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Development of Bird Learning Application by Using Augmented Reality (Birdie: Pet Focus)

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Abstract

Learning about pet birds is important to ensure their health and well-being, but many bird owners still lack access to clear and reliable resources. This study introduces Birdie: Pet Focus, a mobile learning application that uses marker-based Augmented Reality to improve user interaction. The application targets users aged 16 to 45 and features five types of 3D bird models, which include Canary, Parrot, Lovebird, Zebra Finch, and Dove. It provides informative modules covering bird species, bird care, health, and interactive learning activities. The application was developed using the Multimedia Mobile Content Development methodology and is suitable for bird owners, pet shops, or anyone interested in learning more about birds. Based on the System Usability Scale result, the application scored 80.54, which indicates an excellent level of usability and user satisfaction.

1. Introduction

Birds are a diverse class of warm-blooded vertebrates that are integral to ecosystems such as pollinators, seed dispersers, and predators [1]. With over 10,000 species found in a wide range of habitats, birds are not only significant to the environment but also popular as pets due to their intelligence, social behavior, and companionship. However, as the number of bird owners increases, there is a growing demand for reliable and interactive resources to help users better understand birds. Augmented Reality (AR) provides an innovative solution by blending real-world and digital experiences, making complex subjects more approachable [2]. Other than that, AR also creates immersive learning environments that foster deeper engagement and interaction with educational content [3].

Although a few bird-related learning applications are available on mobile platforms, most are limited to basic identification features and superficial information, lacking comprehensive knowledge and interactive experiences. For example, applications like Bird Care: Food and Health [4] offer only text-based content and static images, which fail to effectively convey the complexities of bird care and behavior. Users often express dissatisfaction with the lack of engaging features, resulting in a limited understanding of bird ownership responsibilities.

Therefore, this project aims to design and develop a user-friendly AR application for bird learning, Birdie: Pet Focus, by implementing marker-based AR technology on the Android platform and to evaluate its functionality and user acceptance. The application is targeted at individual aged 16 to 45 who are interested in keeping birds as pets. The Birdie: Pet Focus application consists of five modules: Species Information, Disease, Diet and Care, Activity and AR Viewer. All modules are created based on five types of birds which are Canary, Parrot, Dove, Lovebird, and Zebra Finch. The content is delivered in English. This project adopts the Multimedia Mobile Content Development (MMCD) methodology to ensure the learning application is developed systematically and on schedule. By addressing current limitations in bird education tools, Birdie: Pet Focus is expected to help bird

owners and enthusiasts gain knowledge in an interactive and visually appealing manner, offering a more immersive learning experience through AR technology.

The rest of the paper is arranged as follows: The study domain, the technology employed, and the comparative analysis are all included in Section 2. In Section 3, the MMCD methodology that has been selected for this project is explained along with the results of the analysis and design phases. In addition, Section 4 discusses the result and discussion, while Section 5 states the conclusion of the current progress.

2. Related Work

This section discusses the background of the study, the technology used, and the result of the comparative analysis.

2.1 Birds as pets

Birds as pets are birds that have been tamed or domesticated to live with humans for companionship and enjoyment, rather than for work or food production. Popular species like parrots, canaries, and doves are favored for their vibrant colors, soothing songs, and ability to mimic sounds or human speech. Their small size makes them ideal for apartment living, and they contribute to a lively atmosphere that strengthens the bond between the owner and the pet. Studies have shown that owning pet birds offers psychological and emotional benefits, such as reducing stress and loneliness, while promoting mental stimulation and relaxation through their playful nature [5]. However, bird ownership also requires proper care, a nutritious diet, and a clean living environment to ensure the bird's well-being. Since pet birds offer so many benefits to humans, it is essential to understand how to care for them properly

2.2 Augmented Reality

To support bird owners and enhance their understanding of bird care, emerging technologies such as AR can be leveraged as effective tools. AR is an emerging technology that enhances human-machine interaction by immersing digital elements into the real world [6]. These elements can include sound, visuals, and other sensory inputs, which combine digital data with real-world environments through various hardware and software tools such as applications, screens, and projections. AR creates immersive environments that blend seamlessly with reality. The use of AR in education has grown significantly in recent years, offering opportunities for technology-enhanced learning [7]. By serving as an interactive medium that bridges the gap between the actual and virtual worlds, AR allows users to engage with content in real time, providing simulations, 3D models, and immersive experiences that simplify complex concepts and enhance learning. There are two types of AR that are commonly used which are marker-based and markerless.

2.2.1 Marker-based AR

Marker-based AR uses visual markers like QR codes, images, or patterns to display digital content. The system detects the user's location and focuses on specific areas using predefined markers, applying computer vision techniques. These markers act as reference points for AR-enabled devices such as smartphones and AR glasses, which superimpose virtual objects or data over the real world once the marker is recognized. Markers typically have high contrast and distinct patterns for accurate detection. The system continuously tracks the marker's position, enabling dynamic interaction. Due to its simple setup, marker-based AR is commonly used in education, training, entertainment, and marketing. In the context of bird education and care, marker-based AR can be used to provide interactive 3D models of birds, demonstrate care techniques, and offer visual guides for feeding, grooming, and identifying signs of illness to make the learning experience informative and engaging [8].

2.2.2 Markerless AR

Markerless AR is a form of augmented reality that does not rely on predefined markers like QR codes or images. Instead, it tracks and maps the user's environment using technologies like GPS, accelerometers, gyroscopes, and computer vision algorithms. This allows virtual objects to be placed and interacted with in real time based on the spatial data of the surroundings. Markerless AR utilizes environmental features to determine camera orientation and accurately coordinate assets. It requires a flat surface, such as a table or floor, for proper placement of AR elements. Markerless AR is commonly used in navigation apps, location-based services, and travel guides. It includes four types: overlay contour, projection-based, and location-based [9].

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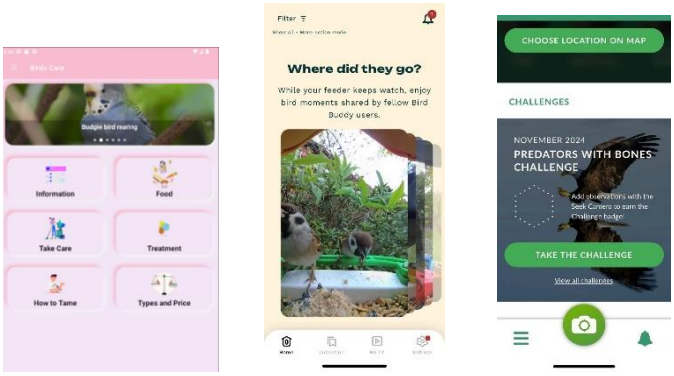
2.3 Comparative Analysis

Comparative analyses were conducted on three related applications to the developed application. The three applications are Bird Care: Food and Health [4], Bird Buddy: Tap into nature [10], and Seek by iNaturalist [11], as shown in Fig. 1(a), (b) and (c), respectively. Table 1 shows the result of the comparative analysis.

The comparison is based on seven different features of the application. The first feature that is being discussed is the purpose of the application, followed by the operating system, purchasing option, types of modules, the technology used, multimedia elements used, and internet connection. In comparison, Birdie: Pet Focus provides information about birds that are common to keep as pets, is available in the Android platform, is free to use, and does not require for internet connection. Furthermore, Birdie: Pet Focus used Marker-based AR technology and used all multimedia elements. It consists of three modules which are Learning, Activity, and AR modules.



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

Fig.1 Screenshots of **(a)** *Bird Care: Food and Health*[4]; *(b) Bird Buddy: Tap into nature* [10]*; (c) Seek by iNaturalist* [11]

Table 1 *Application Comparison*

Applications	Bird Care: Food and Health	Bird Buddy: Tap into nature	Seek by iNaturalist	Birdie: Pet Focus
Purpose	Provides pet care information specifically for pet birds.	Monitors wild birds at feeders	Identifies various wildlife species, including birds, plants, and animals.	Provides information about birds that are common to keep as pets with interactive AR features
Types of birds	All birds species	Wild birds only	Wild birds	Canary, Parrot, Dove, Lovebird, Zebra Finch
Operating system	Support Android platform only	Support both Android and iOS	Support both Android and iOS	Support Android platform only
Purchasing	Free to use	Pay for upgrade	Pay for upgrade	Free to use
Modules	Learning	Learning	Learning	Learning, Activity and AR View
Technology	None	Artificial Intelligence (AI)	Artificial Intelligence	Marker-based AR

Table 1: *Application Comparison* (*Continued)*

Multimedia elements	Involved only images	Involved all multimedia element	Involved all multimedia element	Involved all multimedia element
Internet connection	Require	Require	Not require	Not require

3. Methodology

The Birdie: Pet Focus application has been developed using the Multimedia Mobile Content Development (MMCD) methodology, as shown in Figure 2. This is because MMCD is a framework used for designing or creating mobile learning applications [12]. There are five stages in this methodology which are the application idea creation stage, structure analysis stage, process design stage, main function development stage, and testing stage. The structure analysis stage contains three more sub-stages which are navigation analysis, object analysis, and update the structure stage while the process design stage consists of two sub-stages which are the design object and write single function prototype stage. Main function development also consists of two sub-stages which are integrate the function prototype and upgrade the integrated function stage.

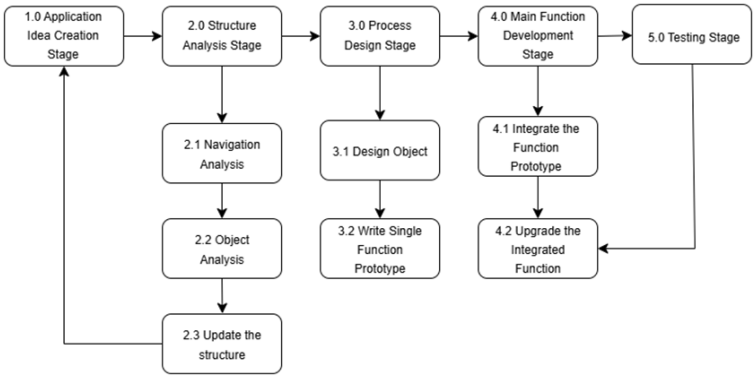


Fig.2 *MMCD methodology* [12]

3.1 Application Idea Creation Stage

In this first phase, the user's requirements needed for the development of the Birdie: Pet Focus Application are determined. This phase reviewed existing applications, an interview with a Subject Matter Expert (SME), and a questionnaire from the target user, people who want to keep birds as pets aged from 16 to 45 years old, which was conducted through Google Forms. An interview session has been conducted with SME Mrs. Nur Afiqah, who is the bird keeper at Zoo Melaka through Google Meet. A total of 20 respondents participated in this questionnaire. As a result, a user's requirement checklist that is extracted from an interview with the SME and a questionnaire has been created, as shown in Table 2. Meanwhile, an application idea creation checklist for the produced application is provided in Table 3, ensuring that all necessary elements are included throughout the development process.

Table 2 *User Analysis Requirement*

Stakeholder category	Role in product	Design implication	Action needed
SME Mrs. Nur Afiqah	Content consultant, expert in bird care field	Easy to use	Avoid using a complex button Ensure that all buttons are visible for users to use.
		Easy to navigate	The framework of navigation should not be excessively complex. Include buttons for home and back
		Multimedia content	Put audio, animation, and images

Table 2: *User Analysis Requirement (Continued)*

General User	End-user of the proposed application	Interested in using AR	Create a free AR learning application on bird learning apps

Table 3 *Application Idea Creation Checklist*

Item	Description
Type of application	Mobile learning application
Target user	People who are around 16-45 years old
Target device	Android mobile devices
Graphical User Interface (GUI)	Species Information Module, Disease Module, Diet and Care Module, Activity Module, AR Module
Images	Icons, bird images
Audio	Bird's species-specific sound
Video	Bird care tips and tricks video
Animation	Bird's flying simulation
AR	Marker-based AR shows 5 types of bird models
Application synopsis	Birdie: Pet Focus is a mobile learning application that uses AR technology. This application is developed for users to gain information about birds that they can keep as pets and experience virtual interaction with the 3D bird model in the app.

3.2 Structure Analysis Stage

In this second phase, it is necessary to understand the requirements needed to develop this project. Table 4 and Table 5 show the functional and non-functional requirements for the application. This phase also includes three sub-stages based on the MMCD methodology which are navigation analysis, object analysis, and structure update. A navigation structure is designed to show the flow between modules, a content structure checklist is prepared to list all multimedia elements, and a flowchart is created to visualize the system process and user interaction. The system flowchart, navigation structure, and content structure for the developed application are shown in Appendix A to Appendix C

Table 4 *Functional Requirements*

Functional Requirement	Module	Description
Autonomous system activities	AR module	The system will show the bird's 3D model once users have calibrated the marker.
	Species information, Disease, Diet and Care module	The system should allow users to learn about five types of birds which are the Canary, Parrot, Lovebird, Zebra Finch, and Dove.
	Activity module	The system should allow users to play puzzle games
User interaction	Main menu module selection	The system should enable users to select a module by clicking on it.
		The system should allow the user to navigate through the application by using the correct button.

Table 4: *Functional Requirements (Continued)*

	AR module	The system should allow users to initiate an AR session through the AR camera button
		The system should allow users to interact with the 3D models in the AR environment using the button provided.
	Activity module	The system should allow users to move the puzzle pieces and solve the whole puzzle.

Table 5 *Non-Functional Requirements*

Non-functional Requirement	Description
Performance	The application should be operated completely offline The application should load and perform all the modules and pages The application should respond in less than 2 seconds for most Android devices that meet the system requirement The time to generate the AR environment should not be more than two seconds.
Implementation	The application should be able to operate on any Android device if it uses Android version 8.0 and above.
Legal	Users should only be able to view the content of the application and are not able to do any editing or modification to the content.
Usability	This application is available for users to access anytime or anywhere without an internet connection This application offers good user experience, is straightforward to learn, and is effective.
Cultural	This application uses a simple English language.
Graphical User Interface Support	This application needs to accommodate all of its elements, including text, images, animation, and audio for varying screen resolutions on Android mobile devices.

3.3 Process Design Stage

The third phase of the MMCD methodology is to plan and design the structure and functionality for the developed application. The assets and elements in the Species Information module, Disease module, Diet and Care module, and Activity module were designed using Adobe Illustrator and Canva. The objects that were designed are buttons, backgrounds, and assets. Meanwhile, Blender software is used to design and create the five types of bird models. It was also used to create animations that were used in the AR module. Additionally, the Unity software is used to compile the assets with scripting. The assets developed for this application are 2D buttons, 3D bird models, 3D animation, video, and audio, as shown in Table 6. Button design for this developed application is shown in Appendix D. Fig.3(a), (b), and (c) show the screenshots of the interface design for this application, starting with the Start interface, followed by the Main interface,

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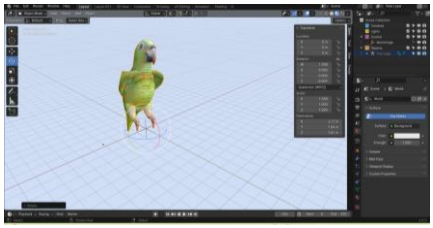
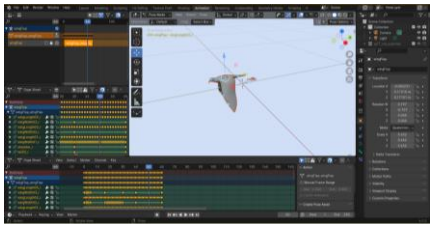
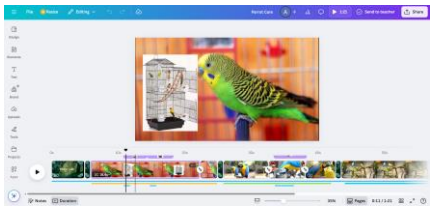
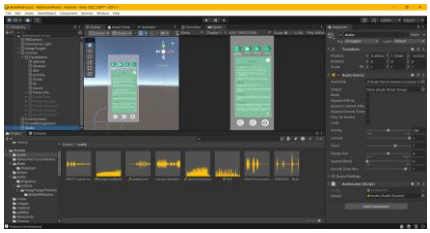
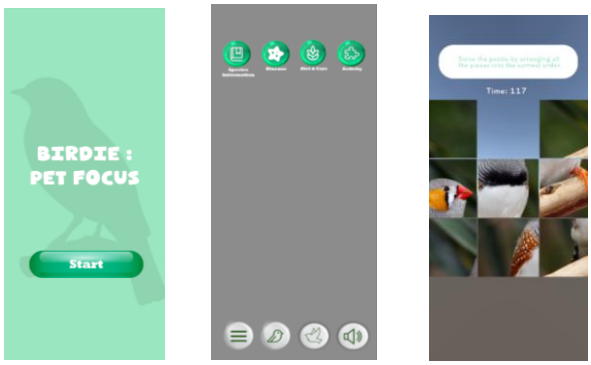
and the Activity interface, respectively. The other interface design is shown in Appendix E. This phase includes two sub-stages, which are designing objects, where all visual elements are created, and writing the single-function prototype scripting, where basic interaction functions are tested using Unity and C#.

Table 6 *Development of Assets in Application*

Types of Assets	Development View	Description
2D Button		All the buttons in the application were created using Adobe Illustrator.
3D Bird Models		All five types of 3D bird models were created by using Blender software. Texturing, Rigging, and Skinning were also done in Blender.
3D animation		All 3D animation that was used in the AR module was created by using the NLA editor in Blender.
Video		Canva is used to create a video for explaining tips and tricks related to bird' care and diet.
Audio		The audio files for the Birdie: Pet Focus application are taken from free online resources such as "Pixabay". Its format is MPEG Audio Layer 3 (MP3).



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

Fig.3 Screenshots of *(a) Start interface (b) Main interface (c) Activity interface*

3.4 Main Function Development Stage

At this stage, the main function of the application was carried out. It involved integrating the assets and the interface with Unity using C# scripting. In the Species Information module, the Disease module, and the Diet and Care module, the main function is to deliver the learning content by displaying the information on the panel that has been set. Meanwhile, for the Activity module, the main function is to integrate a puzzle game that allows users to solve it within the given time. There is also a main function to keep up the timer for the puzzle game in the Activity module. Other than that, there is also a main function to control the interaction in the AR module, ensuring that the module can animate perfectly when needed. The AR creation involves importing 3D bird models into Unity, attaching animations using Animator, and applying AR Foundation with Vuforia to detect markers and render the birds in real-time. In addition, there is a main function to control the audio of the bird's species-specific sound. Subsequently, the C# scripting is used to ensure the main function of the application can work properly. Table 7 lists the main function which includes audio script, bird controller, change scene, game manager, timer UI panel manager and start stop script. Several references, including books and e-books, were used to ensure the accuracy of the content provided in modules such as Disease, Diet and Care, and Species Information [13], [14], [15].

Table 7 *C# Scripting for Unity Integration*

Functions	C# Scripting	Description

Audio Script (Bird's species-specific sound)	using System.Collections;
	using System.Collections.Generic;
	using UnityEngine;
	
	public class audioscript : MonoBehaviour
	{
	public AudioSource sound;
	public void ToggleSound()
	{
	if (sound.isPlaying)
	{
	sound.Stop();
	}
	else
	{
	sound.Play();
	}
	}
	}
		In this script, the AudioSource variable **"sound"** is used to assign and control an audio clip. The ToggleSound() method checks whether the audio is currently playing. If the audio is playing, the method stops the playback using sound.Stop(). Otherwise, it starts the playback using sound.Play(). This allows a single function to toggle audio on and off, providing simple sound control that can be used for UI buttons or in-game actions such as clicking, opening a menu, or interacting with objects.

Table 7: *C# Scripting for Unity Integration (Continued)*

Functions	C# Scripting	Description

Bird Controller (AR module)	using UnityEngine;
	public class BirdController : MonoBehaviour
	{
	[Header("Assign Animator from the burung GameObject")]
	public Animator birdAnimator;
	public void PlayFly()
	{
	if (birdAnimator != null)
	{
	Debug.Log("fly button pressed");
	birdAnimator.SetTrigger("toFly");
	}
	else
	{
	Debug.LogWarning("Animator not assigned!");
	}
	}
	public void PlayStatic()
	{
	if (birdAnimator != null)
	{
	Debug.Log("static button pressed");
	birdAnimator.SetTrigger("toStatic");
	}
	else
	{
	Debug.LogWarning("Animator not assigned!");
	}
	}
	}
		In this script, the Animator variable "birdAnimator" is used to control the animation states of the bird model. The PlayFly() method sets the trigger "toFly" to activate the flying animation when the corresponding button is pressed. Similarly, the PlayStatic() method sets the trigger "toStatic" to return the bird to a static animation. This script enables users to switch animations interactively through UI button inputs.

Game Manager (Activity module)	private bool SwapIfValid(int i, int offset, int colCheck)
	{
	if (((i % size) != colCheck) && ((i + offset) == emptyLocation))
	{
	(pieces[i], pieces[i + offset]) = (pieces[i + offset], pieces[i]);
	(pieces[i].localPosition, pieces[i + offset].localPosition) = (pieces[i + offset].localPosition, pieces[i].localPosition);
	emptyLocation = i;
	return true;
	}
	return false;
	}
		In this script, the method *SwapIfValid(int i, int offset, int colCheck)* is a key component that enables the core puzzle interaction. When a player clicks on a puzzle piece, this method checks if the selected piece is adjacent to the empty space by comparing index positions. If the move is valid, it swaps the selected piece with the empty location both in the pieces list and visually on the game board by switching their localPosition.

Table 7: *C# Scripting for Unity Integration (Continued)*

Functions	C# Scripting	Description

Timer (Activity module)	void Update()
	{
	if (timerIsRunning)
	{
	if (timeRemaining > 0)
	{
	timeRemaining -= Time.deltaTime;
	UpdateTimerDisplay();
	
	if (timeRemaining <= 5f && !isBeeping)
	{
	isBeeping = true;
	InvokeRepeating("PlayBeep", 0f, 1f);
	}
	}
	else
	{
	timeRemaining = 0;
	timerIsRunning = false;
	GameOver();
	}
	}
	}
		In this script, the *Update()* method is responsible for controlling the countdown behavior of the timer. As long as timerIsRunning is true, it subtracts time from timeRemaining using Time.deltaTime. When the time drops to 5 seconds or less, it triggers a beeping sound using InvokeRepeating() to alert the player. If the timer reaches zero, it stops the countdown and calls *GameOver()*, which handles ending the game and updating the UI. This method is crucial for driving the timer-based gameplay and signaling when the game should end.

3.5 Testing Stage

Testing is conducted during this stage to optimize the Birdie: Pet Focus application's functionality, usability, and overall performance. Two types of testing were conducted: functionality testing and user testing. During the development of the Birdie: Pet Focus application, functionality testing was done to ensure all buttons worked correctly and responded properly. This testing was carried out from the early stages until the app was fully completed. Table 8 presents the outcomes of this testing, where each button was assessed under various conditions to confirm its proper functionality. During testing, an issue was discovered with the close button displayed in the Species Information module, Disease module, and Bird and Care module, as it cannot close all the panels at once. To resolve this, the button's functionality was updated to ensure it closes all active panels simultaneously. After the fix was applied, further testing confirmed that the close button now works as intended across all affected modules.

Table 8 *Result of functionality testing*

Test Case	**Expected Result**	**Actual Result**	**Corrective Action**
Start Button	Navigates to Main Menu	Works well as expected	Not needed
Canary Button	Navigates to Canary interface	Works well as expected	Not needed
Dove Button	Navigates to Dove interface	Works well as expected	Not needed
Lovebird Button	Navigates to Lovebird interface	Works well as expected	Not needed

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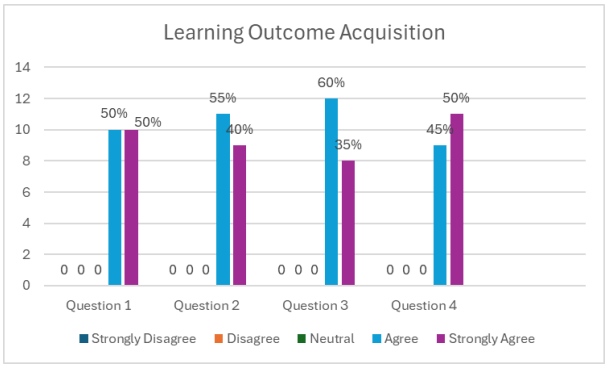
Table 8:*Result of functionality testing (Continued)*

Test Case	Expected Result	Actual Result	Corrective Action
Parrot Button	Navigates Parrot interface	Works well as expected	Not needed
Zebra Finch Button	Navigates to Zebra Finch interface	Works well as expected	Not needed
Species Information Button	Display species information panel	Works well as expected	Not needed
Disease Button	Display disease information panel	Works well as expected	Not needed
Diet and Care Button	Display diet and care information panel	Works well as expected	Not needed
Activity Button	Navigates to activity interface	Works well as expected	Not needed
Main Menu Button	Navigates to Main Menu	Works well as expected	Not needed
Bird Static Button	Display the static condition of the bird's AR model	Works well as expected	Not needed
Bird Fly Button	Display flying condition of bird's AR model	Works well as expected	Not needed
Sound Button	Play bird species-specific sound	Works well as expected	Not needed
Play Button	Play video of bird care tips and tricks in Bird and Care module	Works well as expected	Not needed
Pause Button	Pause video of bird care tips and tricks in Bird and Care module	Works well as expected	Not needed
Replay Button	Replay the puzzle game in Activity module	Works well as expected	Not needed
Home Button	Navigates from Activity module to bird's main interface	Works well as expected	Not needed
Back Button	Navigates to previous panel	Works well as expected	Not needed
Next Button	Navigates to next panel	Works well as expected	Not needed
Close Button	Close panel information	Works well as expected	Not needed

4. Result and Discussion

In this section, the beta testing was collected and analysed. The beta testing for the Birdie: Pet Focus application was carried out through a questionnaire distributed via Google Form. The three primary elements of the questionnaire were "Demographic", "Learning Outcome Acquisition", which had four questions, and "User Acceptance Level", which had ten questions. The User Acceptance Level was assessed using the System Usability Scale (SUS) method to measure the application's usability and user satisfaction. A total of 20 respondents participated in the testing. The testing was done to the target users who are around 16 to 45 years old. Most of the respondents were students of Universiti Tun Hussein Onn Malaysia (UTHM) and the people who live nearby. Feedback from the respondents was grouped into two categories, which are positive feedback as shown in Figure 4 and negative feedback as shown in Figure 5.

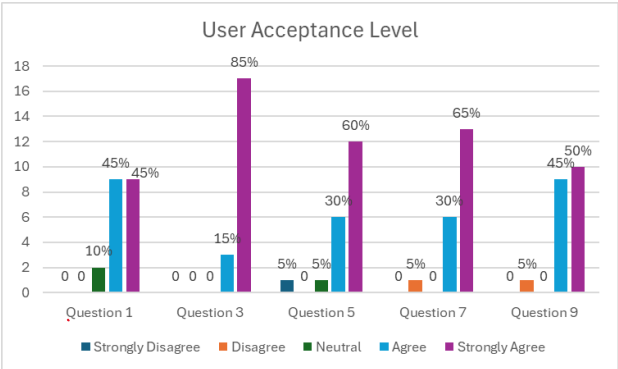
By referring to Fig.4, the Learning Outcome Acquisition section consist of four questions. Based on the data analysis, it shows that for Question 1, 50% of respondents agreed and 50% strongly agreed that they gained new knowledge about bird species. In Question 2, 55% agreed and 45% strongly agreed that the bird care information was clear and easy to understand. For Question 3, 60% agreed and 35% strongly agreed that they felt more confident in taking care of pet birds. Lastly, for Question 4, 45% agreed and 50% strongly agreed that the interactive features in the application helped reinforce their learning. These findings indicate that Birdie: Pet Focus effectively enhanced users' understanding and confidence in bird care through its informative content and interactive elements.



Question 1: I gained new knowledge about bird species after using this application
Question 2: The bird care information was clear and easy to understand.
Question 3: I feel more confident about taking care of pet birds after using the app
Question 4: I find the interactive features helped reinforce my learning

Fig.4 *Learning Outcome Acquisition Result*

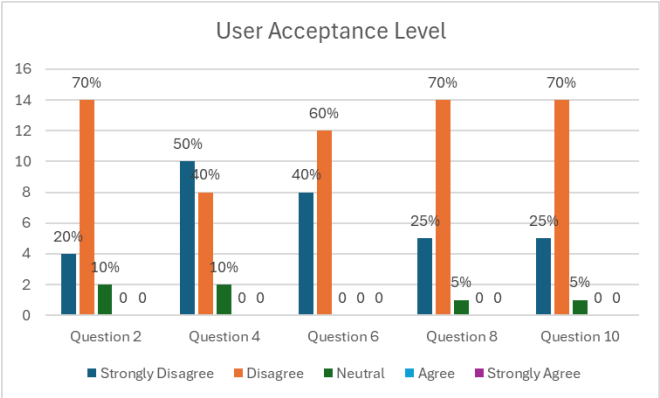
Based on the positive feedback shown in Fig.5, the system received strong user acceptance in areas related to usability and confidence. For Question 1, over 60% of users strongly agreed that they would like to use the system frequently. In addition, Question 3 showed that more than 70% of respondents agreed or strongly agreed that the system is easy to use. For Questions 5 and 7, most of the respondents selected "Agree" or "Strongly Agree," indicating that they found the functions well integrated and believed most people would learn to use the system quickly. Question 9 showed that around 65% of respondents felt confident using the system.



Question 1: I think I would like to use this system frequently
Question 3: I think the system is easy to use
Question 5: I find the various functions in this system are well integrated
Question 7: I imagine that most people would learn to use this system very quickly
Question 9: I felt very confident using the system

Fig.5 *Positive Feedback for User Acceptance Level*

In contrast, Fig.6 shows the negative feedback of User Acceptance Testing. For Question 2, 70% disagreed and 20% strongly disagreed with the idea that the system is unnecessarily complex. Question 4 had around 60% disagreement, suggesting that most respondents felt they did not need technical support. Questions 6, 8, and 10 also received more than 50% disagreement, showing that users did not find the system inconsistent, complicated, or difficult to learn. Overall, this analysis highlights strong user satisfaction with the system, with minimal negative feedback and a few areas that could benefit from improvement.



Question 2: I find the system unnecessarily complex (hard to use)
Question 4: I think I would need the support of a technical person to be able to use this system
Question 6: I think there is too much inconsistency in this system
Question 8: I find the system very complicated to use
Question 10: I needed to learn a lot of things before I could get going with this system

Fig.6 *Negative Feedback for User Acceptance Level*

Table 9 *Respondent's score for SUS*

Respondent	Item Score										Total Score
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	
R01	4	2	4	2	1	2	2	2	2	2	57.5
R02	3	3	4	3	3	2	4	2	4	2	72.5
R03	3	3	5	3	4	2	2	3	4	3	77.5
R04	4	2	5	2	4	2	5	2	4	2	82.5
R05	4	2	5	1	4	1	5	1	5	2	87.5
R06	5	2	5	1	5	2	5	1	4	1	90.0
R07	4	2	5	2	5	1	4	2	5	2	85.0
R08	4	1	5	1	5	2	5	2	5	1	90.0
R09	5	2	5	1	5	1	4	2	5	2	90.0
R10	4	2	5	1	4	2	5	2	4	2	85.0
R11	4	2	5	2	5	2	4	2	5	2	85.0
R12	5	2	4	2	5	1	5	1	4	2	87.5
R13	4	2	5	1	5	1	5	1	5	2	90.0
R14	5	2	5	2	4	1	5	2	5	1	90.0
R15	5	2	5	1	5	2	5	2	5	2	92.5
R16	5	1	5	1	5	2	4	2	4	2	87.5
R17	5	1	5	1	5	1	5	2	4	1	92.5
R18	4	2	5	2	5	2	5	2	4	2	85.0
R19	5	2	5	1	4	2	5	2	5	2	87.5
R20	5	1	5	2	5	1	5	1	5	1	95.0
	Average Score										80.54

The Birdie: Pet Focus application's overall usability score is displayed in Table 9. The average user approval score for usability tests is determined using the System Usability Scale (SUS) [16]. Based on the SUS, the following formula is applied to get usability results:

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

Therefore, Average score

$$= \frac{57.5 + 72.5 + 77.5 + 82.5 + 87.5 + 90.0 + 85.0 + 90.0 + 90.0 + 85.0 + 85.0 + 87.5 + 90.0 + 90.0 + 92.5 + 87.5 + 92.5 + 85.0 + 87.5 + 95.0}{20}$$

= 80.54

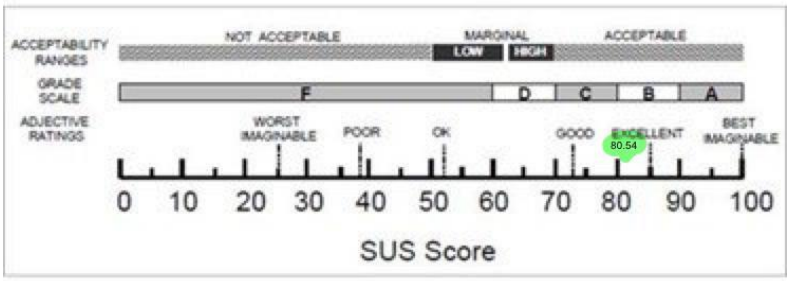


Fig.7 *Scale of SUS Score* [16]

Fig.7 shows the SUS score scale. For Birdie: Pet Focus application, the average score is 80.54, which falls under the category of acceptable. In general, Birdie: Pet Focus might be classified as an application that successfully meets the requirements of the target users.

5. Conclusion

In conclusion, the development of the Birdie: Pet Focus application has successfully met its main objective of providing an interactive and educational mobile platform focused on five types of pet birds: Canary, Dove, Parrot, Lovebird, and Zebra Finch. This project is significant as it addresses the lack of accessible and multimedia-based learning tools related to bird care and pet ownership. Based on the implementation process and testing results, all modules functioned as intended. Both alpha and beta testing showed that users were satisfied with the application's features, usability, and design. The System Usability Scale (SUS) results indicated that the application falls within the acceptable range, showing good user acceptance and functionality.

This project contributes to the field of mobile learning by offering an informative and engaging tool, especially for users aged 16 to 45. The objectives set at the beginning of the project were successfully achieved, including the integration of multimedia elements, delivery of accurate content, and interactive user experience.

The application offers several advantages, such as ease of use, relevant content, and interactive features like 3D models and AR. However, there are some minor limitations, such as limited bird types and minor interface issues, which can be improved in the future. For further enhancement, the application could include more bird species, improve the AR experience, and add more gamified elements to increase user engagement.

and Zebra Finch. Users can interact with 3D bird models, access comprehensive information on bird species, care, diet, and diseases, and participate in interactive activities designed to reinforce their learning.

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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:*** *Athira Balqis Jailani, Norhanifah Murli;* ***data collection:*** *Athira Balqis Jailani, Norhanifah Murli;* ***analysis and interpretation of results:*** *Athira Balqis Jailani, Norhanifah Murli;* ***draft manuscript preparation:*** *Athira Balqis Jailani, Norhanifah Murli. All authors reviewed the results and approved the final version of the manuscript.*

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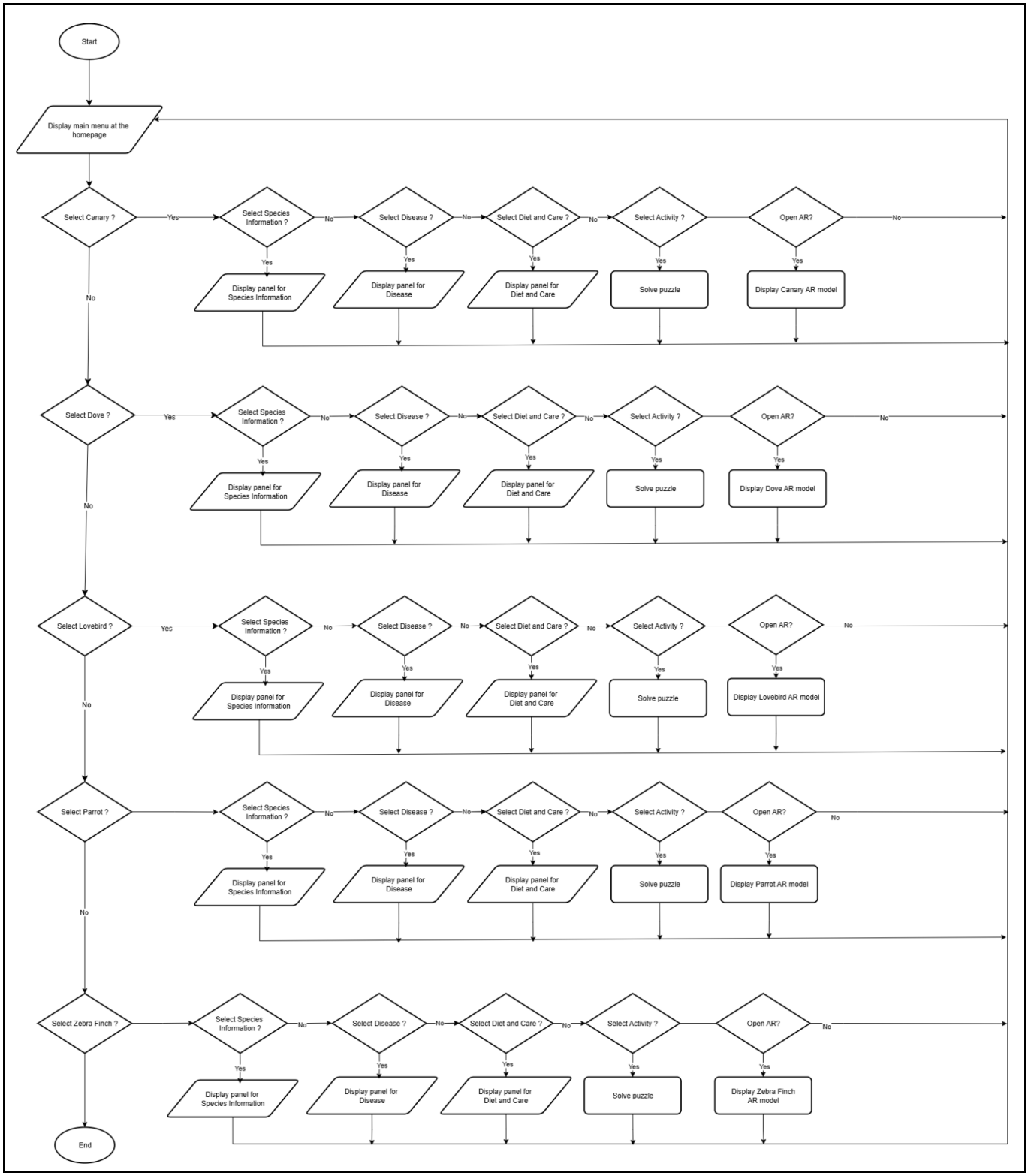
Appendix A: Flowchart for Main System



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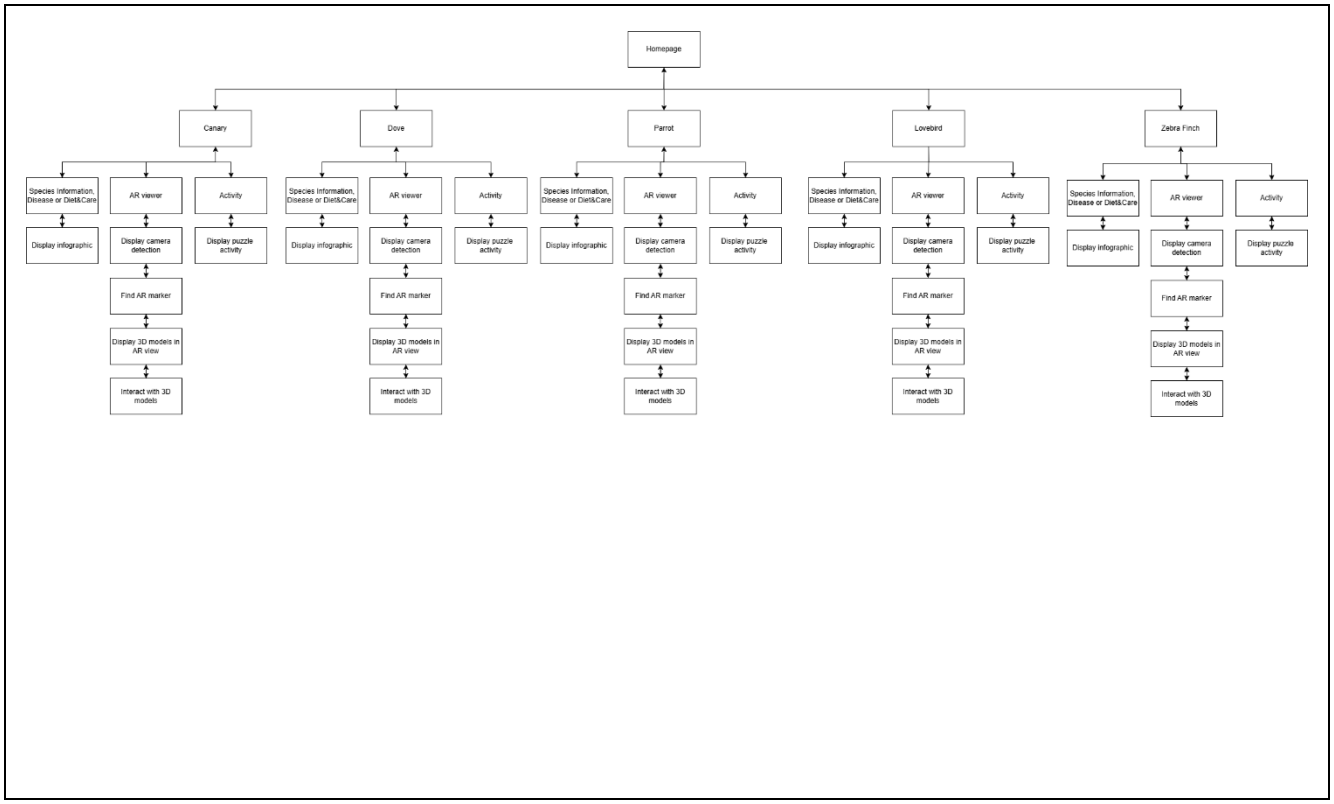
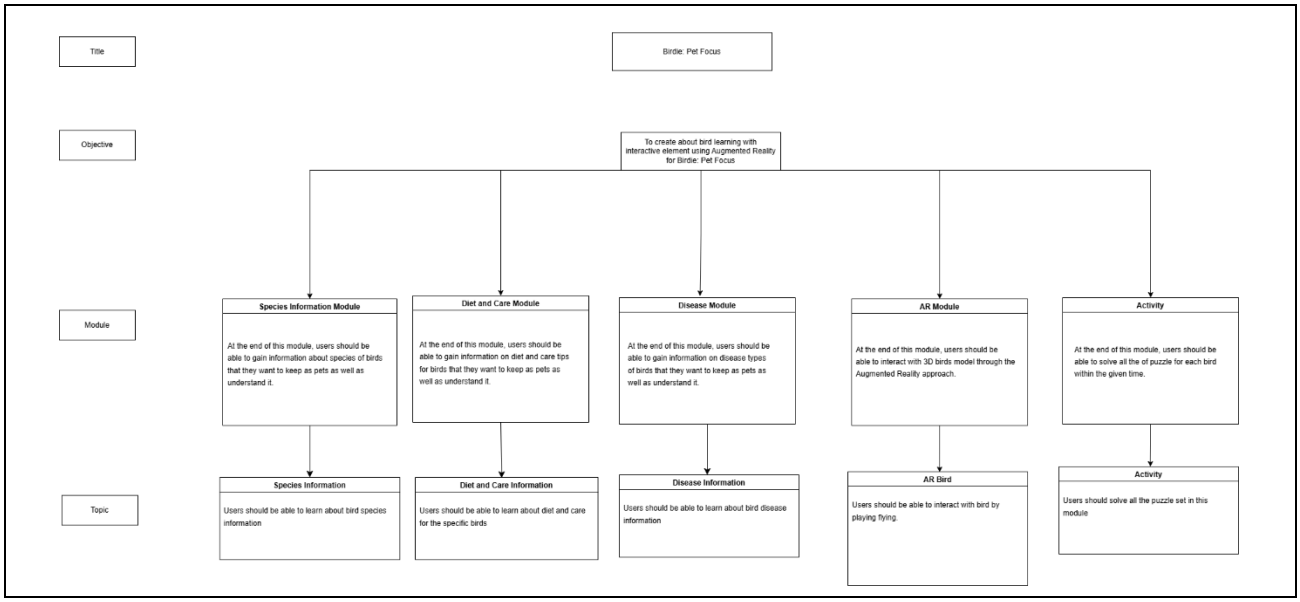
Appendix B: Navigation Structure



Appendix C: Content Structure



Appendix D: Button Design

Button	Description	Button	Description
	This is Start button.		This is Species Information button.
	This is Canary button.		This is Disease button.
	This is quiz Dove button.		This is Diet and Care button.
	This is Parrot button.		This is Activity button.
	This is Lovebird button.		This is Replay button.
	This is Zebra Finch button.		This is Home button.
	This is Main Menu button.		This is Bird Static button.
	This is Bird Fly button.		This is Sound button.
	This is Play button.		This is Pause button.

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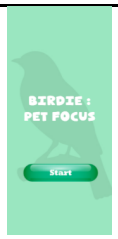
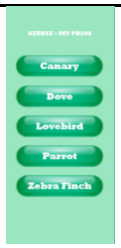
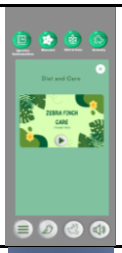
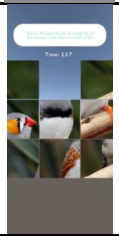
Appendix E: Interface Design

Interfaces	Description
	The first interface Start button will navigate user to main menu
	Main Menu Interface Divided into five selection of choices which are Canary, Dove, Lovebird, Parrot, and Zebra Finch.
	Main Interface Appears when the user chooses any type of bird from the main menu. The interface is already in an AR environment, so users can just show the marker to view the AR model and interact with it.
	Species Information Interface Appears when users tap on the species information button. A panel will appear to display all the related information.
	Disease Interface Appears when users tap on the disease button. A panel will appear to display all the related information.
	Diet and Care Interface Appears when users tap on the diet and care button. A panel will appear to display all the related information.
	Activity Interface Appears when users tap on the activity button. Navigates users to another scene where they need to solve the puzzle game within the given time