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# Green Hero: Mobile Environmental Awareness Campaign For Children Using Gamification Approach

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**Abstract**: Today's technology has been innovated to a various number, encompassing in every aspect of daily life. Gamification is one the technique that has been used widely in the technology domain, which is a way of injecting game-elements into a nongaming system with intention of increasing the users interest and engagement. Despite the qualities poses by it, most sector does not grasp the advantage by implementing the technology especially in the educational sector. Issues such as environmental crisis that are lacking in awareness have yet to be integrated with the technique mentioned. Hence, Green Hero is an initiative taken to merge the environmental issues rising with the gamification method towards the children ranging from 10 to 12 years old since the current syllabuses have less focus on the importance of preserving the earth. Green Hero is expected to raise the awareness of the children towards the significance of concerning the environment.
**Keywords**: Gamification, Environmental Awareness, Mobile Game, Children

## 1. Introduction

The planet earth has grown older and will be more in the upcoming times. While the end is inevitable, it is not the justification to neglect the responsibilities held upon us as the preservers of the earth. The fast technological advancement that occurs in the past years affects its occupants, both living and non-living things. Despite the noble achievement gained by mankind in technology, the situation faced by our mother nature begins to declining even more. The environment, which is a mix of chemical, physical, and biotic factors that interact upon an organism or an ecological community and ultimately determine its form and survival [1] comprises of all of its inhabitants. Hence, it is undeniable that the task of conserving this aging planet falls into our hands. However, the acknowledgement of this issues and their influence towards the future times is rather little to none, especially in allegedly more matured audiences. Due to this cause, the goal of spreading the environmental awareness campaign changed its aim towards the children aged 10 to 12 years old.

Gamification in education refers to the application of game design elements to an educational setting by educators [2]. The implementation of game design aesthetics converged with the motive of

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spreading the initiative that could preserve the environmental crisis will manage to gain children attention and investment towards the game. This method of implementing gamification within the campaign arises after most of the campaign that has been held in local school does not produce the expected result. School syllabuses are still lacking in-depth elaboration towards the importance of keeping the environment prosper. Environmental have yet to be seen as a fully structured subject for school students to learn hence declining the acknowledgement of children towards the issues. This raises questions on whether problems of climate change and sustainable development are being addressed in existing environmental education to increase awareness or positive behavior towards environmental preservation in Malaysia [3]. Gamification approach is expected to be one of the effort to embed the idea of preserving the nature into the future leader's mind. This supported by a founding from a research finding that gamification has huge potential for improving digital competence, as numerous high-impact studies have shown in recent years. The use of fun strategies to help children develop their learning (with a premium on action, experimentation, conflict resolution and interaction between students, etc.) at school and at home, supported by ICT resources, increases the positive impact of a range of everyday skills on the environment and on the development of academic knowledge [4]

The rest of the paper is arranged as follows: Section 2 covers the domain of study, the technology used, and the result of the comparative analysis. Section 3 describes the Game Development Life Cycle(GDLC) methodology that is chosen to apply in this project, as well as the output of the analysis and design phases of this project. Furthermore, Section 4 stated the conclusion of the current progress.

## 2. Related Work

In this section, it will cover discussion of the study domain, technology used, and a detailed comparative analysis of pre-existing application.

### 2.1 Environmental Awareness

Environment is a sum total of living and non-living things that works in biodiversity forming a related chain from the smallest organism to the apex of predators hierarchy. This linking justifies why human must partake in the attempt to alleviate the damage taken by mother nature. Cases of harmful waste secretions, climate change, environmental pollution, and ecosystem breakdown, to name a few, are the environmental catastrophes that are accustomed by the general public [5]. This immorality that occurs happens to be from lack of recognizing the state of today's modern environment. It is undeniable this loophole falls back towards the education system that needs to be re-establish parallel to today's main crisis which is environmental. Education plays an important role in preventing environmental pollution, environmental destruction, and preserving the environment [6]. This project also focuses on flexibility towards its content, making sure that the motive is being spread extensively without knowing the borders of age. Figure 1(a) and figure 1(b) show some application that uses gamification methodology to enhance the learning experience of the students.

**Figure 1(a) : Read Along With Google**


**Figure 1(b) : Kahoot!**

## 2.2 Technology Implemented

The development of this project is aimed towards the concept of gamification, one of the main objectives for creating this application. Gamification is one of the famous methods of integrating educational contents with game design elements to enhance user experience and increase their involvement within the game. Other than that, gamification has proven its influence on education and learning process. For instance, a group of college students in a gamified cell biology class outperformed their lecture-based counterparts by 40% [7]. Gamification has claimed its ground in the technological world because of its criteria which helps users to develop crucial thinking skills such as problem-solving and creating strategy. Hence, the aid of having educational game as a learning method driven the motivation for students to spend their time on the application. Gamification is method that partitioned into two types which is structural and content. The project, Green Hero will take its focus on the content gamification. Content gamification aims to transform existing learning/work content and make it more engaging. Everything becomes part of a game, though the user is still picking up important skills, information, and carrying out important tasks in a non-traditional way [8]. By using backstory that acts as the goals of the role-playing theme, users interest and focus towards finishing the game will increase. Additionally, by using gamification as a method of learning, users can learn and grasp the knowledge on their own momentum. The learning experience is personalized; the learners could evolve in their own rhythm, in a safe way [9].

## 2.3 Comparative Analysis

Under this section, a comparison has been made among the existing applications which are, My City Cleaning Waste Recycle [10], Climate Quest [11], and Recycle Rush [12], and finally the proposed game, Green Hero. Figure 1 shows the main menu interface of the mentioned application respectively. Following that, 8 features pose from the application mentioned before are also being discussed under this section.


**Figure 2 (a) : My City Cleaning [10]**


**Figure 2 (b) : Climate Quest [11]**


**Figure 2 (c) : Recycle Rush [12]**

**Table 1: Comparative analysis between existing applications and proposed application**

| Application / Features | My City Cleaning Waste Recycle | Climate Quest | Recycle Rush | Green Hero |
|---|---|---|---|---|
| Gamification | Provide gamification to the users | | | |
| Modules | 7 levels with different type of tasks | One-time gameplay with different tasks | One gameplay with life system | 3 levels with different settings following the game storyline |
| Game Mechanics | Drag and drop | Tap | Drag bucket and collect the right items | Analog control with responsive button, drag and drop |
| Game Design | Simple 2D illustration | 8-bit pixelated art with top-down view | Simple 2D illustration | 8-bit pixelated art with top-down view |
| Target Users | 3 years and above | 8 years and above | 3 years and above | 10 to 12 years old |
| Category | Puzzle | RPG, Strategy | Catcher game | RPG, Problem-solving |
| Data Security | Does not collect personal data | | | |
| Educational elements | Simple character dialogue about cleanliness | Textual message about climate | Flash cards containing facts about environmental issues | Flash cards containing facts about environmental issues |

Based on Table 1, a comparative analysis between existing application and proposed application is performed. The former applications listed have their weaknesses such as monotonous game theme,

single module games, weak execution on the learning sector which fail to reach towards users understanding towards the issues. Therefore, Green Hero will adhere towards the information gained by the comparative analysis to create a satisfying and interesting application. Features such as vibrant colors and retro styled themed of top down to make sure users keep their interest within the game. Concept such as badges will be implemented in which users need to finish each tasks to gain each unique badges along with flash cards. Other than that, a timer features will be developed to make sure the users do not spend too much time on the game.

## 3. Methodology

The methodology chosen to develop Green Hero is Game Development Life Cycle (GDLC). GDLC is a methodology designed based on its predecessor model which is Software Development Life Cycle (SDLC) with some modification mainly focuses on entertaining the users. As GDLC is created following the likes of SDLC, several GDLC have been proposed by different organization, but none of them properly address how to ensure the qualities and successfully deliver good quality games [13]. Four major GDLC model that have been proposed are Blitz Game Studio, Arnold Hendrick, Doopler Interactive and Heather Chandler [13]. The variations come with their own pros and cons that yet to be improved. A modified model combining the major model proposed before has been done by two researchers from Indonesia, hence it is chosen as the main model of this project development**.**

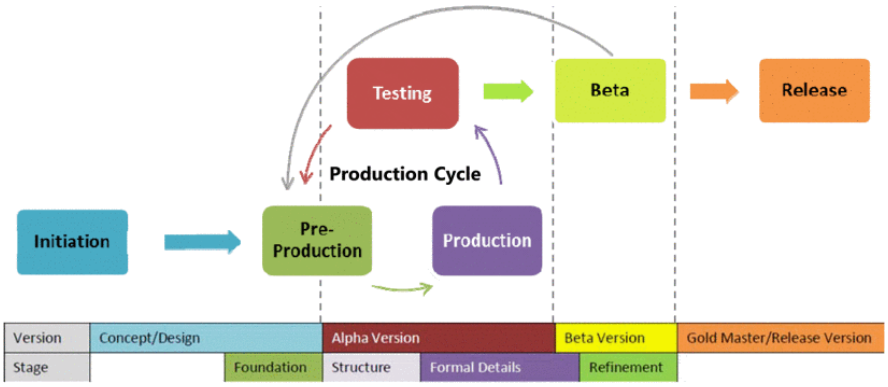



**Figure 2: GDLC Model [13]**

### 3.1 Initiation Phase

The first stage is during the initiation phase of the GDLC methodology. During that phase, the information needed is gained through the method of interviewing and handling out questionnaire. The interview was held with a Subject Matter Expert (SME), Puan Nurul Hakimah. Puan Hakimah is a school counselor in a local primary school located in Kuala Lipis, Pahang. The interview transcript is attached in the Appendix A. The interview session resulting in user analysis section which highlights the needed design implication for modification of the game.

**Table 2: User Analysis**

| Stakeholder Category | Role In Product | Design Implication | Action Needed |
|---|---|---|---|
| Subject Matter Expert | School Counselor in a local primary school | Interface design | • Apply simple design that manages to attract the users attention.<br>• The game design needs to have consistency and interesting to users.<br>. |
| | | Content deliverables | • Written in a suitable way for children to understand and grasp the information.<br>• Use simple English |
| | | Navigation | • Clear navigation throughout the games |

| | | | |
|---|---|---|---|
| | | Multimedia | • Use audio and animation to attract children's interest. |

| Stakeholder Category | Role In Product | Design Implication | Action Needed |
|---|---|---|---|
| Target User (Children 10 – 12) | End-user of the proposed application | User preferences | • The application should be developed on mobile devices.<br>• The application should be developed in the English language.<br>• Audio and animation should be implemented in the learning content. |

**Table 3: Hardware requirements**

| Hardware | Specifications |
|---|---|
| Laptop | • Acer Nitro 5 |
| Central Processing Unit | • AMD Ryzen 7 |
| Random Access Memory (RAM) | • 8GB DDR4 2666 MHz |
| Graphics Processing Unit (GPU) | • Nvidia GeForce GTX 1650 |
| Operating System | • Windows 11 |

**Table 4: Software requirements**

| Software | Specifications |
|---|---|
| Unity 3.4.1 | • For the application development. |
| Microsoft Word | • For application's documentation. |
| Visual Studio 2019 | • For application's scripting. |
| Project Manager | • For project's Gantt Chart |
| Adobe Photoshop 2020 | • For producing application's logo and icon |
| Adobe Illustrator 2020 | • For creating game assets and UI |

**Table 5: Functional requirement**

| Functional Requirement | Description |
|---|---|
| User Interaction | • Main menu page section will allow user to interact with three main functional buttons which is Play button, Learn button, and Exit button. There is an additional button which is Settings button on the tope left corner of the page. Play button allow users to proceed to the next page which is the Level page. Learn button will allow users to use the flash cards provided to learn |

| | |
|---|---|
| | facts about the environment and its related contents. Exit button will allow users to exit the game.<br>• On the Settings page, users will be provided with simple controls such as sound effects switch, background music |

| Functional Requirement | Description |
|---|---|
| | switch, and game timer, an add on system that will allow users to allocate their time to the game.<br>• The Level page will appoint users to choose the levels that they are able to play with, which is City, Forest and Farm. Each level is a pre-requirement before advancing to the next level.<br>• During game mode, two controls button are available for users to use and an analog button for users to move around. Some tasks require users to use touch screen gestures in order to finish the tasks. |
| Autonomous System | • Locked section such as flash cards and levels will be available after users have gained the access by finishing tasks and level.<br>• Progress notification will automatically add up once tasks have finished.<br>• Game will be over if the tasks are not completed on time. |

**Table 6: Non-functional requirement**

| Non-Functional Requirement | Description |
|---|---|
| Performance | • The game can be operated offline and will be available to be accessed at all time. |
| Operational | • The game shall be available on any Android devices that meet the minimum requirements. |
| Cultural | • The game will be developed fully in English |
| Legal | • Users cannot modify the contents displayed in the game |
| Usability | • The game shall be user-friendly and fun for users to involved in |

## 3.2 Pre-Production Phase

The application will be developed based on the structure analyzation. The object and navigation structure has been analyzed and shown in Figure 3a. After that, the flowchart of the game has also been analyzed and illustrated in the Figure 3b. Following that, the content structure is shown in the Figure 3c, showing how the content of the game will proceed.

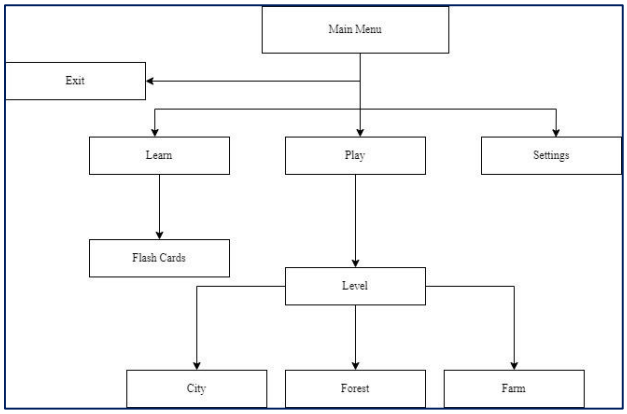



**Figure 3(a) : Navigational Structure**

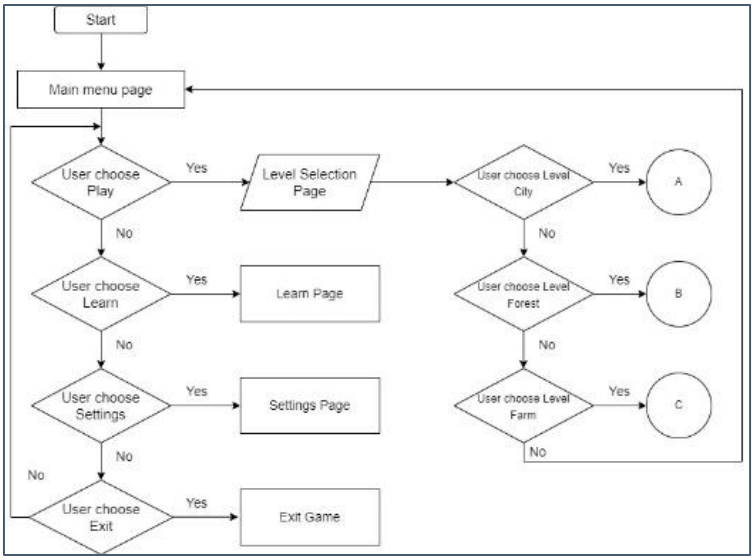



**Figure 3(b) : Flowchart**

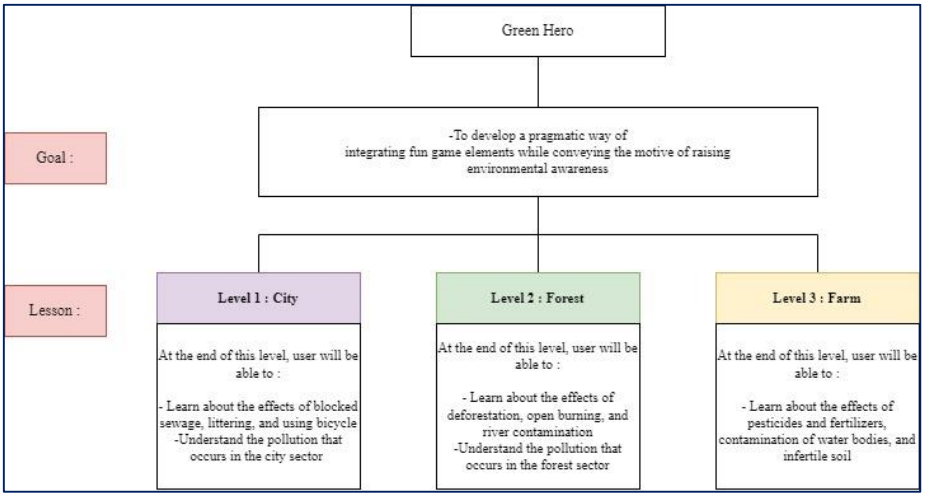



**Figure 3(c) : Content Structure**

## 3.3 Production Phase

This phase of the methodology consists of the main development process. Asset making, game developing, scripting and other major steps needed to be taken for the accomplishment of this project will start during this phase. Software such as Unity, Adobe Photoshop, Adobe Illustrator, Visual Studio, will be used during this phase. The character sprite for this game has been completed inside Adobe Photoshop following pixel art style to suit the game theme. The game's map levels, including City, Forest, and Farm, were created using a freely available tileset asset acquired from OpenGameArt.org and arranged within Unity to depict various elements such as walls, roads, and buildings. The game incorporates task assets, such as recycling, drain cleaning, extinguishing open fires, and matching, which serve as objectives for players, providing structure, purpose, and visual indicators to guide gameplay and enhance player engagement.

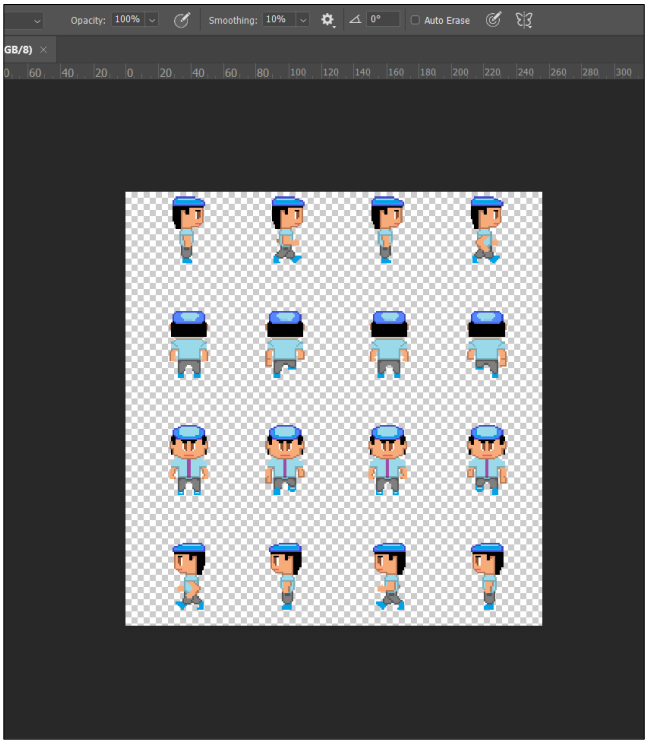



**Figure 4 : Character sprite**

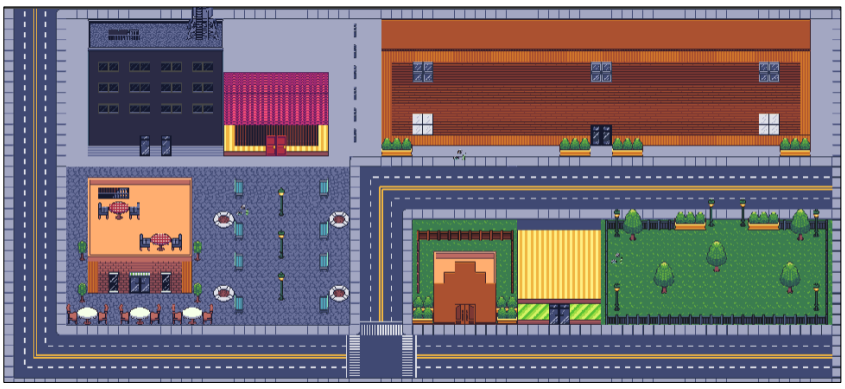


**Figure 5 : Map for City level using tileset**

**Figure 6 : Asset for clogged drain task**

```
private bool TryMove(Vector2 direction)
    {
        int count = rb.Cast(
                direction,
                movementFilter,
                castCollisions,
                moveSpeed * Time.fixedDeltaTime + collisionOffset);

        if (count == 0)
        {
            rb.MovePosition(rb.position + direction * moveSpeed * Time.fixedDeltaTime);
            return true;
        } else
        {
            return false;
        }
    }

    void OnMove(InputValue movementValue)
    {
        movementInput = movementValue.Get<Vector2>();
    }
```

**Figure 7 : Script snippet for DannyController class**

The method "TryMove" is responsible for attempting to move the character in the specified "direction" vector. It uses the Rigidbody2D's "Cast" method to check for collisions in that direction. If no collisions are detected, it moves the character's position using "MovePosition" based on the move speed and time. If collisions occur, it returns false. The "OnMove" method is an event handler that updates the "movementInput" vector based on input values received from the joystick.

```
public class FunctionButton : MonoBehaviour
{
   public int gameStartScene;
   public void StartGame()
   {
      SceneManager.LoadScene(gameStartScene);
       }
}
```

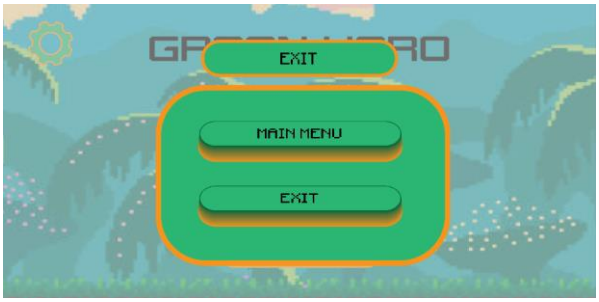
**Figure 8 : Scripting for FunctionButton**

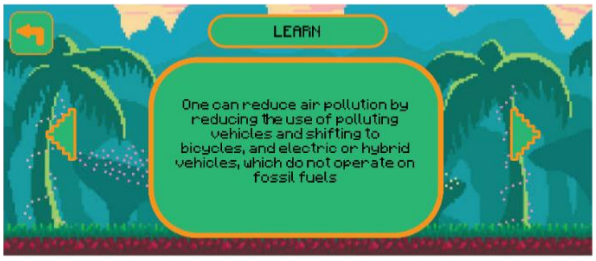
To enable users to customize scenes based on the application's requirements, a load scene script has been developed. The provided code in Figure 5.9 demonstrates the implementation of scene conversion, allowing users to switch between different scenes as needed. This script facilitates flexibility and adaptability within the application, ensuring users can seamlessly navigate and modify the available scenes.

## 3.4 Testing Phase

The testing phase will see Green Hero undergo few test session such as player movement, player task, time constraint, and others. The testing has been conducted by the developer inside the Unity platform to make sure it is working. The project growth will be based on the result of the testing session, whether it needed to recede towards the production cycle again or it can progress to the beta testing phase. Beta testing is a phase post alpha testing where the game being tested internally. Beta testing involves third party and the targeted users as the testers. The beta testing is planned to be picked from local children near Parit Raja as the feedback can be assessed directly, helping the development process.

**Table 7: User interface design**

| User Interface Design | Description |
|---|---|
|  | Start Screen<br>• There are four buttons which are Play, Learn, Settings and Exit.<br>• Play button will proceed to level page.<br>• Learn button will proceed to learn page.<br>• Exit button will proceed to quit prompt page.<br>• Settings button will proceed to the settings page. |
|  | Exit Screen<br>• There are two buttons given in this screen.<br>• The exit button will exit the application as user confirms to exit.<br>• The main menu button will proceed back to start screen. |

| User Interface Design | Description |
|---|---|
|  | Learn Page<br>• User can learn about the environmental trivia.<br>• The left and right button is to scroll through the flash cards. |
|  | Level Page<br>• User can pick the level that they want to play.<br>• However, the level will be locked and needed users to complete the remaining level. |
|  <br>  <br>  | Gameplay<br>• User needed to stroll around the maps looking for tasks listed.<br>• User need to finish the task and complete the progress bar before advancing towards the next level.<br>• There is analog button for users to control the movement and A and B button for users to interact with things. |

### 3.5 Beta Testing Phase

The purpose of beta testing is to gather direct feedback from external end-users, who are not part of the development process, in order to obtain their valuable insights and opinions. Based on the Green Hero target user which is 10 to 12 years old, a beta testing session has been executed and the results are evaluated in Section 4. The testing involve local children and their feedback has been recorded through Google Form questionnaire attached in Appendix B

### 3.6 Release Phase

The Release Phase marks the concluding stage of the GDLC model, where the Green Hero game is fully developed and capable of running successfully on the intended platform, which is an Android device. The game is created using the Unity Game Engine and converted into the .apk format. Subsequently, the .apk file is installed on an Android device, as depicted in Figure 5.

## 4. Results and Discussion

The results and discussion section presents the evaluation of the testing phase. After acquiring the feedback responses from the target users, the results were used to determine whether the game objectives reach the expectation and further improvements to enhance the game experience.

The distributed questionnaire were constructed based on the System Usability Scale (SUS)[14] tool to measure the system usability. The questionnaire consists of 10 questions that will determine the user acceptance rate. Furthermore, the construction of the questionnaire considered the specific needs and requirements of the target user base. The questions were formulated in a manner that allows for comprehensive evaluation and provides valuable insights into the level of acceptance and satisfaction among users.

Figure 9 displays the analysis of the first 5 questions from the Beta testing questionnaire. According to the SUS tool, the questionnaire comprises 5 positively phrased statements and 5 negatively phrased statements. The first question, "I found the Green Hero mobile game easy to use," received a response of 53.3% strongly agreeing and 46.6% agreeing with the statement. Moving on, the question "The navigation in the Green Hero mobile game was complicated" received a response of 56.6% strongly disagreeing, 36.6% disagreeing, and 6.6% being neutral. The third question, "The information presented in the Green Hero mobile game was clear and understandable," received a response of 66.7% strongly agreeing, 23.3% agreeing, and 10% being neutral. In regard to the question "The Green Hero mobile game contents are boring and repetitive," 43.3% strongly disagreed, 33.3% disagreed, and 23.3% responded neutrally. Lastly, for the question "The design and layout of the Green Hero mobile game were visually appealing," 56.6% responded strongly agreeing, 40% agreed, and 3.3% were neutral.

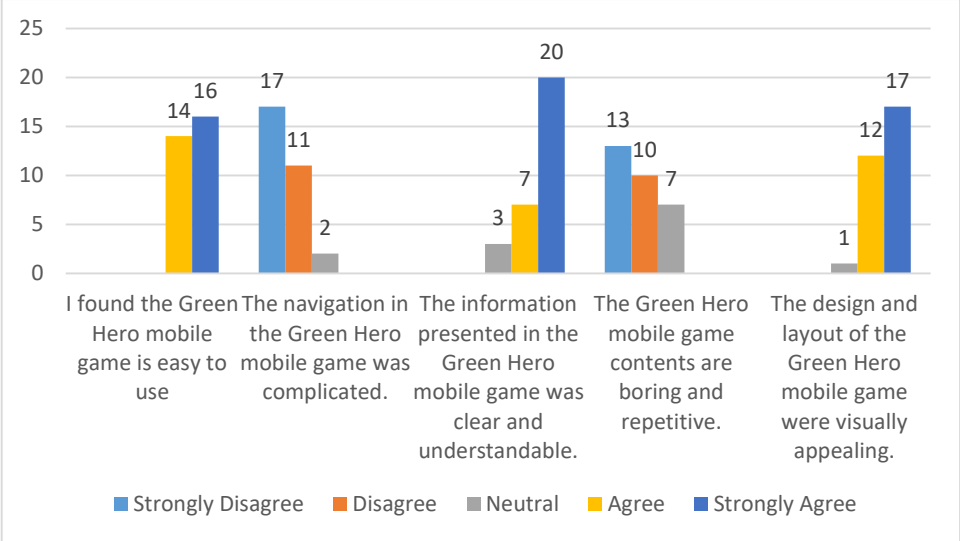



**Figure 9 : Question 1 – Question 5 UAT**

Figure 10 presents the analysis of the last 5 questions from the Beta testing questionnaire. The first question, "It was hard for me to find tasks and complete them in the Green Hero mobile game," received a response of 46.6% strongly disagreeing, 20% agreeing, and 33.3% neutral. Moving on to the question "The Green Hero mobile game provided helpful instructions and feedback throughout," 50% strongly agreed, and 50% agreed with the statement. The third question, "I would not recommend the Green Hero mobile game to others," obtained a response of 63.3% strongly disagreeing, 33.3% agreeing, and 3.3% being neutral. Regarding the question "The Green Hero mobile game offered a variety of interactive and educational challenges," 56.6% strongly agreed, 36.6% agreed, and 6.6% were neutral. Lastly, for the question "Playing the Green Hero mobile game doesn't affect my environmental awareness," 40% strongly disagreed, 43.3% disagreed, and 3.3% were neutral.

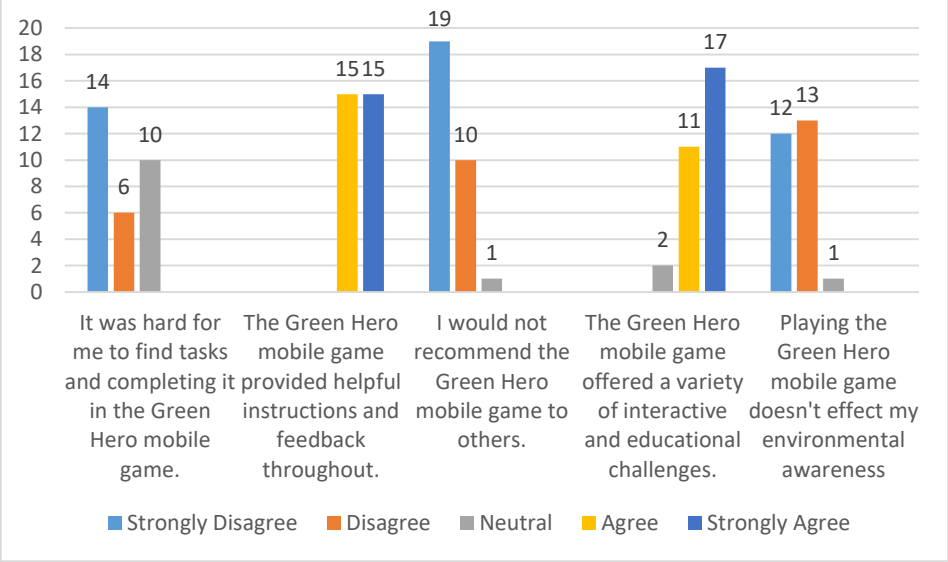



**Figure 10 : Question 6 – Question 10 UAT**

## 5. Conclusion

The proposed project aims to develop a game called "Green Hero" with the purpose of raising awareness about the critical challenges our planet Earth is currently facing. This game specifically targets primary school children between the ages of 10 and 12, recognizing the importance of instilling environmental consciousness from a young age. "Green Hero" not only educates players about the significance of environmental preservation but also ensures an enjoyable gaming experience by incorporating gamification elements. By creating "Green Hero," the project strives to engage young players in an interactive and immersive environment, where they can actively participate in activities that promote environmental responsibility. The game seeks to instill values such as recycling, waste management, and sustainable practices while providing an entertaining and captivating gameplay experience. Through this approach, the project aims to create a positive impact by encouraging children to become proactive contributors to the well-being of the planet.

Overall, "Green Hero" combines education, entertainment, and environmental awareness, making it a powerful tool for shaping the mindset and behaviors of young individuals. By emphasizing the importance of taking care of the environment, the game aspires to inspire a generation of eco-conscious individuals who will become agents of change and contribute towards a sustainable future.

## Acknowledgement

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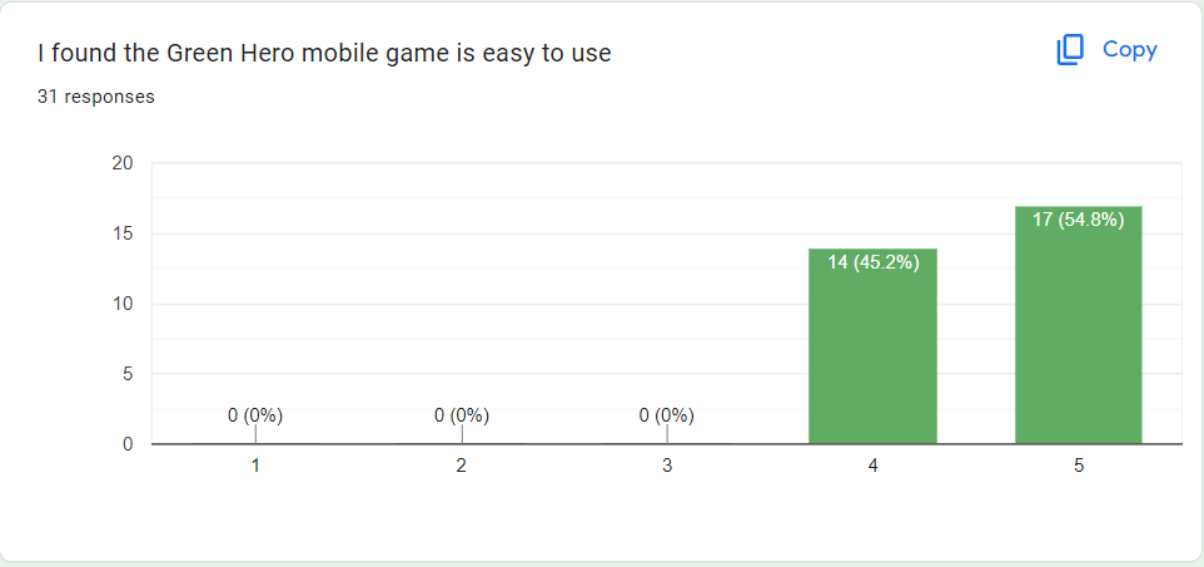
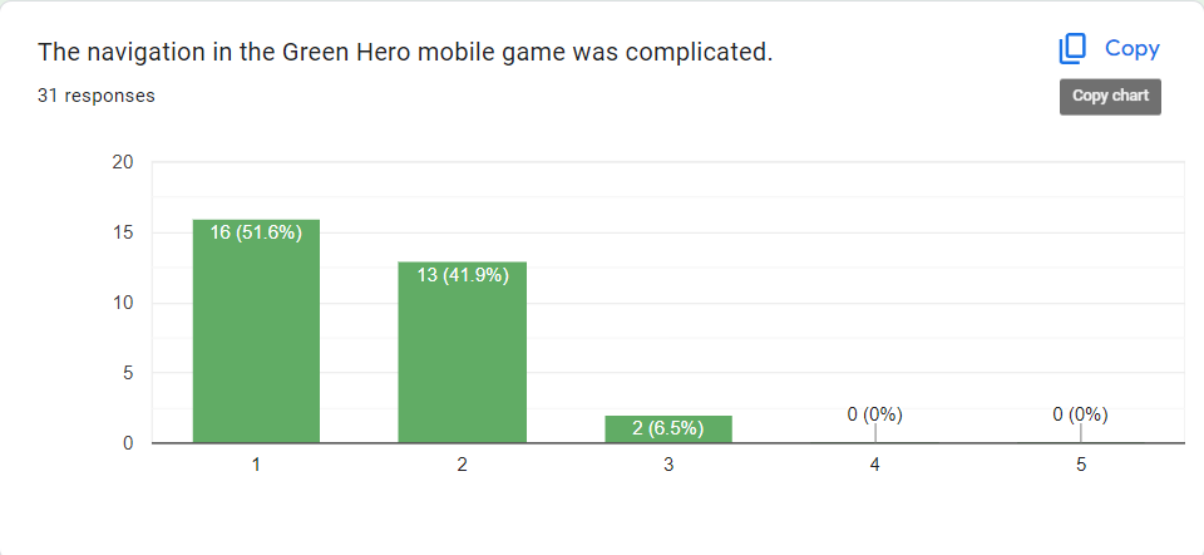
## Appendix A

| | |
|---|---|
| Q : | How well do you think the school student from 10 to 12 years old understand the environmental crisis today? |
| A : | Students understanding for the environmental crisis that is happening today are moderate, there's a lot of room for improvement. |
| Q : | Does student have their effort in keeping the schools clean? |
| A : | Students always shows positivity towards activity that needed them to take care of the school conduciveness |
| Q : | Is there any core structured subject focus mainly on the environment and biodiversity topic? |
| A : | There are only few subjects that cover subtopic of the environmental issues. There is still yet to have a fully specialized environmental subject. |
| Q : | How is the student acknowledgement towards environmental campaign done in school? |
| A : | As mentioned before, students involvement in activities such as environmental campaign has always been great. They give a full cooperation showing that they willing to understand what they are doing. |
| Q : | What is the best method to gain their interest as well as giving them lesson to be taught? |
| A : | The method must be balanced between fun and the lesson that is being delivered. It must blend well to make sure the focus gained by the fun activities part is being utilized by teaching them the related content |
| Q : | Is method such as games and activity efficient in tutoring the students? |
| A : | Absolutely. Especially in this modern digital world. |
| Q : | Is there any digitalized teaching method has been implemented for the children? |
| A : | In PdP (Pengajaran dan Pembelajaran), there is the implementation of digitalized teaching where teachers usually use slides, uses devices such as computer lab, tablet, and others. |
| Q : | What are the challenges in spreading environmental awareness towards children ? |
| A : | The uses of language and delivering the content must be prepared really well. Because environmental crisis is such a big and impactful topic to be exposed to the children. In order to make sure the campaign is working well, the deliverables must be cleared and suitable for the students ages. |

## Appendix B






## References

[1] "environment | biology | Britannica," *Encyclopædia Britannica*. 2023. Accessed: Jan. 09, 2023. [Online]. Available: https://www.britannica.com/science/environment

[2] R. Blankman, "The Fun of Learning: Gamification in Education," *Hmhco.com*, Jan. 28, 2022. https://www.hmhco.com/blog/what-is-gamification-in- (accessed Jan. 09, 2023).

[3] H. Kamaruddin*, N. Othman, S. M. Sum, and N. Z. A. Rahim, "Environmental Education In Malaysia: Past, Present And Future," *The European Proceedings of Social and Behavioural Sciences*, Oct. 2019, doi: 10.15405/epsbs.2019.10.25.

[4] M.-C. Ricoy and C. Sánchez-Martínez, "Raising Ecological Awareness and Digital Literacy in Primary School Children through Gamification," *International Journal of Environmental Research and Public Health*, vol. 19, no. 3, p. 1149, Jan. 2022, doi: 10.3390/ijerph19031149.

[5] N. S. Mei, C. W. Wai, and R. Ahamad, "Environmental Awareness and Behaviour Index for Malaysia," *Procedia - Social and Behavioral Sciences*, vol. 222, pp. 668–675, Jun. 2016, doi: 10.1016/j.sbspro.2016.05.223.

[6] Nur Ilmiyati, Adi Maladona, Nur Azizah Rahman, and D. Rahmawati, "Effort To Facilitate Environmental Awareness Through Science, Environment, Technology, And Society (SETS)," *ResearchGate*, Mar. 03, 2020. https://www.researchgate.net/publication/345149929_Effort_To_Facilitate_Environmental_Awareness_Through_Science_Environment_Technology_And_Society_SETS (accessed Jan. 09, 2023).

[7] S. Kim, K. Song, B. B. Lockee, and J. K. Burton, "Gamification in Learning and Education: Enjoy Learning Like Gaming," *ResearchGate*, 2018. https://www.researchgate.net/publication/322173437_Gamification_in_Learning_and_Education_Enjoy_Learning_Like_Gaming (accessed Jan. 09, 2023).

[8] Sergey Omelchenko, "2 Types of Gamification: Which One is Right For You? | Program-Ace," *Program-Ace*, Jun. 08, 2021. https://program-ace.com/blog/types-of-gamification/#:~:text=There%20are%202%20key%20approaches,%E2%80%93%20structural%20and%20content%2Dbased (accessed Jan. 09, 2023).

[9] Iulian Furdu, Cosmin Tomozei, and Utku Köse, "Pros and Cons Gamification and Gaming in Classroom," *ResearchGate*, Aug. 08, 2017. https://www.researchgate.net/publication/318726293_Pros_and_Cons_Gamification_and_Gaming_in_Classroom (accessed Jan. 09, 2023).

[10] Crazyplex LLC, "My City Cleaning Waste Recycle," *Google.com*, 2021. https://play.google.com/store/apps/details?id=com.crazyplex.mycitycleaning&hl=en&gl=US (accessed Jan. 09, 2023).

[11] EarthGames, "Climate Quest," *Google.com*, 2021. https://play.google.com/store/apps/details?id=com.EarthGames.ClimateQuest&hl=en&gl=US (accessed Jan. 09, 2023).

[12] C. Lin, "Recycle Rush," *Google.com*, 2021. https://play.google.com/store/apps/details?id=com.ColinLin.RecycleRush&hl=en&gl=US (accessed Jan. 09, 2023).

[13] R. Ramadan and Y. Widyani, "Game development life cycle guidelines," *2013 International Conference on Advanced Computer Science and Information Systems (ICACSIS)*, Sep. 2013, doi: 10.1109/icacsis.2013.6761558.

[14] A. Smyk, "The System Usability Scale & How it's Used in UX | Adobe XD Ideas," Adobe, Mar. 17, 2020. https://xd.adobe.com/ideas/process/user-testing/sus-system-usability-scale-ux/ (accessed Jul. 30, 2021).