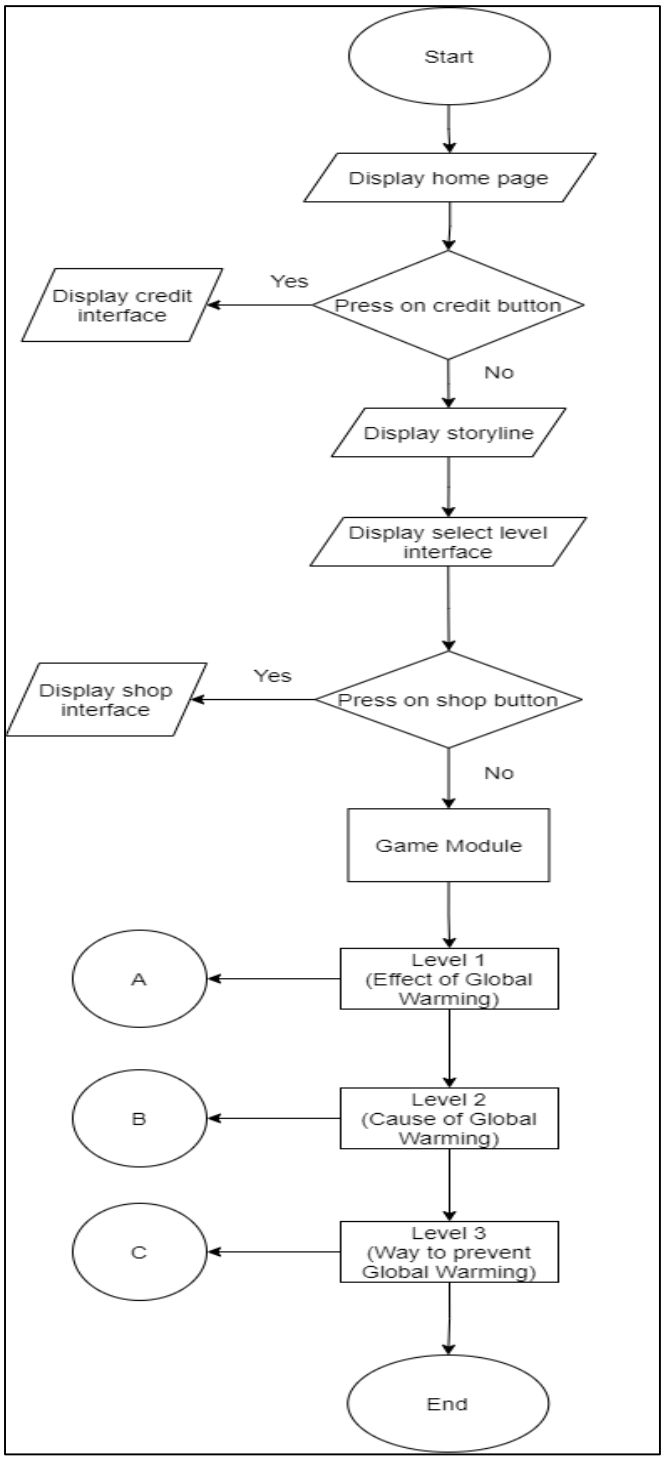


Figure 14: Main flowchart of The Last Glacier mobile game

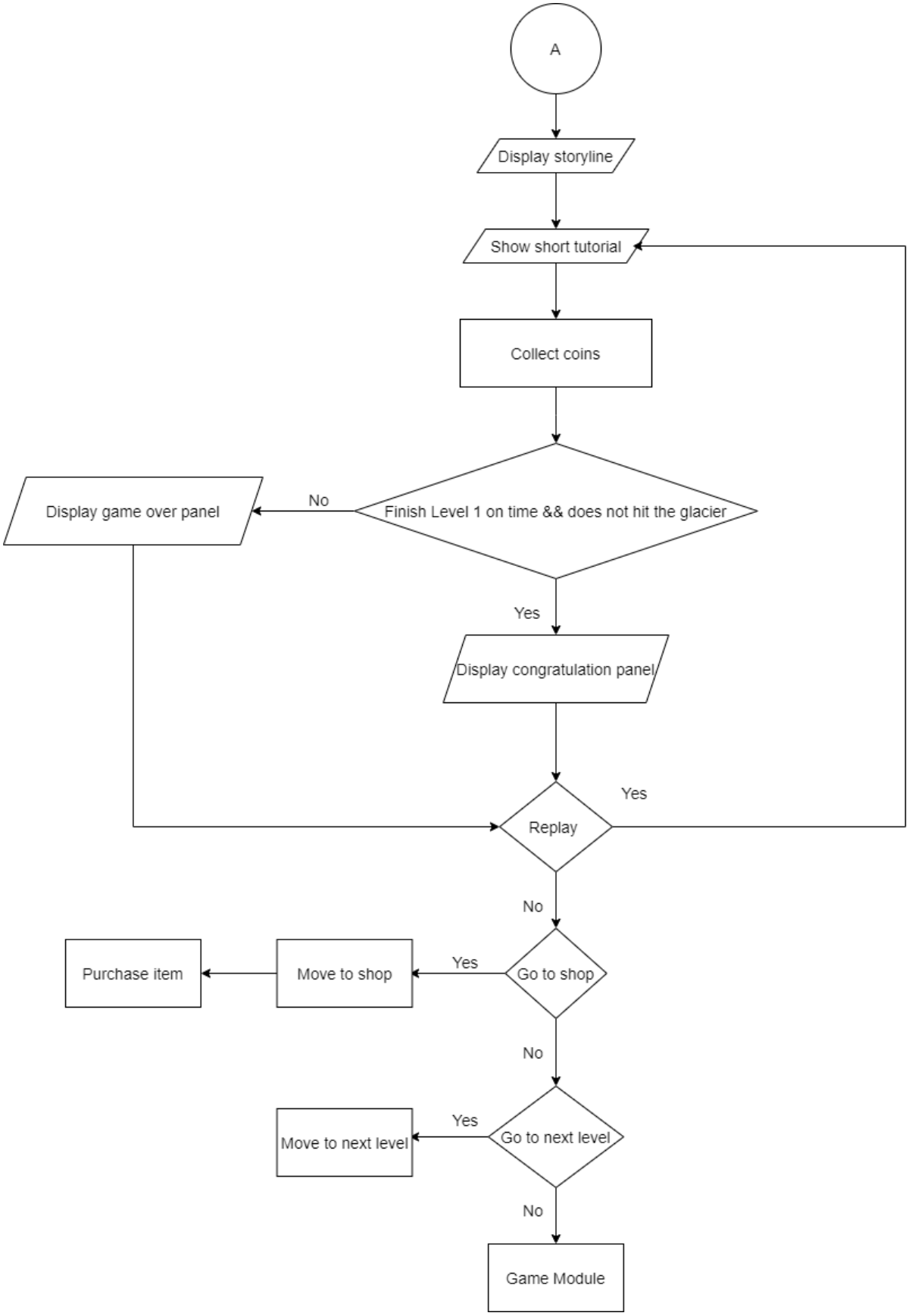


Figure 15: Level 1 flowchart

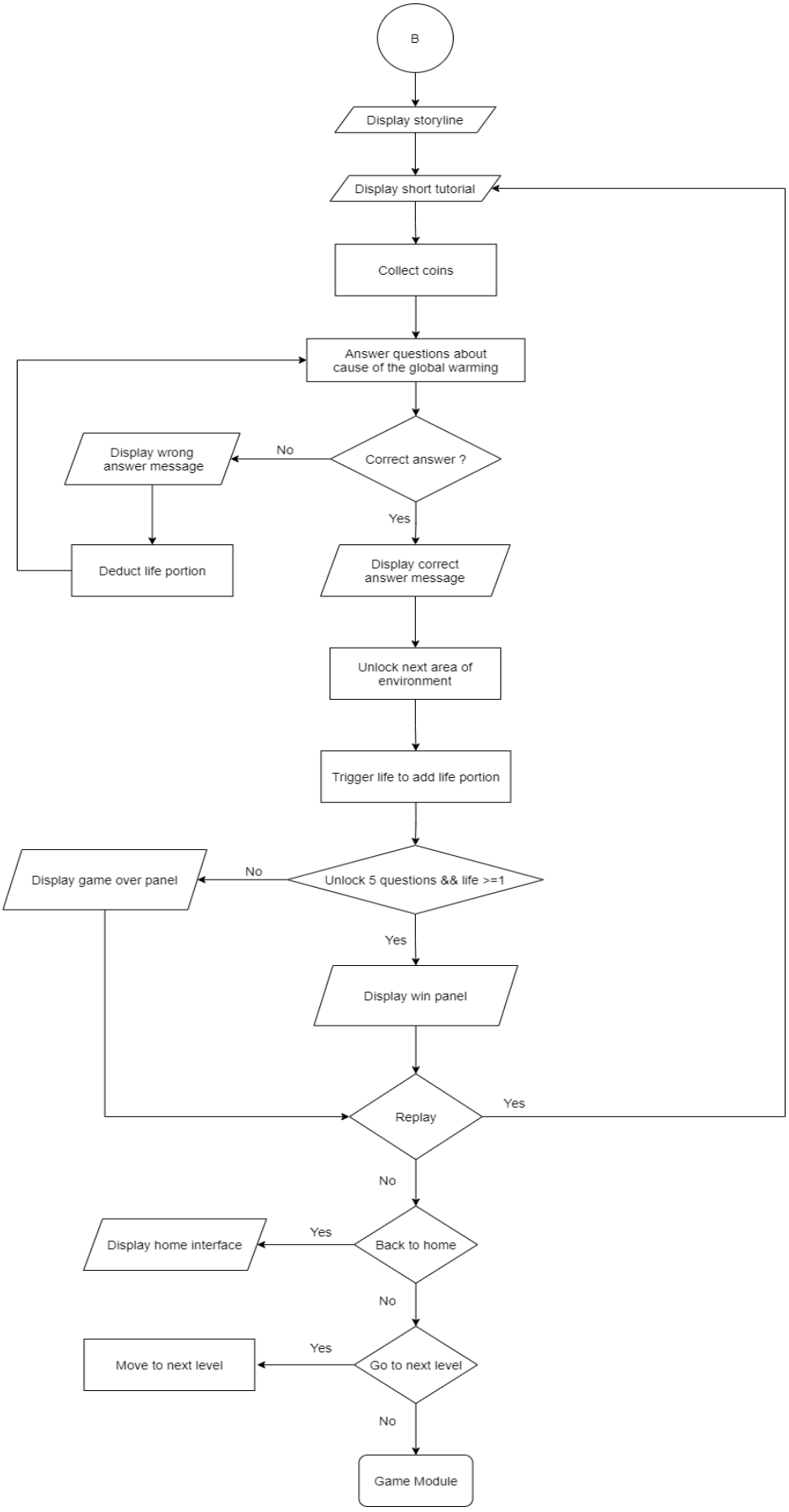


Figure 16: Level 2 flowchart

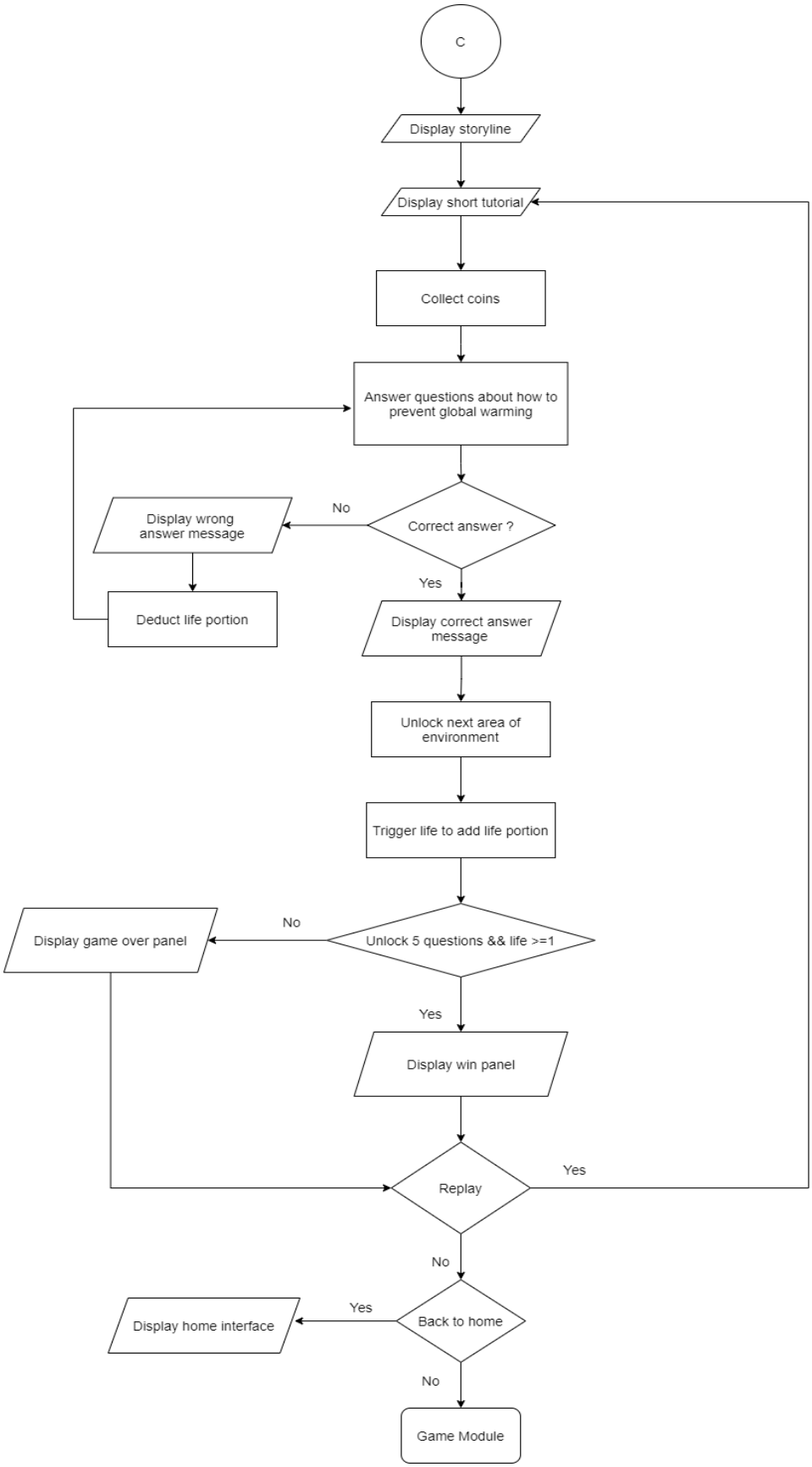


Figure 17: Level 3 flowchart

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