APPLIED INFORMATION TECHNOLOGY AND COMPUTER SCIENCE
e-ISSN: 2773-5141

AITCS

Vol. 5 No. 2 (2024) 945-964
https://publisher.uthm.edu.my/periodicals/index.php/aitcs

Malaysia's Natural Treasures: Development of 2D Mobile Learning Application to Unveil the Riches of Malaysia's Nature

Soh Pei Yi[1], Mohd Farhan Md. Fudzee[1]*

[1] *Fakulti Sains Komputer dan Teknologi Maklumat,*
Universiti Tun Hussein Onn Malaysia, Parit Raja, Batu Pahat, 86400, MALAYSIA

*Corresponding Author: farhan@uthm.edu.my
DOI: https://doi.org/10.30880/aitcs.2024.05.02.050

Article Info

Received: 20 July 2024
Accepted: 16 October 2024
Available online: 30 November 2024

Keywords

Mobile Learning Application, Malaysia's Nature, 2D, Game-Based Learning

Abstract

Malaysia contains an abundance of natural treasures but there is a lack of existing applications introduced about Malaysia's nature with lack of multimedia elements. Therefore, Malaysia's Natural Treasures is proposed with the objectives to develop an interactive mobile learning application for targeted users aged 7 to 12 years old with gamification approach using Android technology and is tested with alpha and beta testing. The Multimedia Mobile Content Development (MMCD) method is used to develop the proposed application. The usability testing has resulted in an average score of 93.375 which is within the range of "Acceptable" in the Acceptability Ranges Score Scale, graded "A" on the Grade Scale, and rated "Excellent" based on the System Usability Scale (SUS). Therefore, it can be concluded that Malaysia's Natural Treasures is suitable for children aged between 7 to 12 years old to know and learn more about Malaysia's nature from different categories with enjoyment.

1. Introduction

Malaysia is one of the countries in Southeast Asia that contains an abundance of natural treasures. Malaysia, situated between Thailand and Singapore, is well-known for its varied ecosystem, distinct biodiversity, and pristine landscapes [1]. The country's natural treasures include dense rainforests, massive mountains, and pristine coastlines. The iconic biodiversity is found in Malaysia's huge rainforests, such as Taman Negara, one of the oldest rainforests in the world. The Tapir, Rafflesia flower, Malayan Tiger, and so on can all be found amid the tall trees and vivid flora in the Taman Negara [2]. The exploration of Malaysia's natural treasures extends to the amazing coral reefs of the Perhentian Islands and the aromatic Gaharu forests, indicating Malaysia's commitment to preserving its ecological heritage [2]. The ecosystem balance that makes Malaysia a true treasure chest of diverse flora, fauna, and aquatic lives, makes Malaysia more attractive as a collection of natural beauty.

In today's digital era, various types of digital applications for smart mobile devices are growing fast. A child mobile learning application is a digital educational tool specially designed to spark curiosity and foster learning in children. These apps offer a diverse array of age-appropriate lessons, games, and activities that make learning engaging and fun. They provide a safe and accessible way for children to explore various subjects [3]. Unlike traditional books, apps maintain updated information [4], eliminating the need for costly reprints. Moreover, children naturally prefer these learning applications [4], making them an essential tool for learning in the 21st century. Apps also offer the benefit of individualized learning [4], allowing students to progress at their own pace.

These factors make educational apps an asset in modern classrooms, enhancing both the learning experience and outcomes for students.

There is a lack of applications in the market that introduce Malaysia's natural treasures. The mobile applications in the market are focused on the whole world or continents instead of only Malaysia. Besides, the applications found on the market focus on a few general natural creatures without classification. The nature-related applications in the market have fewer multimedia elements and are less interactive. Only images and text are utilised for the content and delivered the information to the users with long text content. The absence of multimedia elements lowered the users', especially children's, attraction and interest in using it. Without the utilising of engaging visuals, audio, or other interactive features, the applications become less appealing.

The objectives of this study are to design a child learning 2D mobile application, Malaysia's Natural Treasures, using a gamification approach, to develop a child learning 2D mobile application, Malaysia's Natural Treasures, using Android technology, and to implement alpha and beta testing on the developed application. The proposed application is developed for children aged 5 to 12 years old to learn about Malaysia's nature. The Subject Matter Expert (SME) participating in this project is Teacher Chew Yi Jing, who teaches both Geography and Local Study subjects for secondary and primary levels respectively at Qi Meng Education. Multimedia elements like audio, image, video, voice-over, animations, and text will be utilised in the application. The proposed application contains the learning module, the quiz module, and the game module.

Malaysia's Natural Treasures application is designed to be developed in the English language. It consists of the learning module, the quiz module, and the game module [5]. The learning module will deliver general information on Malaysia's different natures according to 4 categories – flora, fauna, aquatic, and environment. The learning contents of the application are estimated to be suitable for the target user. Besides, the voice-over to narrate the contents must pronounce each word clearly and correctly. In the quizzes section, the range of the questions should be based on what the users have learned from the learning section. The application should be able to test the user's understanding of the knowledge, record the user's score while the user is answering the questions and show the users whether they are answering the questions correctly or not. In the game section, three types of mini-games, scramble words, memory puzzles and sliding puzzles with several functions should be functioning well.

The rest of the paper is sorted as follows: Section 2, related works, explains the domain of the study, the technology used in the project, and the result of the comparative analysis. Section 3 covers the applied methodology for this project, which is the Multimedia Mobile Content Development (MMCD). Section 4 states the result and discussion of the project and lastly, the conclusion will be summarised in Section 5.

2. Related Work

This section discussed the study domain, the technology used, and the result of the comparative analysis.

2.1 Malaysia's Natural Treasures

Malaysia is a country with an abundance of natural creatures located in Southeast Asia. Natural creatures are considered treasures because they maintain global biodiversity and ecological equilibrium. Malaysia has a diverse range of species, including unique endemics, which represent the nation's significant contribution to the protection of the natural heritage of the globe [6]. In addition to their ecological value, these creatures are culturally significant too, weaving into local folklore and traditions, becoming the symbols of national identity [6]. From the elusive tapir, the charismatic orangutan swinging from tree to tree, to the colourful and diverse marine life found in the water surrounding the country, Malaysia has a truly remarkable biodiversity [7]. The country's ecosystems are also home to an abundance of bird species, such as the iconic hornbills and the colourful kingfishers, along with a rich tapestry of plant life, including rare orchids, towering trees, and medicinal herbs [7]. In essence, the natural creatures of Malaysia represent not only biological riches but also cultural icons and economic assets, emphasizing the multifaceted importance of preserving these treasures for the present and future generations.

2.2 Technology

2.2.1 Mobile Learning App

Mobile learning, also known as M-learning, is a concept that involves knowledge acquisition via the use of mobile devices such as smartphones and tablets [8]. M-learning overcomes the limitations of traditional education by offering the unparalleled advantage of accessing educational content anytime and anywhere [8]. This flexibility enables learners to personalize their educational experiences to their schedules and preferences [8]. Fundamentally, M-Learning utilizes a variety of interactive applications, games, and activities to bring an element of enjoyment into the learning process. The interactive and multimedia capabilities of mobile devices make learning more accessible, more engaging, and immersive learning experiences [9]. Furthermore, M-learning

promotes informal learning, enabling individuals to explore topics of personal interest in a self-directed manner, fostering a sense of independent thinking and curiosity. Essentially, M-learning arises as a flexible and practical instructive worldview that adjusts flawlessly to the developing requirements and inclinations of current students.

2.2.2 Android Technology for Mobile Platform

The proposed application will be released on the Android mobile platform. Android is a Linux-based mobile operating system (OS) that runs on smartphones and tablets [10]. It is an open-source software stack that includes the OS, middleware, and built-in mobile applications [11]. Android was developed by Open Handset Alliance, led by Google, and other companies. Built on the Linux kernel, Android ensures a robust and secure platform, integrating seamlessly with Google services through an intuitive interface. The Google Play Store [12] is a store for third-party applications which offers millions of applications for different games, multimedia materials, and productive tools. Frequent version releases and upgrades help to improve security, enhance functionality, and stay up to speed with new developments in technology. In essence, Android's open nature, extensive app ecosystem, and continual evolution highlight its crucial role in shaping the dynamic landscape of mobile technology.

2.3 Game-Based Learning

Game-based learning is an innovative educational approach that leverages the engaging and interactive nature of games to impart knowledge and skills. By integrating educational content within a gaming framework, this approach transforms traditional learning into a dynamic and enjoyable experience [13]. Game-based learning promotes critical thinking, collaboration, and problem-solving skills, as players navigate through scenarios that require strategic thinking and decision-making The immersive nature of games captures learners' attention, fostering a sense of motivation and excitement that can enhance retention and understanding of complex subjects [14]. However, like other approaches, game-based learning also has its limitations, such as the fact that it requires careful design so that children will not easily get distracted, and the application puts attention on the wrong point, which outweighs the game features instead of learning [13].

2.4 Comparative Analysis

In this section, a comparison between existing applications and the proposed application will be described. The existing applications are USA Map Kids Geography Games [15], Nature – Africa [16], and Learn Animals for Kids [17]. The differences between the existing applications and the proposed application are presented in Table 1.

Based on Table 1, several limitations and strengths of the proposed application can be concluded. First, the proposed application has different modules – learning, quiz, and game modules. Second, the application will focus on Malaysia's nature with different categories like flora, fauna, aquatic, and environment. Third, the existing applications only applied various multimedia elements such as text, graphics, and audio. Thus, to improve users' engagement with the proposed application, videos and voice-overs will be applied to the learning modules. The proposed application is available for devices with the operating system Android 5.1 and above which is more compatible with more devices. Lastly, the proposed application utilises a landscape layout so the content in the interfaces will not be crowded and provide a good user interface.

Table 1 *Comparison between existing application and proposed application*

Element	USA Map Kids Geography Games	Nature - Africa	Learn Animals for Kids	Malaysia's Natural Treasures
Operating System	Android 5.0 and above.	Android 4.4 and above.	Android 7.1 and above.	Android 5.1 and above.
Information Presentation	Text, images, and audio.	Text, images, and audio.	Text, images, videos, audio, and voice-over.	Text, images, videos, audio and voice-over.
Content	Provide detailed information and images of the content in the United States.	Provide the names, detailed information, and images of the natural creatures in Africa.	Provide naming and images of the general animals.	Provide detailed information, videos, and voice-overs about the natural creatures specifically in Malaysia.
Layout	Landscape	Portrait	Landscape	Landscape
Area covered	United States	Africa	Whole world	Malaysia

Table 1 *Comparison between existing application and proposed application (cont)*

Element	USA Map Kids Geography Games	Nature - Africa	Learn Animals for Kids	Malaysia's Natural Treasures
Learning Module	Provide a learning module that divides the learning materials by the states of the United States.	Provide a learning module which categorized by the types of nature.	Provide three types of learning modules, which are the naming of the animals, the voice-over about the characteristics of the animals, and the educational video showcasing realistic animals.	Provide a learning module on natural treasures that are divided by the type of nature in Malaysia.
Quiz Module	None	Provide a quiz module that gives images of the related natural creatures for the questions.	Provide a quiz module that requires rearranging the scrambled words based on the image given.	Provide a quiz module that includes multiple-choice questions for images, text questions, and sound questions.
Game Module	Provide 6 games: Guess the State Name, Match the State Capital, Match the State Flag, State Jigsaw Puzzles, Identify the Neighboring States, and Find the State.	None	Provide 2 games which are jigsaw puzzles, and memory card games.	Provide a game module that includes scramble words, memory puzzles, and sliding puzzles.
Payment Charges	Partially free of charge and in-app purchases.	Free of charge.	Partially free of charge and in-app purchases.	Free of charge.

Based on Table 1, several limitations and strengths of the proposed application can be concluded. First, the proposed application has different modules – learning, quiz, and game modules. Second, the application will focus on Malaysia's nature with different categories like flora, fauna, aquatic, and environment. Third, the existing applications only applied various multimedia elements such as text, graphics, and audio. Thus, to improve users' engagement with the proposed application, videos and voice-overs will be applied to the learning modules. The proposed application is available for devices with the operating system Android 5.1 and above which is more compatible with more devices. Lastly, the proposed application utilises a landscape layout so the content in the interfaces will not be crowded and provide a good user interface.

3. Methodology

The methodology chosen to develop the proposed application is Multimedia Mobile Content Development (MMCD) [18]. This is due to MMCD being the methodology specially designed for creating mobile learning applications [18]. MMCD can help the developers speed up the application development process and at the same time optimize the mobile processing usage and data usage. Fig. 1 shows the structure of the MMCD methodology.

Applied Information Technology and Computer Science Vol. 5 No. 2 (2024) p. 945-964

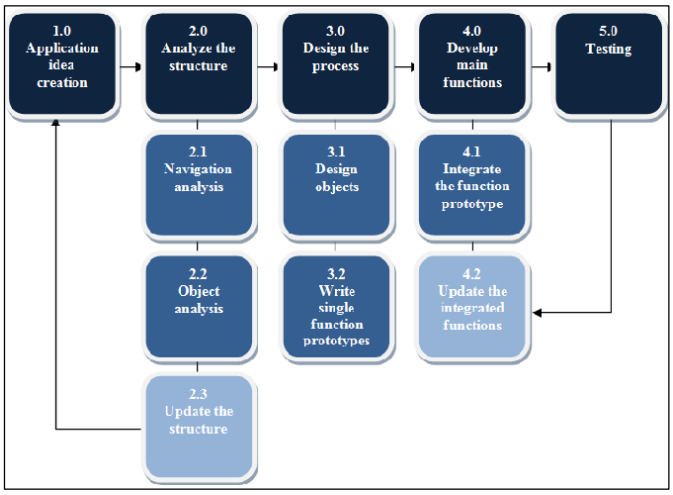


Fig. 1 *MMCD methodology structure*

3.1 Application Idea Creation

The first phase, the application idea creation stage in MMCD, analyses and organizes the important information needed before carrying on to the next stage and before the design and development of the proposed application start.

Table 2 *Application Idea Checklist*

Item	Description
Type of application	Mobile learning application
Target device	Android-based devices
Target users	Children between 7 to 12 years old
Graphic User Interface (GUI)	Background for the home, main menu, highest score interface, log-in and register interface, Learning module, Quiz module, and Game module.
Images	Icons, backgrounds, and contents.
Animation	App opening transition, and buttons.
Audio	App opening transition, and buttons.
Application synopsis	Malaysia Treasures is an application that introduces the treasures in Malaysia to the users. The prototype version will only cover the Animals, Plants, and Environments. The application also contains quizzes and mini-games to improve users' understanding and decrease boredom while learning.

The application idea creation checklist for the necessary information is tabulated in Table 2. Furthermore, two types of information-gathering methods, interview and questionnaire, are carried out to determine the user requirements. The interview session was conducted with Teacher Chew Yi Jing, the SME of this project.

A questionnaire is conducted and distributed to the public via Google Forms. A total of 23 responses have been collected. The user experience analysis and preferable multimedia analysis are the underscore issues under user analysis. In the user analysis, 16 respondents claimed that they have basic knowledge about Malaysia's nature while 6 respondents were neutral about the statement. 13 respondents agreed that learning Malaysia's nature from books is hard to understand and only a respondent disagreed with this. Moreover, 16 respondents think that books and text are hard to express the beauty of Malaysia's nature while 4 of the respondents are neutral and 3 respondents disagree about it. 20 respondents agree and no one disagrees that learning Malaysia's nature through text is boring. 15 respondents claimed that they often find information about Malaysia's nature through different resources and 7 of them are neutral about this statement. 13 respondents responded that they have a lot of opportunities to explore Malaysia's nature in real life while the rest of the respondents are divided equally to the group of disagree and neutral. 20 respondents show their interest in learning Malaysia's nature and the rest of them are neutral about this.

Table 3 *User Analysis*

Stakeholder Category	Role in product	Design implications	Action needed
Subject Matter Expertise (SME)	Content consultant expert in related field	Based on the interview, Content design	• Divide the learning module into different categories.
		Simpler user interface design	• Use fonts that show the correct alphabet, like. • Use labelled buttons for the module button. • Icon-based buttons for the common buttons instead of text-based buttons. • All the navigational buttons should be consistent in terms of shape, size, and color. • Use simple images to create the backgrounds of the application • Use a smaller amount of color to create the backgrounds of the application.
		Multimedia content	• Use joyful audio that is attractive to children. • Use voice-over so that children can understand the meaning of the text and pronounce the words. • The buttons should have sound effects when clicked.
General User	End-user of the application	Based on the questionnaire, User preferences	• The application should be developed on a mobile device. • The application should contain a game module. • The application should contain a quiz module.

The results of the user analysis are tabulated in Table 3. To summarize, the majority 87% prefer to use mobile platforms to learn about Malaysia's nature, 65.2% of the respondents agree to include the quiz module in the proposed application, and 100% of the respondents agree to include the game module in the proposed application.

3.2 Analyze the Structure

This phase analyses the structure of the proposed application. This includes the analysis of navigation used in the application.

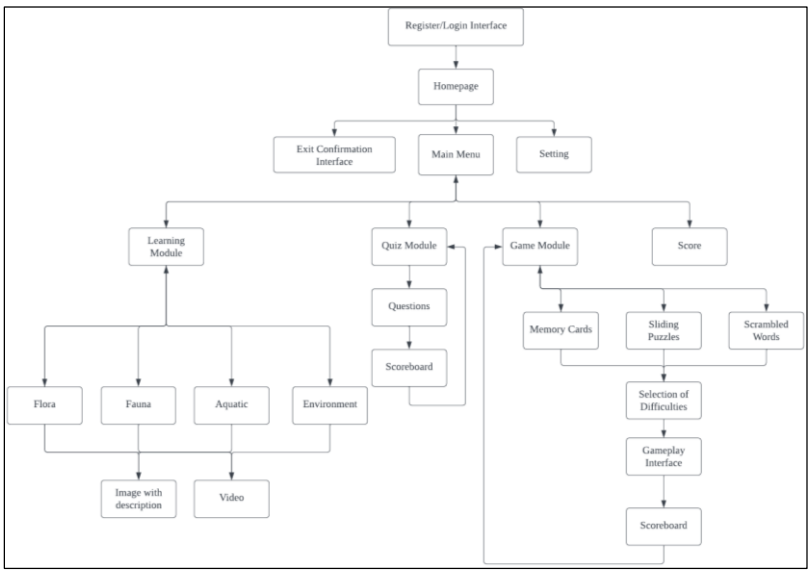


Fig. 2 *Navigational structure*

Applied Information Technology and Computer Science Vol. 5 No. 2 (2024) p. 945-964

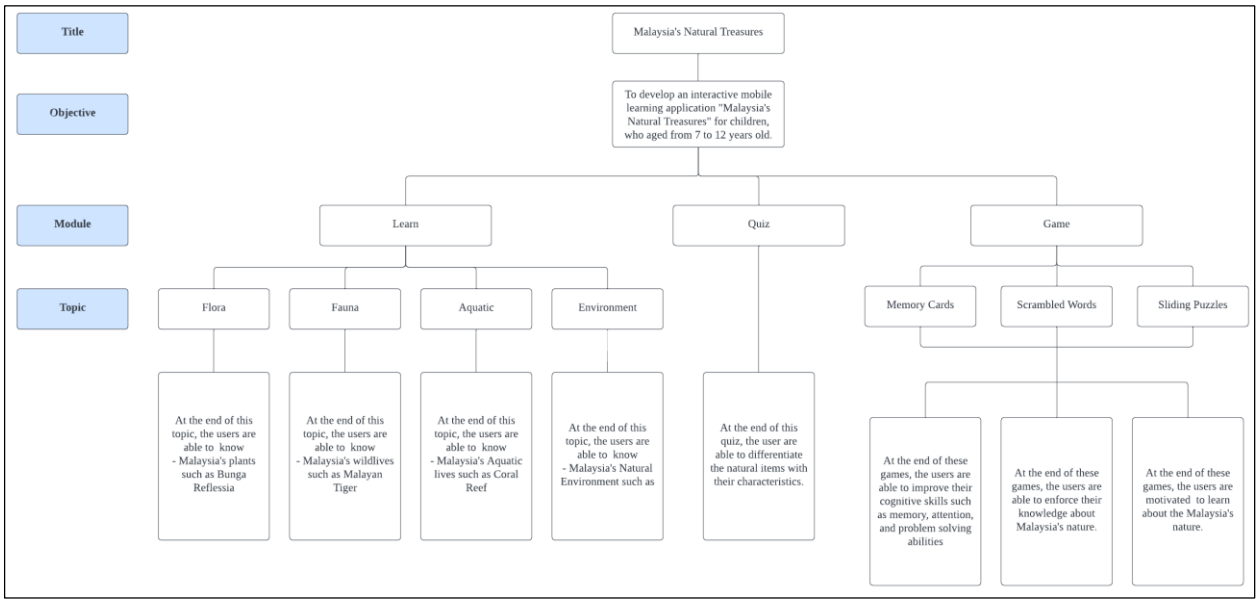
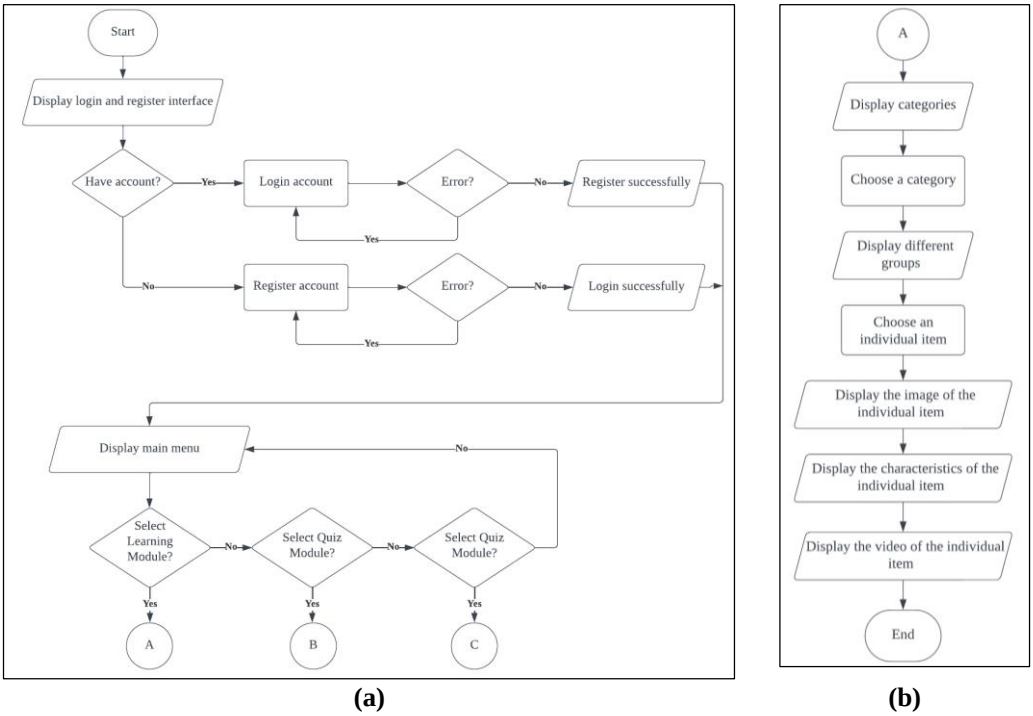
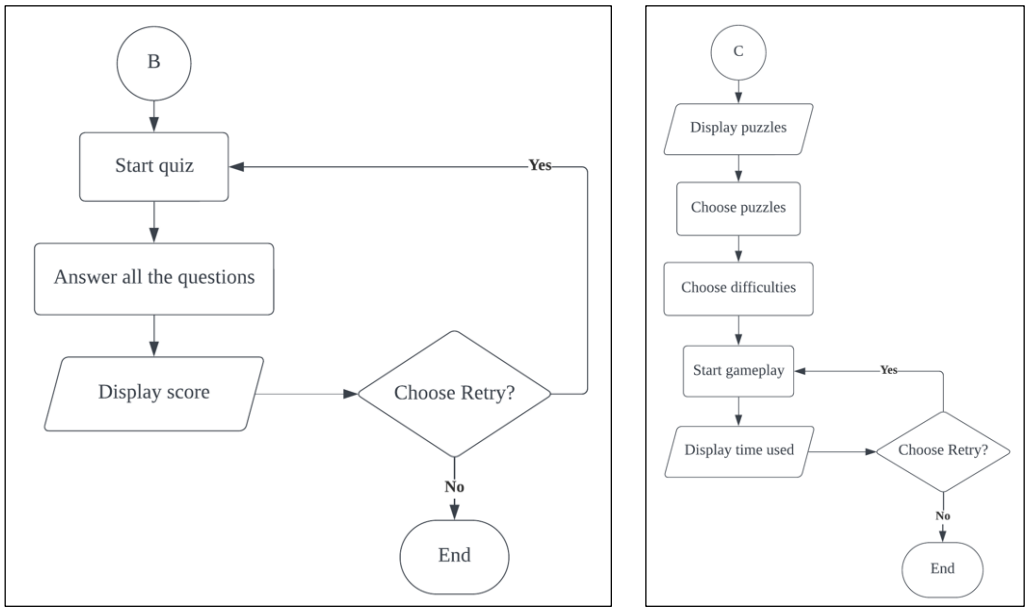


Fig. 3 *Content Structure*



(a) **(b)**

Fig. 4 *(a) System flowchart; (b) Learning module flowchart*



(c) **(d)**

Fig. 5 *(c) Quiz module flowchart; (d) Game module flowchart*

Fig. 2 and Fig. 3 depicts the navigational structure and the content structure respectively. The system flowchart and modules are shown in Fig. and Fig. 4.

Table 4 *Functional requirements*

Functional requirements	Module	Description
Autonomous system activities		• Divide the learning module into different categories. • The application should auto-sync data such as the update of the ranking in the background. • Once the user logs in, the application shall validate the users' login details as they sign in and load the users' profiles from the Playfab SDK. • The application shall disconnect between the user and the Playfab SDK once they log out from the application.
	Quiz Module	• The questions should be able to be displayed in an inconsistent order. • Once the user answers the quiz, the application should respond that it is a right or wrong answer. • The score for the quiz will be stored in the leaderboard by the built-in PlayerPrefs in Unity.
	Game Module	• Once the user starts playing the puzzles, the time will automatically start counting. • The shortest time used to solve the puzzles should update automatically in the background by built-in PlayerPrefs in Unity.
Provide Learning Content	Flora Module	• The application should allow the user to learn about different types of Malaysia's important animals.
	Fauna Module	• The application should allow the user to learn about different types of Malaysia's important plants.
	Aquatic Module	• The application should allow the user to learn about different types of Malaysia's important aquatic creatures.
	Environment Module	• The application should allow the user to learn about different types of Malaysia's natural environments.

Table 4 *Functional requirements (cont)*

Functional requirements	Module	Description
User Interaction Support	Main Interface	• The application should allow the user to click the play button to start the application.
	Main Menu	• The application should allow the user to choose the preferable module by clicking on the labelled buttons for each module.
	Learning Module	• The application should display images of Malaysia's nature. • The application should allow the user to control the voice-over with control buttons.
	Quiz Module	• The application should allow the user to select the buttons with the correct answers. • The application should allow the user to restart the exercise by clicking the restart button. • The application should allow the user to pause the quiz and continue to answer with the pause and play buttons respectively.
	Game Module	• The application should allow the user to play the game with the play button. • The application should allow the user to select the difficulties of the game with different levels of buttons. • The application should allow the user to pause the game and pause the stopwatch with the pause button.

Table 5 *Non-functional requirements*

Non-functional requirements	Description
Performance	• The application should be able to load all the modules. • The average response time between the click and reaction shall not be more than 3 seconds. • The login process should successfully load within 5 seconds.
Legal	• User should be able to access but should not be able to modify the content of the application.
Usability	• The application should be user-friendly. • The application is online based. • User should be able to access the application at anywhere and anytime. • Simple words and phrases should be used by the application to deliver the learning content. • Each button and interface should be clear and easy to access.
Cultural	• The application should apply simple English language as it is a worldwide language. • The application should use a metaphor for icons, symbols, and text that are understandable by Malaysians.
Operational	• The application should be able to operate on Android devices with Android version 5.1 and above.

Table 4 depicts the functional requirement for the proposed application while Table 5 shows the non-functional requirements for the application.

3.3 Design the Process

This section contains the design objects and the single-function prototype scripting subphases. The prototype for the modules will be completed at the end of this process. Authoring tools like Canva, Procreate, and JianYing are used to create the contents of the application and the storyboard. Unity software is used to compile the assets with scripting.

Table 6 *Button Design*

Button	Description	Button	Description
	This is a home button.		This is a labelled button for the Learn Module.
	This is a back button.		This is a labelled button for the Quiz Module.
	This is a setting button.		This is a labelled button for the Game Module.
	This is a retry button.		This is a labelled button for the Score.
	This is a sign-out button.		This is a labelled button for the Aquatic Module.
	This is an info button.		This is a labelled button for the Fauna Module.
	This is a play button.		This is a labelled button for the Flora Module.
	This is a pause button.		This is a labelled button for the Environment Module.
	This is a close button		This is a labelled button for the Memory Cards Game.
	This is a labelled Login button.		This is a labelled button for the Scrambled Words Game.
	This is a labelled Register button.		This is a labelled button for the Sliding Puzzle Game.

Table 6 shows each of the button design that are planned to be utilised for this application.

Table 7 *Interface Design*

Interface	Description
 	This is a Login/Register interface. Once the users launch the application, the first interface will be displayed.

Table 7 *Interface Design (cont)*

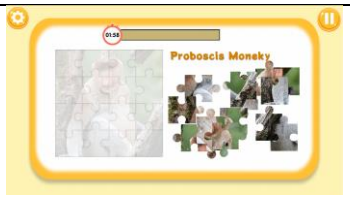
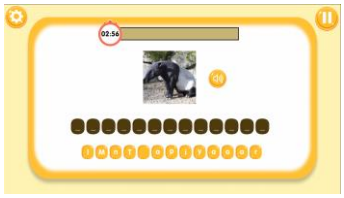
Interface	Description
	This is the main menu interface, which lets users choose the modules with the labelled buttons.
 	These are learning interfaces with 4 buttons for different categories in which users choose the module they want to learn and control the learning content interface with the next and previous buttons.
   	These are game interfaces which have 4 types of different games that allow users to choose and play. The stopwatch is designed to record the time taken for users to complete the game.
	This is the quiz interface in which questions images or audio are provided with the answer buttons.

Table 7 shows the design of the interfaces for the proposed application, Malaysia's Natural Treasures.

3.4 Develop Main Function

At this phase, the main function of Malaysia's Natural Treasures is developed. The integration of C# scripts of the application improved throughout the development phase until all the methods were integrated perfectly as shown in Table 9.

Table 8 *Development of assets*

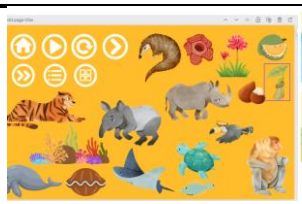
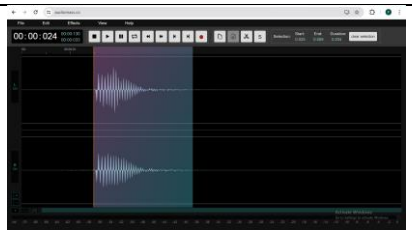
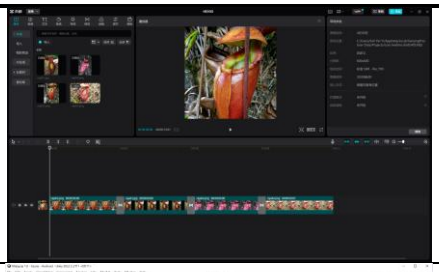
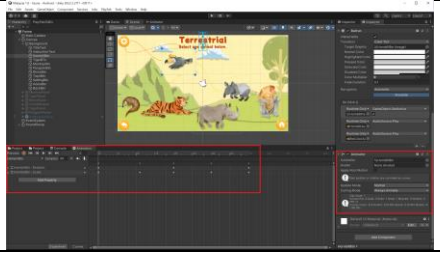
Assets	Development	Description
Graphics	 	CanvaPro and Figma platforms are utilised to design the elements inside them. Then the designs are exported without backgrounds for further use in Unity.
Audio		All the audio files are saved in MP3 format and AudioMass is used for basic sound effects editing for all the audio.

Table 8 *Development of assets (cont)*

Assets	Development	Description
Videos		Video editing software JianYing is utilised to edit the videos by combining the images and short videos obtained from online platforms such as CanvaPro and Pixabay.
2D Animations		The 2D animations are created inside Unity by simply adding an Animator component to the game object and inserting the keyframes into different properties.

This stage involves developing the assets for the application, such as graphics, audio, animation, and animations, and integration of the assets into Unity as shown in Table 8. In addition, functional scripts are integrated into Malaysia's Natural Treasures application to ensure all the buttons perform as designed and every gameplay is functioning as expected.

Table 9 *Integration in Unity with Scripting*

Functions	Code Segment	Description

Text highlighting for learning content	`string HighlightWord(string word)`
	`{string highlightedText = "";`
	`for (int i = 0; i < words.Length; i++)`
	`{if (i == currentWordIndex){`
	`highlightedText += "<color=#" + ColorUtility.ToHtmlStringRGBA(highlightColor) + ">" + words[i] + "</color>";}`
	`else{highlightedText += words[i];}`
	`if (i < words.Length - 1){`
	`highlightedText += " ";}}`
	`return highlightedText;}`
		Highlight the text in the learning contents when the voice-over of the content text is played.

Update the highest score on the quiz	`if (resultCount > highestScore){`
	`highestScore = resultCount;`
	`PlayerPrefs.SetInt("HighestScore", highestScore);`
	`PlayerPrefs.Save();`
	`Debug.LogWarning("SAVING HIGHSCORE out of question");`
	`SaveHighestScore();}`
		Update the highest score and display it on the game-over panel when result score is higher than the previous highest score. Save it to PlayerPrefs and PlayFab.

Flip the memory cards	`for (float i = 0f; i <= 180f; i += 10f){`
	`transform.rotation = Quaternion.Euler(0f, i, 0f);`
	`if (i == 90f){`
	`rend.sprite = faceSprite;}`
	`yield return new WaitForSeconds(0.01f);}`
		Rotate the memory cards 180 degree to show face up if it is facing down for matching purposes.

Find the first empty placeholder for the scrambled words puzzle	`private int FindFirstEmptyPlaceholderIndex(){`
	`for (int i = 0; i < answerWordList.Length; i++){`
	`if (answerWordList[i].wordValue == '_')`
	`{return i;}}`
	`return answerWordList.Length;}`
		After the user undoes the letter, the next selected letter should find the first empty placeholder to fill in.

Table 9 *Integration in Unity with Scripting (cont)*

Functions	Code Segment	Description
Login to the user account	`public void Login(){ var request = new LoginWithEmailAddressRequest{ Email = EmailLoginInput.text, Password = PasswordLoginInput.text, InfoRequestParameters = new GetPlayerCombinedInfoRequestParams{ GetPlayerProfile = true}}; PlayFabClientAPI.LoginWithEmailAddress(request, OnLoginSuccess, OnError);}`	Users can log in to their personal account for the game by entering email address and password.
Handle user registration	`public void RegisterUser(){ var request = new RegisterPlayFabUserRequest{ DisplayName = UsernameRegisterInput.text, Email = EmailRegisterInput.text, Password = PasswordRegisterInput.text, RequireBothUsernameAndEmail = false}; PlayFabClientAPI.RegisterPlayFabUser(request, OnRegisterSuccess, OnError);}`	Users can register a new account by entering the username, email address and set a password for the account.
Leaderboard system	`public void GetLeaderboard(){ var requestLeaderboard = new GetLeaderboardRequest{ StatisticName = "HighestScore", StartPosition = 0, MaxResultsCount = 5 }; PlayFabClientAPI.GetLeaderboard(requestLeaderboard, OnLeaderboardGet, OnError);} void OnLeaderboardGet(GetLeaderboardResult result){ for (int i = 0; i < playerNameTexts.Length; i++){ if (i < result.Leaderboard.Count){ playerNameTexts[i].text = $"{result.Leaderboard[i].DisplayName}"; playerScoreTexts[i].text = result.Leaderboard[i].StatValue.ToString();} else{ playerNameTexts[i].text = ""; playerScoreTexts[i].text = "";}}}`	Update and display the top 5 highest score users to the leaderboard and show their highest score with their username.
Background music setting	`void Awake(){ Instance = this; DontDestroyOnLoad(gameObject);} private void Start(){ AssignSliderEvents();} public void AssignSliderEvents(){ if (backgroundSlider != null){ backgroundSlider.onValueChanged.AddListener(delegate { UpdateSound(); });}} public void SetSlider(Slider slider){ backgroundSlider = slider; backgroundSlider.value = BackgroundVolume; AssignSliderEvents();}`	Loop the background music and ensure it is continuously playing across the scenes. Additionally, its volume should be adjusted by the sliders.

Table 9 depicts the code segment of scripts.

3.5 Testing

This is the last phase of the MMCD methodology where 2 types of testing, alpha testing and beta testing, will be performed in this phase to ensure the outcome of the developed application is as expected and meets the objective.

Table 10 *Functional Testing*

Test	Expected Result	Actual Result	Corrective Action
Setting Button	Open the settings panel.	Work well as planned.	Not required.
Cross Button	Close the setting panel.	Work well as planned.	Not required.
Login Button	Login the user to their accounts.	Work well as planned.	Not required.

Table 10 *Functional Testing (cont)*

Test	Expected Result	Actual Result	Corrective Action
Register Button	Register a new account for the user.	Work well as planned.	Not required.
Forgot Password Button	Navigate the recovery interface.	Work well as planned.	Not required.
Reset Button	Send a recovery email to the user.	Work well as planned.	Not required.
Start Button	Start the application.	Work well as planned.	Not required.
Credit Button	Navigate to the credit interface.	Work well as planned.	Not required.
Sign Out Button	Sign out the account of the user.	Work well as planned.	Not required.
Back Button	Return to the previous interface.	Work well as planned.	Not required.
Home Button	Navigate to the Main Menu interface.	Work well as planned.	Not required.
Learn Module Button	Enter the Learn Module interface.	Work well as planned.	Not required.
Terrestrial Button	Enter the Terrestrial Module.	Work well as planned.	Not required.
Flora Button	Enter the Flora Module.	Work well as planned.	Not required.
Aquatic Button	Enter the Aquatic Module.	Work well as planned.	Not required.
Environment Button	Enter the Environment Module.	Work well as planned.	Not required.
Play Button	Play and resume the video, voice-over and text highlighter of the learning content.	Work well as planned.	Not required.
Pause Button	Pause the video, voice-over and text highlighter of the learning content.	Work well as planned.	Not required.
Stop Button	Stop the video, voice-over and text highlighter of the learning content.	Work well as planned.	Not required.
Next Button	Navigate to the next learning content.	Work well as planned.	Not required.
Previous Button	Navigate to previous learning content.	Work well as planned.	Not required.
Quiz Module Button	Enter the Quiz Module.	Work well as planned.	Not required.
Quiz Start Button	Start the quiz.	Work well as planned.	Not required.
Quiz Audio Button	Play the audio for the corresponding question.	Work well as planned.	Not required.
Correct Answer Button	Invoke function in the script for the increment of score.	Work well as planned.	Not required.
Wrong Answer Button	Invoke function in the script for the deduction of life.	Work well as planned.	Not required.
Game Module Button	Enter the Game Module.	Work well as planned.	Not required.
Memory Cards Button	Enter the Memory Cards Puzzle.	Work well as planned.	Not required.
Scrambled Words Button	Enter the Scrambled Words Puzzle.	Work well as planned.	Not required.
Sliding Puzzle Button	Enter the Sliding Puzzle.	Work well as planned.	Not required.
Difficulty Selection Buttons	Select the difficulty of the puzzle.	Work well as planned. Work well as planned.	Not required.
Score Button	Navigate to the Leaderboard interface.	Work well as planned.	Not required.
Pause Button	Pause the timer and time bar for the puzzle or quiz.	Work well as planned.	Not required.
Resume Button	Resume timer and time bar for the puzzle or quiz.	Work well as planned.	Not required.

Table 10 *Functional Testing (cont)*

Test	Expected Result	Actual Result	Corrective Action
Retry Button	Retry the puzzle or quiz.	Work well as planned.	Not required.
Levels Buttons	Navigate to the Levels interface of the puzzle.	Work well as planned.	Not required.
Login System	Register a new account for the users and log in to their accounts.	Work well as planned.	Not required.
Audio Setting System	Adjust the volume of the background music, sound effects and voice-overs.	Work well as planned.	Not required.
Leaderboard System	Show the leaderboard of the top 5 highest score players with their highest score.	The leaderboard does not show the 5 highest score players with their highest score.	Save the highest scores of every player to the statistic in the Playfab.

The alpha testing which is the functional testing throughout the development phase and user acceptance testing which involves target users. Once bugs are discovered in this phase, the project will return to the previous phase to modify and update the integrated functions to solve the bugs. The result of functional testing is tabulated in Table 10. For the beta testing which is also the user acceptance testing, 20 respondents were involved in answering the questionnaire through Google Forms. The System Usability Scale (SUS) is utilized to test the usability of the application the result will be displayed at the next section.

4. Result and Discussion

For the result of alpha testing, all the buttons as well as the modules' performances are functioning well as expected. The result of the beta testing is shown in Figures 6 and 7 and the outcomes are analyzed.

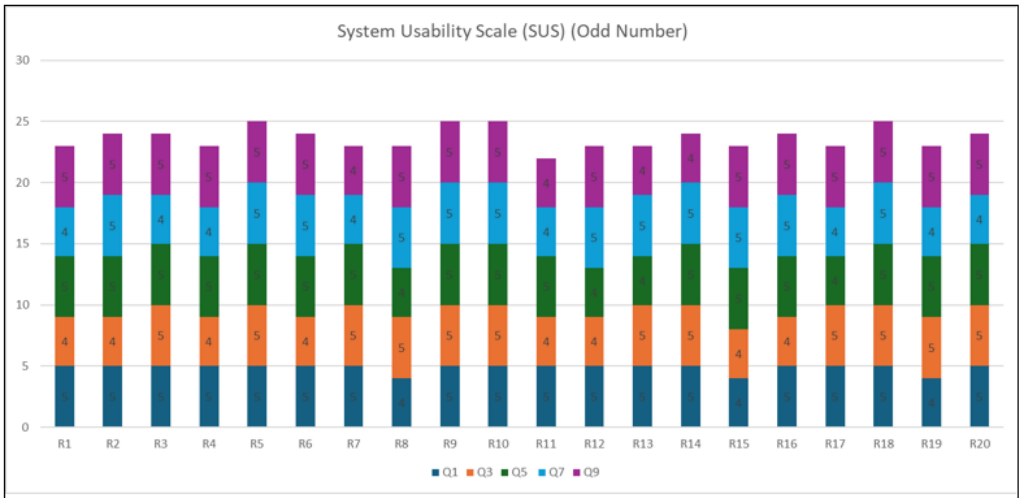
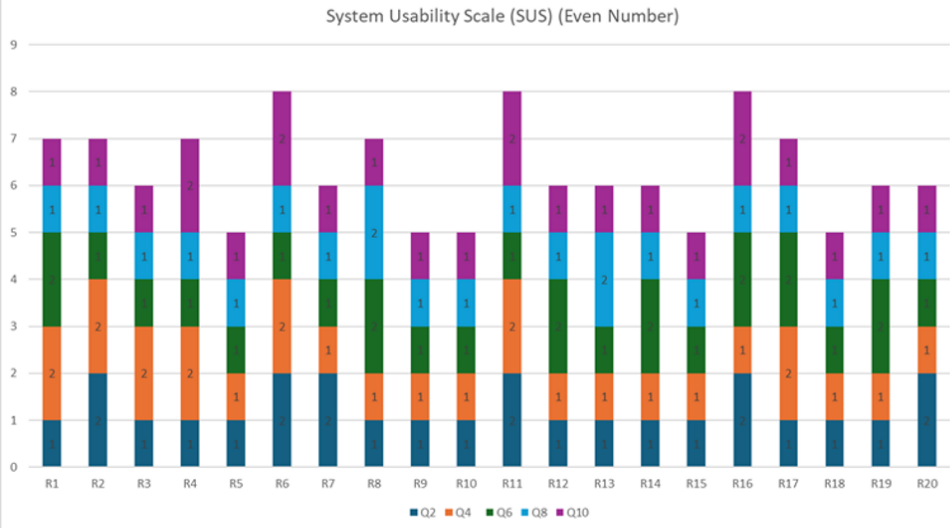


Fig. 6 *SUS Positive Question Result*

Based on Figure 6, all respondents gave 4 marks and above, which reflects a positive user experience, with respondents generally agreeing that they would like to use the system frequently, found it easy to use, believed its functions were well integrated, and felt confident using it. Overall, it shows a high level of satisfaction and confidence among the users about the developed application.



Question 2: I found the application unnecessarily complex.
Question 4: I think that I would need assistance to explore the 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*

Based on Figure 7, all respondents gave 2 marks and below, which indicates that the respondents did not find the system to be unnecessarily complex, inconsistent, cumbersome, or in need of technical support. Overall, the system seems to have minimal usability issues according to the even-numbered questions.

Respondent	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Total Score
R1	5	1	4	2	5	2	4	1	5	1	90
R2	5	2	4	2	5	1	5	1	5	1	92.5
R3	5	1	5	2	5	1	4	1	5	1	95
R4	5	1	4	2	5	1	4	1	5	2	90
R5	5	1	5	1	5	1	5	1	5	1	100
R6	5	2	4	2	5	1	5	1	5	2	90
R7	5	2	5	1	5	1	4	1	4	1	92.5
R8	4	1	5	1	4	2	5	2	5	1	90
R9	5	1	5	1	5	1	5	1	5	1	100
R10	5	1	5	1	5	1	5	1	5	1	100
R11	5	2	4	2	5	1	4	1	4	2	85
R12	5	1	4	1	4	2	5	1	5	1	92.5
R13	5	1	5	1	4	1	5	2	4	1	92.5
R14	5	1	5	1	5	2	5	1	4	1	95
R15	4	1	4	1	5	1	5	1	5	1	95
R16	5	2	4	1	5	2	5	1	5	2	90
R17	5	1	5	2	4	2	4	1	5	1	90
R18	5	1	5	1	5	1	5	1	5	1	100
R19	4	1	5	1	5	2	4	1	5	1	92.5
R20	5	2	5	1	5	1	4	1	5	1	95
											93.375

Fig. 8 *Respondent's Score*

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 – 1
Even items (Q2, Q4, Q6, Q8, Q10) = 5 – contribution

Fig. 9 *Formula to calculate the SUS score* [19]

Applied Information Technology and Computer Science Vol. 5 No. 2 (2024) p. 945-964

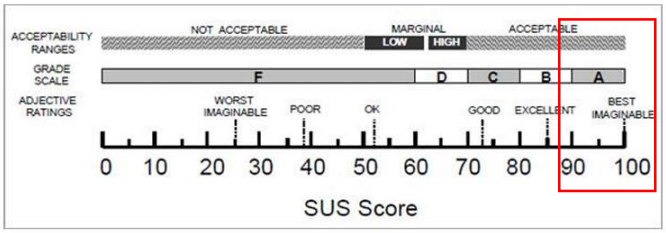


Fig. 10 *Grade rankings of SUS scores* [19]

The total scores for each question from the questionnaire were obtained by calculating the average score by using the formula based on Figure 8. The average score is 93.375 which is within the range of "Acceptable" in the Acceptability Ranges score scale. The Grade Scale is "A" and the Adjective Rating is "Excellent". To conclude, the developed applications have successfully met the needs of the target users.

5. Conclusion

In conclusion, the Malaysia's Natural Treasures has successfully developed three main modules, which are the Learning module, the Game module and the Quiz module.

All three objectives set for the proposed application have been met by designing the application using a game-based learning approach. The design phase in the MMCD methodology consists of the navigational structure, flowchart, storyboard, interface design, and button design. Second, the Malaysia's Natural Treasures is successfully developed for the Android platform with the Android Application Package Kit (APK) is successfully build. Third, the alpha testing was carried out throughout the development phase and the beta testing obtained the SUS score of 93.375 which is within the "Acceptable" in the Acceptability Ranges score scale, grade "A" for the Grade Scale, and rated "Excellent" for the Adjective Rating based on the System Usability Scale (SUS).

Malaysia's Natural Treasures application has several advantages. It provides positive learning outcomes acquisition for learning content about Malaysia's nature with different categories such as Terrestrial, Flora, Aquatic, and Environment with complete functionality as all the texts, buttons, audio, animations and graphics are displayed and operated correctly and as expected. In addition, it contains simple and fun puzzles, such as Scrambled Words, Sliding Puzzle and Memory Cards for children to play and strengthen their knowledge with enjoyment. Lastly, the application has a high level of user acceptance, where the target users agree that the application is easy to use.

Malaysia's Natural Treasures application provides not more than 6 elements in each category for the educational content for the Learning module. The number of questions for the Quiz module is limited as well as a few levels for the puzzles for the Game module. Hence, for future work, it is suggested that the Learning module should implement more learning content for each category, add more diverse questions to the existing question list and develop more levels for the existing puzzle.

Acknowledgement

The authors would like to thank the Faculty of Computer Science and Information Technology, University Tun Hussein Onn Malaysia for its support.

Conflict of Interest

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

Author Contribution

This journal requires that all authors take public responsibility for the content of the work submitted for review. The contributions of all authors must be described in the following manner:

The authors confirm contribution to the paper as follows: **study conception and design**: Soh Pei Yi, Mohd Farhan Bin Md. Fudzee; **data collection**: Soh Pei Yi, Mohd Farhan Bin Md. Fudzee; **analysis and interpretation of results**: Soh Pei Yi, Mohd Farhan Bin Md. Fudzee; **draft manuscript preparation**: Soh Pei Yi, Mohd Farhan Bin Md. Fudzee. All authors reviewed the results and approved the final version of the manuscript.

References

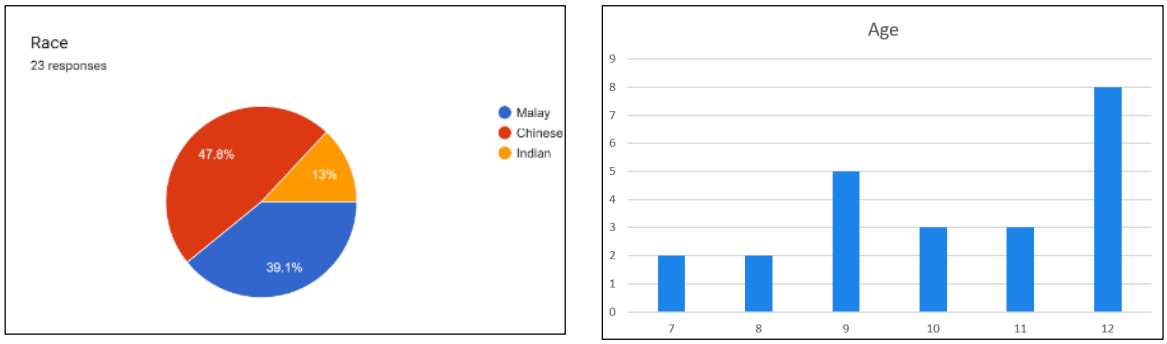
[1] S. A. Sabaruddin, S. A Jamal, and H. Wee, "Redefining Nature-Based Tourism in Malaysia: Activities and Nature Sites," *Int. J. Acad. Res. Bus. Soc. Sci.*, vol. 13, no. 5, 2023, doi: 10.6007/ijarbss/v13-i5/17016.

[2] A. Jambari *et al.*, "Quantifying species richness and composition of elusive rainforest mammals in Taman

Negara National Park, Peninsular Malaysia," *Glob. Ecol. Conserv.*, vol. 18, 2019, doi: 10.1016/j.gecco.2019.e00607.
[3] H. Y. Nee and N. Wahid, "Development of Mobile Learning Application for Chinese Pinyin with Virtual Assistant," *Appl. Inf. Technol. Comput. Sci.*, vol. 0, no. 0, pp. 0–000, 2000, [Online]. Available: https://doi.org/10.30880/aitcs.0000.00.00.000
[4] O. S. Kodirovna, "Several concepts on advantages and disadvantages of using textbooks," *Acad. An Int. Multidiscip. Res. J.*, vol. 10, no. 12, 2020, doi: 10.5958/2249-7137.2020.01917.5.
[5] S. S. M. Teoh and M. F. Md Fudzee, "Malaysia Run: The Development of a Mobile Game Application to Promote Malaysia Culture using Gamification Approach," *Appl. Inf. Technol. Comput. Sci.*, vol. 3, no. 1, pp. 153–168, 2022, [Online]. Available: https://doi.org/10.30880/aitcs.2022.03.01.010
[6] "Biodiversity: our life, our heritage, our future | The Star," The Star. Accessed: Dec. 28, 2023. [Online]. Available: https://www.thestar.com.my/news/nation/2023/05/30/biodiversity-our-life-our-heritage-our-future
[7] K. Huda, "Article 3: Biodiversity Of Fauna In Malaysia - GlobinMed," *Global Information Hub On Integrated Medicine*, Jun. 13, 2023. Accessed: Dec. 28, 2023. [Online]. Available: https://globinmed.com/conservation/article-3-biodiversity-of-fauna-in-malaysia-2/
[8] R. Masero, "Mobile Learning Benefits: The Advantages Of Learning On-The-Go," eLearning Industry. Accessed: Dec. 28, 2023. [Online]. Available: https://elearningindustry.com/mobile-learning-benefits-the-advantages-of-learning-on-the-go
[9] F. Ozdamli and N. Cavus, "Basic elements and characteristics of mobile learning," *Procedia - Soc. Behav. Sci.*, vol. 28, pp. 937–942, Jan. 2011, doi: 10.1016/J.SBSPRO.2011.11.173.
[10] E. Mixon, "What is Android OS? | Definition from TechTarget," TechTarget Mobile Computing. Accessed: Dec. 28, 2023. [Online]. Available: https://www.techtarget.com/searchmobilecomputing/definition/Android-OS
[11] M. Brambilla and P. Fraternali, "Implementation of applications specified with IFML," *Interact. Flow Model. Lang.*, pp. 279–334, 2015, doi: 10.1016/B978-0-12-800108-0.00010-2.
[12] "Android Apps on Google Play," Google Play. Accessed: Dec. 28, 2023. [Online]. Available: https://play.google.com/store/apps?utm_source=apac_med&hl=en-MY&utm_medium=hasem&utm_content=Sep2120&utm_campaign=Evergreen&pcampaignid=MKT-EDR-apac-my-1003227-med-hasem-ap-Evergreen-Sep2120-Text_Search_BKWS-BKWS%7CONSEM_kwid_43700057160100308_creativeid_684431230799_device_c&gclid=CjwKCAiAs6-sBhBmEiwA1Nl8s3I1oVlhPNL-Pct-bOdZeKezwjpoXK6q-Te8rzSIFINruG7O1NkR-hoCRDQQAvD_BwE&gclsrc=aw.ds
[13] Z. Y. Liu, Z. A. Shaikh, and F. Gazizova, "Using the concept of game-based learning in education," *Int. J. Emerg. Technol. Learn.*, vol. 15, no. 14, 2020, doi: 10.3991/ijet.v15i14.14675.
[14] U. Tokac, E. Novak, and C. G. Thompson, "Effects of game-based learning on students' mathematics achievement: A meta-analysis," *J. Comput. Assist. Learn.*, vol. 35, no. 3, pp. 407–420, Jun. 2019, doi: 10.1111/JCAL.12347.
[15] "USA Map Kids Geography Games – Apps on Google Play," IDZ Digital Private Limited. Accessed: Dec. 28, 2023. [Online]. Available: https://play.google.com/store/apps/details?id=com.iz.games.usa.maps.educational.learning.kids.puzzle.geography.states.flags&hl=en-MY
[16] saragozza, "Nature - Africa – Apps on Google Play," Google Play. Accessed: Dec. 28, 2023. [Online]. Available: https://play.google.com/store/apps/details?id=ch.saragozza.natureaf&hl=en-MY
[17] Kokotots Inc, "Learn Animals for Kids – Apps on Google Play," Google Play. Accessed: Dec. 28, 2023. [Online]. Available: https://play.google.com/store/apps/details?id=com.kokotots.animalkingdom&hl=en-MY
[18] W. Sazli, N. Saifudin, S. Salam, M. Haziq, and L. Abdullah, "MULTIMEDIA MOBILE CONTENT DEVELOPMENT FRAMEWORK AND METHODOLOGY FOR DEVELOPING M-LEARNING APPLICATIONS," *J. Tech. Educ. Train.*, vol. 4, no. 1, p. 14, 2012, Accessed: Dec. 28, 2023. [Online]. Available: https://publisher.uthm.edu.my/ojs/index.php/JTET/article/view/481
[19] J. Brooke, "SUS : A Retrospective," no. January 2013, 2020.

Applied Information Technology and Computer Science Vol. 5 No. 2 (2024) p. 945-964

Appendix A



(a) **(b)**

Fig. 11 *User demographic for (a) Race; (b) Age*

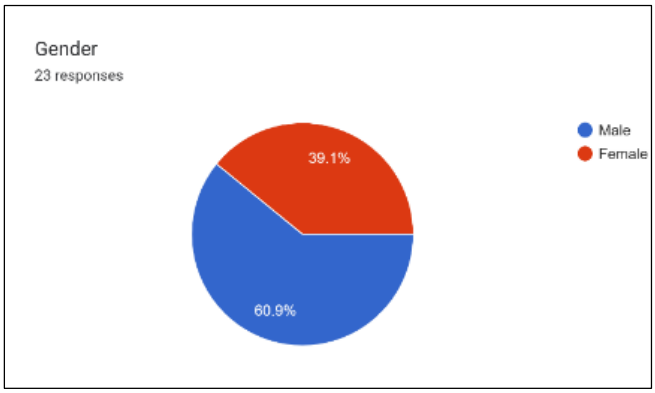


Fig. 12 *User demographic for Gender*

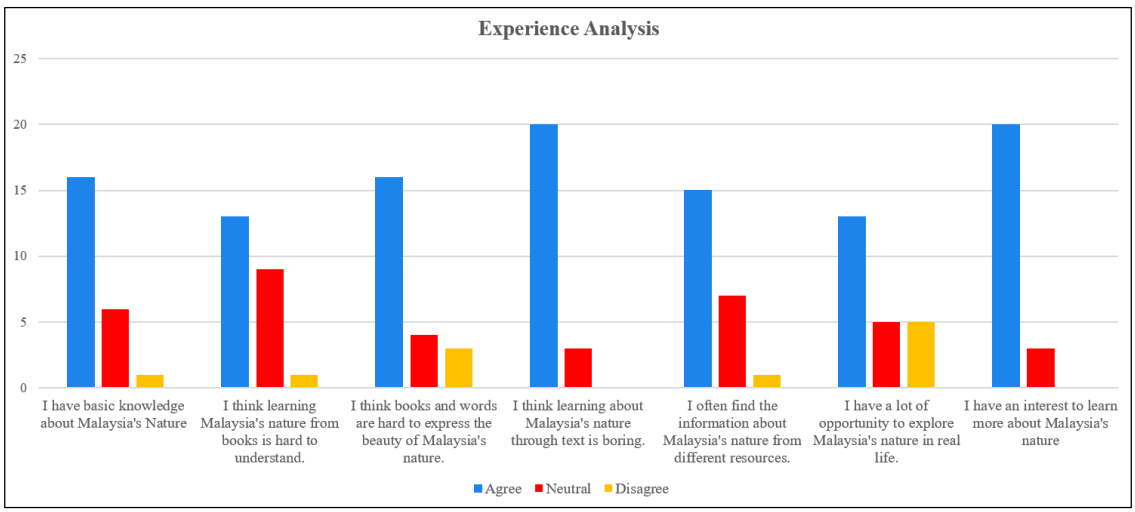
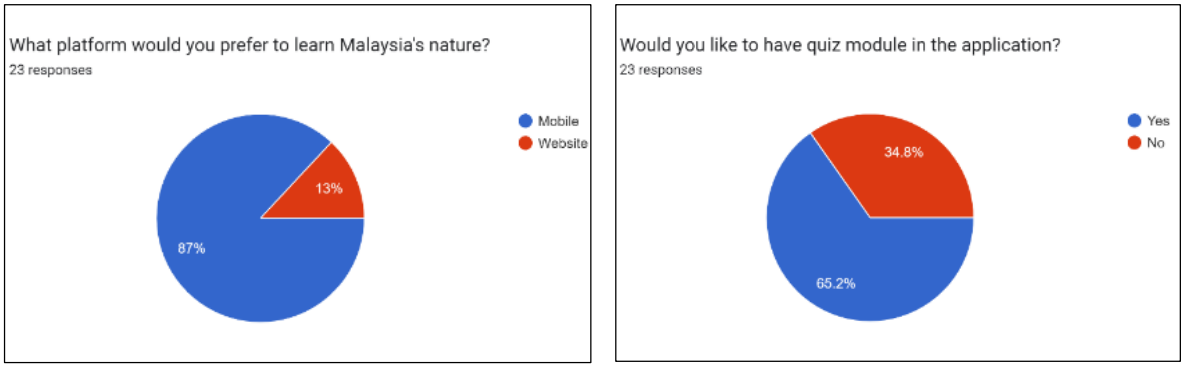


Fig. 13 *User experience about Malaysia's nature*



(a) **(b)**

Fig. 14 *Preferable multimedia elements for (a) platform; (b) quiz module*

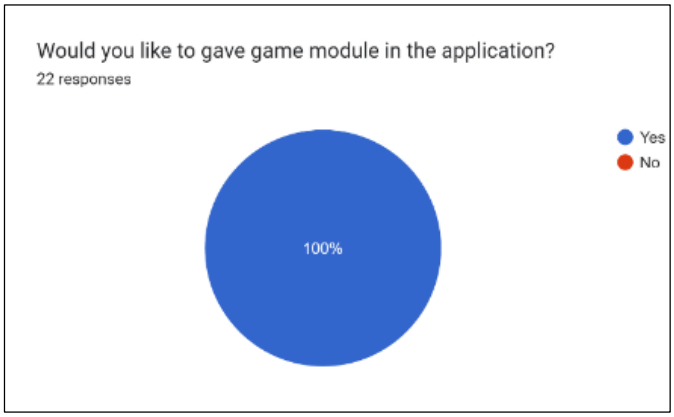


Fig. 15 *Preferable multimedia elements for game module*