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The Development of Turtle Trek: Sea Turtle Odyssey

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Abstract

"Turtle Trek: Sea Turtle Odyssey" is a 2D side-scrolling mobile game designed to raise awareness about sea turtle conservation by engaging users with an interactive and educational experience. The lack of awareness among the public will increase the threats to the sea turtle population. Through comprehensive testing, the game demonstrated high functionality and usability, achieving an average System Usability Scale (SUS) score of 71.63, which indicates an acceptable level of user satisfaction, graded "C", and the Adjective Rating is "OK". The game successfully educated players about the life stages of sea turtles and the threats they face, combining entertainment with valuable learning outcomes. User feedback confirmed the game's effectiveness, highlighting strengths such as its immersive learning experience, educational impact, and diverse multimedia elements. Overall, "Turtle Trek: Sea Turtle Odyssey" proved to be a successful tool for promoting environmental awareness and conservation efforts, suggesting a good place for similar educational initiatives in the future.

1. Introduction

This project, "Turtle Trek: Sea Turtle Odyssey" responds to the imminent endangerment of sea turtles, highlighting their crucial role in marine ecosystems. The problem at hand revolves around the escalating threats to sea turtles, including pollution and habitat destruction. They have survived for millions of years and are the "dinosaurs" of the ocean. But now six out of seven sea turtle species are currently threatened [1]. For instance, the global turtle population has noticeably decreased, and this is largely due to plastic pollution in recent years [2]. With pollution, habitat destruction, and poaching threatening these ancient creatures, urgent conservation efforts are essential. Existing mobile games lack educational depth and fail to emphasize the challenges faced by sea turtles. In response, this project proposes a 2D mobile game as a dynamic tool to raise awareness and educate users about sea turtle conservation.

The environmental challenges, including pollution and habitat destruction, pose severe threats to sea turtles not only in Malaysia, but the whole world. Traditional conservation methods have struggled to engage the younger generation. However, existing sea turtle-related mobile games lack educational value and do not include conservation messages. The "Turtle Trek: Sea Turtle Odyssey" project aims to address this gap by developing an immersive 2D mobile game, fostering empathy, understanding, and responsibility for sea turtle conservation.

The project's objectives include designing an interactive side-scrolling mobile game application named "Turtle Trek: Sea Turtle Odyssey" using a two-dimensional (2D) approach, to develop the proposed mobile game application by using Unity on the Android platform and testing the functionality and usability of "Turtle Trek: Sea Turtle Odyssey". The project is designed for those who lack awareness of sea turtles and ocean conservation especially those aged above 6.

The project encompasses designing and developing a 2D side-scrolling endless runner game, featuring pixel-based sea turtle characters facing obstacles such as pollution and predators. Educational content will be integrated

into gameplay to convey the ecological significance of sea turtles. Emphasis will be on user-friendly mechanics, accessibility, and playtesting for an inclusive experience.

Anticipated outcomes include a fully functional, educational mobile game that effectively communicates the challenges faced by sea turtles. The game aims to inspire real-world actions in support of sea turtle conservation, contributing to marine ecosystem preservation.

"Turtle Trek: Sea Turtle Odyssey" has far-reaching significance, serving as an educational tool for schools, tourist spots, and wildlife centers. It offers inspiration for educational games, corporate social responsibility, and research into conservation awareness. Ultimately, the project aims to make people aware of the importance of protecting sea turtles and the oceans.

The rest of the paper structure includes Section 2: Related Work, Section 3: Game Development Life Cycle (GDLC) methodology, Section 4: Results and Discussion, and Section 5: Conclusion. Each section contributes to a comprehensive understanding of the project's background, objectives, development process, and potential future directions.

2. Related Work

This section goes into the background of environmental conservation through gaming, exploring domains, and technology, as well as providing a comparative analysis.

2.1 Sea Turtles and Environmental Conservation

The domain of "Turtle Trek: Sea Turtle Odyssey" revolves around the fascinating and important area of sea turtles and environmental conservation. Known for their ancient existence and complex life cycles, sea turtles have navigated Earth's waters for centuries. These extraordinary creatures are not only wonders of nature but also profound symbols of ocean conservation efforts.

In the face of historical resilience, sea turtles face unprecedented challenges in modern times. Threats such as pollution and poaching cast a shadow on their survival. Habitat destruction and the prevalence of harmful materials, especially plastics, put sea turtles at risk. Research paints a worrying picture, with predictions suggesting significant declines in sea turtle populations that could lead to extinction within the next decade [3]. While the efforts of individuals and organizations are laudable, conservation outcomes often fall short of expectations.

Recognizing the urgency of sea turtle conservation, Turtle Trek: Sea Turtle Odyssey aims to address these challenges through an innovative mobile gaming platform. The selection of mobile games is in line with a wider trend of leveraging the widespread reach of mobile devices to engage diverse audiences [4]. Mobile devices, including educational games, are considered powerful tools for environmental education and sustainable development [5].

The project draws inspiration from the potential of environmentally friendly play. While existing environmentally friendly mobile games have varying results, "Turtle Trek: Sea Turtle Odyssey" hopes to effectively combine entertainment and education. Through in-depth case studies and examples of successful environmental games, the project aims to integrate strategies that entertain, educate, and inspire players to contribute to sea turtle and ocean conservation.

2.2 Technology

The technology behind Turtle Trek: Sea Turtle Odyssey is carefully chosen to create an immersive, educational, and widely accessible gaming experience. In recent years, interactive games have become integral to the lives of children and teenagers, presenting an opportunity to not only entertain but educate as well [6].

In the realm of game development, the choice between 2D and 3D games carries significance, and Turtle Trek: Sea Turtle Odyssey chooses the friendly accessibility of 2D. This decision aligns with the project's goal to reach a broad audience, including those with limited access to the latest technology. Research indicates a preference for 2D gaming environments, making it a suitable choice for inclusivity and educational focus [7]. The simplicity of 2D games not only accelerates the creative process but also makes the game more cost-effective, ensuring quick and economical updates when needed. Embracing the popular hyper-casual game category, known for its quick and easy entertainment, further enhances the game's appeal [8].

The game type chosen for Turtle Trek: Sea Turtle Odyssey is a 2D side-scrolling endless runner. This game type, where the camera is set to a side view, aligns with the project's objectives of providing an engaging and accessible experience for players of varying skill levels. The endless running mode adds excitement and challenge, fostering an immersive gameplay experience. The side-scrolling approach maximizes the available space, creating a compelling environment where players navigate challenges that mirror real threats to sea turtles, such as plastic pollution and poachers. This strategic choice strikes a balance between entertainment and education, ensuring players enjoy the game while gaining awareness of sea turtle conservation challenges.

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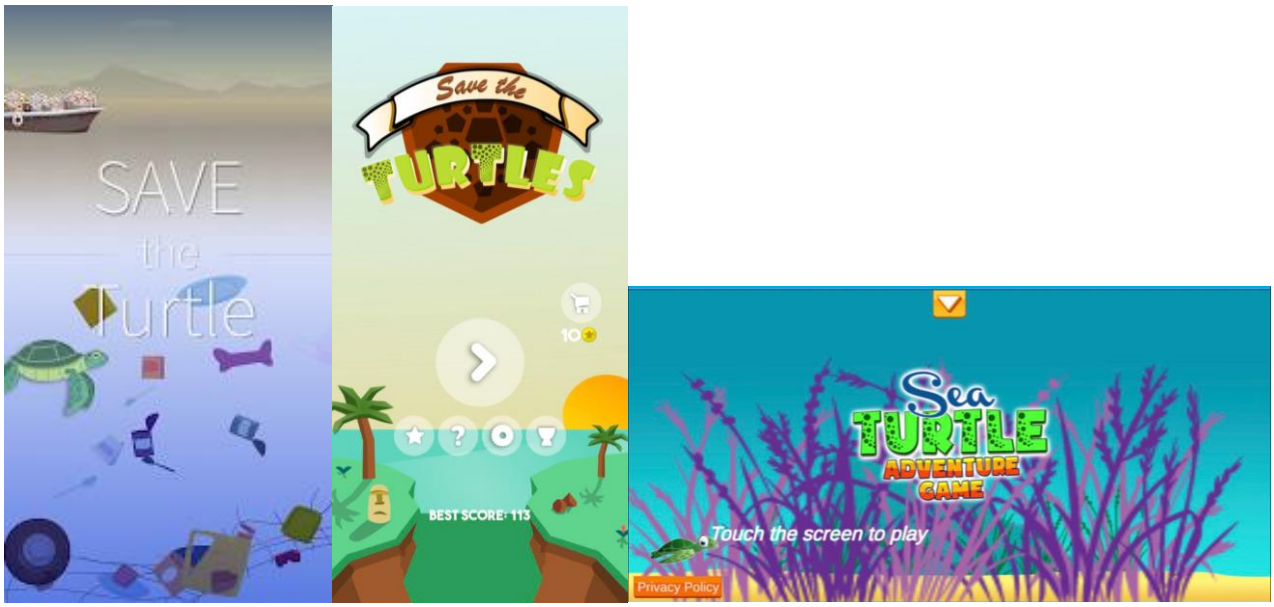
The game employs gamification elements, including a scoring system within the gameplay module. This scoring system significantly influences player satisfaction and encourages replayability. Motivating players to achieve higher scores enhances their sense of accomplishment and curiosity about the unfolding conservation story. By incorporating gamification, Turtle Trek: Sea Turtle Odyssey aims to make learning about sea turtle conservation not only impactful but also enjoyable.

2.3 Comparative Analysis

A comparative analysis will be conducted to highlight the unique features of Turtle Trek: Sea Turtle Odyssey in comparison to other games related to sea turtles which are Save the turtle [9], Save the turtle: Clean ocean [10], and Sea Turtle Adventure Game [11]. This analysis aims to showcase the distinctive aspects of the game, emphasizing its contribution to the realm of environmental education through gaming. Figure 1 below shows the existing applications in Google Play [12], which are shown in (a) Save the turtle, (b) Save the turtle: Clean ocean, and (c) Sea Turtle Adventure Game. In addition, the comparative analysis between the existing applications is shown in detail in Table 1.



(a) **(b)** **(c)**

Fig. 1 *Existing applications (a) Save the turtle; (b) Save the turtle: Clean Ocean; (c) Sea Turtle Adventure Game*

Table 1 *Comparative analysis between existing applications*

Element	Save the turtle	Save the turtle: Clean ocean	Sea Turtle Adventure Game	Turtle Trek: Sea Turtle Odyssey
UI	Minimalistic with basic elements	Well-designed with multiple pages	Simple UI design	Streamlined, emphasizing gameplay
Language	English	English	English	English
Target User	3 years old and above	3 years old and above	3 years old and above	7 years old and above
Internet Connection	Only when the hint is required	Not required	Not required	Not required
Purchasing	Free to use	In-app purchases	Free to use	Free to use
Level	Puzzle-solving stages	Continuous gameplay	Endless mode	Endless mode and Story mode which depicting life journey of sea turtle
Module	Game	Game	Game	Story and Game
Game Mechanic	Puzzle-solving	Bullet avoidance	Side-scrolling adventure	Side-scrolling adventure
Booster	Available	Not available	Available	Available

Table 1 *Comparative analysis between existing applications (cont.)*

Element	Save the turtle	Save the turtle: Clean Ocean	Sea Turtle Adventure Game	Turtle Trek: Sea Turtle Odyssey
Educational Content	No educational content	Limited educational content	Lack of educational content	Focus on educational content, especially in the story module
In-Game Purchase	No in-game purchases	Skins, maps, and diamonds	Power-ups using in-game coins	Unlock new characters using in-game coins
Advertisement	Yes	Yes	Yes	No
Strength	• Unique puzzle-solving concept • Free to play • Able to play on • both Android • and iOS	• Attractive store • features • Attractive UI	• Simple controls • Free to play	• Emphasis on • educational and • immersive • Free to play
Limitation	• Need to watch ads to get the hints • Doesn't have a volume bar • Doesn't have a menu interface	• Need to watch ads after playing several games • Doesn't have a volume bar	• Need to watch ads after playing several games • Doesn't have a volume bar	• Only operate on the Android platform

3. Methodology

In this section, the methodology applied for developing the mobile game application, Turtle Trek: Sea Turtle Odyssey, is explained. The chosen methodology is the Game Development Life Cycle (GDLC), and this chapter offers a comprehensive breakdown of each phase.

3.1 Introduction

This section presents the project's GDLC approach, emphasizing its relevance to the gaming industry. It foreshadows the subsequent parts of an in-depth study of each phase of the GDLC.

3.2 Game Development Life Cycle (GDLC)

Software Development Life Cycle (SDLC) is a study of concepts used in the gaming industry and converted into GDLC to improve process management in the gaming industry [13]. Since Turtle Trek: Sea Turtle Odyssey is a mobile game application, the GDLC model is applied to it as the methodology model in this project. The development life cycle of a game is made up of different stages, like those in a typical software development process [14]. According to the researchers [15], the GDLC model consists of 6 development phases which are the initiation phase, pre-production phase, production phase, testing phase, beta phase, and release phase, as shown in Figure 2.

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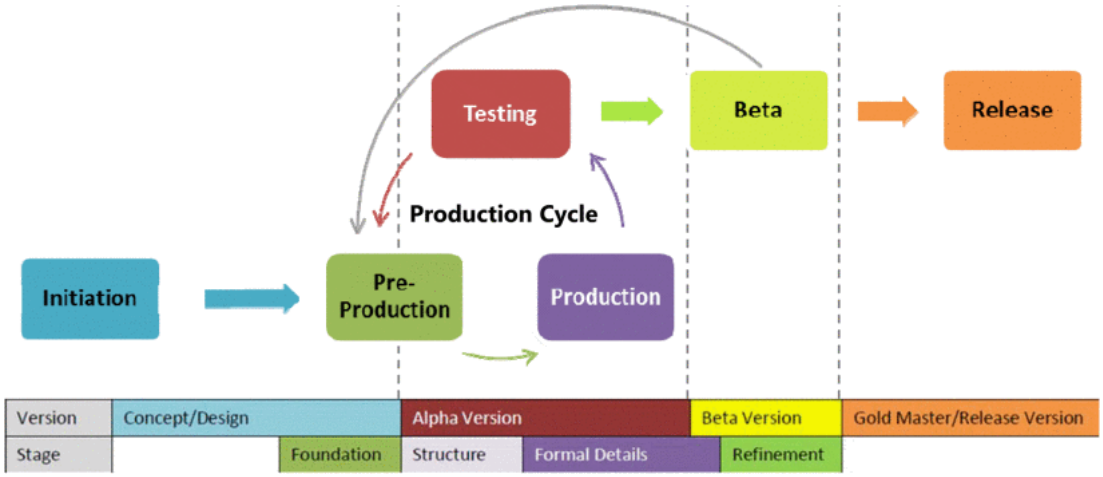

Fig. 2 *Game Development Life Cycle (GDLC) model*

3.2.1 Initiation Phase

The initiation phase marks the beginning of the project, assessing feasibility, defining goals, and outlining the game concept. This phase provides a basic understanding of the scope and purpose of the project. Outputs include project proposals, user requirements, system requirements, and Gantt charts. The Gantt chart will be included and shown in Appendix A.

3.2.2 Pre-Production Phase

Detailed planning occurs in the pre-production phase, involving the creation of a game design document, game prototypes, and the clarification of game pitch requirements. The output consists of a flowchart, navigation structure, and storyboard, serving as a crucial roadmap for subsequent development stages. Besides that, the requirements of the project will also be investigated in this phase. The requirements that will be analyzed will be user requirements, system requirements which include functional requirements and non-functional requirements, and hardware and software requirements. The navigation structure is shown in Figure 3 and the flowcharts about the game are shown in Figure 4, the clearer version of the flowchart will be included in Appendix C. There is a user requirements analysis done in Table 2 which shows the stakeholder, role in the product, design implication, and actions needed for the users, while the other tables such as hardware and software requirements will be included in Appendix C.

Table 2 *User Requirements Analysis*

Stakeholder	Role in Product	Design Implication	Actions Needed
General user	End-user of the application	Preferences for the English language in the game	Ensure language options, and prioritize English content
		Importance of game interface design	Prioritize intuitive and visually appealing designs
		Preference for multiple game modes	Implement of Story mode and Endless mode in the game
		Motivation through a reward system in the game	Integrate a rewarding system for user engagement
		Significance of an in-game store	Develop an in-game store with valuable items such as the new character

Table 2 *User Requirements Analysis (cont.)*

Stakeholder	Role in Product	Design Implication	Actions Needed
General user	End-user of the application	Preference for 2D design in mobile games	Focus on 2D design, ensuring accessibility and appeal
		Desire for environmental or conservation messages	Integrate conservation messages within the game, especially in Story mode
		Recognition of the impact of mobile games on awareness	Emphasize environmental issues in-game content
		Awareness of threats faced by sea turtles	Incorporate educational content about sea turtle threats
		Inclusion of multimedia elements in a mobile game	Integrate the multimedia elements in the game as much as possible

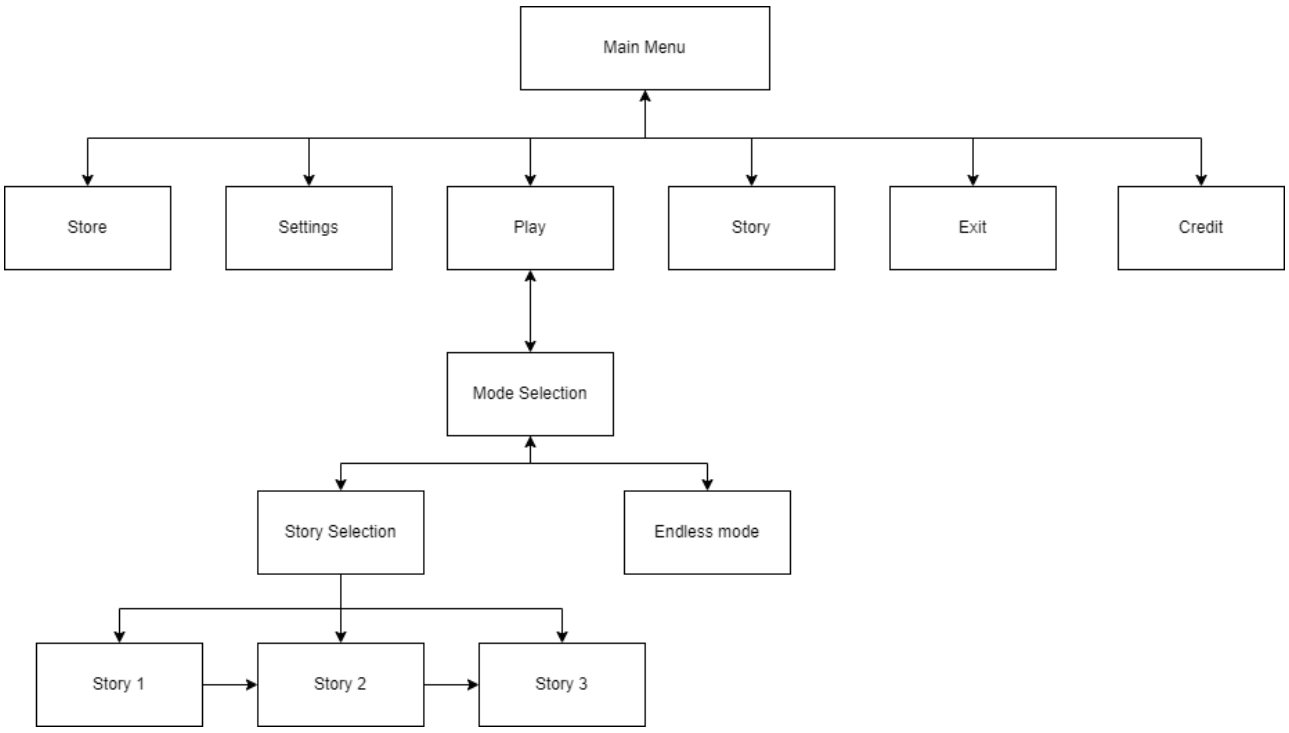

Fig. 3 *Navigation Structure*

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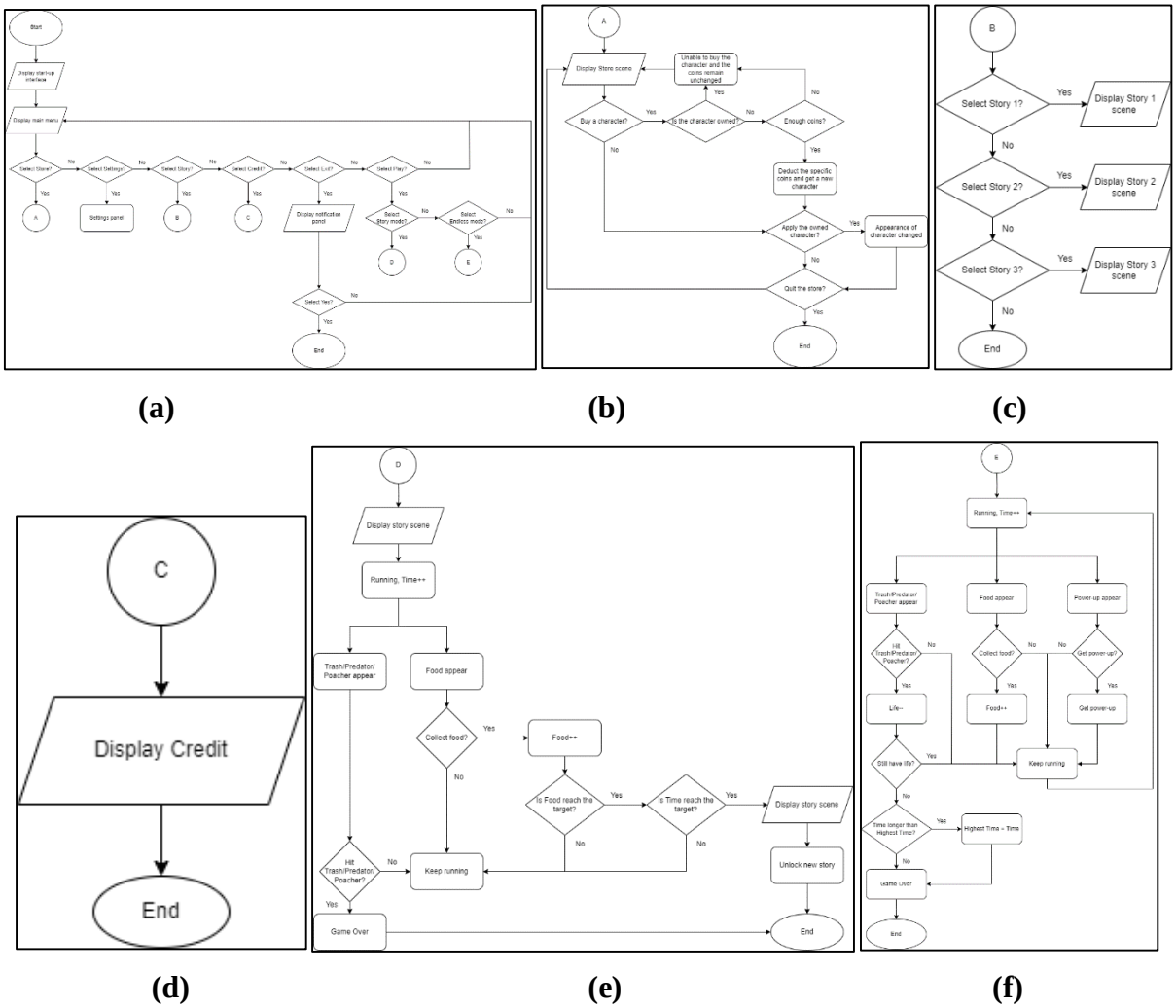


Fig. 4 *Flowcharts (a) Main Menu; (b) Store; (c) Story; (d) Credit; (e) Story mode; (f) Endless mode*

3.2.3 Production Phase

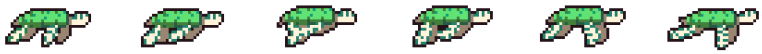
The actual development of Turtle Trek: Sea Turtle Odyssey initiates in this phase. Game assets, characters, and educational content are created, integrating graphics and animations. Multimedia tools like Procreate, Pixel Studio, Adobe Photoshop, CapCut, DaVinci Resolve, and Unity are employed. The output encompasses game assets, characters, background, graphics, animations, and C# programming source code. A table with the character's animation design using Pixel Studio is shown in Table 3 below.

3.2.4 Testing Phase

Testing is essential for every mobile application in the development process. This is because this process helps the developer determine whether an application can be run smoothly and accepted by the target users. Testing in GDLC means internal testing conducted to test the game's usability and playability [15]. Quality assurance takes the spotlight in the testing phase. The game undergoes rigorous testing to identify and rectify bugs, glitches, or gameplay issues.

On the other side, the game idea, game features, game sound, game interfaces, and functionality of game buttons will be tested in this phase to check whether they can function well. The result of the output of testing will decide whether the developer can move to the next phase [15]. This phase is crucial to ensure a flawless and seamless gaming experience for players.

Table 3 *Character Animation Design*

Character's Motion	Design
Green Sea Turtle (Walking)	
Flatback Sea Turtle (Walking)	
Kemp's Ridley Sea Turtle (Walking)	
Leatherback Sea Turtle (Walking)	
Loggerhead Sea Turtle (Walking)	
Olive Ridley Sea Turtle (Walking)	

3.2.5 Beta Phase

A beta is a phase conducted by third-party or external testers called beta testing [15]. There are two types of beta testing which are closed beta and open beta. In a closed beta, participation is limited to invited individuals, whereas in an open beta, anyone who registers can become a participant [15]. The beta phase introduces the game to a select audience for extensive testing in a real-world setting.

In this project, the mobile game application, Turtle Trek: Sea Turtle Odyssey will be tested by 10 target users who are above 6 years old. Feedback from the target users is invaluable for fine-tuning gameplay, addressing any remaining issues, and gauging user reactions to improve the user experience of this application. The end of a Beta session is primarily attributed to the end of the Beta period or the completion of testing reports from designated Beta testers, possibly initiating another production phase for product improvements, or continuing to the release phase if deemed satisfactory [15]. This phase acts as a final checkpoint before the official release, ensuring a refined and well-received product.

3.2.6 Release Phase

The last phase of the GDLC is the release phase which involves product launch, project documentation, knowledge sharing, postmortems, maintenance, and game expansion planning [15]. In this phase, where Turtle Trek: Sea Turtle Odyssey is launched to the public, the application is completely done with development and released on the Android platform. After that, the final report of this project will be released in Portable Document Format (PDF) format.

3.3 Application Development Workflow

This section will go into the specific workflow adopted during the development phases of the mobile game application, Turtle Trek: Sea Turtle Odyssey. During the project progress, the workflow for each phase in GDLC with the individual task and output is determined as shown in Table 4.

Table 4 *Workflow in GDLC*

Phase	Task	Output
Initiation	• Create and draft a game idea concept. • Create a basic game description. • Define the scope, user requirements, and system requirements of the project. • Make a review and comparison between the existing applications and the proposed application. • Determine the time frame for each task of the project.	• Project proposal • User requirements • System requirements • Gantt chart
Pre-production	• Game design. • Development of game prototype. • Clarify the game pitch requirements. • Make the flowchart and storyboard.	• Flowchart • Storyboard
Production	• Create the game assets. • Create the game characters. • Draw the game background. • Make the animation. • Write the source code. • Combine the game assets and the source code.	• Game assets • Game characters • Game background • Graphics • Animation • C# programming source code
Testing	• Test the game for issues, fix bugs, and ensure smooth gameplay.	• Bugs report
Beta	• Test the game with target users, collect feedback, and make improvements.	• User feedback
Release	• Launch the game to the public. • Share project documentation.	• Mobile game application, Turtle Trek: Sea Turtle Odyssey

3.4 Concept Design

A storyboard acts as a game plan for Turtle Trek: Sea Turtle Odyssey. It serves as a design document where the game's ideas are illustrated and arranged in a step-by-step order. This helps in visualizing the development and flow of the game. The storyboard for Turtle Trek: Sea Turtle Odyssey includes sketches of all the interfaces, along with descriptions of buttons, graphics, text, audio, and other elements as shown in Table 5.

3.5 Game Development

At this phase, the development of the game will proceed to make the main function of Turtle Trek: Sea Turtle Odyssey. This stage involves developing the game assets for the game application such as graphics, audio, and animations, and integrating these assets into Unity. The integration of C# scripts of the game application will be implemented in this phase of development as shown in Table 7 to make sure the game will function well.

There are several core components needed for this game to make it perform well. Some of these components will be chosen and shown in this section. The scripts handle the turtle's movements and interactions with the game environment and generate the game levels by adding and removing game objects and rooms based on the player's position. Table 7 shows the script for those functions.

Table 5 *Storyboard*

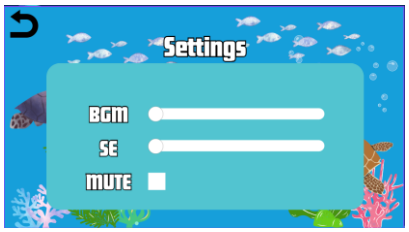
Interface	Description	Interface	Description
	This is the main menu interface that contains the game module and story module.		This is the settings interface which will open when the settings button is clicked.
	This is the mode selection interface when the play button is clicked.		This is the story selection interface when the story button is clicked.
	This is the in-game interface which will show when the game starts.		

Table 6: *Development of game assets*

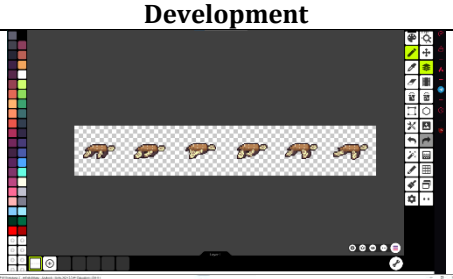
Assets	Development	Description
Graphics		Pixel Studio is used to make the character design for Turtle Trek: Sea Turtle Odyssey. The different motions in an image act as the different frames of the animations.
Animations		**Unity is used to make the different motions in the image become different frames for the sea turtle animations by inserting the frame into the animator in Unity.**

Table 7: *C# Script for Turtle Trek: Sea Turtle Odyssey*

Functions	Source Code	Description

Collect Food	`void CollectFood(Collider2D foodCollider)`
	`{`
	`foods++;`
	`foodsCollectedLabel.text = foods.ToString();`
	`Destroy(foodCollider.gameObject);`
	`}`
		Source code for collecting food. This shows the logic when the player touches the food, the food counter will increase, and the food will disappear.

Hit by enemies	`void HitByEnemy(Collider2D enemyCollider)`
	`{`
	`isDead = true;`
	`Destroy(enemyCollider.gameObject);`
	`playerAnimator.SetBool("isDead", true);`
	`}`
	
	`void HitByMoveEnemy(Collider2D moveEnemyCollider)`
	`{`
	`isDead = true;`
	`playerAnimator.SetBool("isDead", true);`
	`}`
		Source code for hit by enemies. This code shows the logic when the player touches the enemy, the player will trigger the boolean isDead become true.

On Trigger Enter 2D	`private void OnTriggerEnter2D(Collider2D collider)`
	`{`
	`if (collider.gameObject.CompareTag("Foods"))`
	`{`
	`CollectFood(collider);`
	`}`
	`else if (collider.gameObject.CompareTag("Enemy"))`
	`{`
	`HitByMoveEnemy(collider);`
	`}`
	`else`
	`{`
	`HitByEnemy(collider);`
	`}`
	`}`
		Source code for responding to collisions with foods, enemies, and obstacles. When the player touches the object, if the object with the tag “Foods” then the CollectFood() will trigger on, else if the tag is “Enemy” then the HitByMoveEnemy() will trigger on, if not both, HitByEnemy() will trigger.

Add Room	`void AddRoom(float farthestRoomEndX)`
	`{`
	`if (currentRoomCounter >= RoomRepetitionLimit || currentRoomIndex == -1)`
	`{`
	`int newRoomIndex;`
	`do`
	`{`
	`newRoomIndex = Random.Range(0, availableRooms.Length);`
	`} while (newRoomIndex == currentRoomIndex);`
	
	`currentRoomIndex = newRoomIndex;`
	`currentRoomCounter = 0;`
	`}`
	`GameObject room = (GameObject)Instantiate(availableRooms[currentRoomIndex]);`
	`float roomWidth = room.transform.Find("Floor").localScale.x;`
	`float roomCenter = farthestRoomEndX + roomWidth * 0.5f;`
	`room.transform.position = new Vector3(roomCenter, 0, 0);`
	`currentRooms.Add(room);`
	`currentRoomCounter++;`
	`}`
		When the current room is moved away from the camera, this code automatically adds the new room.

Table 7 *C# Script for Turtle Trek: Sea Turtle Odyssey (cont.)*

Functions	Source Code	Description

Generator Check	`private IEnumerator GeneratorCheck()`
	`{`
	`while (true)`
	`{`
	`if (PlayerController.Instance != null && PlayerController.Instance.isDead)`
	`yield break;`
	`GenerateRoomIfRequired();`
	`GenerateObjectsIfRequired();`
	`yield return new WaitForSeconds(0.25f);`
	`}`
	`}`
		This code will check when the room can be generated for the scene.

Generate Room If Required	`private void GenerateRoomIfRequired()`
	`{`
	`List<GameObject> roomsToRemove = new List<GameObject>();`
	`bool addRooms = true;`
	`float playerX = transform.position.x;`
	`float removeRoomX = playerX - screenWidthInPoints;`
	`float addRoomX = playerX + screenWidthInPoints;`
	`float farthestRoomEndX = 0;`
	`foreach (var room in currentRooms)`
	`{`
	`float roomWidth = room.transform.Find("Floor").localScale.x;`
	`float roomStartX = room.transform.position.x - (roomWidth * 0.5f);`
	`float roomEndX = roomStartX + roomWidth;`
	`if (roomStartX > addRoomX)`
	`{`
	`addRooms = false;`
	`}`
	`if (roomEndX < removeRoomX)`
	`{`
	`roomsToRemove.Add(room);`
	`}`
	`farthestRoomEndX = Mathf.Max(farthestRoomEndX, roomEndX);`
	`}`
	`foreach (var room in roomsToRemove)`
	`{`
	`currentRooms.Remove(room);`
	`Destroy(room);`
	`}`
	`if (addRooms)`
	`{`
	`AddRoom(farthestRoomEndX);`
	`}`
	`}`
		This code will generate the room if the conditions of GeneratorCheck() are met. Then, this code will remove the room and add the room based on the conditions.

4. Results

In this section, the testing phase of Turtle Trek: Sea Turtle Odyssey during the development will be discussed in detail. A comprehensive testing strategy was implemented to ensure the functionality, performance, and usability of the game. In this project, alpha and beta testing were conducted to evaluate the functions properly. The developer conducted alpha testing throughout the development process until Turtle Trek: Sea Turtle Odyssey was completed, while the beta testing was conducted with the target users after the game was completed. The testers were asked to fill in an online questionnaire through Google Forms. The questionnaire consists of 10 questions that focus on the usability of the application by using the System Usability Scale (SUS) [16] to test the user acceptance level.

Firstly, Figure 5(a) and Figure 5(b) show are Gender of users and Age of users. In the beta testing, a total of 20 testers took part. The 20 respondents are 13 males (65%) and 7 females (35%) as shown in Figure 5(a). On the other side, there are 5 (25%) respondents who are 7-12 years old and 13-18 years old respectively. 8 (40%) respondents are 19-29 years old, and the rest 2 (10%) respondents are 30 years old and above.

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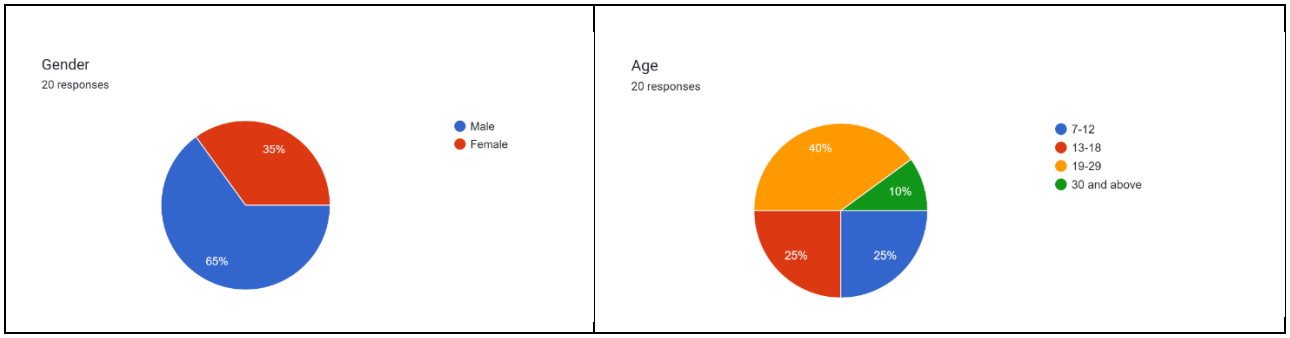
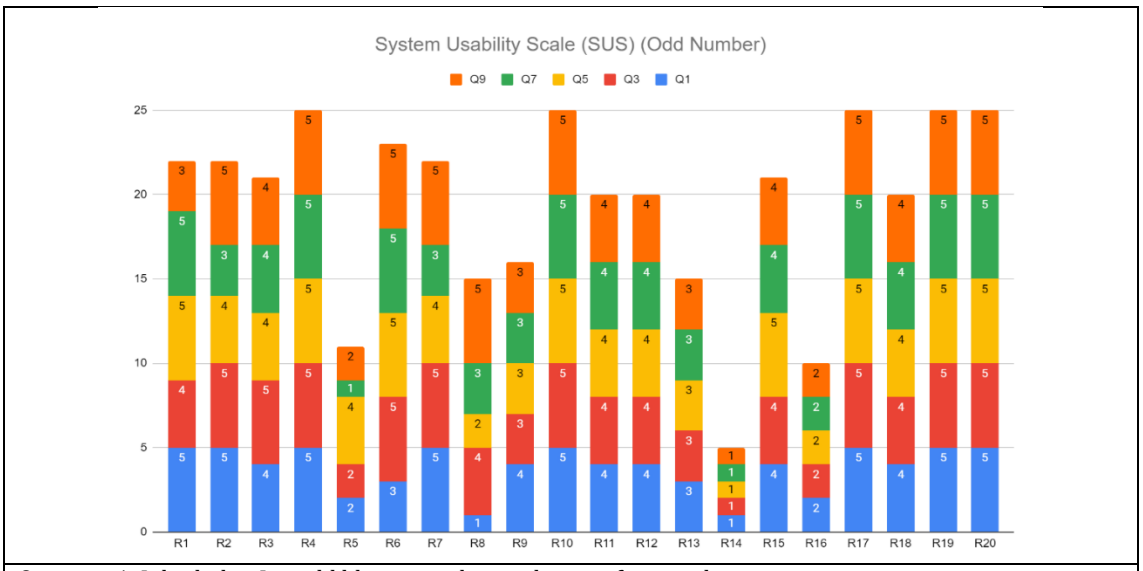


(a) **(b)**

Fig. 5 *Flowcharts (a) Gender; (b) Age*

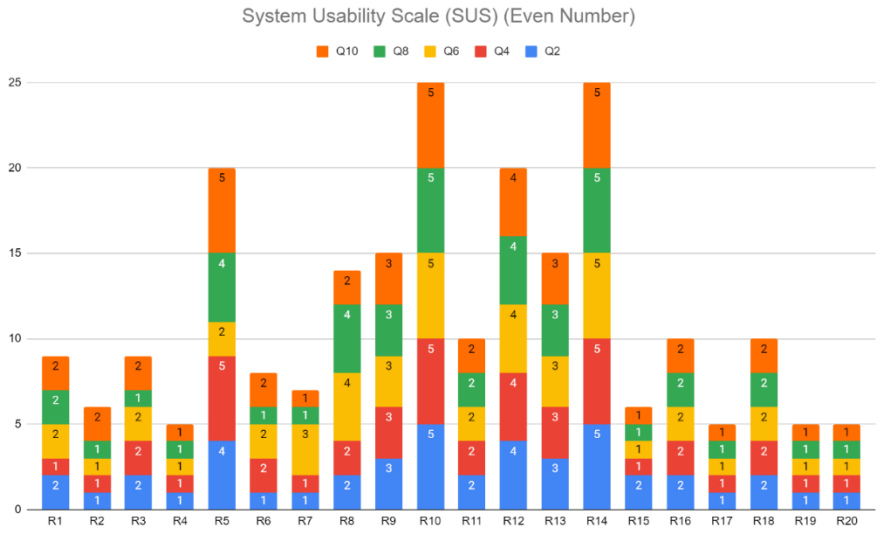


Question 1: I think that I would like to use this application frequently.
Question 3: I thought the application was easy to use.
Question 5: I found the various functions in this application were well integrated.
Question 7: I would imagine that most people would learn to use this application very quickly.
Question 9: I felt very confident using this application.

Fig. 6 *SUS Positive Question Result*

Based on Figure 6, all respondents gave 4 marks and above, which agrees with the positive statement in the questionnaires. However, 3 respondents disagreed with the positive outcome and gave most of the questions below 3 marks. Some questions obtained 3 marks which is neutral.

Based on Figure 7, 5 respondents gave marks above 3 marks, which agrees with the negative statement in the questionnaires. 2 respondents gave 3 marks which are neutral to these negative statements and the rest gave marks below 3 marks which disagree with the negative statements.



Question 2: I found the application unnecessarily complex.
Question 4: I think that I would need the support of a technical person to be able to use this application.
Question 6: I thought there was too much inconsistency in this application.
Question 8: I found the application very cumbersome to use.
Question 10: I needed to learn a lot of things before I could get going with this application.

Fig. 7 *SUS Negative Question Result*

The overall result of SUS questions shows that over half of respondents do not have much problem using the Turtle Trek: Sea Turtle Odyssey game application. The total scores for each question from the user tests are shown in Table 8 in detail, followed by calculating the average score by using the SUS formula.

Table 8 *Respondents' Score*

Respondent	Item Score										Total Score
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	
R1	5	2	4	1	5	2	5	2	3	2	82.5
R2	5	1	5	1	4	1	3	1	5	2	90
R3	4	2	5	2	4	2	4	1	4	2	80
R4	5	1	5	1	5	1	5	1	5	1	100
R5	2	4	2	5	4	2	1	4	2	5	27.5
R6	3	1	5	2	5	2	5	1	5	2	87.5
R7	5	1	5	1	4	3	3	1	5	1	87.5
R8	1	2	4	2	2	4	3	4	5	2	52.5
R9	4	3	3	3	3	3	3	3	3	3	75
R10	5	5	5	5	5	5	5	5	5	5	62.5
R11	4	2	4	2	4	2	4	2	4	2	75
R12	4	4	4	4	4	4	4	4	4	4	50
R13	3	3	3	3	3	3	3	3	3	3	50
R14	1	5	1	5	1	5	1	5	1	5	0
R15	4	2	4	1	5	1	4	1	4	1	87.5
R16	2	2	2	2	2	2	2	2	2	2	50
R17	5	1	5	1	5	1	5	1	5	1	100
R18	4	2	4	2	4	2	4	2	4	2	75
R19	5	1	5	1	5	1	5	1	5	1	100
R20	5	1	5	1	5	1	5	1	5	1	100
Average Score											**71.63**

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The formula used to obtain usability results based on the SUS is:

Total score = (odd items + even items) x 2.5

$$\text{Average score} = \frac{\text{Total score}}{\text{Total respondents}}$$

Where:

Odd items (Q1, Q3, Q5, Q7, Q9) = contribution - 5

Even items (Q2, Q4, Q6, Q8, Q10) = contribution – 1

Therefore,

$$\text{Average score} = \frac{82.5+90+80+100+27.5+87.5+87.5+52.5+75+62.5+75+50+50+0+87.5+50+100+75+100+100}{20}$$

$$= 71.63$$

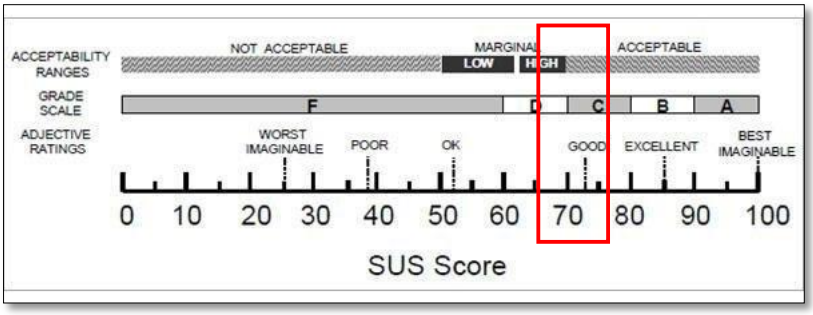

Fig. 8 *System Usability Scale (SUS)*

The total scores for each question from the testers were obtained by calculating the average score by using the formula based on the System Usability Scale (SUS). The average score is 71.63 which is within the range of "acceptable" in the Acceptability Range score scale. The Grade Scale is "C" and the Adjective Rating is "OK" as shown in Figure 8. Overall, the built-in applications can be classified as successfully meeting the needs of the target users.

5. Conclusion

In summary, the target users' feedback evaluates the effectiveness of the "Turtle Trek: Sea Turtle Odyssey" project, highlighting its success in achieving its primary objectives, identifying its strengths and limitations, and proposing improvements for future development. For example, "Turtle Trek: Sea Turtle Odyssey" has several strengths and limitations that impact the user experience. One notable strength is its interactive learning approach, which combines entertainment with educational content to provide an immersive learning experience about sea turtles and marine conservation. Additionally, the game has a significant educational impact, raising awareness about the importance of marine life conservation and protecting sea turtle habitats. The game's high functionality ensures that all features, including controls and multimedia elements, work effectively, providing a seamless user experience. Another strength is its offline functionality, which allows users to play the game without an internet connection, which is helpful for those with limited connectivity. Additionally, "Turtle Trek: Sea Turtle Odyssey" utilizes various multimedia elements, such as graphics, animations, and sound effects, to enhance the gaming experience and keep players engaged. However, there are some limitations to consider. The game's side-scrolling format can lead to potential game repetition, which may reduce user interest over time. Additionally, the game's availability is limited to English, limiting accessibility for non-English speakers. While the game functions well, it lacks advanced features such as leaderboards or multiplayer modes that could further enhance user engagement and competitiveness. In conclusion, "Turtle Trek: Sea Turtle Odyssey" successfully met its objectives, creating an engaging and educational game that raises awareness about sea turtle conservation. The project achieved high user satisfaction, though there are areas for future enhancement. The recommendations aim to broaden the game's educational reach, improve user engagement, and make it more accessible and appealing to a diverse audience.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: **study conception and design**: Ng Gu Feng, Ezak Fadzrin; **data collection**: Ng Gu Feng; **analysis and interpretation of results**: Ng Gu Feng, Ezak Fadzrin; **draft manuscript preparation**: Ng Gu Feng, Ezak Fadzrin. All authors reviewed the results and approved the final version of the manuscript.

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Appendix A: Gantt Chart

Figure 9 shows the Gantt Chart for the development of Turtle Trek: Sea Turtle Odyssey.

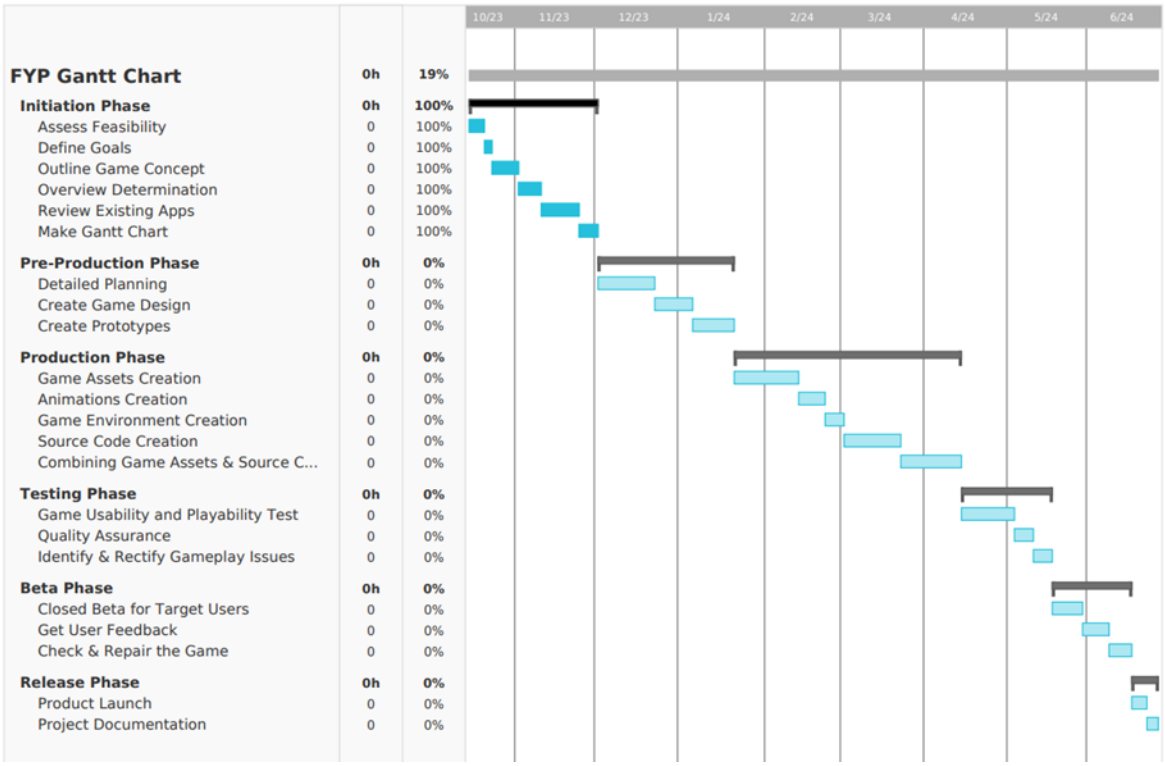
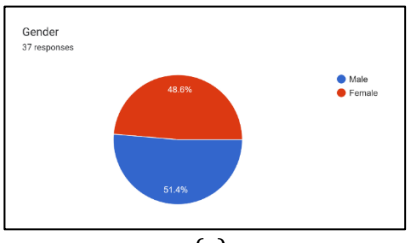


Fig. 9 *Gantt Chart for the development of Turtle Trek: Sea Turtle Odyssey*

Appendix B: Result of the Questionnaire for User Requirements Analysis

This section shows the results of the questionnaires for user analysis.



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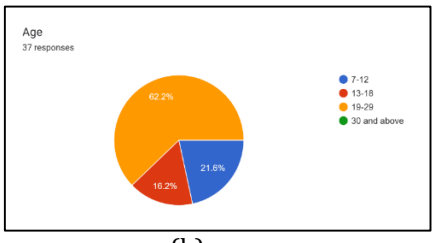

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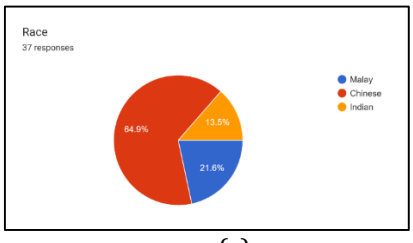

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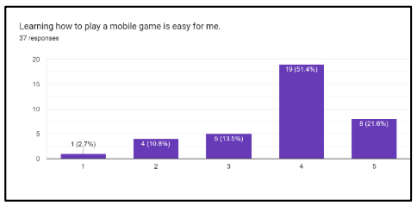
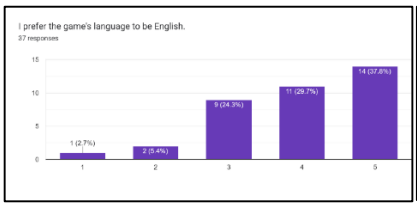
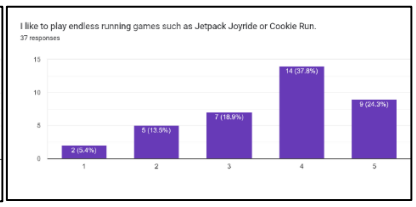


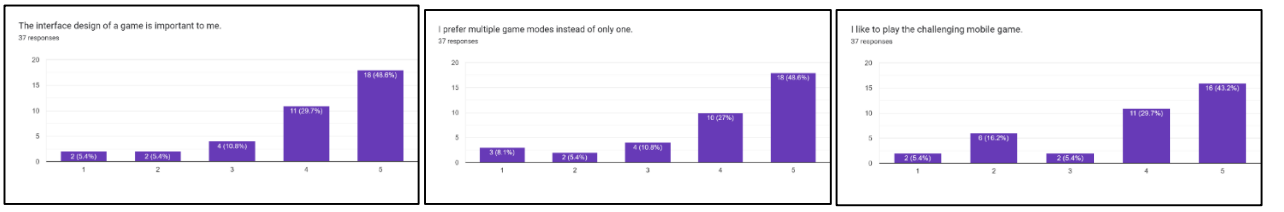
(d)



(e)

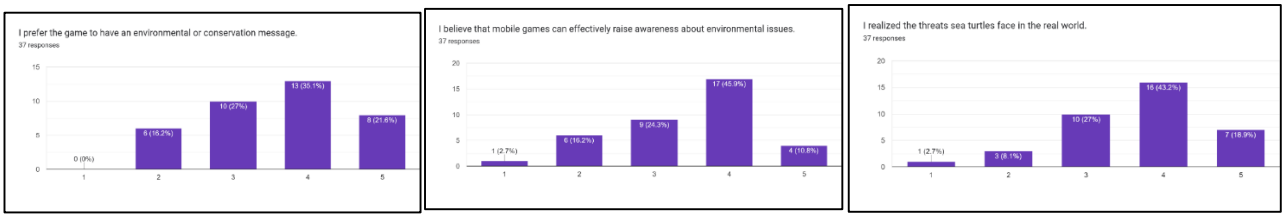


(f)

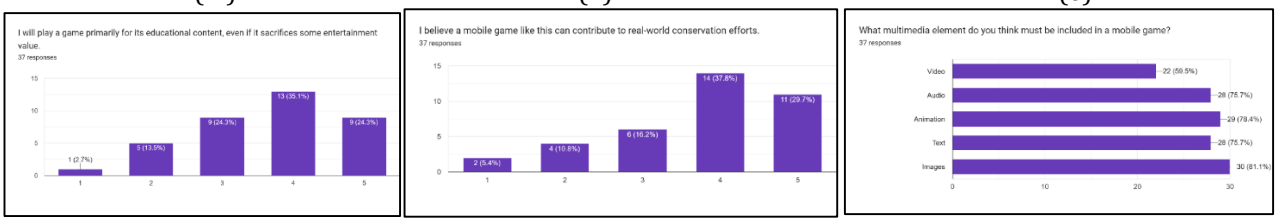


(g) (h) (i)

(j) (k) (l)



(m) (n) (o)



(p) (q) (r)

Fig. 10 *Results (a) Question 1; (b) Question 2; (c)Question 3; (d) Question 4; (e) Question 5; (f) Question 6 (g) Question 7; (h) Question 8; (i) Question 9; (j) Question 10; (k) Question 11; (l) Question 12; (m) Question 13; (n) Question 14; (o) Question 15; (p) Question 16; (q) Question 17; (r) Question 18.*

Appendix C: Hardware and Software Requirements

This section shows the hardware and software requirements.

Table 10 *Hardware and Software Requirements for the Developer*

Requirement	Item		Description
Software	Operating System		For mobile phones: • Android 5.1 and above For laptop: • Windows 10
	Unity		This game engine is used to combine assets and build the game application
	Adobe Photoshop 2023		Raster graphics editor application used to edit the game elements
	Pixel Studio		Pixel art editor application used to make the game characters, buttons, and more
	Procreate		Raster graphics editor application used to create and design the game elements
	CapCut and DaVinci Resolve		Video editing applications are used to combine the static cutscene graphics into animation and editing the video
	Legion 5 Pro-16ACH6H Laptop (Lenovo)	Processor	AMD Ryzen 7 5800H
		Random Access Memory (RAM)	16GB
		Graphic Card	NVIDIA GeForce RTX 3060 Laptop GPU
	iPad Air 5		To use Procreate and CapCut applications
	Android mobile phone		2GB RAM and 500MB storage is the minimum requirements to allow the developer to test the application
	Input-output devices	laptop	• Mouse • Keyboard • Headphone
		iPad	• Apple Pencil

Table 11 *Hardware and Software Requirements for the Users*

Requirement	Item	Description
Software	Operating system	Android 5.1 or above
Hardware	Android mobile phone	2GB RAM and 500MB storage is the minimum requirements to allow the users to install and play the application