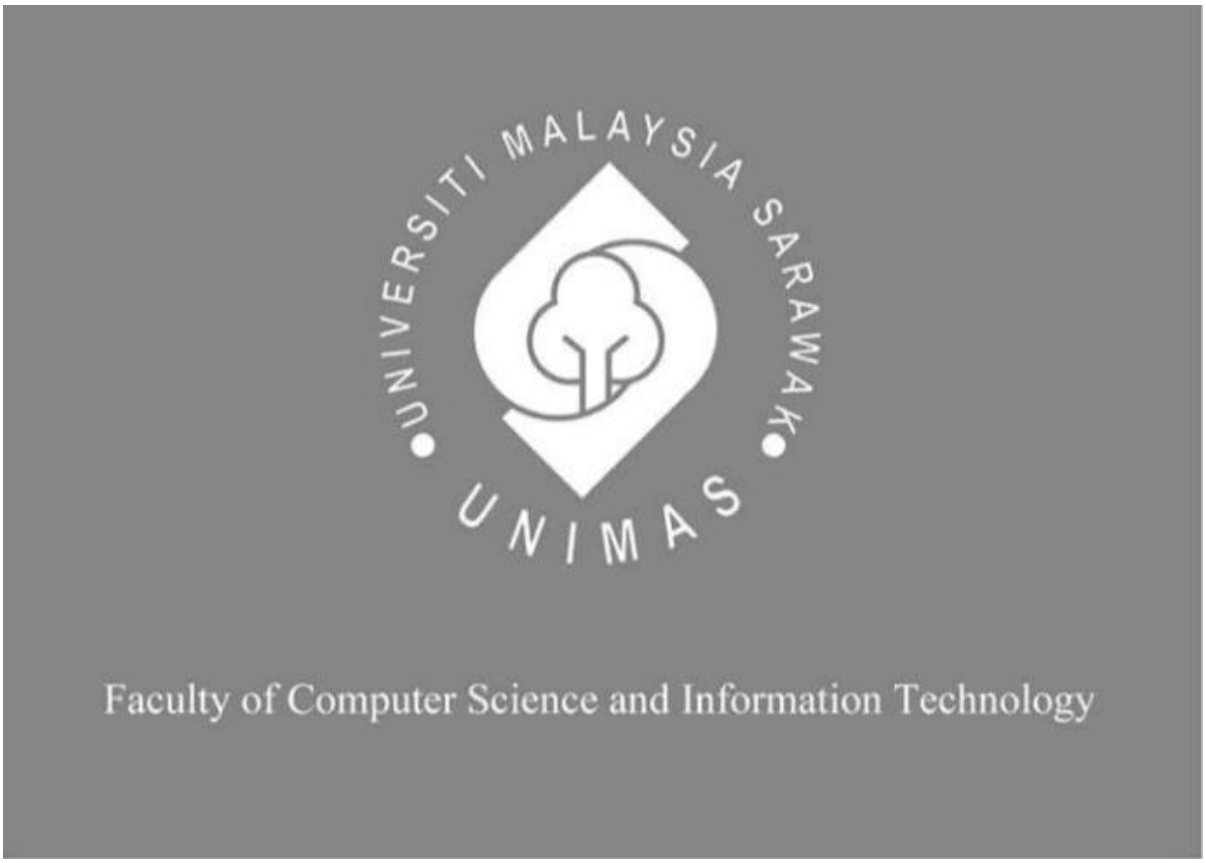

EcoLyfeAR: Immersive Technology for Environmental Education on Species Extinction

Mariatul Shamin Binti Mahadar
79972

Bachelor of Computer Science with Honours

(Multimedia Computing)

2025

ECOLYFEAR: IMMERSIVE TECHNOLOGY FOR ENVIRONMENTAL EDUCATION ON SPECIES EXTINCTION

MARIATUL SHAMIN BINTI MAHADAR

This project is submitted in partial fulfilment of the

requirements for the degree of Bachelor of

Computer Science with Honours (Multimedia Computing)

Faculty of Computer Science and Information Technology

UNIVERSITI MALAYSIA SARAWAK

2025

UNIVERSITI MALAYSIA SARAWAK

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TITLE: ECOLYFEAR – IMMERSIVE TECHNOLOGY FOR ENVIRONMENTAL EDUCATION ON SPECIES EXTINCTION

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ACKNOWLEDGEMENT

First and foremost, I would like to express my deepest gratitude to Ts Dr. Suriati Khartini Binti Jali, my project supervisor and examiner, Ts Dr. Lim Phei Chin, for their guidance, support, and knowledge throughout the way I was getting ready for my final year project. Special thanks go to my family and friends for their unwavering support, patience, and encouragement throughout this journey. Their belief in my abilities motivated me to strive for excellence. Furthermore, I am thankful to everyone who contributed, directly or indirectly, to the successful completion of this project. Your support has been invaluable.

Lastly, I want to thank myself for not giving up during this four-year degree and for persevering through the challenges of completing this project. Thank you for being strong, for believing in my abilities, and for pushing forward even when the path seemed uncertain. This journey has been a test of resilience, determination, and growth, and I am proud of the person I have become through it all. Every late night, every moment of doubt, and every step forward has been worth it, and I am grateful for the strength to see it through.

ABSTRACT

Global biodiversity is seriously threatened by species extinction, which has dire consequences for ecosystems and human welfare. Conventional approaches to bringing attention to this important problem frequently fall short in terms of engaging audiences or demonstrating the need for immediate action. By creating an Augmented Reality (AR)-enhanced booklet that blends immersive technology with instructional material, this initiative fills this gap. The booklet gives readers the opportunity to engage with augmented reality (AR) pictures and personally experience the effects of species extinction using the EcoLyfeAR app. The project's goals are to raise users' awareness of species extinction, enhance their comprehension of its causes and effects, and motivate practical conservation measures. The initiative offers a fresh take on environmental education by fusing augmented reality (AR) with a tangible booklet, bridging the gap between cutting-edge technology and accessibility. The research shows how AR can be a powerful tool for raising environmental awareness and encouraging sustainable behaviour through user testing and feedback.

ABSTRAK

Kepupusan spesies merupakan ancaman serius kepada biodiversiti global, dengan implikasi besar terhadap ekosistem dan kesejahteraan manusia. Kaedah tradisional untuk meningkatkan kesedaran mengenai isu kritikal ini sering gagal menarik perhatian khalayak atau menggambarkan keperluan tindakan secara berkesan. Projek ini menangani jurang tersebut dengan membangunkan buku skrap yang dipertingkatkan dengan Realiti Terimbuh (AR), yang menggabungkan teknologi imersif dengan kandungan pendidikan. Menggunakan aplikasi EcoLyfeAR, buku skrap ini membolehkan pengguna berinteraksi dengan visual AR dan merasai kesan kepupusan spesies secara menarik dan peribadi. Objektif projek ini adalah untuk meningkatkan kesedaran tentang kepupusan spesies, memperdalam pemahaman pengguna mengenai punca dan akibatnya, serta memberi inspirasi kepada usaha pemuliharaan yang berkesan. Dengan menggabungkan teknologi AR dan buku fizikal, projek ini menghubungkan inovasi teknologi dengan kebolehcapaian, menawarkan pendekatan baharu dalam pendidikan alam sekitar. Melalui ujian pengguna dan maklum balas, projek ini menunjukkan potensi AR sebagai alat yang berkesan untuk meningkatkan kesedaran alam sekitar dan mendorong tingkah laku yang lestari.

TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

AR	Augmented Reality
UX	User Experience
MDLC	Multimedia Development Life Cycle
SDLC	Software Development Life Cycle
3D	3 Dimensional
IUCN	International Union for Conservation of Nature
NGOs	Non-Governmental Organisations

CHAPTER 1: INTRODUCTION

1.1 Introduction

In recent years, AR has found applications in a variety of industries, including entertainment and education, and it is also increasingly being used to solve global concerns like environmental awareness. According to Oueida et al. (2023), they highlight the relevance of augmented reality in enhancing the educational sector and raise awareness of the use of this method. A review is being done to prove the effectiveness of AR in improving learning outcomes, retention and enthusiasm for learning in lessons, and knowledge level. Alrowaily & Kavakli (2018) finds that mobile augmented reality technology can help people learn about their surroundings and become more environmentally conscious. Based on their research, augmented reality can increase users' awareness of their surroundings more than traditional means such as radios, maps, and portable displays. Furthermore, AR can increase the user's learning interest and reinforce learning. Environmental challenges like species extinction continue to worsen, yet many people do not see the necessity of addressing them. To close this gap, Augmented Reality (AR) provides a booklet and effective tool to engage individuals by bringing global issues directly into their own surroundings. AR combines the physical and digital worlds, allowing users to engage with virtual material placed in their real environment. This project, named EcoLyfeAR for Environmental Awareness on species extinction, uses augmented reality technology to create an immersive and interactive educational experience that illustrates the impact of issues related to the environment on species extinction.

This project involves important technical abilities, such as AR programming using Unity *(Unity Technologies., n.d.)* and 3D model production with Sketchfab *(Sketchfab, n.d.).* Furthermore, environmental research and the development of multimedia materials, such as writing, pictures, and 3D models, will be essential. User Experience (UX) design is also required to guarantee that AR interactions are intuitive and usable. By integrating

these abilities with the EcoLyfeAR app, this project will produce an engaging teaching tool that not only promotes awareness but also inspires users to take real action on issues related to the environment, specifically on species extinction.

The core of this project is an educational booklet that combines physical content with augmented reality, which users may scan with the specific AR applications, EcoLyfeAR. The application will launch dynamic visualisations, such as 3D models of animals, allowing users to view these concerns as if they were happening in their own community. The project's goal in producing this hybrid booklet and some flashcard are to make environmental education more accessible and powerful, encouraging people to take meaningful action to protect our world.

1.2 Problem Statement

Environmental challenges such as species extinction are widely acknowledged, yet individuals often struggle to relate to these issues personally, limiting the effectiveness of awareness campaigns and conservation efforts. The decline of biodiversity poses severe ecological and societal consequences, especially as many near-extinct species remain overlooked in current education efforts. Traditional methods, such as museum exhibits and textbooks, fail to fully engage audiences or communicate the urgency of preserving biodiversity.

Research by Gardoni et al. (2020) underscores the limitations of static presentations in inspiring action, while studies by Yuen, Yaoyuneyong, and Johnson (2011) highlight the potential of augmented reality (AR) to revolutionise learning. AR fosters immersive, interactive, and dynamic experiences, making it a promising tool for bridging the gap between abstract environmental concepts and real-world action.

This project addresses the need for innovative, accessible solutions by developing EcoLyfeAR, an AR-enhanced booklet and some AR Flashcard. By integrating real-time visualisations of biodiversity loss, interactive learning elements, and personalised content, this project aims to foster deeper connections to species conservation, particularly for younger audiences, and encourage

sustainable behaviours. Additionally, it seeks to make learning engaging and impactful, offering tools to preserve near-extinct species while empowering communities to take action.

1.3 Scope

The purpose of this project is to build an AR-enhanced environmental awareness booklet that teaches users about important issues like species extinction. The app is designed for users aged 12 and above, especially students and educators who enjoy interactive learning. Users may use the EcoLyfeAR app to scan booklet pages and flashcard which launch immersive AR experiences that blend physical and digital visualisations. The application focuses on endangered species from different categories, including **birds, mammals, reptiles, amphibians, and marine life**. The selection is based on their conservation status and relevance to environmental awareness. The app aims to provide **both localised and global perspectives** on species extinction. While local species such as Malayan Tiger, Bornean Orangutan, Asian Giant Tortoise, Asian Elephant and Hawksbill Turtle may be prioritised for direct impact, globally recognised species like Mountain Gorilla, Yellow-crested cockatoo, Javan rhinoceros, Black Rhinoceros, Blue whale, vaquita, Red panda, monarch Butterfly, Amur leopard and African Elephants could also be included for comparative learning. The project will prioritise user-friendly design to allow smooth interaction with AR content. Furthermore, the AR booklet's usefulness in boosting environmental awareness, particularly regarding species extinction, will be assessed through user testing and feedback.

1.4 Aim and Objectives

This project aims to increase users' knowledge of environmental concerns on species extinction by using Augmented Reality (AR) technology to build an interactive educational booklet and flashcard that shows how environmental issues, such as species extinction affect their local habitats. Users will be able to comprehend species extinction and take action in a more immersive and interesting way as a result.

1) To design an AR-enhanced booklet with EcoLyfeAR that shows real-time environmental effects that lead to species extinction, making complicated environmental issues accessible and understandable

2) To develop EcoLyfeAR's multimodal AR features that enable users to engage with real-time environmental impacts through immersive and interactive content, fostering a deeper understanding of the need for species preservation.

3) To evaluate the effectiveness of EcoLyfeAR in improving user engagement while enhancing understanding of species extinction.

1.5 Brief Methodology

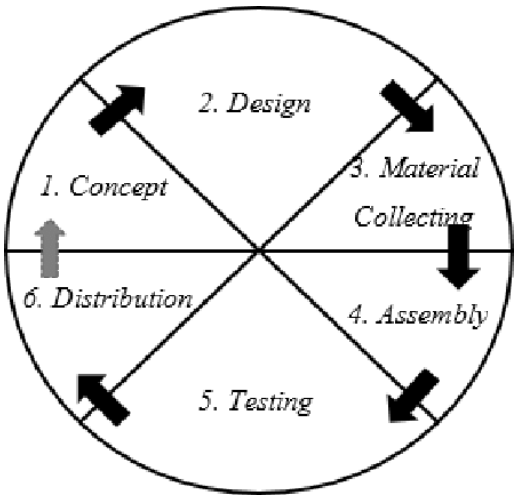


Figure 1.1 *Multimedia Development Life Cycle (MDLC) (Sulaeman & Aji, 2021)*

This project's methodology is based on the Multimedia Development Life Cycle (MDLC) model, which consists of six main stages: conception, design, collecting materials, assembly, testing, and distribution. Roedavan, & Bambang (2022) stated that despite having the same development foundations as the Software Development Life Cycle (SDLC), MDLC has distinct aspects linked to the creation and usage of multimedia assets. Technology is rapidly evolving, particularly in the field of interactive multimedia. The process consists of six critical

steps that combine technical expertise, environmental research, and UX design to create an appealing user experience focused on species extinction.

1.5.1 Conception

Concept is the first step of the Multimedia Development Life Cycle (MDLC). For this phase, it will define goals for instruction and choose species extinction issues. Determine technological requirements for AR development in Unity *(Unity Technologies., n.d.)* and 3D modelling use Sketchfab *(sketchfab., n.d.)* as well as identify the application's target audience.

1.5.2 Design

During the design process, the booklet will include distinct sections on species in danger of extinction, their habitats, fun facts and the reasons for their extinction, with AR markers prompting interactive experiences using the EcoLyfeAR app. Users will see 3D species models, all guided by an easy-to-follow flow and straightforward scanning instructions. Engaging activities, such as zoom in and out, animations, and suggestions for further investigation, will improve the user experience and make the material more accessible and inspiring, promoting action on environmental concerns.

1.5.3 Collecting Materials

During the collecting materials phase, research on species extinction will be done, including data gathered from literature and case studies. Multimedia elements such as text, photographs, and 3D models of animals and environments will be collected or generated to enhance the AR experience and offer users with accurate, visually appealing material.

1.5.4 Assembly

During the assembly phase, the EcoLyfeAR app will be built with Unity to offer an interactive AR experience. This entails including 3D models, multimedia, and interactive

elements that cause real-time visualisations when users scan the pages, highlighting endangered animals and their ecosystems through dynamic, immersive material.

1.5.5 Testing

During the testing process, usability and functionality tests will be performed to verify that the EcoLyfeAR app provides a smooth, intuitive experience. User comments will assist to improve the app's content and user experience, ensuring its efficacy in teaching and engaging users about species extinction and environmental challenges.

1.5.6 Distribution

During the distribution phase, the EcoLyfeAR booklet will be created and distributed to the target audience, which includes schools, museums, and environmental organisations. The application will be available through direct links, with the goal of raising environmental awareness and inspiring conservation efforts.

1.6 Significance of Project

This project is important because it has the potential to significantly improve the effectiveness of environmental education, particularly in terms of raising awareness about species extinction. Traditional techniques of teaching the public about endangered species and the value of biodiversity sometimes fail to adequately convey the seriousness of the situation. This project is a fully functional mobile app, EcoLyfeAR, that will come with an AR-enhanced booklet and flashcard that educates users on the critical issue of species extinction. Users will be able to see the effects of species loss in their own communities, making the problem more relevant and personal. This technique not only raises awareness but also stimulates people to take action by improving understanding and developing a stronger connection to the issue.

1.7 Project Schedule

The project schedule specifies the phases and activities for the Augmented Reality (AR) project to raise awareness about species extinction. It involves species extinction research, EcoLyfeAR content production, AR experience testing, and project completion. The calendar ensures timely completion by setting defined deadlines and deliverables. **Appendix A** has a full project timetable, as well as a Gantt chart for this FYP 1.

1.8 Expected Outcome

The project's goal is to create a fully functional mobile app, EcoLyfeAR, that will come with an AR-enhanced booklet and flashcard that educates users on the critical issue of species extinction. The application is intended for students, educators, and anybody else interested in environmental conservation. It enables users to engage with the booklet and flashcard while seeing immersive AR information, therefore improving their understanding of the impact of extinction on biodiversity.

The purpose is to increase awareness about the importance of preventing species extinction, explain its causes and consequences, and promote action to conserve endangered species. By focusing on young people and educators, the app makes learning about the environment more entertaining and understandable. The AR booklet and app are intended to be more successful than standard learning tools at engaging in attention, enhancing awareness, and encouraging long-term behaviours. User testing and feedback will ensure the app achieves its aims and connects users with conservation efforts.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter explores current research and conceptual foundations related to the development and execution of EcoLyfeAR, an augmented reality (AR) initiative designed to raise public awareness regarding species extinction. It conducts a thorough evaluation of the literature on key subjects such as the use of augmented reality in educational contexts, the influence of immersive technology on learning outcomes, and the present status of learning about the environment in relation to biodiversity loss. This chapter analyses previous studies to identify shortcomings in traditional methods to environmental awareness and investigates how AR technology might bridge these gaps by delivering interactive and engaging learning experiences. It also reviews processes and frameworks for creating AR apps to verify that EcoLyfeAR follows best practices and meets its goals efficiently. The findings of this assessment will inform the design and implementation of the EcoLyfeAR project, emphasising its potential to inspire real conservation efforts and encourage sustainable behaviours.

2.2 Review on Existing Applications

This section will examine and evaluate a few current uses of the same learning idea in further detail. There are four existing web applications chosen for the purpose of reviewing and comparing which are:

i) Endangered Animals Offline App

ii) Safari Central: Wildlife AR

iii) Animal 4D+

iv) Animal Safari AR

2.2.1 Endangered Animals Offline App

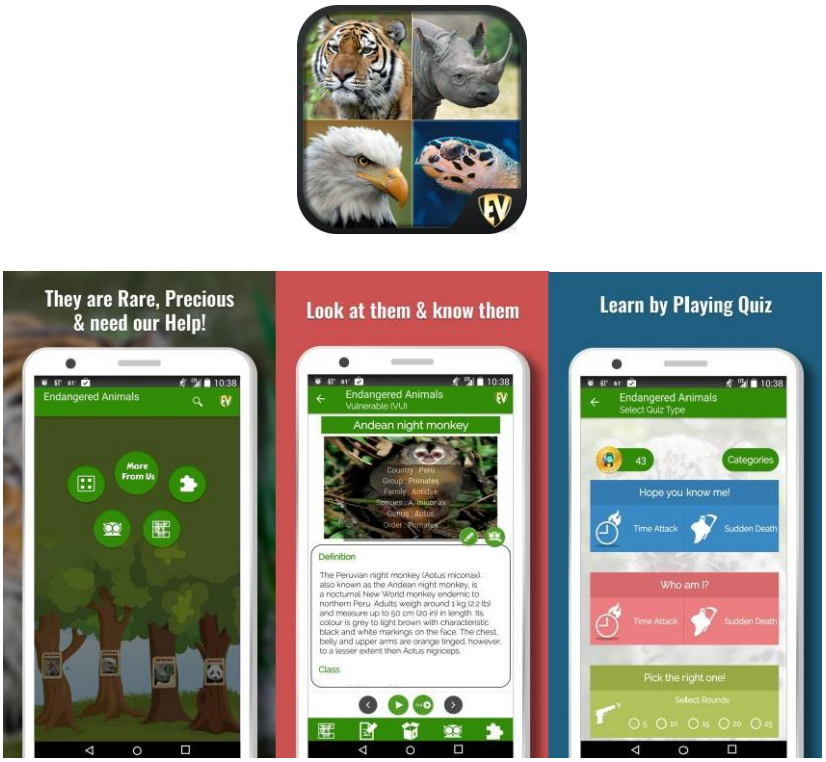


Figure 2.1 Endangered Animals Offline App *(Endangered Animals Offline APP, 2024)*

Edutainment Ventures produced the Endangered Animals Offline App, which was released on the Google Play Store in 2018. This application contains information on over 1600 endangered species, organised for simple navigation. Users may access it offline, making it ideal for distant or low-connectivity environments. It is accessible for Android smartphones (Endangered Animals Offline APP, 2024).

Users may utilise the Endangered Animals Offline App by downloading and installing it from the Google Play Store on their Android smartphones. Once installed, users may use the app's user-friendly layout to discover extensive information about over 1,600 endangered species. Users may easily find relevant information by searching by species type, habitat, or conservation status.

Users may save species profiles for easy access, build lists for instructional reasons, and use the application offline without an active internet connection, making it particularly helpful for remote or low-connectivity places. The app also offers interactive features such as quizzes and multimedia pieces to help students learn and participate.

The Endangered Animals Offline App is a comprehensive educational and informational tool meant to promote awareness about endangered animals while encouraging learning through interactive elements. It is especially useful for students, educators, and researchers, since it provides a dependable source of knowledge that may be utilised as a supplement in classrooms or wildlife education programs, particularly in places with restricted internet connectivity. The app also appeals to wildlife enthusiasts and conservationists, giving information on diverse species, ecosystems, and conservation statuses, making it an effective tool for increasing awareness and encouraging conservation activities.

Advantages include offline capabilities, which allows for usage without an internet connection, and interactive quizzes, which improve learning engagement. However, disadvantages include a lack of real-time updates due to its offline nature, as well as occasional user complaints regarding the navigation interface.

2.2.2 Safari Central: Wildlife AR

Figure 2.2 Safari Central: Wildlife AR *(Safari Central: Wildlife AR, 2017)*

Safari Central: animal AR, produced by Internet of Elephants in 2017, is a mobile app that uses augmented reality (AR) to teach people about animal conservation. The software, which is available for both iOS and Android, allows users to interact with virtual creatures such as elephants, giraffes, and pangolins by placing 3D models in their real-world environment using their device's camera. This augmented reality technology enhances the experience by producing life-sized, realistic animal encounters that seem visual, enabling users to investigate conservation activities in a fun, engaging way *(Safari Central: Wildlife AR, 2017)*.

Safari Central: Animal AR's scope is based on its capacity to promote animal awareness and conservation through education, entertainment, and technology. Using Augmented Reality (AR), the app provides immersive and engaging experiences that allow users to visually interact with endangered and iconic animal species in their natural environments. This makes it an ideal educational outreach tool, aimed at kids, educators, and wildlife lovers, as well as a supplement to schools and environmental initiatives. It promotes public awareness and conservation advocacy by allowing users to learn about animals, their habitats, and behaviours in an engaging manner, resulting in empathy and knowledge of the need to maintain biodiversity.

To utilise the application, users must first download it to their AR-compatible device, then choose an animal and point their camera in any direction to see the virtual animal emerge and interact. The augmented reality portion is especially exciting because it bridges the gap between digital education and real-world participation by immersing people in the delights of nature. However, while the program raises awareness and provides in-app revenues to conservation groups, its instructional breadth is restricted to a few species, and its reliance on AR-compatible hardware may limit accessibility (Safari Central, 2017).

The application has two benefits, as it promotes participatory conservation awareness and provides real-time, relatable wildlife education. These are compatible with EcoLyfeAR projects since both use AR to provide immersive and powerful teaching experiences, particularly on important environmental concerns. Safari Central's drawbacks include a small species range and a dependency on AR-compatible devices, which may restrict its educational breadth and accessibility. Addressing such limitations in EcoLyfeAR might increase its scope and reach, especially by incorporating wider content and device compatibility.

2.2.3 Animal 4D+ Application

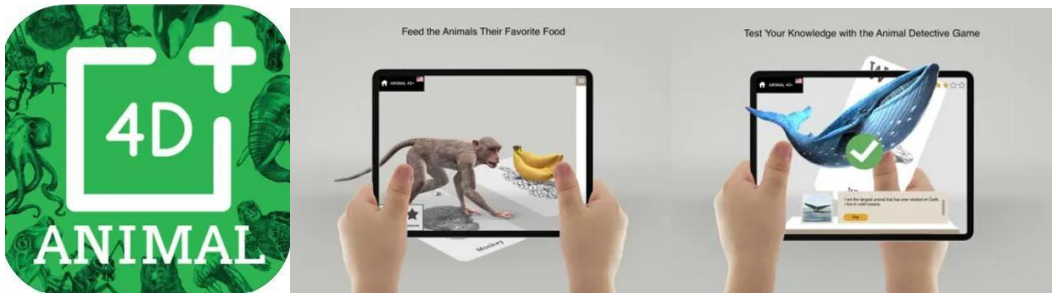


Figure 2.3 Animal 4D+ (*Animal 4D+ ,2015*).

Octagon Studio created Animal 4D+, an Augmented Reality (AR) teaching application in which animals are brought to life through interactive 3D models. By scanning certain flashcards with the app, users may experience realistic animal animations with lifelike motions and noises. The program is primarily intended for educational reasons, allowing children and

students to engage in immersive learning experiences. Each animal exhibited has basic information, such as its name and traits, making it an engaging and dynamic tool for learning about wildlife. One of the most notable aspects of Animal 4D+ is its ability to scan numerous cards at once, allowing users to see various creatures appear in the same space. This makes the learning experience more dynamic by allowing users to investigate animal relationships and compare their traits. The program is compatible with both Android and iOS devices and requires a camera to scan the flashcards. Animal 4D+ improves traditional learning for young learners by using appealing images and an interactive design (*Animal 4D+ ,2015*).

Based on the findings, Animal 4D+ is a useful mobile application for improving biology instruction in secondary schools. The study concludes that Animal 4D+, like other AR-based applications, promotes bio(eco)centrism by allowing pupils to engage with realistic 3D representations of animals. This interactive technique allows students to better comprehend biological principles, making learning more interesting and immersive. The article also shows that including such mobile applications into the curriculum can increase students' comprehension and involvement in biology lectures, which contributes to the overall efficacy of mobile Internet devices in education (Stepanyuk et al., 2020).

EcoLyfeAR, like Animal 4D+, uses Augmented Reality (AR) to augment learning experiences, but it focusses on environmental awareness. While Animal 4D+ allows users to explore and learn about numerous animal species in an interactive manner, EcoLyfeAR expands on this notion by visualising environmental repercussions and sustainability issues. EcoLyfeAR, an AR-enabled content scanner, teaches users about concerns such as deforestation, pollution, and species extinction, making it a useful tool for boosting environmental consciousness. Both applications aim to change education through immersive technology, making it more interesting and meaningful for users of all ages.

2.2.4 Animal Safari AR

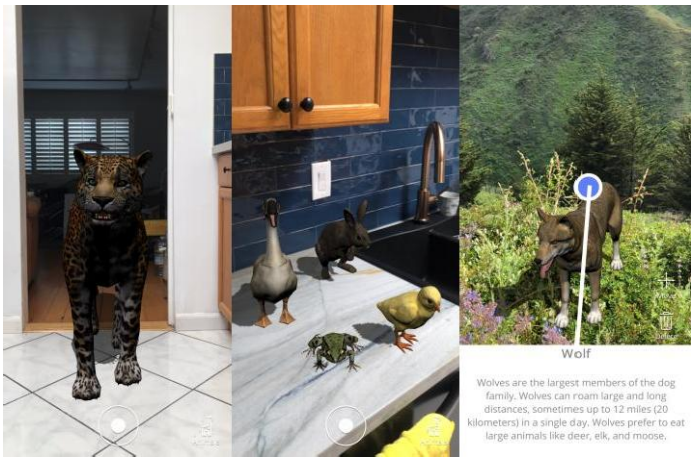


Figure 2.4 Animal Safari AR *(Animal Safari AR - 3D Learning, 2019).*

The *Animal Safari AR - 3D Learning App* was developed by LightUp Inc. and released in 2020. This augmented reality (AR) app offers an engaging experience where users can interact with life-size 3D animals, listen to their sounds, and learn about their diet, habitat, and other facts through information cards. It is available on iOS and Android platforms, catering to users of all ages, particularly educators and young learners. The scope of Animal Safari AR revolves around its capacity to utilise Augmented Reality (AR) to deliver an exciting and informative experience while raising awareness about species and their natural habitats. By incorporating virtual animals into users' real-world environments, the app provides an interactive platform that appeals to a wide range of audiences, including children, families, educators, and wildlife lovers.

To use the application, users must first download it to their device, then open it to place a virtual "target grid" on a flat surface and choose an animal to appear. They may then walk around the 3D animal, notice its size and features, engage with it by feeding or moving it, and learn more about it using the app. This interactive and instructional approach makes it a favourite among educators and youngsters. It combines AR technology with practical learning opportunities (Animal Safari AR - 3D Learning, 2019).

The application's advantages include its capacity to create an immersive learning environment by allowing users to see animals in their real-world settings, as well as its adaptability in delivering enjoyable and instructive features such as feeding virtual animals and discovering prehistoric creatures like dinosaurs. However, some limitations include its reliance on AR-compatible devices, which may limit accessibility, and the presence of in-app purchases for additional animal packs, which might possibly limit the experience for people wanting free content (Scholar, 2022).

2.4 Comparison of Existing Applications and Proposed Application

The comparison of features for existing applications which are Endangered Animals Offline App, Safari Central: Wildlife AR Animal 4D+ and Animal Safari AR with the proposed application, EcoLyfeAR are stated as below:

Table 2.1 *Comparison of Features between Existing Applications and Proposed Application*

Name / **Criteria**	Endangered Animals Offline App	Safari Central: Wildlife AR	Animal 4D+	Animal Safari AR	EcoLyfeAR (Propose App)
Price	Free (In-app purchases for extra content)	Free (In-app purchases for additional animals)	Free (In-app purchases for additional packs)	Free (In-app purchases for additional animal packs)	Free (In-app purchases for extra features)
Supported Operating System	Android	iOS, Android	iOS, Android	iOS, Android	Android
Language	English	English	English	English	English
Audio	Basic audio (sound effects in quizzes)	Animal sounds (interactive, based on AR experience)	Animal sounds	Animal sounds (interactive, feeding animals, etc.)	Environmental sound effects (related to species extinction, habitats, etc.)

Graphics	Static images and text-based educational content	AR animals with lifelike graphics and animations	3D models	Life-like AR graphics with 3D animals	3D models of endangered species in AR with environmental animations
Interactivity	Quizzes and interaction with animal facts	AR interaction (feeding, walking around animals, rotating, resizing)	Rotate, zoom in/out	AR interaction with animals, feeding, rotation, zooming	Scanning booklets to view AR, interactive learning, exploring endangered species
Augmented Reality (AR)	No	Yes	Yes (AR flashcards)	Yes (AR animals in real space)	Yes (AR-enhanced environmental education)
Quizzes	Yes (in quizzes section for each species)	No	No	No	Yes (in educational sections, quizzes on environmental issues)
Educational Booklet	No	No	No	No	Yes (AR-enhanced educational Booklet focused on species extinction)

Based on table 2.1, the comparison of features between existing applications and proposed applications can be analysed as follows.

Multimedia Elements

- **Audio:** EcoLyfeAR combines environmental sounds (such as habitat damage and endangered species noises) with narrative to teach users about the distinct extinction dangers faced by individual species. While applications like Endangered Animals Offline App and Animal 4D+ give animal sounds for immersion, EcoLyfeAR takes it

a step further by integrating narration that highlights how human actions contribute to species extinction. This allows people to learn not just about the species, but also about the challenges they face in a dynamic and compelling manner.

- **Graphics:** EcoLyfeAR improves learning by providing high-quality 3D models and animations of endangered animals in their natural habitats. Unlike the Endangered Animals Offline App, which uses 2D photos, EcoLyfeAR includes 3D models that users may interact with. These models depict species at danger of extinction owing to issues such as climate change, poaching, and deforestation. The vivid images of EcoLyfeAR make the environmental effect more real and engaging, resulting in a more impactful learning experience than Safari Central: Wildlife AR or Animal 4D+.
- **Interactivity:** EcoLyfeAR focusses on interactive species discovery, letting users to observe, and zoom in on endangered creatures and their habitats. Beyond that, it adds the capacity to engage with environmental changes that influence organisms. For example, users can investigate the consequences of habitat loss on specific species in real time. This degree of interactivity goes beyond the simple zooming found in applications like Animal 4D+ and Safari Central: Wildlife AR, which focus on animals. EcoLyfeAR connects interaction directly to understanding extinction concerns.
- **Augmented Reality (AR):** EcoLyfeAR use augmented reality to transport endangered creatures into the user's real-world surroundings, allowing them to witness firsthand the effects of habitat loss and climate change. While Safari Central: Wildlife AR and Animal 4D+ allow users to engage with animals through augmented reality, EcoLyfeAR explicitly visualises the consequences of human activity on endangered species and their ecosystems, making it a more potent tool for environmental education.

Users can observe how the ecosystem changes over time, emphasising the importance of conservation.

- **Quizzes:** Unlike previous applications, EcoLyfeAR incorporates interactive quizzes to test users' understanding about species extinction. These quizzes assess users' knowledge of extinction causes, endangered species, and methods for preventing further loss. This capability is not accessible in Safari Central: Wildlife AR, Animal 4D+, or Animal Safari AR, therefore EcoLyfeAR serves as both a learning tool and an assessment tool.
- **Educational Booklet:** EcoLyfeAR includes an AR-enhanced teaching pamphlet that explains species extinction in greater depth. Scanning the pages reveals interactive AR material such as 3D representations of endangered animals and animations of their declining habitats. This booklet approach, which is not included in other applications such as Animal 4D+ or Safari Central: Wildlife AR, provides an immersive teaching experience that enhances comprehension of species extinction while also serving as an easy-to-navigate, tangible learning resource.

2.5 Brief Overview of Proposed Application - EcoLyfeAR

An innovative augmented reality (AR) program called EcoLyfeAR was created to increase public awareness of environmental problems, including the loss of species. Through immersive and interactive 3D visualisations, EcoLyfeAR combines cutting-edge augmented reality technology with educational information to enable users to investigate the impacts of environmental issues, such as habitat loss. By making complicated environmental topics more approachable and practical, this educational tool aims to motivate users to take part in conservation initiatives.

The application will have interactive educational booklets and flashcard with extensive information about endangered species, their habitats, and the causes of extinction. AR allows users to scan physical items such as booklets to bring up three-dimensional models of these animals in their natural context, providing a better understanding of the urgent need for conservation. The EcoLyfeAR application also includes quizzes and interactive exercises to evaluate users' understanding of environmental concerns, making learning enjoyable and engaging. EcoLyfeAR, unlike other existing AR applications that mostly focus on animals and static information, intends to combine the power of immersive technology with dynamic educational materials, bridging the gap between digital education and real-world action. The application will be available for Android smartphones, ensuring a wide audience reach. It also distinguishes out for its focus on environmental education, notably around species extinction, which is frequently under-represented in mainstream AR applications.

EcoLyfeAR takes advantage of the rising interest in augmented reality technology to improve the educational experience while developing empathy and responsibility for environmental protection. EcoLyfeAR has the ability to change environmental education by engaging users with interactive 3D models and offering thorough, context-based learning experiences.

2.6 Summary

This chapter discusses existing augmented reality apps and their function in environmental education, with an emphasis on species extinction. It explores apps such as Endangered Animals Offline App, Safari Central: Wildlife AR, Animal 4D+, and Animal Safari AR, highlighting their advantages and disadvantages. While these applications provide interactive AR experiences, they do not place a heavy emphasis on environmental conservation problems like extinction. The proposed application, EcoLyfeAR, seeks to bridge this gap by

mixing AR with quizzes, 3D visualisations, and educational booklets to promote awareness about endangered species and their ecosystems. The chapter concludes that EcoLyfeAR has the potential to become a more engaging and powerful learning tool for environmental education, encouraging users to take action for conservation.

CHAPTER 3: REQUIREMENT ANALYSIS AND DESIGN

1.1 Introduction

This chapter provides a detailed explanation of the approach utilised to construct the proposed application. There are several methodologies accessible, including the Rapid Application Development (RAD), Agile model, and Waterfall model. Selecting the appropriate approach is crucial for guiding the development of the proposed application.

1.2 Multimedia Development Life Cycle (MDLC)

The suggested application will be developed using the Multimedia Development Life Cycle (MDLC) approach. Figure 3.1 illustrates that the MDLC process has six important phases: Concept, Design, Material Collection, Assembly, Testing, and Distribution.

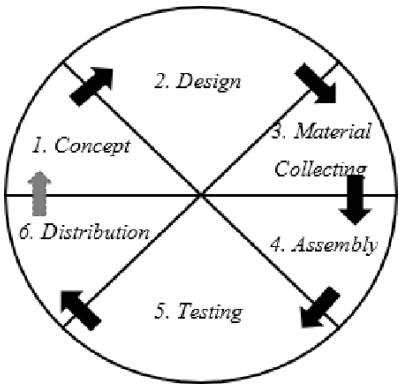


Figure 3.1 *Multimedia Development Life Cycle (MDLC) (Sulaeman & Aji, 2021)*

1.2.1 Concept

As described in Chapter 1, the goal of this project is to develop an interactive mobile application with Augmented Reality (AR) elements that uses a physical educational booklet and flashcard as a marker to improve and assist the learning experience. Before beginning to construct the suggested application, the project's needs will be thoroughly defined and analysed.

A) Questionnaire

This project established a questionnaire using Google Form to collect data and information from users' viewpoints (see Appendix B). The procedure of gathering information from users was conducted over 9 days from 16th to 23rd December 2024, to ensure that the proposed application satisfies the demands of the intended users. The chosen data collection method involved distributing the questionnaire via WhatsApp and Instagram, as these platforms allowed for quick, efficient, and broad dissemination. A total of 52 responses were received, providing valuable feedback for the project.

Section A: Demographic

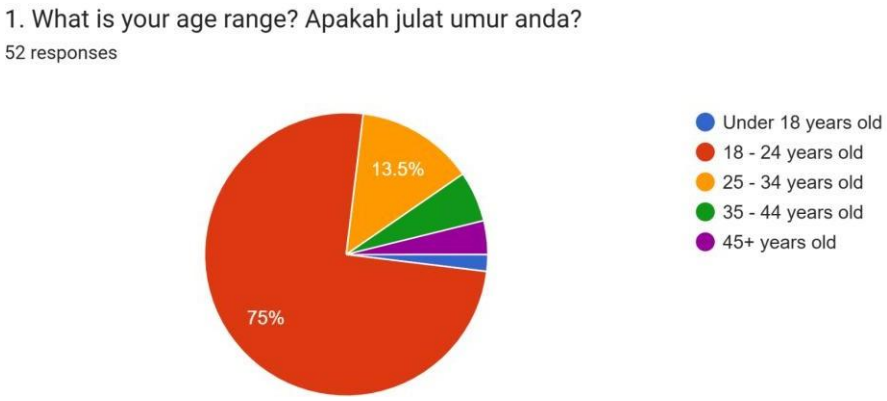


Figure 3.2 *Respondents' age*

The first section of the survey, Demographics, collected statistical data about the respondents' characteristics. As shown in Figure 3.2, 75% of the respondents (39 respondents) were between the ages of 18 and 24, 13.5% of the respondents (7 respondents) were between the ages of 25 and 34, 5.8% of the respondents (3 respondents) were between the ages of 35 and 44, and the remaining respondents were 45 years or older.

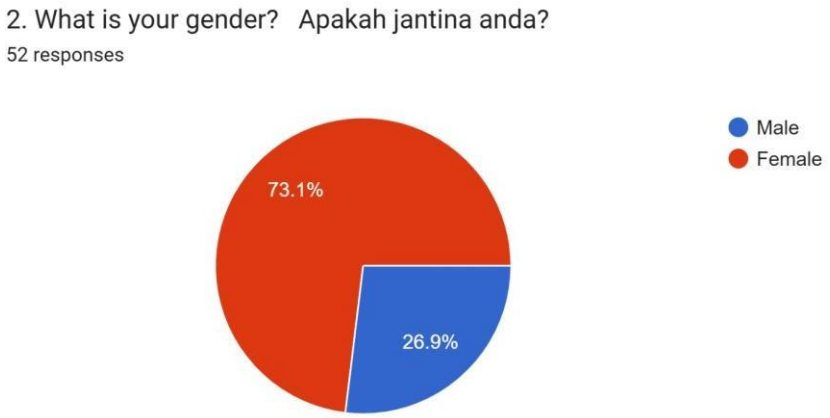


Figure 3.3 *Respondents' gender*

Next, as shown in Figure 3.3, the majority of respondents, 73.1% (38), were female, while the remaining 26.9% (14 respondents) were male. This considerable gender distribution indicated that females comprise a greater share of survey participants. The gap might have been due to the target audience's demographics or special interest in the survey issue. Understanding the gender mix of respondents was critical because it could have provided insights into prospective response patterns and helped in developing suggestions or interventions that took into account the dominant group's opinions. This distribution also emphasised the significance of having equal representation in future research to capture a more diverse range of viewpoints and experiences.

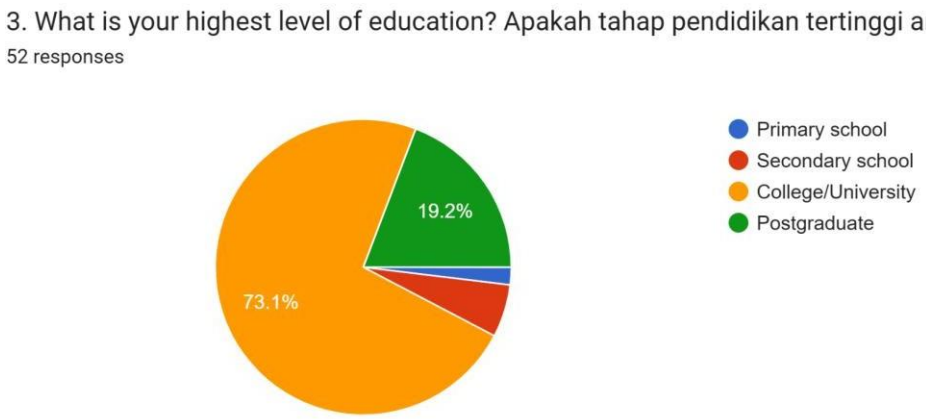


Figure 3.4 *Respondents' highest level of education*

In Figure 3.4, the majority of respondents, 73.1% (38), identified their highest level of education as college or university. This was followed by 19.2% (10 respondents) who have finished their postgraduate studies. Furthermore, three respondents identified secondary school as their greatest level of education, while one had only finished primary school.

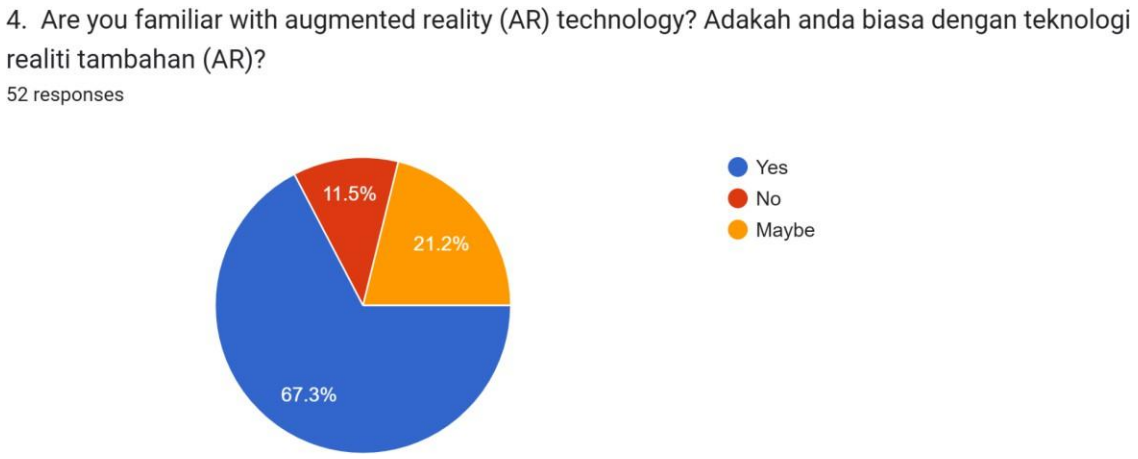


Figure 3.5 *Respondents' Familiarity with AR Technology*

Figure 3.5 illustrates that 67.3% (35 respondents) were familiar with augmented reality (AR) technology. This suggests that AR is gaining recognition and knowledge among participants, which may reflect its growing usage in current technology and applications. Meanwhile, 21.2%

(11 respondents) expressed confusion, claiming that they may be familiar with augmented reality. This category might include those who have met AR in some way but are unaware of its entire meaning or extent. However, 11.5% (6 respondents) acknowledged being completely unfamiliar with AR technology. This focuses on a smaller percentage of the population who might benefit from further exposure or education about AR and its potential. The data collected highlight different levels of knowledge with AR, implying potential to increase awareness and comprehension, particularly among those unfamiliar with the technology (refer to Figure 3.5).

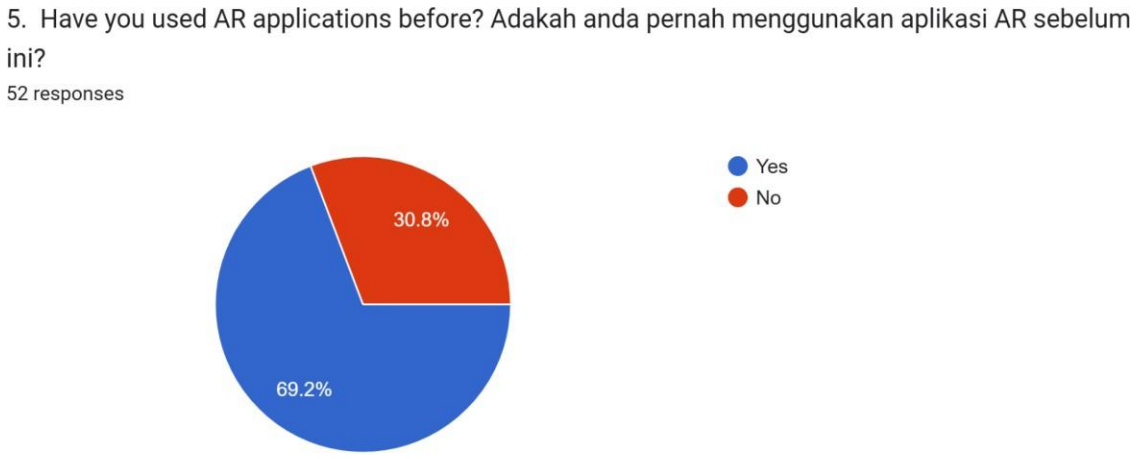


Figure 3.6 *Respondents' Experience with AR Applications*

According to the survey findings that shown in figure 3.6, 69.2% (36 respondents) had used augmented reality (AR) applications before. This shows that the participants have had a high amount of exposure to AR technologies. Meanwhile, 30.8% (16 respondents) stated that they had never used AR applications previously, indicating an opportunity to expose AR experiences to individuals who may be unfamiliar with its practical applications.

Section 2: Awareness and Interest in Environmental Issues

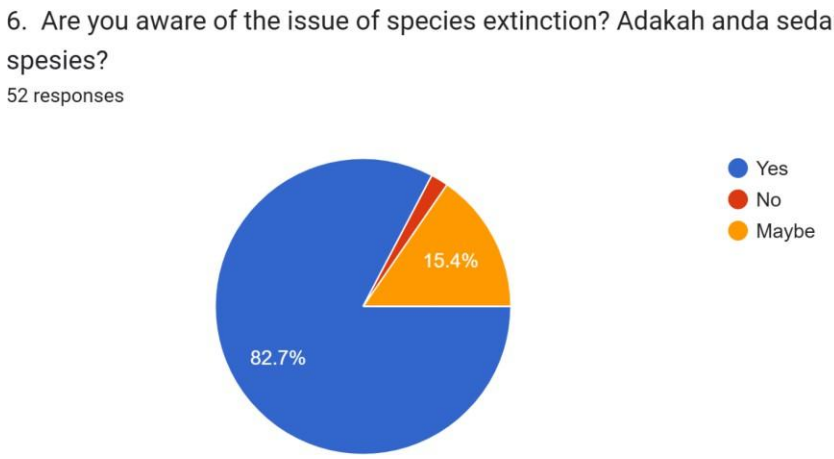


Figure 3.7 *Respondents' Awareness of Species Extinction*

The findings from the survey showed that a large percentage of respondents, 82.7% (43 respondents), were aware of the subject of species extinction. Furthermore, 15.4% (6 respondents) indicated that they could be aware of the problem, implying some ambiguity. Only 1.9% (1 respondent) reported being unaware of this major environmental, highlighting the need for more education and awareness activities (refer to Figure 3.7).

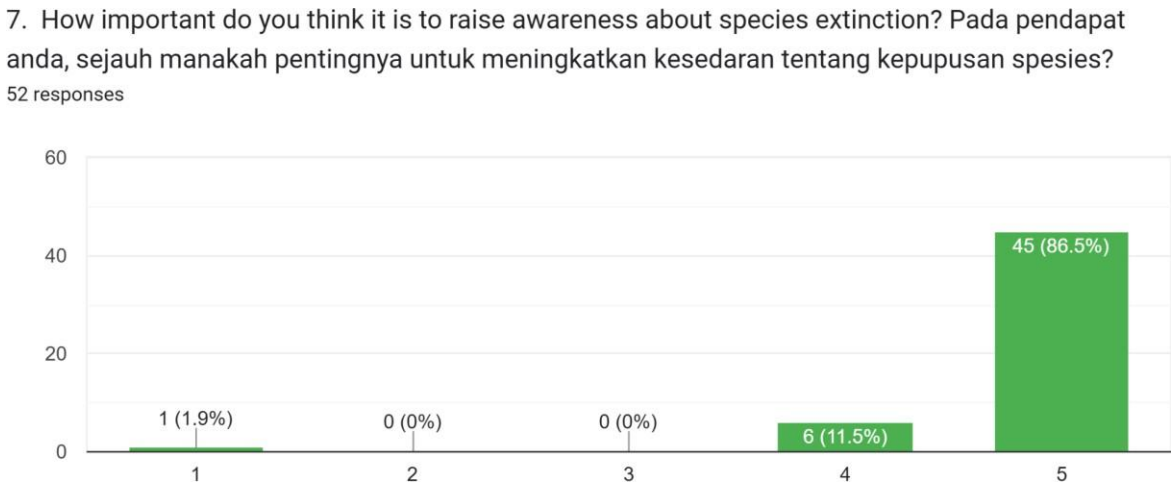


Figure 3.8 *Importance of Raising Awareness About Species Extinction*

Based on Figure 3.8, the survey findings revealed that a significant majority, 86.5% (45 respondents), considered it is important to raise awareness about species extinction. This demonstrates universal acknowledgement of the importance of this environmental issue. In contrast, 11.5% (6 respondents) believe it was crucial, indicating widespread agreement on the cause's significance. Only 1.9% (1 respondent) felt that increasing awareness regarding species extinction was unnecessary, indicating a minor dissident opinion on this topic.

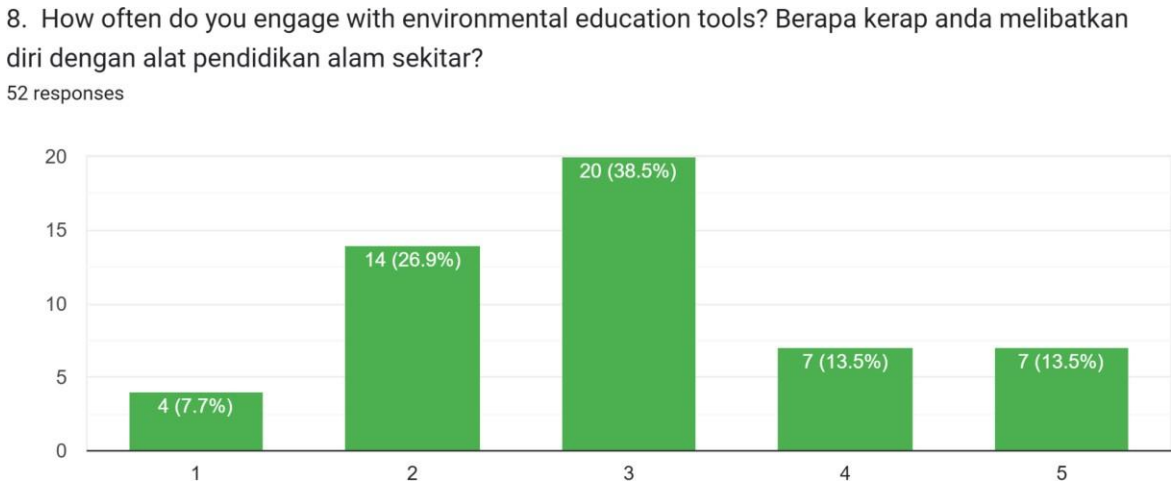


Figure 3.9 *Engagement with Environmental Education Tools*

The survey findings showed a range of involvement with environmental education materials. A significant percentage of respondents, 38.5% (20 respondents), acknowledged using these technologies occasionally, indicating infrequent use. Meanwhile, 26.9% (14 respondents) reported rarely using environmental education materials, and 7.7% (4 respondents) stated they never used them. On the other hand, 13.5% (7 respondents) indicated that they interacted almost frequently, while another 13.5% (7 respondents) reported frequent engagement, indicating that a smaller but significant number is routinely interested in environmental education. These findings implied that, while many participants engaged with environmental

education tools to some extent, there remained room to increase the frequency of involvement throughout all of the participants (refer to Figure 3.9).

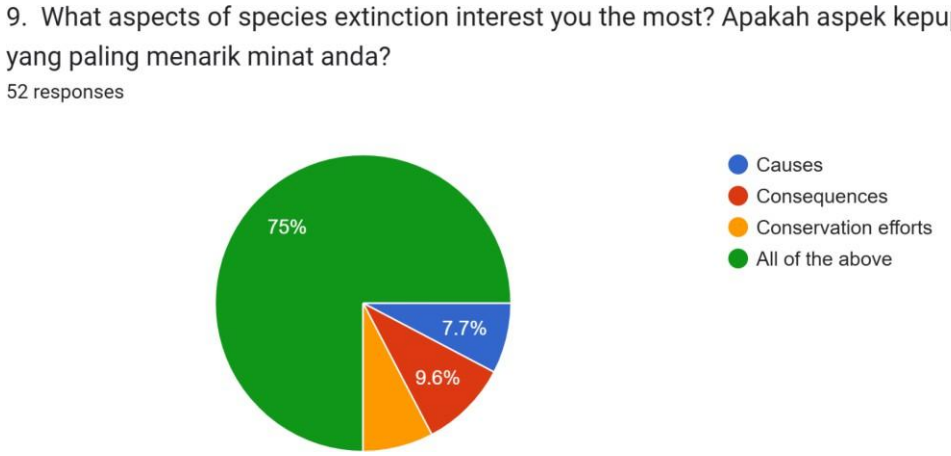


Figure 3.10 *Respondents' Aspects of Species Extinction of Most Interest*

The survey findings show that a vast majority of respondents, 75% (39 respondents), are interested in all elements of species extinction, implying that they understand the issue's interconnection, including causes, effects, and conservation activities. This demonstrates a thorough awareness and care for the more significant implications of species extinction.

In contrast, 9.6% (5 respondents) reported a strong interest in the implications of species extinction, particularly the possible long-term repercussions on ecosystems, biodiversity, and humanity as a whole. Furthermore, 7.7% (4 respondents) concentrated on the causes of extinction, which might include variables such as habitat loss, climate change, and human activity. Another 7.7% (4 respondents) expressed interest in conservation activities, showing worry about steps done to safeguard endangered species and ecosystems.

These findings indicated that, while the majority of respondents consider the extinction problem a multidimensional issue that requires attention in many areas, they have specific worries about its consequences, its causes, and measures to prevent it. This might help to shape

future campaigns and educational activities aimed at increasing awareness of species loss and encouraging focused action (refer to Figure 3.10).

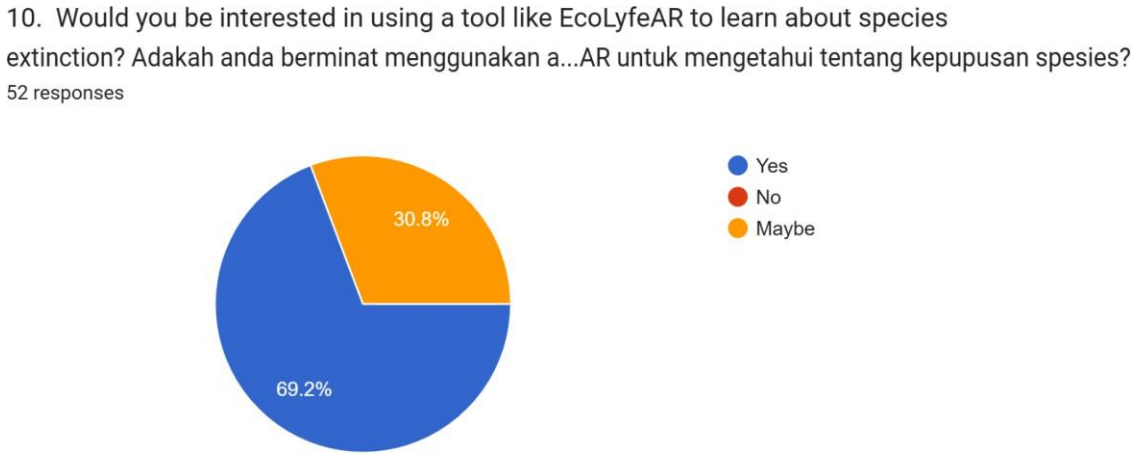


Figure 3.11 *Respondents' Interest in Using EcoLyfeAR for Learning About Species Extinction*

According to the survey findings in Figure 3.11, 69.2% (36 respondents) expressed interest in learning about species extinction utilising a platform such as EcoLyfeAR. This suggested a high desire for interactive and innovative techniques, such as augmented reality (AR), to teach people about environmental challenges. The high level of curiosity indicates that respondents are receptive to engaging and novel approaches, which could enhance their understanding of species extinction by making the learning experience more immersive and effective.

Furthermore, 30.8% (16 respondents) expressed an interest in using such a tool, demonstrating both doubt and responsiveness to the concept. These respondents might have been influenced by further exposure or demonstrations of the tool's potential benefits, showing that there is an audience for educational AR applications if presented effectively.

Section 3: Feedback on EcoLyfeAR Concept

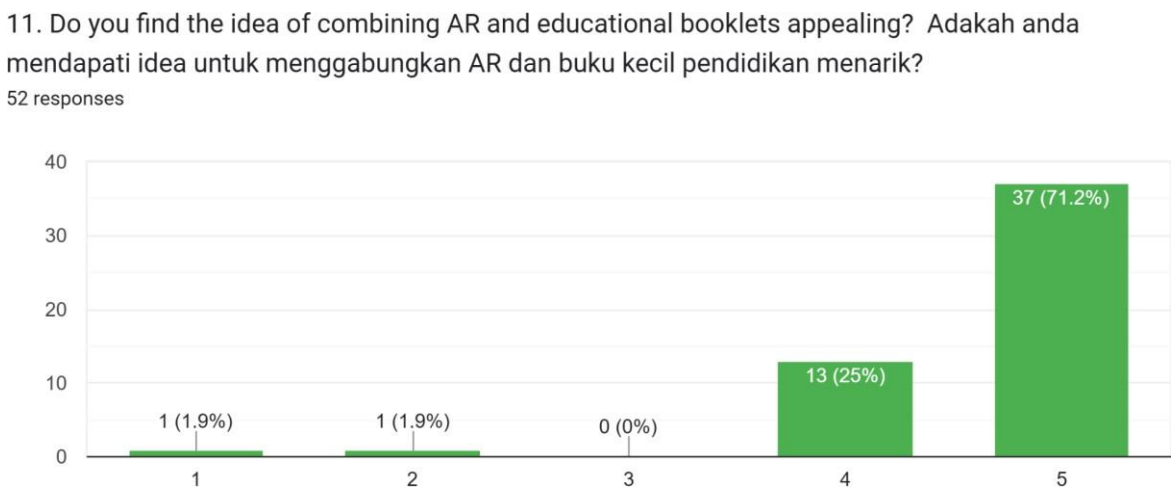


Figure 3.12 *Appeal of Combining AR with Educational Booklets*

Figure 3.12 showed that a large majority of respondents, 71.2% (37 respondents), found the idea of mixing augmented reality (AR) with educational materials booklets very appealing. This indicates a strong interest in augmenting traditional instructional tools with interactive and immersive technology. Moreover, 25% (13 respondents) considered the idea intriguing, indicating a strong response to this idea. On the other hand, only 1.9% (1 respondent) found it unappealing or marginally attractive, demonstrating that the combination of AR and instructional booklets is widely regarded positively, with minimal disagreement. This highlighted AR's potential to transform educational experiences by making them more engaging and interactive.

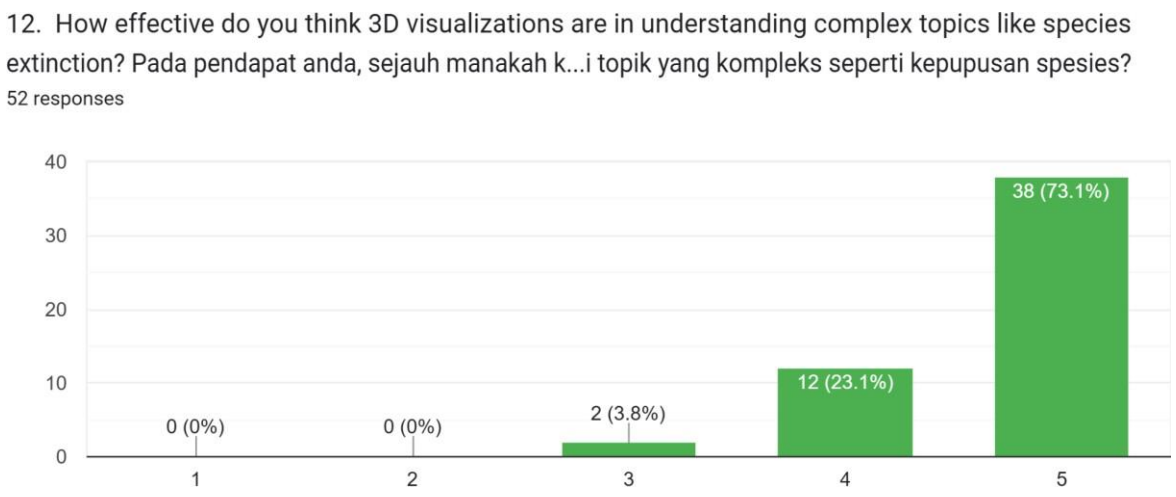


Figure 3.13 *Effectiveness of 3D Visualizations in Understanding Species Extinction*

Other than that, according to the survey findings presented in Figure 3.13, a significant majority of respondents, 73.1% (38 respondents), agreed that 3D visualisations were extremely useful in learning complicated themes such as species extinction. This showed considerable support for the use of 3D technology to help people learn and understand environmental issues. Additionally, 23.1% (12 respondents) found 3D visualisations to be useful, indicating that many people see their worth in expressing difficult information. Only 3.8% (2 respondents) believed that 3D visualisations were ineffective, demonstrating that while there is widespread excitement for their usage, a few may be underestimating their potential.

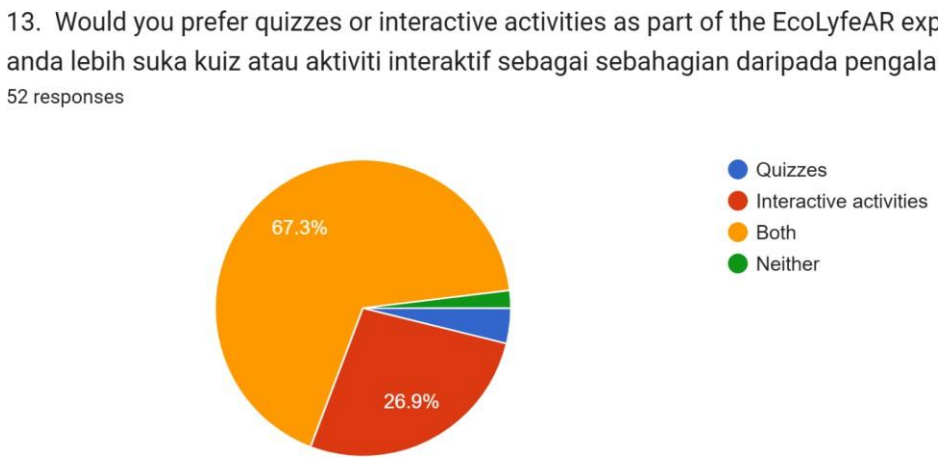


Figure 3.14 *Preference for Quizzes or Interactive Activities in EcoLyfeAR*

Based on the survey outcomes (Figure 3.14), almost all of respondents, 67.3% (35 respondents), would want to have both quizzes and interactive activities included in the EcoLyfeAR experience, indicating a desire for a well-rounded, engaging learning experience. Meanwhile, 26.9% (14 respondents) preferred interactive activities, indicating a need for hands-on, immersive experiences. Only 3.8% (2 respondents) preferred quizzes, demonstrating that, while quizzes may be appealing, they were not as popular as more interactive aspects. These findings indicate that mixing various types of interactive elements may improve user engagement with EcoLyfeAR.

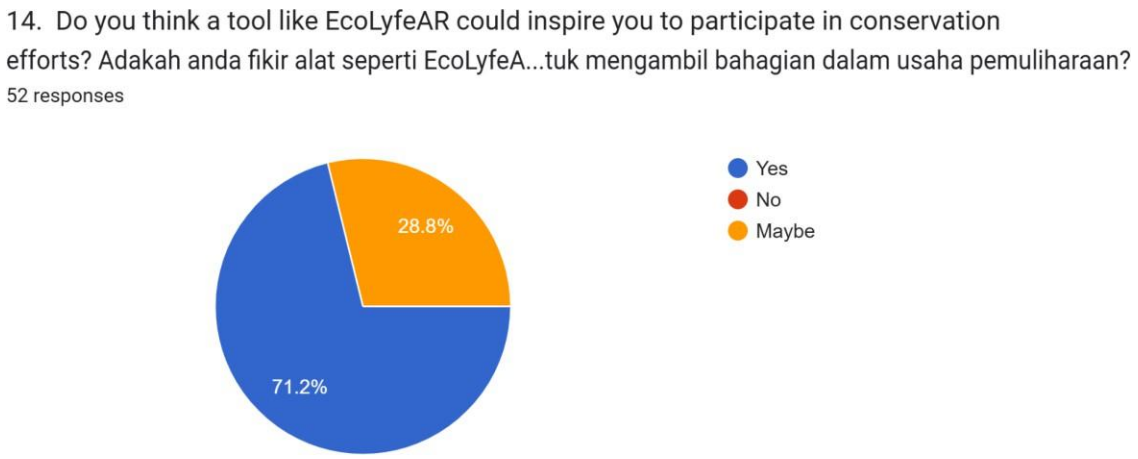


Figure 3.15 *Potential of EcoLyfeAR to Inspire Conservation Efforts*

According to the results of the survey in Figure 3.15, 71.2% (37 respondents) feel that an app like EcoLyfeAR can motivate individuals to join in conservation activities. This demonstrates the potential of augmented reality (AR) as a motivator and instructional device for promoting real-world action. Furthermore, 28.8% (15 respondents) indicated hesitation, implying that while they see some promise, they may need more proof or experience with the tool to be convinced of its effectiveness. Also, none of the respondents (0%) said EcoLyfeAR would fail to inspire them, highlighting the app's recognised effectiveness in promoting environmental participation and understanding.

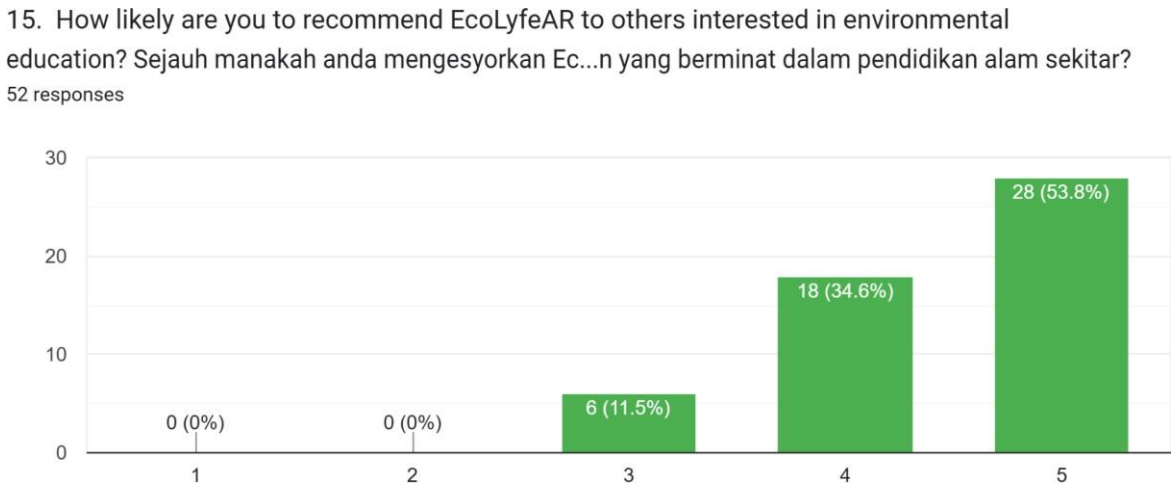


Figure 3.16 *Likelihood of Recommending EcoLyfeAR for Environmental Education*

Next, based on the results shown in Figure 3.16, 53.8% (28 respondents) were very likely to recommend EcoLyfeAR to people interested in environmental education. This reflected a great excitement for the tool and confidence in its ability to provide an effective learning experience. Furthermore, 34.6% (18 respondents) said they were willing to suggest it, indicating its popularity among participants. A smaller fraction, 11.5% (6 respondents), said they are relatively likely to refer to EcoLyfeAR, indicating that there is an opportunity for future improvement to further enhance its perceived value. These findings emphasised the tool's potential as an effective resource for promoting environmental awareness through augmented reality.

Section 4: User Experience and Design Preferences

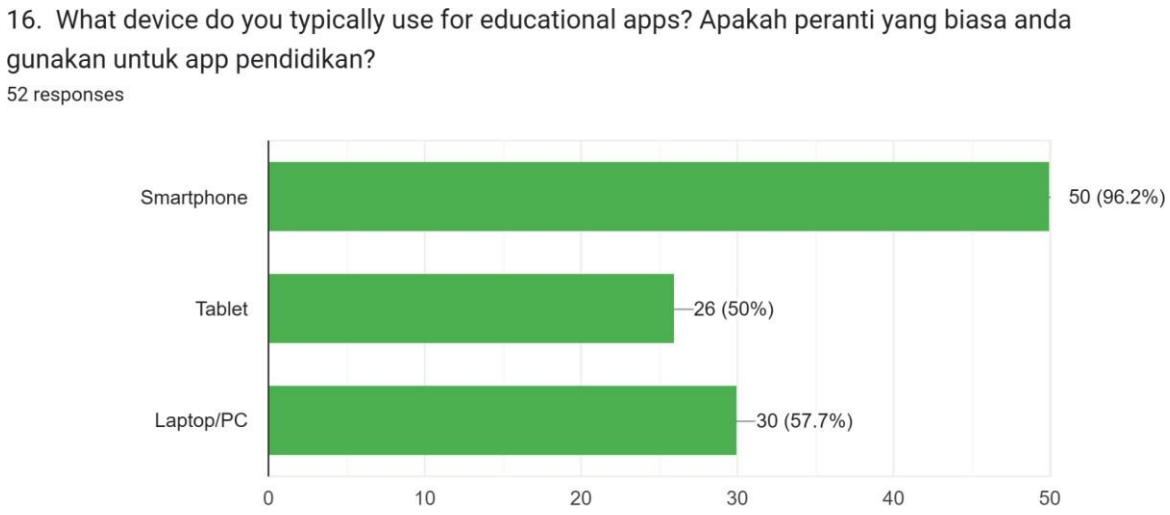


Figure 3.17 *Respondents' Preferred Devices for Using Educational Apps*

The survey results indicated that the majority of respondents (96.2%) used smartphones for educational apps, demonstrating the ease and accessibility of mobile devices for learning. Laptops or PCs were also popular, with 57.7% of respondents using them, demonstrating their preference for more in-depth tasks or multitasking. Tablets were utilised by 50% of respondents, highlighting their popularity as portable, larger-screen alternatives to smartphones. These findings emphasised the need of ensuring that educational applications, such as EcoLyfeAR, were compatible and optimised across multiple platforms, notably smartphones, which were the most commonly used (refer to Figure 3.17).

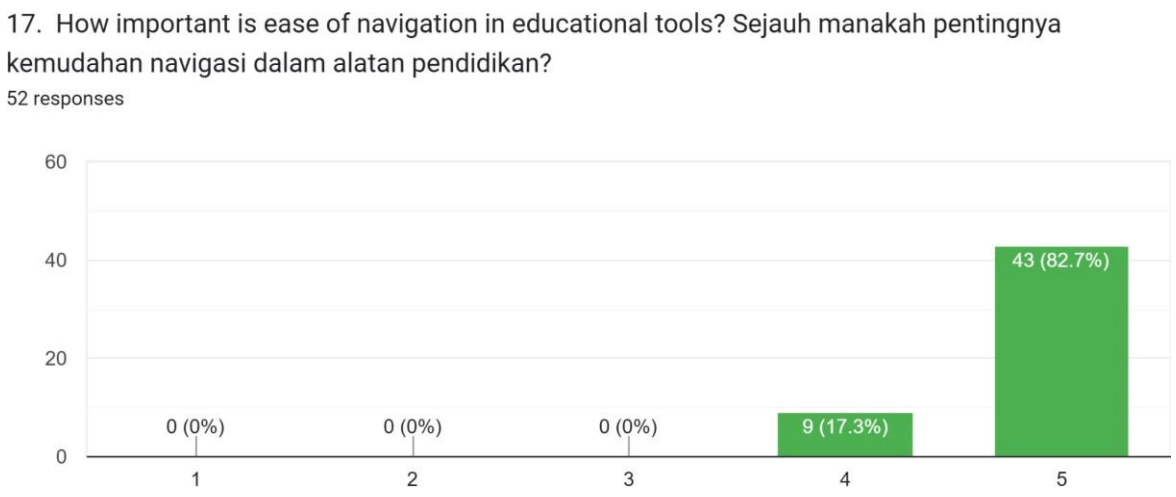


Figure 3.18 *Importance of Ease of Navigation in Educational Tools*

Figure 3.18 presented the survey findings which highlighted the significance of ease of navigation in instructional tools, with 82.7% (43 respondents) considering it extremely significant. This suggested that users placed a high importance on straightforward design, that allowed them to easily access features and content. A smooth navigation experience reduced frustration, improved usability, and stimulated engagement, making it an essential component in the success of educational tools like EcoLyfeAR.

Moreover, 17.3% (9 respondents) rated ease of navigation as crucial, further highlighting that user expected a well-structured, user-friendly interface. The lack of any respondents who deemed it trivial emphasised its universal importance.

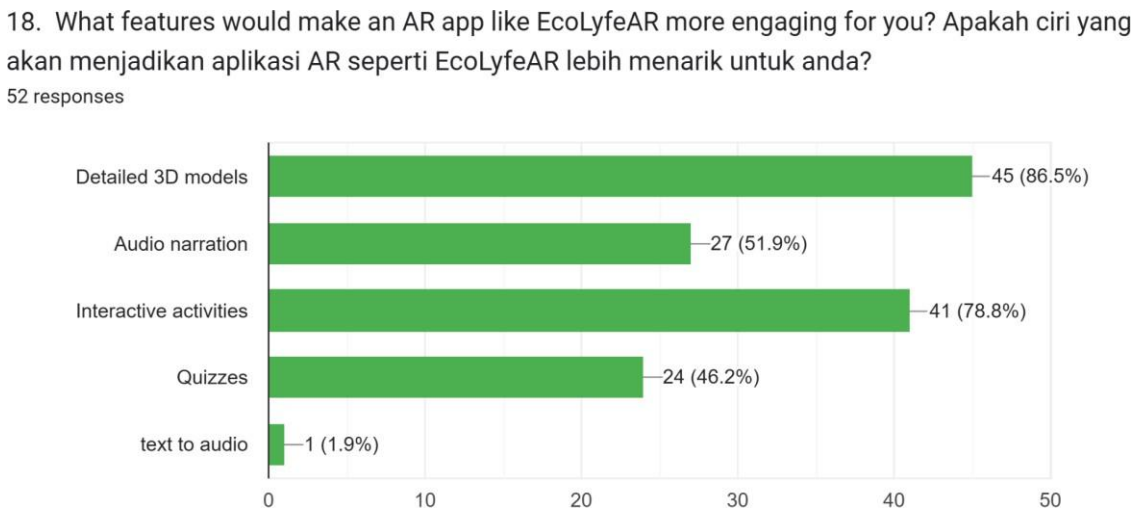


Figure 3.19 *Respondents' Desired Features for Enhancing Engagement in EcoLyfeAR*

Referring to Figure 3.19, the survey results illustrated which features respondents believed would make augmented reality (AR) applications like EcoLyfeAR more engaging. Detailed 3D models were ranked as the most preferred element, with 86.5% of respondents citing their significance. This emphasised the value of visually rich and realistic representations in increasing knowledge and interest.

Interactive activities followed closely, with 78.8% of respondents choosing them as a desired feature, demonstrating the demand for hands-on, immersive experiences that actively involved users in the learning process. Audio narration was chosen by 51.9% of respondents, emphasising its importance in providing guidance and improving the app's narrative capabilities. Furthermore, 46.2% of respondents expressed interest in quizzes, suggesting that include evaluations might increase engagement by allowing users to test their knowledge in an enjoyable manner. These findings indicate that integrating visually realistic 3D models, interactive components, audio support, and gamified features such as quizzes may considerably improve the user experience of EcoLyfeAR. By incorporating these features, the app may cater

to a wide range of user preferences, making it a more interesting and effective instructional tool.

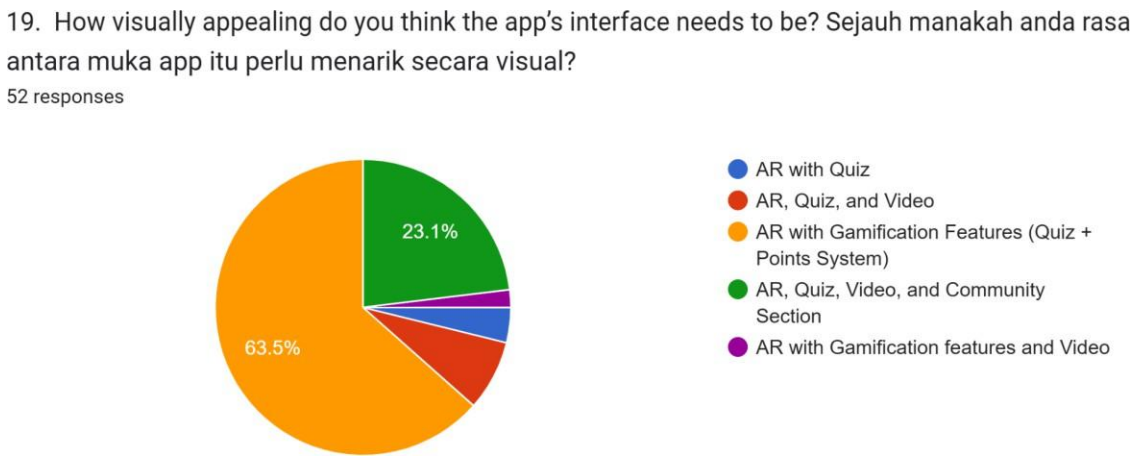


Figure 3.20 *Respondents' preferences for visually appealing features in the App's Interface*

The study's observations revealed respondents' preferences for visually appealing aspects in the app's UI, with 63.5% (33 respondents) preferring an interface that combined augmented reality (AR) with gamification elements such as quizzes and a points system, highlighting a strong interest in features that make learning enjoyable and rewarding

Additionally, 23.1% (12 respondents) favoured a more comprehensive approach that included incorporating augmented reality, quizzes, movies, and a community section, indicating a desire for social interaction and multimedia components that encourage connectedness and different learning approaches. A smaller group of 7.7% (4 respondents) opted for a simplified version with AR, quizzes, and videos, showing interest in multimedia elements without a social component. Other preferences were AR with quizzes (3.8%, 2 respondents) and AR with gamification features and videos (1.9%, 1 respondent), reflecting niche interests in more simple or alternative combinations.

These findings indicate that most respondents choose a visually appealing interface with gamified components and a variety of multimedia capabilities, focusing on interactivity, engagement, and community-building potential (refer to Figure 3.20).

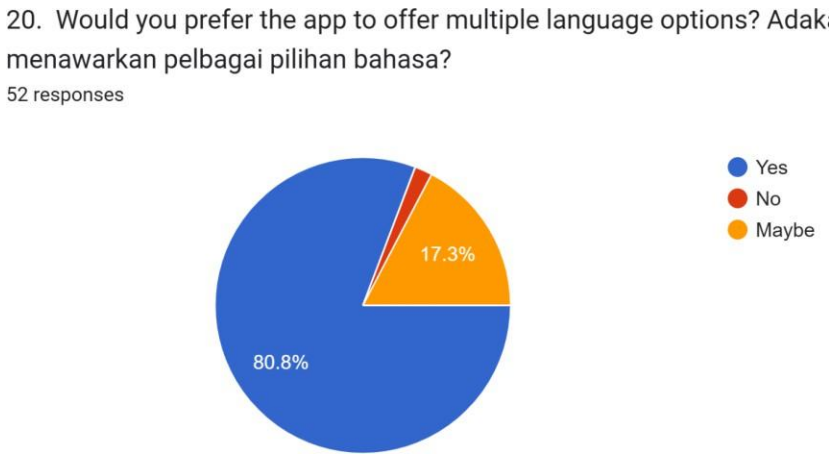


Figure 3.21 Respondents' preference for Multiple Language Options in the App

Figure 3.21 illustrated that 80.8% (42 respondents) wanted multiple language options in the app emphasising the need of linguistic inclusion for broader accessibility and appeal. Furthermore, 17.3% (9 respondents) expressed interest in having several language alternatives, indicating an openness to the idea, especially if it meets their personal or cultural demands. Only 1.9% (1 respondent) opposed the introduction of this feature, suggesting that most respondents perceive the benefit of providing information in multiple languages.

These findings demonstrated the importance of including multilingual support in EcoLyfeAR to reach a wider audience, reduce language barriers, and increase its effectiveness as an instructional tool.

Section 5: Overall Feedback and Suggestions

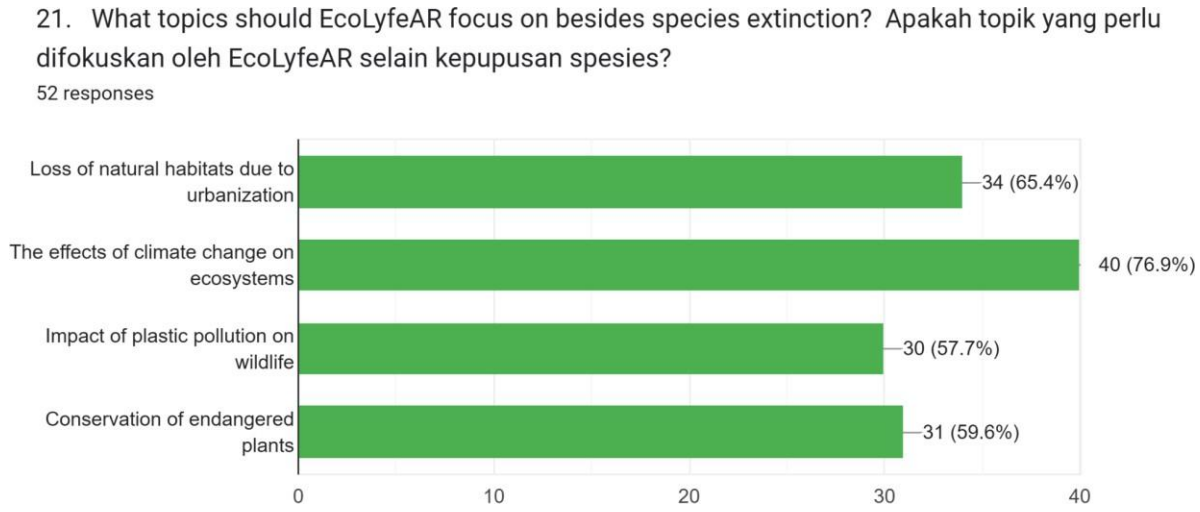


Figure 3.22 *Respondents' suggested Topics for EcoLyfeAR Beyond Species Extinction*

In addition to species extinction, the survey results suggested that EcoLyfeAR should focus on a number of other issues. The most popular recommendation, chosen by 76.9% of respondents, was to address the consequences of climate change on ecosystems. This demonstrates a great interest in studying how climate change impacts natural habitats and-wildlife.

65.4% of respondents highlighted habitat loss due to urbanisation, emphasising the importance of investigating how human development affects biodiversity. Furthermore, 59.6% of respondents recommended focusing on the protection of endangered plants, demonstrating a strong interest in conserving flora often overlooked in conservation efforts. The impact of plastic pollution on wildlife was chosen by 57.7% of respondents, reflecting concern about the rising threat of pollution to animals and their habitats.

These findings suggested that EcoLyfeAR could enhance its focus by including these crucial environmental issues, resulting in a more general teaching experience. Covering topics such as climate change, urbanisation, pollution, and plant conservation would increase the app's relevance and appeal to environmentally conscious users.

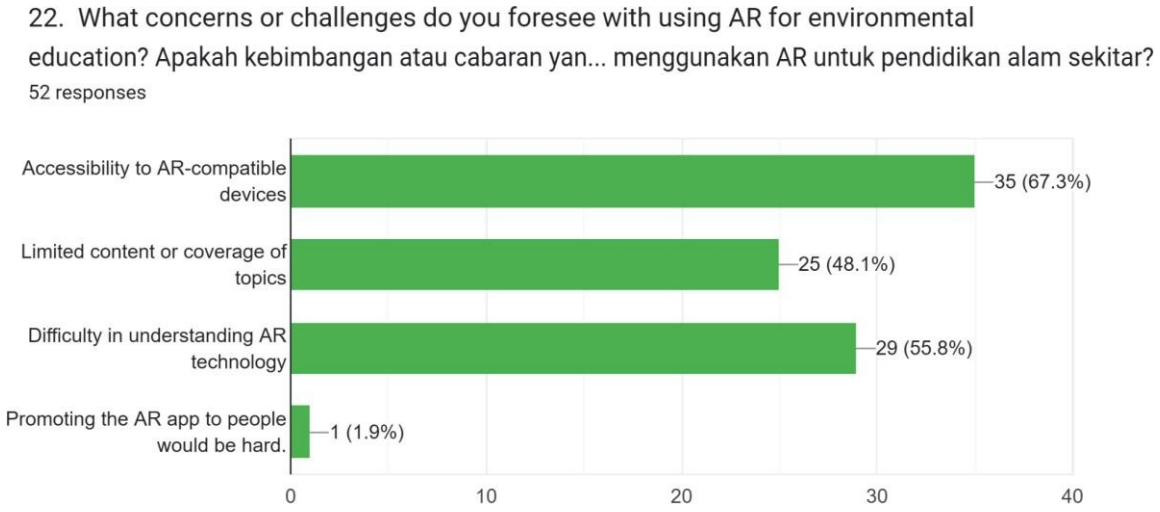


Figure 3.23 *Respondents' Concerns and Challenges in Using AR for Environmental Education*

The survey results (Figure 3.23) revealed many important problems and obstacles that respondents anticipated when utilising augmented reality (AR) for environmental education. The most common issue, chosen by 67.3% of respondents, was limited access to AR-compatible devices, emphasising the possible limitations provided by technological requirements and cost. Moreover, 55.8% of respondents reported difficulty understanding AR technology, showing that user familiarity and simplicity of usage were critical factors for successful adoption. 48.1% of respondents expressed concern about the app's limited content or coverage of topics, highlighting the significance of providing broad and thorough instructional resources. A small percentage of respondents, 1.9%, stated that promoting the app to others would be difficult, suggesting the necessity for effective marketing strategies to boost

knowledge and interest in the application. These findings highlighted the need of ensuring accessibility, user-friendly design, and diverse content in order to overcome barriers and enhance the effectiveness and acceptance of AR-based environmental education tools like EcoLyfeAR.

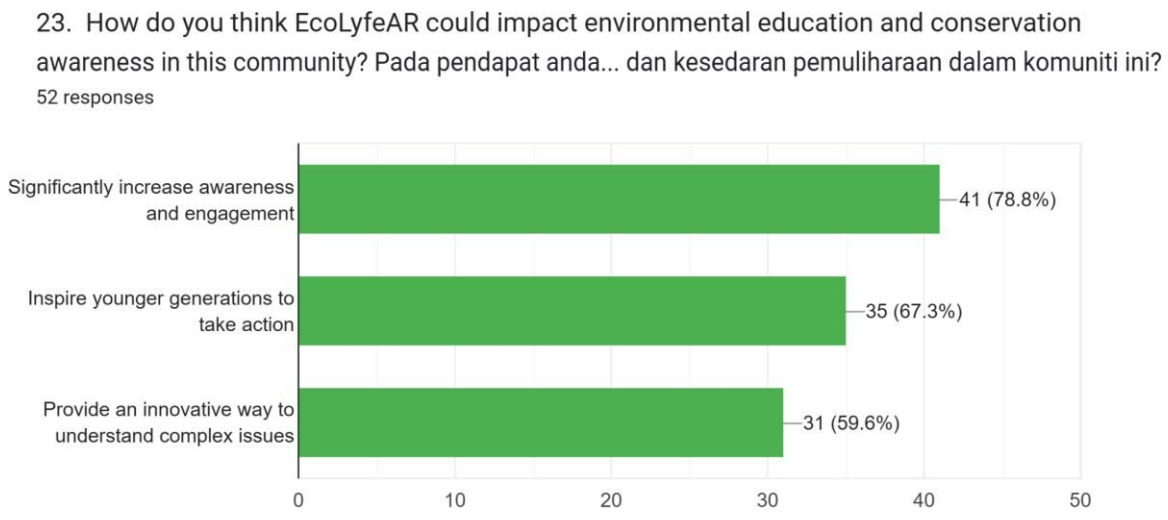


Figure 3.24 Potential Impact of EcoLyfeAR on Environmental Education and Awareness

The survey findings clarified the possible ways EcoLyfeAR could support the community with environmental education and conservation awareness. A large majority of respondents, 78.8%, believed the tool has the ability to improve awareness and participation considerably, emphasising its value as an educational resource. Additionally, 67.3% of respondents felt EcoLyfeAR could inspire future generations to take action, demonstrating its ability to stimulate meaningful participation in conservation efforts and appeal to younger audiences. Furthermore, 59.6% of respondents viewed EcoLyfeAR as a novel approach to understanding complex issues such as species extinction and habitat degradation. This demonstrates the app's ability to simplify and make complex environmental subjects understandable through immersive and interactive experiences (Figure 3.24).

These findings implied that EcoLyfeAR has the potential to be a game-changing tool in environmental education, increasing community awareness, involvement, and proactive activities.

Based on the last question, the respondents made good suggestions to improve the EcoLyfeAR app, with an emphasis on developing a user-friendly and engaging experience. Recommendations included making the app more enjoyable and appealing by incorporating elements like fun facts, music, sound effects, and visually appealing designs, as well as guaranteeing a simple and easy-to-navigate interface, particularly for senior users. Many emphasised the educational value of the content by incorporating suggestions, extensive information about endangered species, and captivating tales that contextualised species extinction. Realistic visualisations were proposed to create immersive and engaging experiences that improve user understanding. Respondents suggested cooperating with environmental non-governmental organisations (NGOs), incorporating a conservation contribution function, and exposing more people to the app to boost outreach and community participation. Furthermore, creative solutions such as including a chatbot driven by generative AI were proposed to boost engagement and support. These insights indicated EcoLyfeAR's potential to become an impactful and widely accepted educational tool (refer to Table 3.1).

Table 3.1 *Respondents' suggestions and feedback EcoLyfeAR*

Suggestions and feedback
Make it fun
Can include fun facts.
make it more easier for elderly people to use the apps
Aesthetically pleasing with nice UI
Add music and sound effects.
Need an easy interface

Make it attractive
Make the game or quiz more interesting
Exposed more about EcolyfeAR to people surround me
easy navigation for the app
Minimalistic but engaging interface
as long as, it is simple UI with minimal design elements making it understandable and user-friendly
Include donations for the community to save the species from extinction.
I'd like to see some interesting tips/facts in the app.
Maybe a realistic visualisation that can make user feel an enjoyable and interesting experience, in which I believe can make the user more understanding the context
Try to team up with Environmental NGOs to promote it.
If possible, make this app more interesting by putting some important information about the endangered species and the storyline of this happening so that generations can see and understand this. The rest, this Idea is very interesting and good for the young generation nowadays.
Maybe a chatbot using generative AI could help with future inquiries from the users

Functional Requirement

1. Allow users to scan pages from the educational booklet to access augmented reality (AR) information, such as 3D models and animations of endangered species and their ecosystems.
2. Allow users to view high-quality, interactive 3D models of animals, with information about their appearance, habitat, and threats.
3. Provide written materials, images, and videos about species extinction, its causes, and conservation efforts.
4. Include quizzes and activities to let users evaluate their understanding of environmental issues and reinforce learning.
5. Provide audio with relevant sound effects, such as animal sounds or environmental sounds, to enhance immersion.

6. Allow users to access previously downloaded educational content without requiring an internet connection.
7. Track and display users' progress in completing activities, quiz scores, or exploring AR content.

Non - Functional Requirement

1. Ensure smooth AR rendering and fast loading of 3D models for seamless user experiences across devices.
2. Support a wide range of devices running iOS and Android, with a focus on AR-compatible smartphones and tablets.
3. Provide an intuitive user interface (UI) with easy navigation and clear instructions for interacting with AR content.
4. Ensure minimal downtime with robust error handling to prevent crashes during use.
5. Deliver visually appealing graphics and UI elements that engage users while maintaining professional standards.

B) Hardware Specification

The hardware specifications of the devices used for the development and testing are as depicted in Table 3.2 below.

Table 3.2 *The hardware specifications used in developing EcoLyfeAR*

Hardware	Description	Specification
Laptop	Used throughout the development of the project	HP Pavilion Laptop 14
Processor	Used to respond and process basic instructions for programs execution	11th Gen Intel(R) Core (TM) i5-1135G7 @ 2.40GHz, 2419 Mhz, 4

		Core(s), 8 Logical Processor(s)
Random Access Memory (RAM)	Temporary storage of hardware which facilities the software usage to increase the general speed of the hardware.	16.0GB
Graphic Processing Unit (GPU)	Used to manipulate the use of memory to accelerate the speed of image processing	NVIDIA GeForce MX450
Testing Equipment	Tablet device used for testing the mobile application development	Samsung Tab A8 (Android)

C) Software Specification

As shown in Table 3.3, the software specifications used for developing EcoLyfeAR are assessed as below.

Table 3.3 *The software specifications used in developing EcoLyfeAR.*

Software	Description	Specification
Operating System	To support the software used to implement the proposed mobile application	Microsoft Windows 11
Application Development Tool	Used in building the mobile application	Unity *(Unity Technologies., n.d.).*
Augmented Reality (AR) Development	An extension used for developing the Augmented Reality (AR) feature in Unity	Vuforia *(PTC Inc., n.d.).*
Graphical Design Tools	Used to design the booklet and assets to be used in Unity	Canva *(Canva., n.d.)* and

1.2.2 Design

The design phase includes determining the major components of the EcoLyfeAR-enhanced environmental awareness booklet and deciding how to effectively deliver the concept to users. This phase will include the preparation of project requirements, diagrams, user interface, and a navigation framework to provide a consistent user experience.

The project requirements for EcoLyfeAR will include hardware and software requirements, such as AR app-compatible devices such as smartphones or tablets, as well as software tools such as Unity for AR creation and Sketchfab for 3D modelling *(Sketchfab., n.d.)*. The designs and storyboarding will depict the flow of AR interactions, such as scanning booklets pages to activate particular environmental awareness material, such as endangered species animations or interactive visualisations of environmental changes. The navigation framework will guarantee that users can engage smoothly between the booklets, flashcard and the EcoLyfeAR app, with easy instructions on how to scan pages and enjoy AR experiences. By tackling these issues at the design process, the project will be better positioned to provide an engaging and instructive experience that effectively increases awareness regarding the environment.

1.2.2.1 Unified Modelling Language (UML) Diagram

A key phase before moving further with application development is creating Unified Modelling Language (UML) diagrams, which provide the developer with an overall first design by outlining the interactions of the application system. An activity diagram, use case diagram, sequence diagram, and class diagram are among the UML diagrams.

1.2.2.1.1 Use Case Diagram

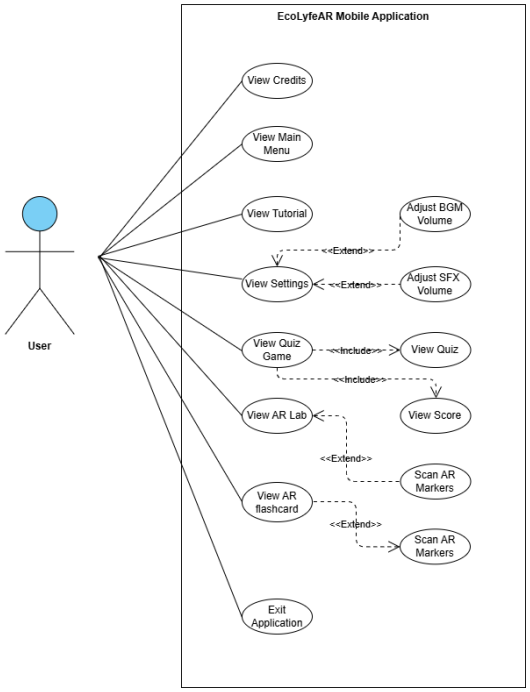


Figure 3.25 *Use case diagram for EcoLyfeAR*

A use case diagram in Figure 3.26, uses actors and use cases as symbols to show the functional needs of an application. The EcoLyfeAR application's use case diagram is shown in Figure 3.26. It displays many exchanges between the application (EcoLyfeAR Mobile Application) and the actor (user). Viewing the Credits, Main Menu, Tutorial, Settings, Quiz Game, AR lab, AR flashcard and closing the application are all included in this use case. Changing the sound effect loudness and background music is another feature of viewing settings. Quiz viewing is part of viewing Quiz game. In the meanwhile, scanning the AR marker is another feature of AR Lab and AR flashcard.

3.2.2.1.1 Use Case Descriptions

This section shows the use case description of each use case illustrated in the use case diagram.

Table 3.4 *Use case description for Credits*

Use Case Name	View Credits

Short Description	Allows the user to view credits, including contributors and acknowledgments for the application.
Actor	User
Pre-Condition(s)	The application must be launched, and the main menu should be accessible.
Post-Condition(s)	The credits shown and user exit the page
Main Flow	1. User selects the "Credits" option from the main menu. 2. The application displays the credits page.
Alternative Flow	None
Exception Flow	If the credits page fails to load, an error message is displayed.

Table 3.5 *Use case description for Main Menu*

Use Case Name	View Main Menu
Short Description	Displays the application's main menu, providing navigation options to other functionalities.
Actor	User
Pre-Condition(s)	The application must be launched successfully.
Post-Condition(s)	The main menu is displayed with all available options.
Main Flow	1. The application starts and automatically loads the main menu.
Alternative Flow	None
Exception Flow	If the main menu fails to load, an error message or fallback page is shown.

Table 3.6 *Use case description for Tutorial*

Use Case Name	View Tutorial
Short Description	Provides an instructional guide or tutorial for using the

	EcoLyfeAR app.
Actor	User
Pre-Condition(s)	The main menu must be accessible, and the tutorial module should be available.
Post-Condition(s)	The tutorial content is displayed.
Main Flow	1. User selects the "Tutorial" option from the main menu. 2. The application displays the tutorial content.
Alternative Flow	None.
Exception Flow	If the tutorial fails to load, an error message is displayed.

Table 3.7 *Use case description for Settings*

Use Case Name	View Settings
Short Description	Allows the user to adjust application settings, including background music (BGM) and sound effects (SFX).
Actor	User
Pre-Condition(s)	The application must be launched, and the main menu should be accessible.
Post-Condition(s)	The settings page is displayed.
Main Flow	1. User selects the "Settings" option from the main menu. 2. The application displays adjustable settings for BGM and SFX volumes.
Alternative Flow	None.
Exception Flow	If the settings page fails to load, an error message is displayed.

Table 3.8 *Use case description for Quiz Game*

Use Case Name	View Quiz Game

Short Description	Provides interactive quizzes for users to test their environmental knowledge.
Actor	User
Pre-Condition(s)	The quiz game module must be loaded, and questions should be preconfigured.
Post-Condition(s)	The quiz interface is displayed.
Main Flow	1. User selects the "Quiz Game" option from the main menu. 2. The application displays the quiz interface.
Alternative Flow	None.
Exception Flow	If the quiz module fails to load, an error message is displayed.

Table 3.9 *Use case description for AR Lab*

Use Case Name	View AR Lab
Short Description	Allows users to interact with AR markers and explore environmental topics via AR.
Actor	User
Pre-Condition(s)	AR markers and content must be preloaded.
Post-Condition(s)	AR visualizations are displayed.
Main Flow	1. User selects the "AR Lab" option from the main menu. 2. The application launches the AR interface and accesses the camera.
Alternative Flow	None.
Exception Flow	If AR markers fail to load or the camera fails to initialize, an error message is displayed.

Table 3.10 *Use case description for AR flashcard*

Use Case Name	View AR Flashcard
Short Description	Allows users to interact with AR markers and explore environmental topics via AR using flashcard.
Actor	User
Pre-Condition(s)	AR markers and content must be preloaded.
Post-Condition(s)	AR visualisations are displayed.

Main Flow	3. User selects the "AR flashcard" option from the main menu. 4. The application launches the AR interface and accesses the camera.
Alternative Flow	None.
Exception Flow	If AR markers fail to load or the camera fails to initialize, an error message is displayed.

Table 3.11 *Use case description for Exit*

Use Case Name	Exit Application
Short Description	Allows the user to close the application.
Actor	User
Pre-Condition(s)	The application must be running.
Post-Condition(s)	The application is closed.
Main Flow	5. User selects the "Exit" option from the main menu. 6. The application confirms the exit and closes.
Alternative Flow	None.
Exception Flow	If the application fails to close, a fallback prompt is displayed.

3.2.2.1.2 Activity Diagram

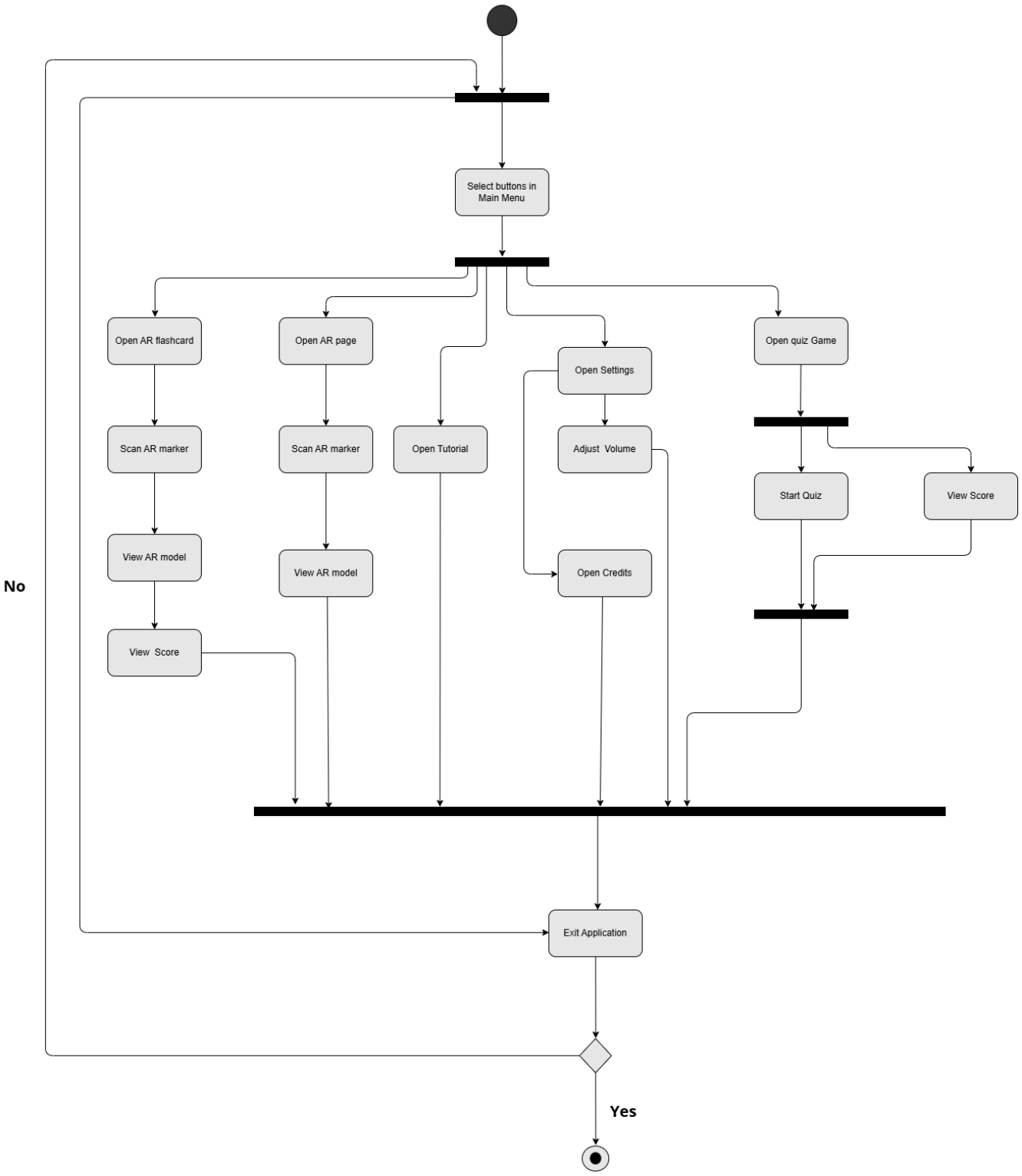


Figure 3.26 *Activity Diagram of EcoLyfeAR App*

As illustrated in Figure 3.25, the activity diagram visualises the step and flow of the proposed app named EcoLyfeAR. The user begins by entering the Title screen. At the title screen, the user can select “Start” to enter the main menu screen, and the user can select “Credits” to show the credits of the game and click back to go back to the main menu page. When the user selects the “Start” option, it will go to another page where the user can choose options like “Open AR,” “Tutorial,” “Settings,” “AR flashcard” and “Quiz Game” screens. If the user selects “Open AR,” users can scan the booklet, and the AR model will appear. For the “Tutorial” screen, it will show the users instructions on how to use the app, and for “Settings,” users can adjust the music volume and sound effects of the application. Then, for the “AR flashcard” user users can scan the flashcards for the mini games about the animal extinction and environmental awareness, view user scores, and the AR model will appear. Lastly, on the “Quiz game” screen, users can play and answer the quiz after their read-through and scan the booklet.

3.2.2.1.3 Sequence Diagram

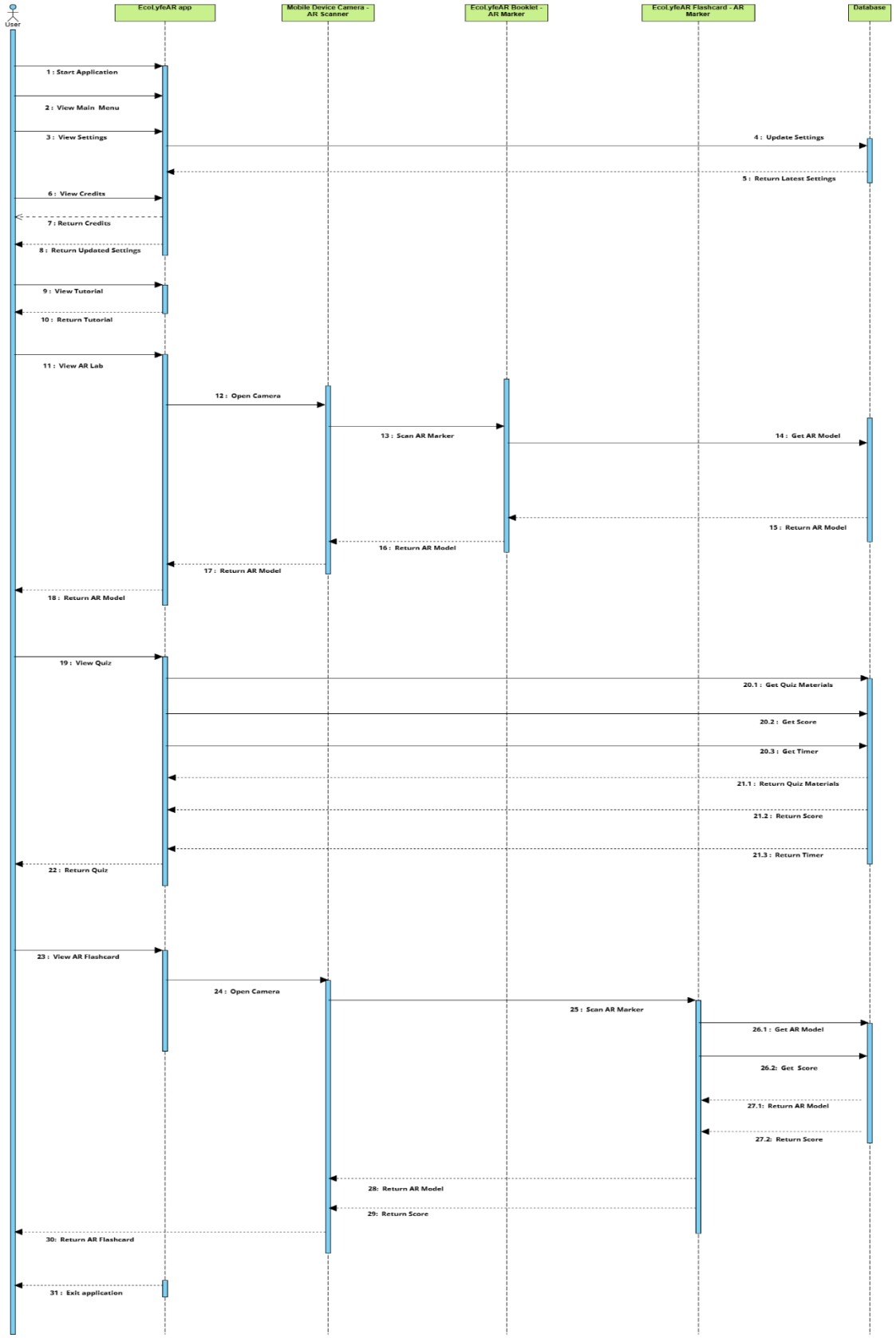


Figure 3.27 *Sequence diagram for EcoLyfeAR App*

Figure 3.27 illustrates the EcoLyfeAR application's sequence diagram. These diagrams are useful for including subsystems into the prototype and illustrating how items interact to accomplish a particular task.

EcoLyfeAR Sequence description:

1. **Start Application**

   The user launches the EcoLyfeAR application on their mobile device.

2. **View Main Menu**

   After the app loads, the main menu interface is displayed.

3. **View Settings**

   The user navigates to the settings section to adjust application preferences.

4. **Update Settings (Database interaction happens here)**

   The app processes the user's setting changes and updates the database in the background.

5. **Return Latest Settings**

   The app retrieves the updated settings and displays them to the user.

6. **View Credits**

   The user accesses the credits section to view contributor information.

7. **Return Credits**

   The app shows the credits content.

8. **Return Updated Settings**

   Any recently changed settings are confirmed and shown again if necessary.

9. **View Tutorial**

   The user chooses to view a tutorial on how to use the app.

10. **Return Tutorial**

    The app plays or displays the tutorial content.

11. **View AR Lab**

    The user enters the AR Lab feature to begin interacting with AR models.

12. **Open Camera**

The app activates the device's camera to scan AR markers.

13. **– 18. Scan AR Marker → Return AR Model**

    The app processes the scan and displays the relevant AR model to the user (interaction with external systems like AR markers and database occurs in the background).

19. **View Quiz**

    The user opts to take a quiz related to the AR content.

20. **– 22. Quiz Material, Score, Timer Retrieval → Return Quiz**

    The app fetches quiz content, score, and timer details as well as the leaderboard and displays them to the user.

23. **View AR Flashcard**

    The user selects the flashcard AR feature.

24. **Open Camera**

    The app activates the camera again for scanning.

25. **– 30. Scan Marker → Return AR Model & Score → Return AR Flashcard**

    After scanning, the app shows the AR flashcard and returns the relevant score based on interaction.

31. **Exit Application**

The user exits the EcoLyfeAR app.

3.2.2.1.4 Class diagram

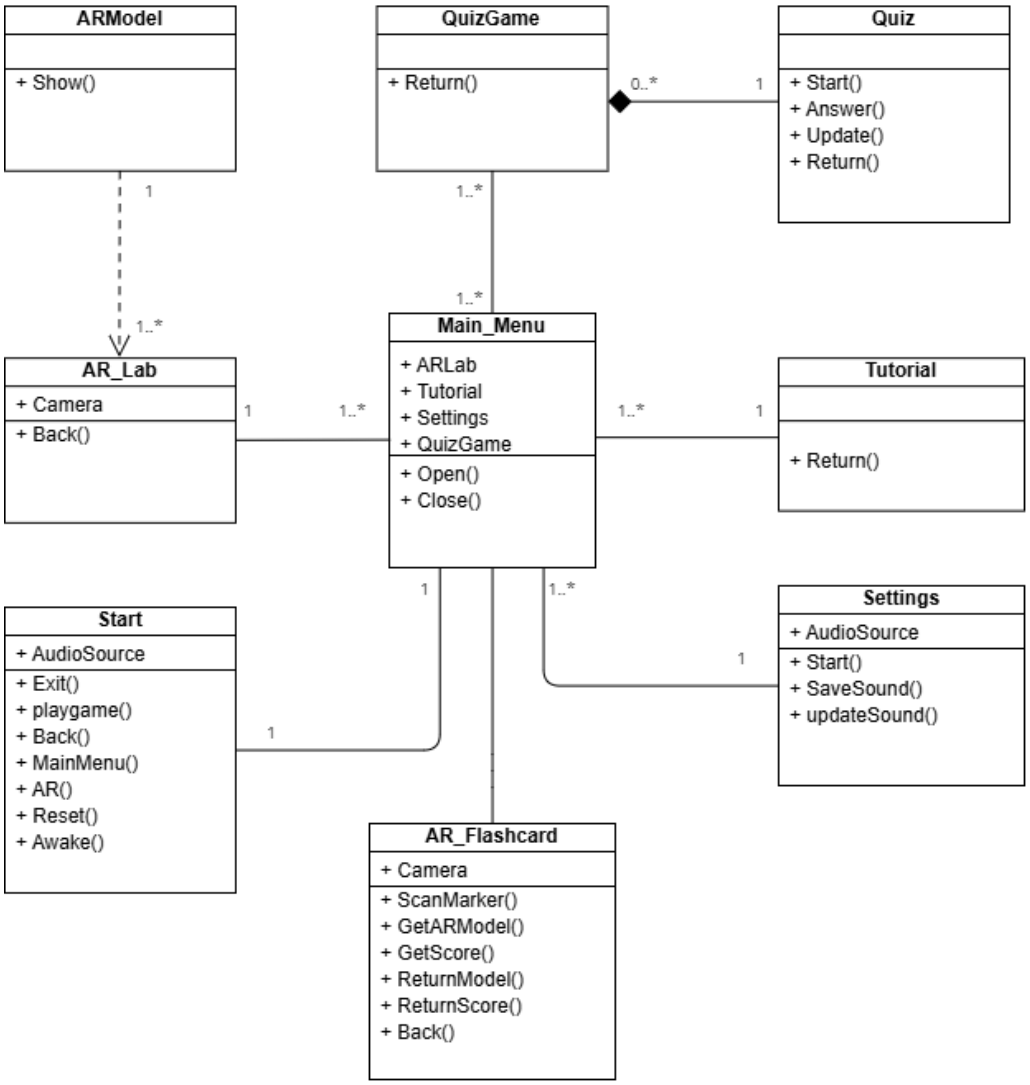


Figure 3.28 *Class diagram for EcoLyfeAR App*

The EcoLyfeAR application's class diagram depicts a modular augmented reality-based teaching system. The Start class launches the app and navigates to the Main_Menu, which contains basic modules such as AR_Lab, QuizGame, Tutorial, Settings, and the recently introduced AR_Flashcard. AR_Lab and AR_Flashcard use the ARModel class to render 3D material when AR markers are scanned. The QuizGame maintains numerous Quiz instances and handles quiz logic such as start, answer, update, and return results. The Settings and Tutorial classes let users to change their settings and learn how to use the program, respectively. Each class contains unique behaviours while preserving a logical navigation flow and

responsibilities, ensuring that the app is engaging, instructive, and extendable. Figure 3.28 depicts the class diagram for the proposed mobile application.

1.2.2.2 Interface Design

Effective communication between players and mobile apps requires a well-designed graphical user interface (GUI or UI). It offers the impression of influencing users' willingness to utilise the mobile application. Canva *(Canva., n.d.)* is used for designing interfaces, whereas Sketchfab *(Sketchfab., n.d.)* are used for project assets. All items, including pictures, videos, and music, will be properly credited to the appropriate owner.

1.2.2.2.1 Start Screen

Figure 3.29 *Start Screen for EcoLyfeAR App*

When a user launches the EcoLyfeAR app on their smartphone or tablets, they will see the start screen as illustrated in Figure 3.29. The application's name is displayed on the start screen, along with buttons for START, CREDIT, SETTINGS and QUIT. Tap the START button to access the application's main menu. To view the credit screen, tap CREDIT, To adjust volumes of the application tap SETTINGS, then to leave the app, tap QUIT.

1.2.2.2.2 Credit

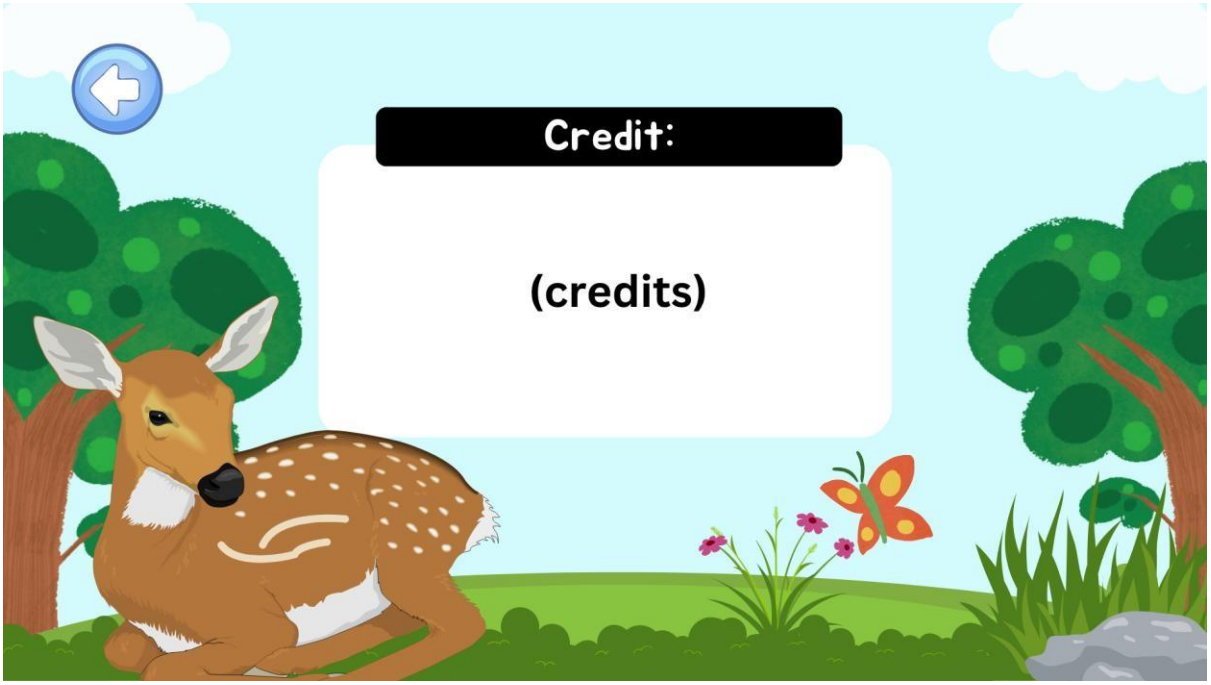


Figure 3.30 *Credit interface for EcoLyfeAR App*

When users access the credit screen (Figure 3.30), they will see a list of credits or acknowledgements. To exit this screen, click the back button in the top left corner.

1.2.2.2.3 Main Menu

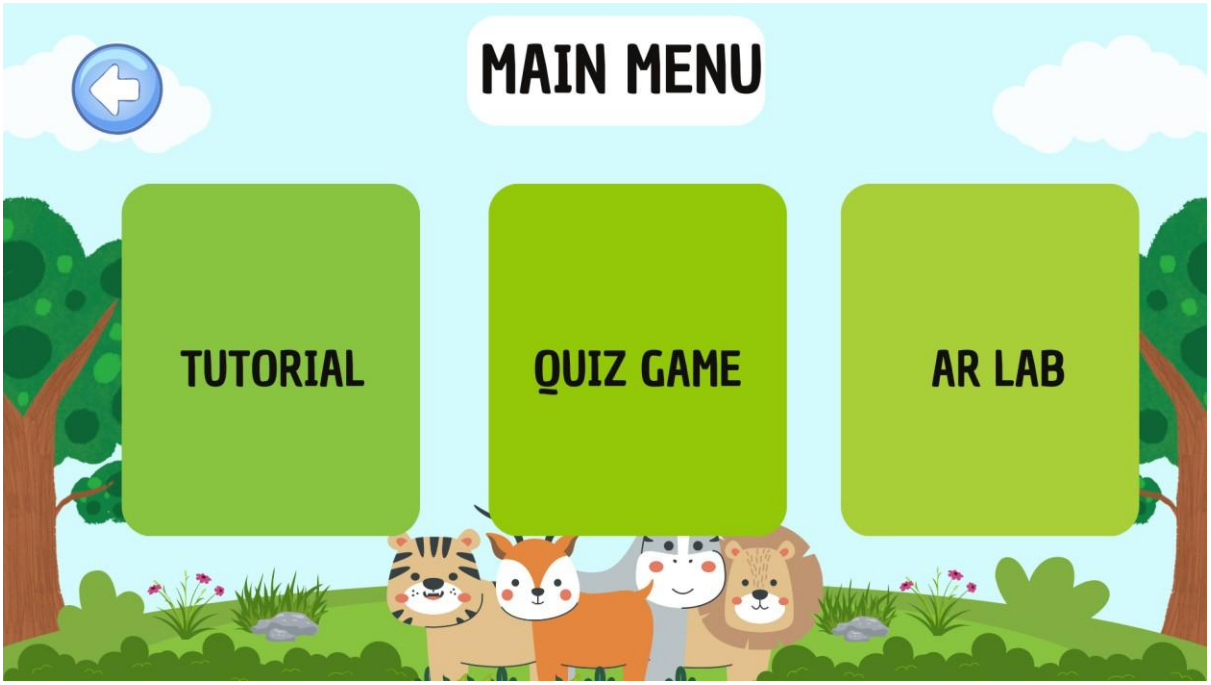


Figure 3.31 *Main menu interface for EcoLyfeAR App*

After tapping the START button, the main menu screen will appear, as illustrated in Figure 3.31. The primary menu contains four separate options: Tutorial, Quiz Game, and AR Lab. The Settings button sits in the top-right corner of the screen. Meanwhile, a back button is present in the top-left corner of the screen, which is touched if the user wants to return to the start screen.

1.2.2.2.4 AR lab for EcoLyfeAR

Figure 3.32 *AR lab camera for EcoLyfeAR App*

The AR Lab button in the Main Menu opens the mobile device's back camera, allowing users to scan AR markers in the booklet. Figure 3.32 shows how users can look at AR models by pointing their cameras at the markers. The back button located in the upper left corner. Tap it to return to the main menu.

1.2.2.2.5 Quiz Game

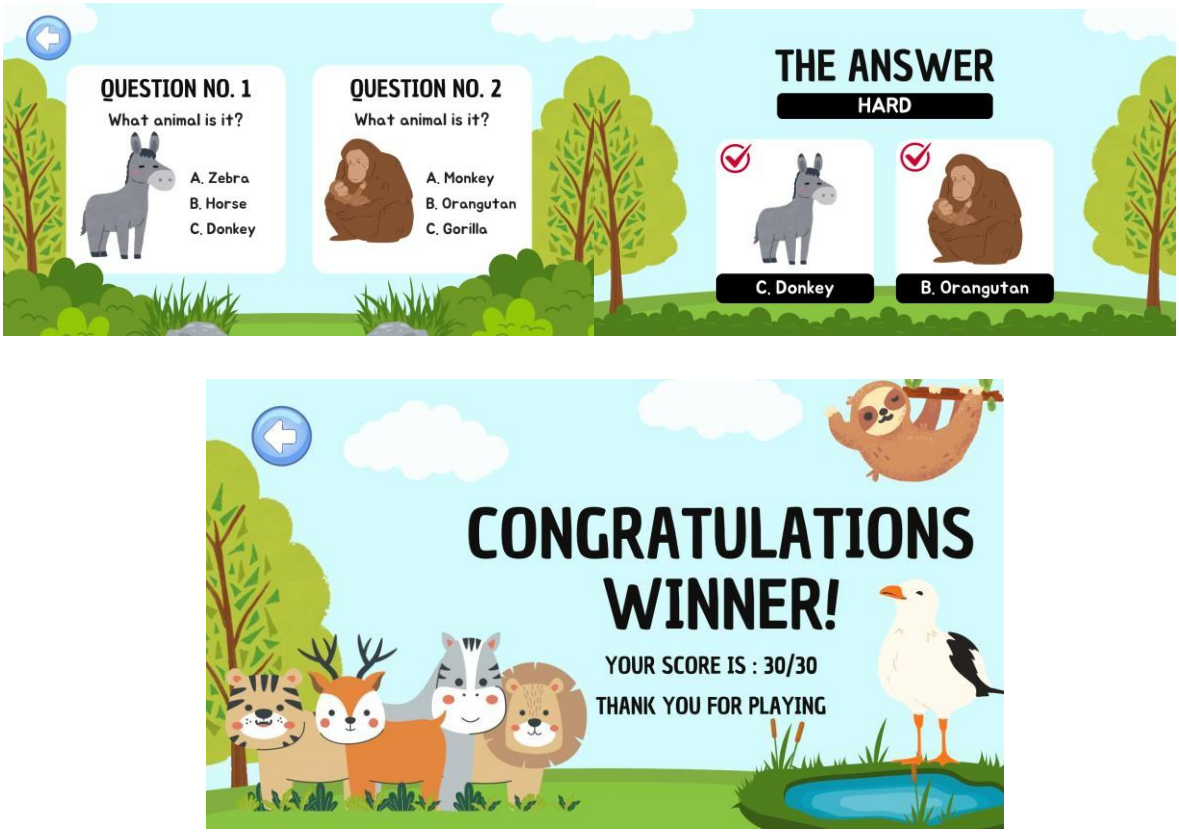


Figure 3.33 *Quiz Game's interface for EcoLyfeAR App*

When a user hits the Quiz Game button, a Quiz Game screen displays (see Figure 3.33). The quiz will start and the user must answer the right answer. Correct answers add 10 marks to the score, while incorrect answers subtract 10 points from the existing score. The centre of the screen displays users' final scores. To quit the revision screen, hit the back button in the top left corner to return to the main menu.

3.2.2.2.5 Tutorial

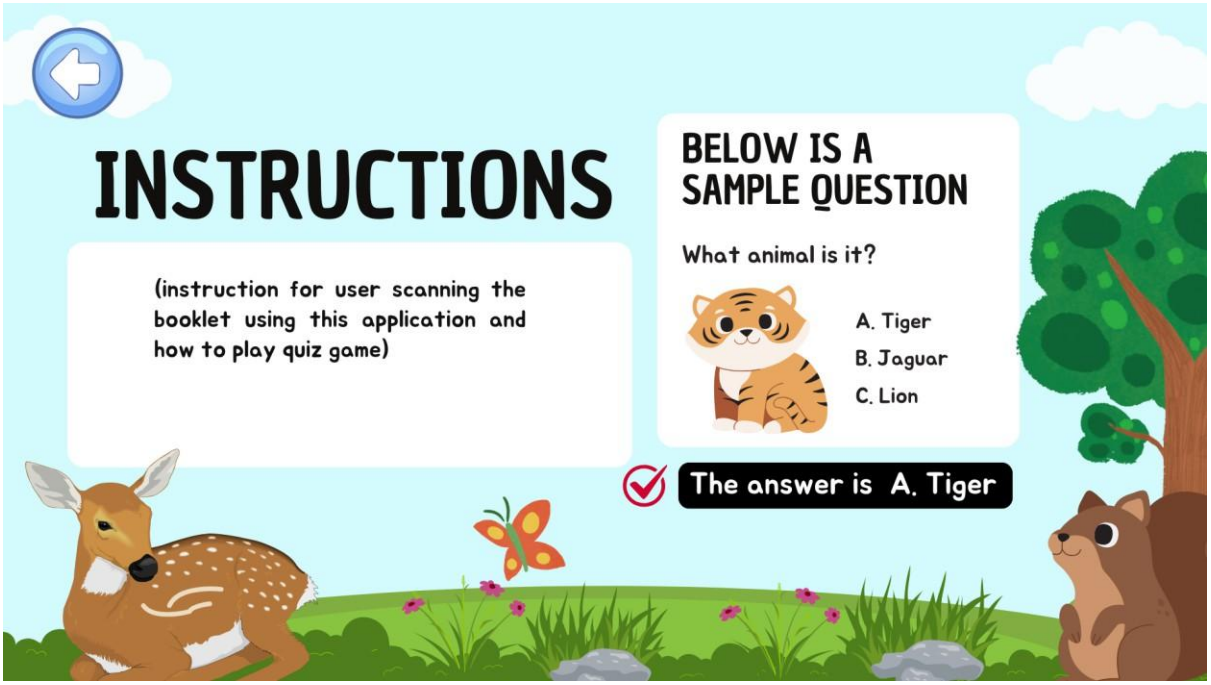


Figure 3.34 *Tutorial interface for EcoLyfeAR App*

Figure 3.34 shows the tutorial screen for the EcoLyfeAR application. Users can see and read the instructions on how to use the application, like how to scan the AR Lab and how the quiz game works. As usual, a Back button is located at the top-left corner of the screen to go back to the main menu.

3.2.2.2.6 Settings

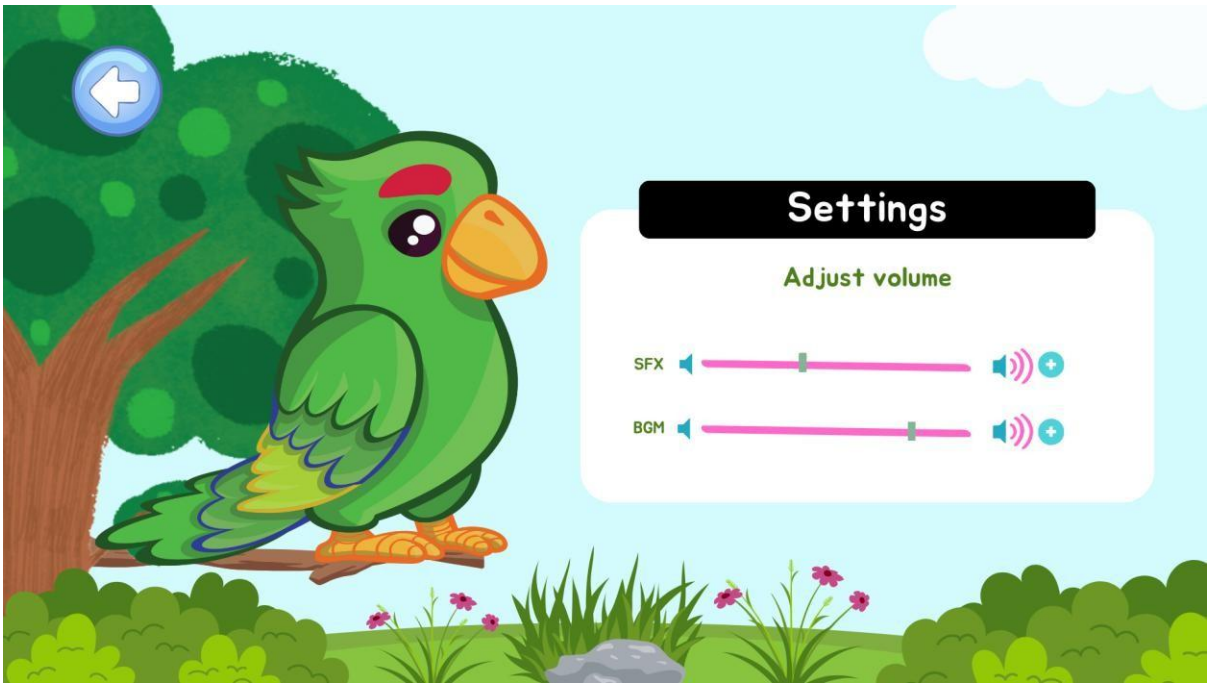


Figure 3.35 *Settings interface for EcoLyfeAR App*

Figure 3.35 shows the settings screen for the EcoLyfeAR application. Users can adjust the sound effect and background music by moving the volume adjustment slider provided. As usual, a Back button is located at the top-left corner of the screen to go back to the Main menu.

3.2.2.2.7 EcoLyfeAR Booklet

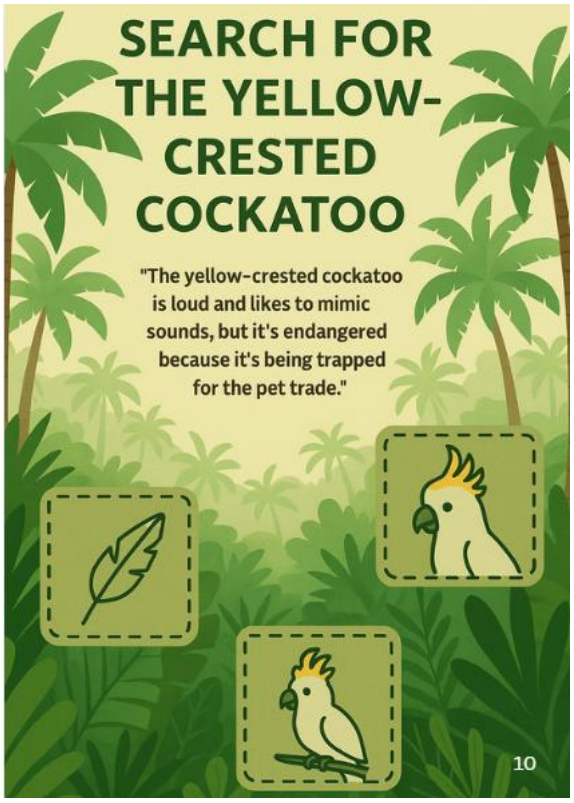


Figure 3.36 *Booklet Concept for EcoLyfeAR App*

Figure 3.36 shows this booklet serves as a companion to the EcoLyfeAR app, allowing users to scan the material to access an engaging Augmented Reality (AR) experience. The booklet contains thorough information regarding habitat extinction, including the causes, effects, and urgency of the situation. It also gives detailed information on diverse habitats and their respective ecosystems. By merging traditional reading with interactive AR technology, this booklet attempts to increase awareness about the essential need to conserve the environment. It is an educational tool that encourages individuals to take action and help to the conservation of endangered environments.

1.2.3 Material Collecting

The material collecting phase of the EcoLyfeAR project involves gathering all of the resources required to construct an interesting and instructive augmented reality (AR) application about species extinction. This phase entails extensive study on endangered species,

ecosystems, and the causes and consequences of biodiversity loss. To guarantee that the material is accurate and relevant, reliable information will be gathered from scientific journals, conservation reports, and verified databases such as the International Union for Conservation of Nature (IUCN) Red List. In addition to textual information, multimedia features are critical to the AR experience. High-quality 3D models of endangered species and habitats will be generated or acquired from platforms such as Sketchfab. These models must be optimised for AR rendering in order to provide seamless interactions on mobile devices. Audio aspects like animal sounds and ambient impacts will also be captured to improve the immersive experience. Visual assets such as images, graphics, and textures will be used to add context and strengthen the instructive booklet function.

Furthermore, the collection will include interactive components such as quizzes and exercises that are connected with the project's educational aims. User input from surveys or focus groups may also be used to influence material selection and development in order to match the app to the preferences and learning needs of its intended audience. This complete approach assures that EcoLyfeAR provides an engaging, accurate, and meaningful teaching experience.

1.2.4 Assembly

During the EcoLyfeAR project's assembly phase, many multimedia elements and capabilities are integrated into a logical, interactive augmented reality (AR) application. This step starts with importing optimised 3D models of endangered species, habitats, and ecosystems into a development environment like Unity. These models are then designed to adapt dynamically to user inputs, resulting in seamless and engaging AR experiences. The instructional booklet function is also created by connecting textual material, high-resolution photos, and audio-visual features to the appropriate AR triggers. The app UI is intended to be user-friendly, with straightforward navigation that allows users to scan actual publications or materials to obtain

AR content. Audio features, such as animal sounds and ambient effects, are synced with graphic elements to provide a truly realistic experience. Quizzes and interactive exercises are included at this level, which correspond with educational objectives and improve user engagement and learning results.

The assembly step also includes thorough testing of AR functions to ensure that 3D models render seamlessly and are compatible with Android devices. The feedback from early test users is used to improve user interactions and rectify any technical concerns. By merging all of these pieces, the assembly process turns the EcoLyfeAR idea into a practical prototype that can be tested further and eventually distributed.

1.2.5 Testing

The EcoLyfeAR project's testing phase is crucial to ensuring that the application runs smoothly and provides an excellent user experience. This phase includes extensive usability and performance testing to assess the app's augmented reality capabilities, user interface, and interactive elements. The 3D models, audio features, and quizzes are thoroughly tested to guarantee that they work seamlessly and respond appropriately to user inputs. The app's interoperability with multiple devices, operating systems (Android), and AR features is also evaluated to discover and repair any technical concerns.

During this phase, a small number of users, like eight students will participate in pilot testing. Participants submit input on the app's usability, instructional value, and general engagement level. Their insights assist in identifying areas for development, such as improving AR rendering, fine-tuning navigation, or introducing new instructional material. Testing also assesses the app's capacity to successfully explain difficult environmental ideas, such as species extinction, in an interactive and immersive format. Stress testing is also performed to guarantee that the app works properly under various situations, such as device requirements. The feedback gathered during testing is analysed and incorporated into iterative development cycles

to improve the app even more. By the end of the testing phase, EcoLyfeAR should be ready for deployment, providing a dependable, engaging, and powerful tool for environmental education.

1.2.6 Distribution

The EcoLyfeAR project's distribution phase is focused on efficiently delivering the application and related teaching materials to the target population. To guarantee that both Android users can use the software, it will be launched on key platforms such as the itch.io. A dedicated website and social media sites will be created to market the app, give user manuals, and provide updates. These platforms will serve as the primary locations for downloading the app, finding extra materials, and providing feedback.

Additionally, internet marketing tactics such as social media promotions will be used to reach a larger audience. Feedback methods inside the app and on linked platforms will be utilised to gather user feedback, enabling for incremental enhancements. EcoLyfeAR's complete distribution strategy seeks to maximise its reach and impact, promoting general use as an educational tool for environmental awareness and species protection.

1.3 Summary

The third chapter is on the EcoLyfeAR application's requirement analysis and design, defining the primary functional and non-functional needs for development. It identifies the target audience, which includes students, educators, and conservationists, as well as the necessity for Android platform compatibility. The chapter also emphasises the necessity of intuitive navigation, high-quality 3D models, and augmented reality capabilities for an immersive learning experience. It covers the app's design foundation, such as the user interface layout, educational material integration, and interactive elements like quizzes and 3D visualisations. By addressing these needs and providing a defined design architecture, this chapter guarantees

that the project achieves its aim of developing an engaging and powerful tool for environmental education and species extinction prevention.

CHAPTER 4: IMPLEMENTATION

4.1 Introduction

This chapter will cover the implementation of the EcoLyfeAR Mobile Application. Implementation is an important stage in this project since it involves the actual development of the application, which has been thoroughly developed and discussed in earlier chapters.

4.2 Tool Implementation

This project develops and builds the application using a few lists of software and its capabilities. Preparing the appropriate tools for this project is critical to ensuring a smooth and successful implementation. This section will cover the tools and their functions.

4.2.1 Development of Tools and System Platform

Software Use

These are the software used to develop the application in this project:

a. Operating System

Windows 11 was the operating system used to create the EcoLyfeAR mobile application. Android OS runs on a different operating system. During development, Android 16 is the version of the operating system that is used to execute and test the application.

b. Unity (Game Engine 2022.3.11.f1)

In this project, Unity is used to create and assemble all of the EcoLyfeAR app's features. This comprises a start scene, credits scene, settings scene, main menu scene (with AR camera features), Checklist scene, Credit scene and tutorial scene.

c. Vuforia Engine

A platform for creating software for Augmented Reality (AR) applications is called Vuforia Engine. This program is an installable Unity package that is being used in this project to develop and include the augmented reality component of the application. Vuforia is used to upload the target markers to an online database.

d. Canva

Canva was used as a design tool to build the visual background for the EcoLyfeAR mobile application, resulting in a unified and user-friendly interface. Additionally, Canva was used in the design and layout of the EcoLyfeAR booklet, allowing the combination of instructive text with visually appealing components. This method aims to improve the overall presentation and efficacy of the educational materials, therefore helping the project's goal of raising awareness about the environment through both digital and printed media.

Hardware Requirements

Hardware requirements are also a significant consideration when designing this application. The hardware utilised is as follows:

a. **Processor**: 11th Gen Intel(R) Core(TM) i5-1135G7 @ 2.40GHz, 2419 Mhz, 4 Core(s), 8 Logical Processor(s)

This device is a central processing unit (CPU). It is the primary chip of a computer that handles all tasks. The CPU runs and supports Unity and Canva, allowing each program to be utilised for application development.

b. **RAM**: 16.00GB

In the creation and implementation of this project, a 16.00GB RAM is employed, which stores the software application programs and data that are now in use so that the computer's CPU may access them rapidly.

4.3 EcoLyfeAR

The EcoLyfeAR Mobile Application's user interfaces, codes, and augmented reality markers are covered in this section.

4.3.1 Start Screen

Figure 4.1 *Start Screen*

On the start screen, there is the title of the application, which is EcoLyfeAR. The start screen, as shown in Figure 4.1, consists of two different buttons, which are START and QUIT. The START button will lead to the main menu screen. Lastly, the QUIT button will allow the users to exit the application.

4.3.2 Credit Screen

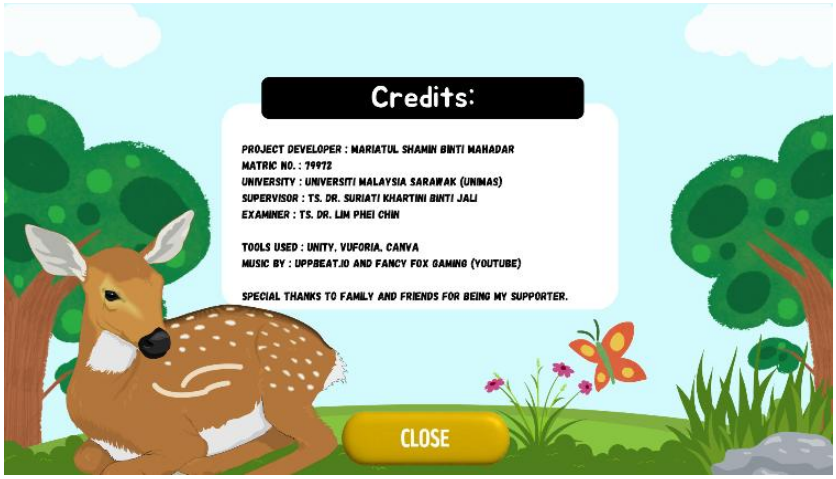


Figure 4.2 *Credit Screen*

The list of acknowledgements and contributions made to the creation of this application is

displayed on the credit screen. As seen in Figure 4.2, the screen includes a close button, developer credit, tools used, sound effects, background music, and acknowledgement. Users click close button to close the credits screen.

4.3.3 Main Menu Screen

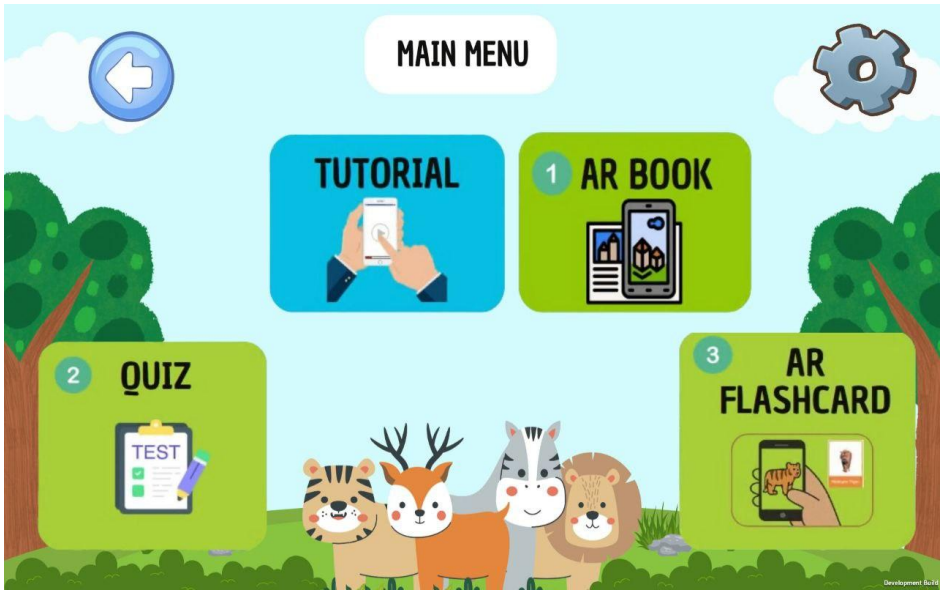


Figure 4.3 *Main Menu Screen*

As seen in Figure 4.3, the back button, settings button, tutorial button, AR booklet button, and AR flashcard button make up the main menu screen. Users may return to the Start screen by clicking the back button. Selecting the settings button will bring up the settings page. Click the tutorial icon to read the instructions for using this program. To utilise the AR functionality, click the AR booklet button before selecting the Quiz button to bring up the Quiz screen. Then, user can select AR Flashcard to play mini game about animal fun facts and scan AR from the flashcard.

4.3.4 Settings Screen

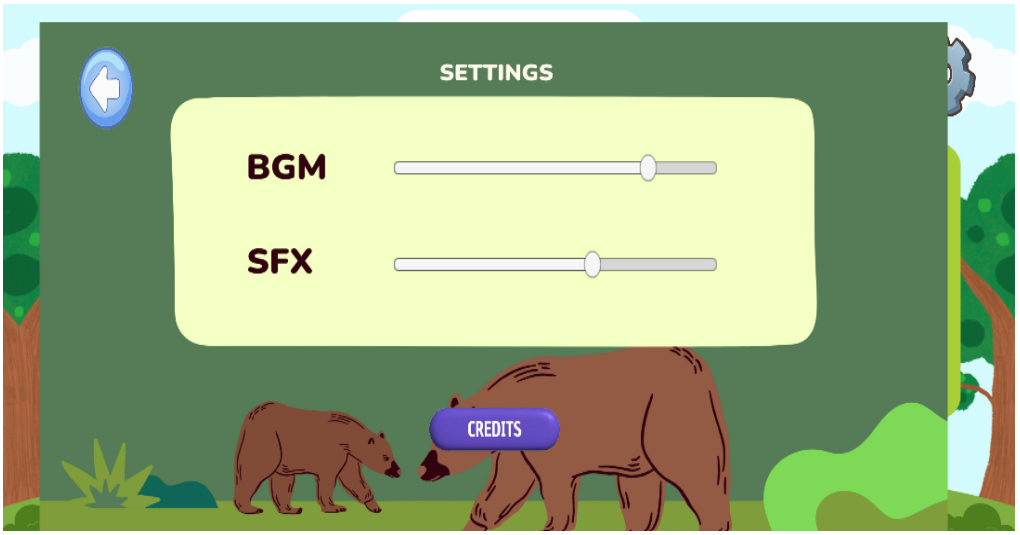


Figure 4.4 *Settings Screen*

Figure 4.4 shows the settings screen. The controls include a back button, a BGM slider, and an SFX slider. To adjust the volume for BGM and SFX, hold the slider handle and slide it left or right. Users can click the Credits button to show application credits as shown in Figure 4.4.

4.3.5 Tutorial Screen

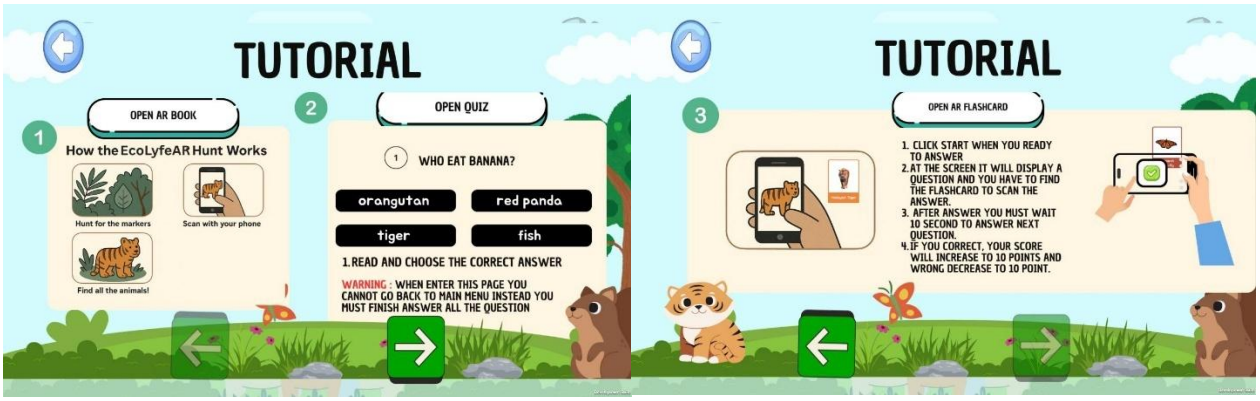


Figure 4.5 *Tutorial Screen*

Figure 4.5 shows a tutorial screen with directions for navigating the application. To exit the tutorial screen, click the back button. The user also can also click next and back button at the bottom to see the tutorial.

4.3.6 Confirmation Screen

Figure 4.6 Confirmation Screen

Figure 4.6 shows the confirmation screen. To start the quiz, users must click the Start button. Users can only quit the quiz after answering all 20 questions.

4.3.7 Quiz Screen

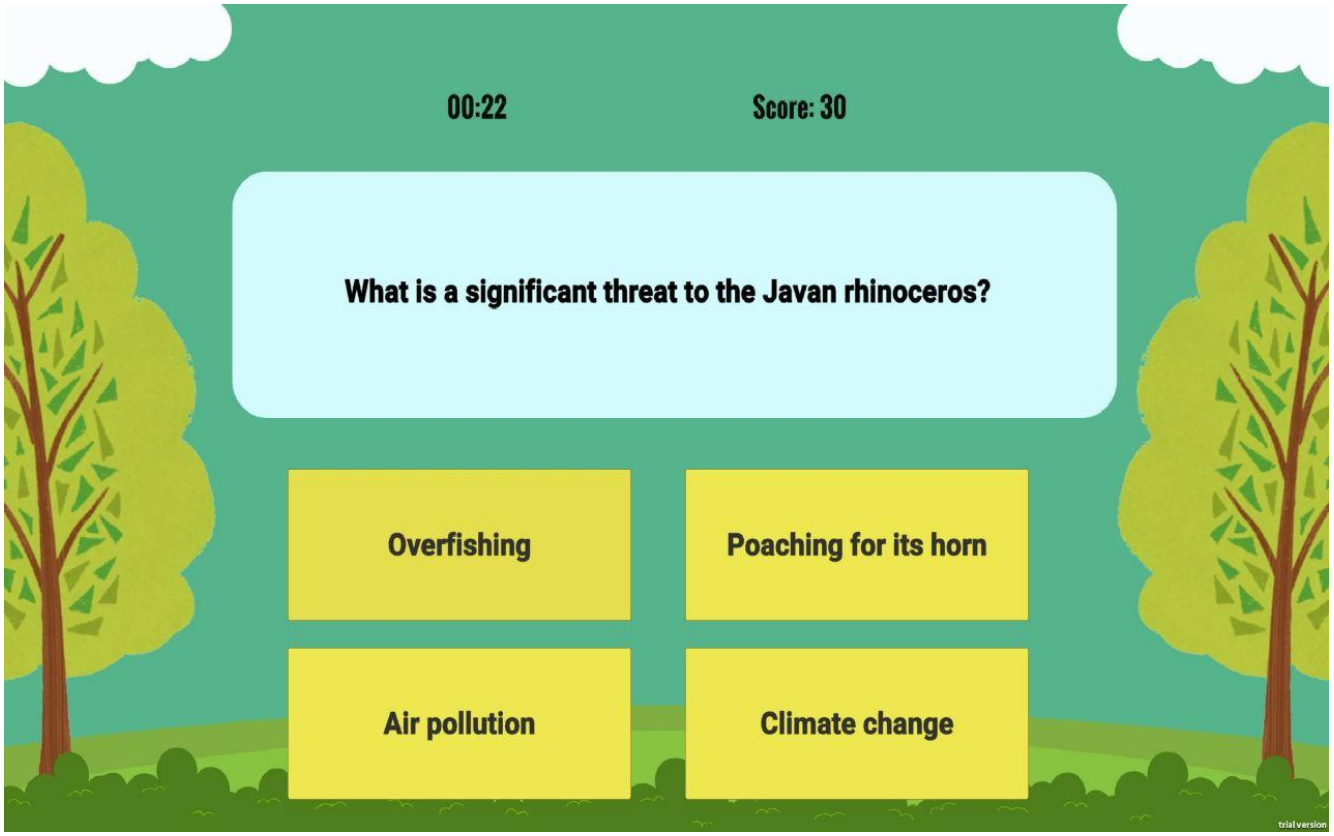


Figure 4.7 *Quiz Screen*

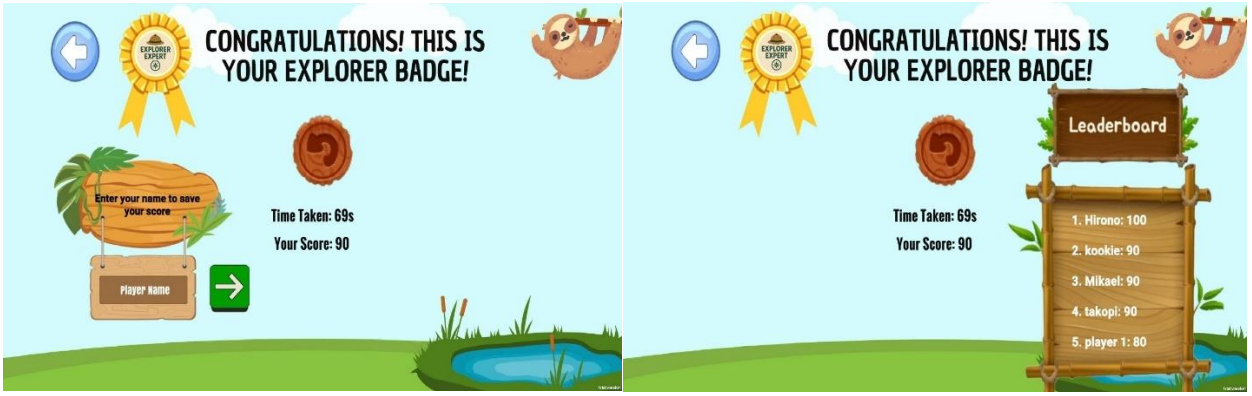


Figure 4.8 *Quiz Ending Screen with leaderboard*

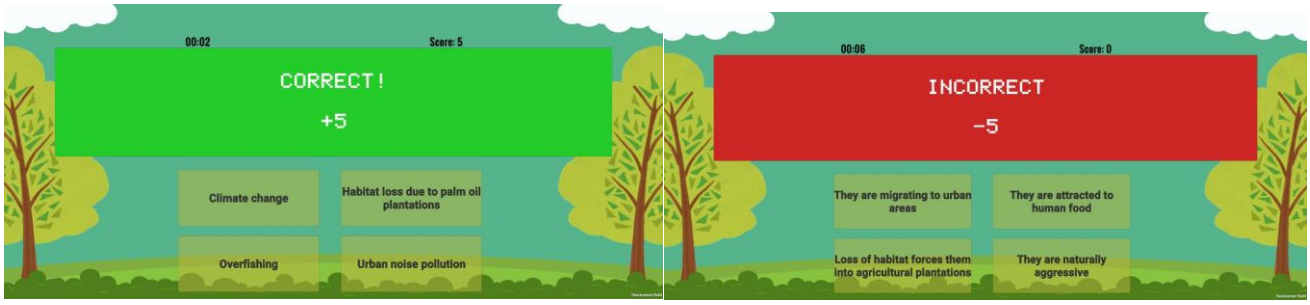


Figure 4.9 *Quiz panel for correct and incorrect answer*

Figure 4.7 shows an example of a quiz screen, while Figure 4.8 shows a quiz end screen. The quiz consists of ten multiple-choice questions that closely follow the reasons for the animals' extinction during the user scans the AR marker at the EcoLyfeAR booklet. During the whole answering duration, users are unable to exit the quiz screen until they have reached the end screen. Users will enter the quiz end screen once they have finished answering all 20 questions. Exiting the end screen will reset the user's score point and timer while they are answering the question. Thus, they are advised to take note of it before exiting back to the main menu screen. If the user answers the correct answer or the wrong answer, it will notify the user, like shown in Figure 4.9, and automatically go to the next question. After the user finishes answering the questions, the quiz end screen will appear and will show the user score and time taken while they were answering the questions, as shown in Figure 4.8.

4.3.8 AR Book and AR flashcard

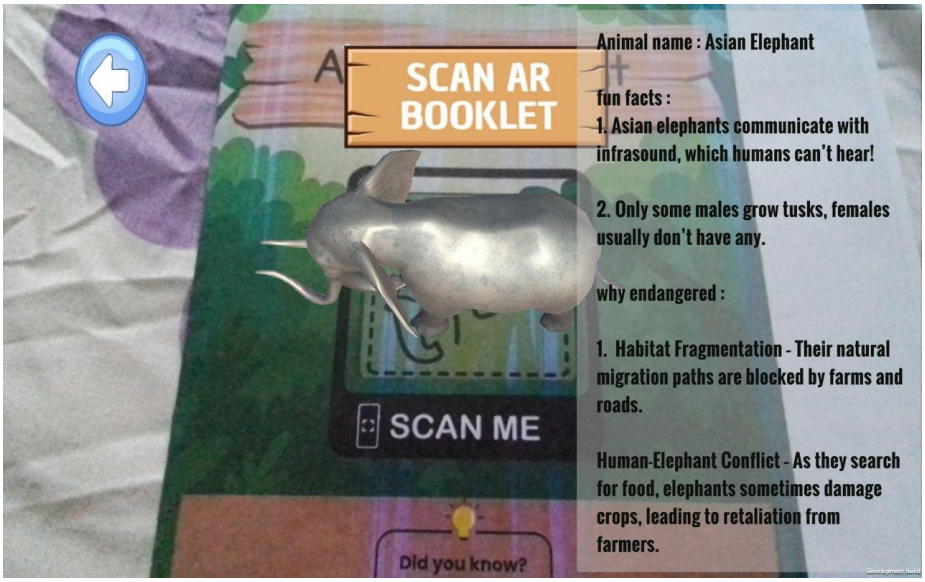


Figure 4.10 *AR with 3D object*

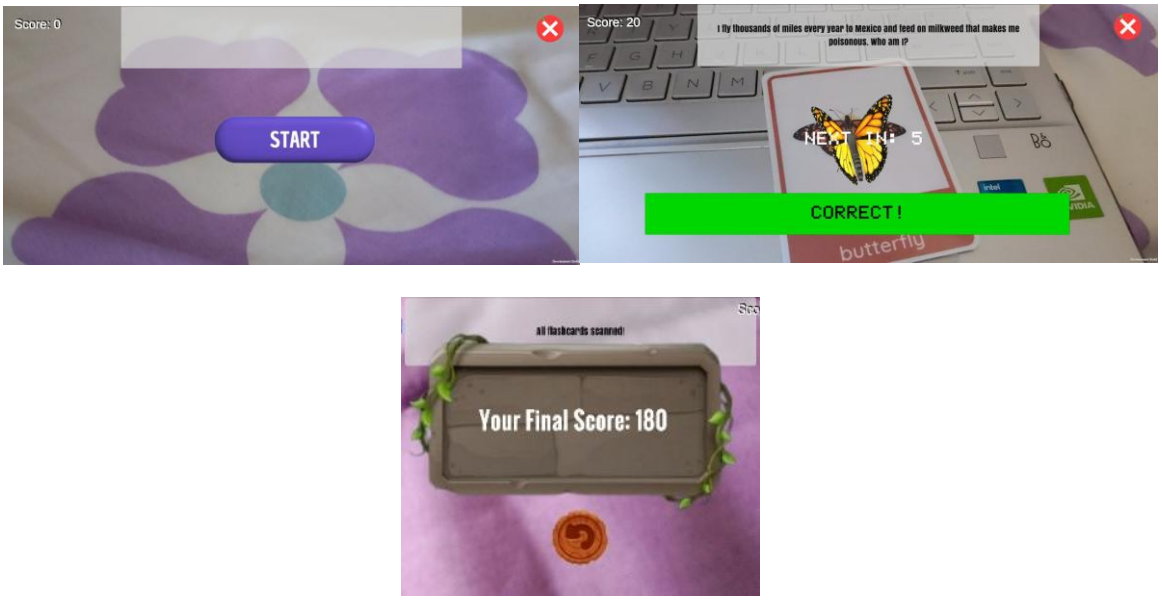


Figure 4.11 *AR Flashcard*

Entering the AR Booklet will automatically open the user's device camera to access the AR feature in the application. Users will need to open the EcoLyfeAR booklet and point the camera towards the images marked with the scan icon like shown in Figure 4.10. Users are able to scan images in the EcoLyfeAR booklet to view the AR models with their description. Same goes to AR Flashcard, it will automatically open user's device camera to access the AR features in the application and will have mini game like guess the animals based on their fun fact or environmental features. This screen will ask questions and the user must scan the flashcard based on the question that given and will record user's

score based on their answer. If the user scan correct flashcard it will pop up the correct and incorrect panel which is shown in Figure 4.11.

4.3.9 Codes

In order for EcoLyfeAR to function properly, certain parts of the application, such as assigning the switching between scenes in Unity, audio settings, quiz answering, quiz background sound, interaction of 3D object, timer, and scoring, need to be coded. The programming language used in the development of this application is C#.

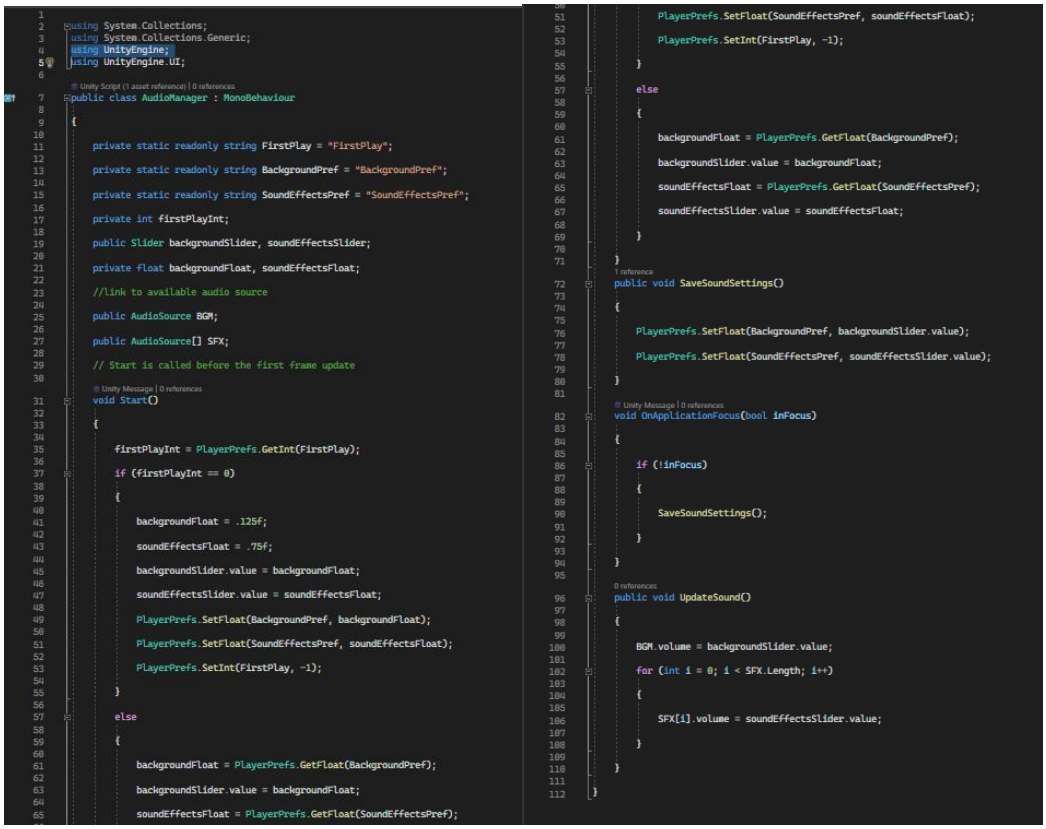
- **Scene Switcher**

```
using System.Collections.Generic;
using UnityEngine;
using UnityEngine.SceneManagement;

Unity Script (9 asset references) | 0 references
public class screenswitcher : MonoBehaviour
{
    //homepage
    0 references
    public void homepage()
    {
        SceneManager.LoadScene(0);
    }

    0 references
    public void ARCamera()
    {
        SceneManager.LoadScene(1);
    }

    0 references
    public void MainMenu()
    {
        SceneManager.LoadScene(2);
    }


    0 references
    public void Quizscene()
    {
        SceneManager.LoadScene(3);
    }

    0 references
    public void Endingscene()
    {
        SceneManager.LoadScene(4);
    }

    0 references
    public void flashcard()
    {
        SceneManager.LoadScene(5);
    }

    0 references
    public void confirm()
    {
        SceneManager.LoadScene(6);
    }
}
```

Figure 4.12 *Code for Screen Switcher*

In Figure 4.12, each scene in this project is assigned a number in the project settings. This enables the app to transition between scenes as specified in Unity. This code is utilised throughout the entire program.

- **Audio Settings**

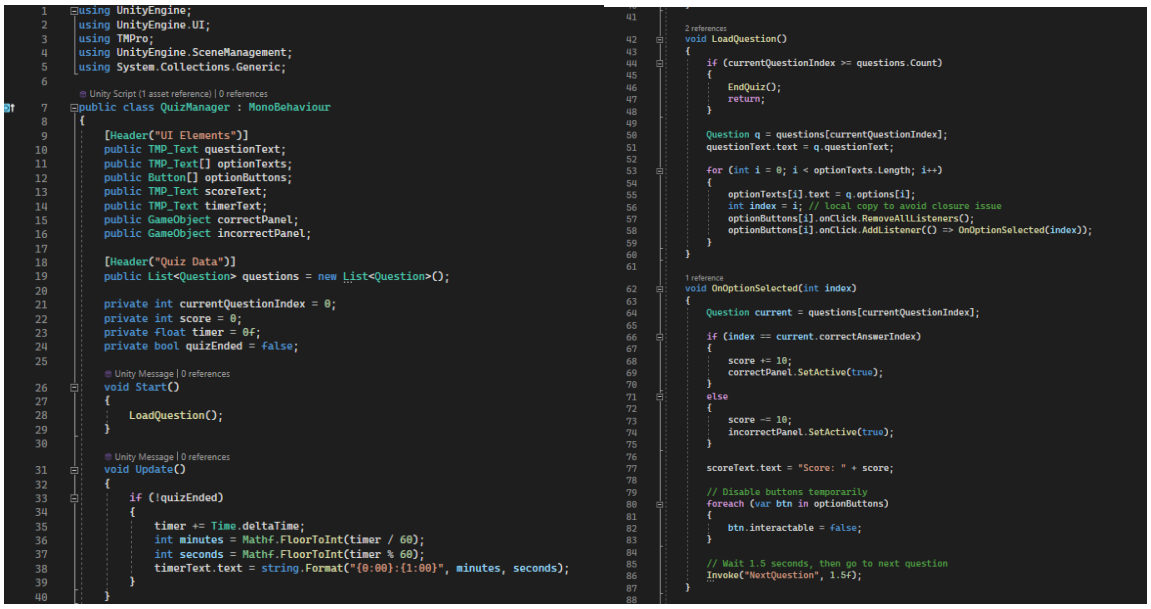


```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;
using UnityEngine.UI;

Unity Script (1 asset reference) | 0 references
public class AudioManager : MonoBehaviour
{

    private static readonly string FirstPlay = "FirstPlay";

    private static readonly string BackgroundPref = "BackgroundPref";

    private static readonly string SoundEffectsPref = "SoundEffectsPref";

    private int firstPlayInt;

    public Slider backgroundSlider, soundEffectsSlider;

    private float backgroundFloat, soundEffectsFloat;

    //link to available audio source

    public AudioSource BGM;

    public AudioSource[] SFX;

    // Start is called before the first frame update

    Unity Message | 0 references
    void Start()

    {

        firstPlayInt = PlayerPrefs.GetInt(FirstPlay);

        if (firstPlayInt == 0)

        {

            backgroundFloat = .125f;

            soundEffectsFloat = .75f;

            backgroundSlider.value = backgroundFloat;

            soundEffectsSlider.value = soundEffectsFloat;

            PlayerPrefs.SetFloat(BackgroundPref, backgroundFloat);

            PlayerPrefs.SetFloat(SoundEffectsPref, soundEffectsFloat);

            PlayerPrefs.SetInt(FirstPlay, -1);

        }

        else

        {

            backgroundFloat = PlayerPrefs.GetFloat(BackgroundPref);

            backgroundSlider.value = backgroundFloat;

            soundEffectsFloat = PlayerPrefs.GetFloat(SoundEffectsPref);

            PlayerPrefs.SetFloat(SoundEffectsPref, soundEffectsFloat);

            PlayerPrefs.SetInt(FirstPlay, -1);

        }

        else

        {

            backgroundFloat = PlayerPrefs.GetFloat(BackgroundPref);

            backgroundSlider.value = backgroundFloat;

            soundEffectsFloat = PlayerPrefs.GetFloat(SoundEffectsPref);

            soundEffectsSlider.value = soundEffectsFloat;

        }

    }
    1 reference
    public void SaveSoundSettings()

    {

        PlayerPrefs.SetFloat(BackgroundPref, backgroundSlider.value);

        PlayerPrefs.SetFloat(SoundEffectsPref, soundEffectsSlider.value);

    }

    Unity Message | 0 references
    void OnApplicationFocus(bool inFocus)

    {

        if (!inFocus)

        {

            SaveSoundSettings();

        }

    }

    0 references
    public void UpdateSound()

    {

        BGM.volume = backgroundSlider.value;

        for (int i = 0; i < SFX.Length; i++)

        {

            SFX[i].volume = soundEffectsSlider.value;

        }

    }

}
```

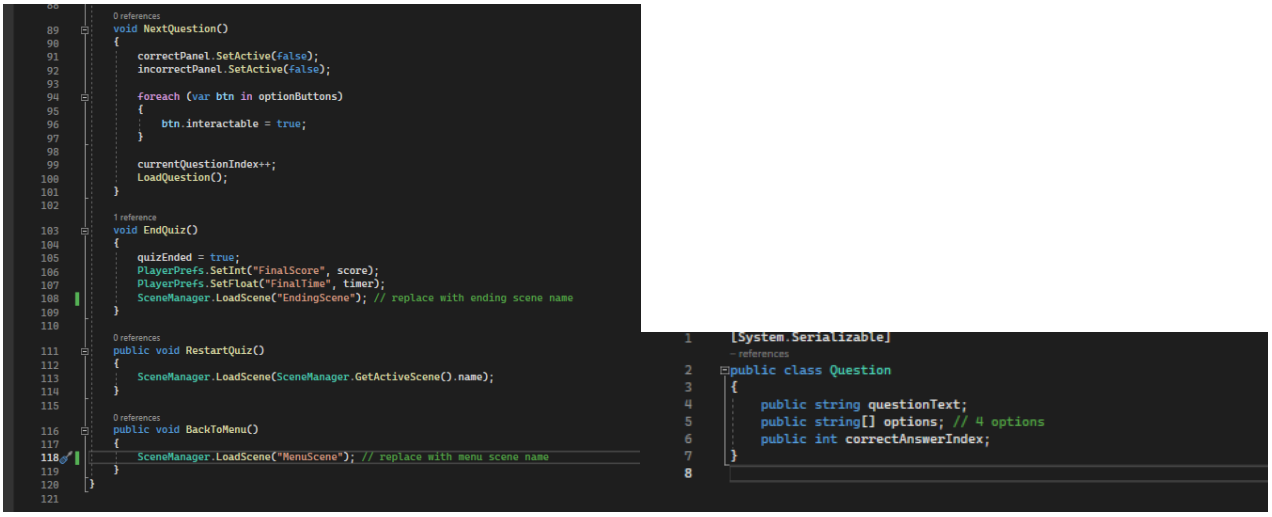
Figure 4.13 *Code for Audio Settings*

This code assigns a slider for background music and sound effect volume. Slider modifications are automatically stored and updated throughout the entire scene based on this Figure 4.13.

- **Quiz and Question**



```
using UnityEngine;
using UnityEngine.UI;
using TMPro;
using UnityEngine.SceneManagement;
using System.Collections.Generic;

Unity Script (1 asset reference) | 0 references
public class QuizManager : MonoBehaviour
{
    [Header("UI Elements")]
    public TMP_Text questionText;
    public TMP_Text[] optionTexts;
    public Button[] optionButtons;
    public TMP_Text scoreText;
    public TMP_Text timerText;
    public GameObject correctPanel;
    public GameObject incorrectPanel;

    [Header("Quiz Data")]
    public List<Question> questions = new List<Question>();

    private int currentQuestionIndex = 0;
    private int score = 0;
    private float timer = 0f;
    private bool quizEnded = false;

    Unity Message | 0 references
    void Start()
    {
        LoadQuestion();
    }

    Unity Message | 0 references
    void Update()
    {
        if (!quizEnded)
        {
            timer += Time.deltaTime;
            int minutes = Mathf.FloorToInt(timer / 60);
            int seconds = Mathf.FloorToInt(timer % 60);
            timerText.text = string.Format("{0:00}:{1:00}", minutes, seconds);
        }
    }

    2 references
    void LoadQuestion()
    {
        if (currentQuestionIndex >= questions.Count)
        {
            EndQuiz();
            return;
        }

        Question q = questions[currentQuestionIndex];
        questionText.text = q.questionText;

        for (int i = 0; i < optionTexts.Length; i++)
        {
            optionTexts[i].text = q.options[i];
            int index = i; // local copy to avoid closure issue
            optionButtons[i].onClick.RemoveAllListeners();
            optionButtons[i].onClick.AddListener(() => OnOptionSelected(index));
        }
    }

    1 reference
    void OnOptionSelected(int index)
    {
        Question current = questions[currentQuestionIndex];

        if (index == current.correctAnswerIndex)
        {
            score += 10;
            correctPanel.SetActive(true);
        }
        else
        {
            score -= 10;
            incorrectPanel.SetActive(true);
        }

        scoreText.text = "Score: " + score;

        // Disable buttons temporarily
        foreach (var btn in optionButtons)
        {
            btn.interactable = false;
        }

        // Wait 1.5 seconds, then go to next question
        Invoke("NextQuestion", 1.5f);
    }
```



```
0 references
void NextQuestion()
{
    correctPanel.SetActive(false);
    incorrectPanel.SetActive(false);

    foreach (var btn in optionButtons)
    {
        btn.interactable = true;
    }

    currentQuestionIndex++;
    LoadQuestion();
}

1 reference
void EndQuiz()
{
    quizEnded = true;
    PlayerPrefs.SetInt("FinalScore", score);
    PlayerPrefs.SetFloat("FinalTime", timer);
    SceneManager.LoadScene("EndingScene"); // replace with ending scene name
}

0 references
public void RestartQuiz()
{
    SceneManager.LoadScene(SceneManager.GetActiveScene().name);
}

0 references
public void BackToMenu()
{
    SceneManager.LoadScene("MenuScene"); // replace with menu scene name
}
}
```

```
[System.Serializable]
references
public class Question
{
    public string questionText;
    public string[] options; // 4 options
    public int correctAnswerIndex;
}
```

Figure 4.14 *Code for Quiz and Question*

In Figure 4.14, the script includes a QuizManager, which manages the flow of a multiple-choice quiz by displaying questions, accepting user input, monitoring score and time, and transitioning between scenes. The quiz selects from a list of Question objects, each of which has a question text, four alternative responses, and the index of the correct answer. The manager populates the UI with the current question and its alternatives, and dynamically assigns button listeners to handle response selection. After selecting an answer, the script displays a feedback panel (correct/incorrect), modifies the score (+10 or -10), temporarily disables buttons, and loads the next question. A timer keeps track of how long the player takes, and after the quiz is finished, the score and time are recorded using PlayerPrefs before switching to the final scene. The script provides ways for restarting the quiz and returning to the main menu.

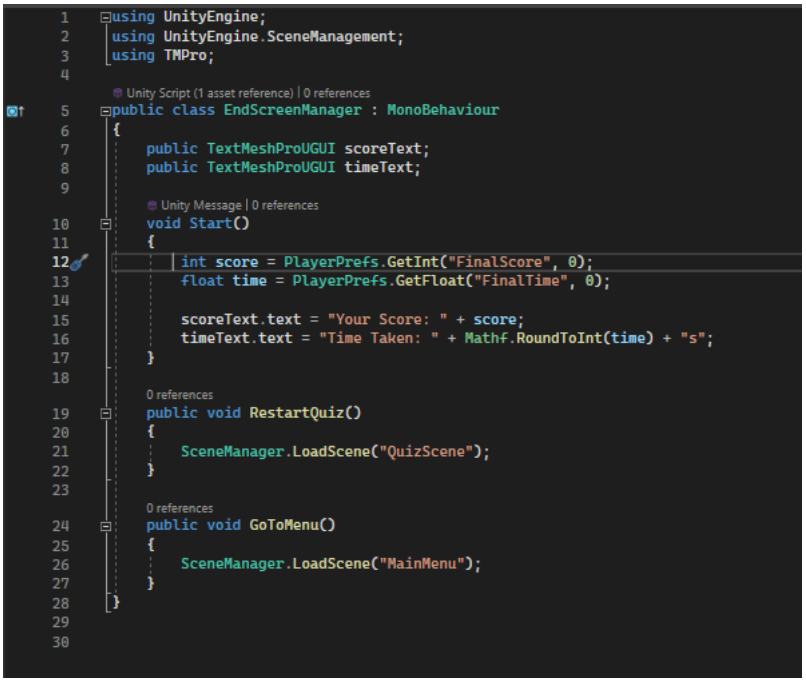
- **Tutorial**

```
using UnityEngine;
using UnityEngine.UI;

Unity Script (1 asset reference) | 0 references
public class TutorialManager : MonoBehaviour
{
    public Image tutorialImage;
    public Sprite[] tutorialPages;

    public Button nextButton;
    public Button backButton;

    private int currentPage = 0;

    Unity Message | 0 references
    void Start()
    {
        ShowPage(currentPage);

        nextButton.onClick.AddListener(NextPage);
        backButton.onClick.AddListener(BackPage);
    }

    3 references
    void ShowPage(int index)
    {
        tutorialImage.sprite = tutorialPages[index];

        backButton.interactable = index > 0;
        nextButton.interactable = index < tutorialPages.Length - 1;
    }

    1 reference
    void NextPage()
    {
        if (currentPage < tutorialPages.Length - 1)
        {
            currentPage++;
            ShowPage(currentPage);
        }
    }

    1 reference
    void BackPage()
    {
        if (currentPage > 0)
        {
            currentPage--;
            ShowPage(currentPage);
        }
    }
}
```

Figure 4.15 *Code for Tutorial button*

This script in Figure 4.15, manages a simple tutorial UI in Unity by displaying a series of images (tutorialPages) controlled through "Next" and "Back" buttons. It uses an Image component (tutorialImage) to show the current tutorial page, and tracks which page is being shown with the currentPage integer. When the game starts, it displays the first page and sets up the button click listeners. The ShowPage() function updates the displayed image based on the current index, and enables or disables the navigation buttons depending on whether the user is at the start or end of the tutorial. The NextPage() and BackPage() methods increment or decrement the currentPage index and call ShowPage() to reflect the change.

- **Ending Scene**



```
using UnityEngine;
using UnityEngine.SceneManagement;
using TMPro;

Unity Script (1 asset reference) | 0 references
public class EndScreenManager : MonoBehaviour
{
    public TextMeshProUGUI scoreText;
    public TextMeshProUGUI timeText;

    Unity Message | 0 references
    void Start()
    {
        int score = PlayerPrefs.GetInt("FinalScore", 0);
        float time = PlayerPrefs.GetFloat("FinalTime", 0);

        scoreText.text = "Your Score: " + score;
        timeText.text = "Time Taken: " + Mathf.RoundToInt(time) + "s";
    }

    0 references
    public void RestartQuiz()
    {
        SceneManager.LoadScene("QuizScene");
    }

    0 references
    public void GoToMenu()
    {
        SceneManager.LoadScene("MainMenu");
    }
}
```

Figure 4.16 *Code for Ending Scene*

Then in Figure 4.16, this script handles the quiz end screen by displaying the player's final score and time using TextMeshProUGUI elements. When the scene starts, it retrieves the saved score and time from PlayerPrefs using the keys "FinalScore" and "FinalTime". It then updates the scoreText and timeText fields to show this data, rounding the time to the nearest second. The script also provides two public methods: RestartQuiz() to reload the quiz scene, and GoToMenu() to return to the main menu, both using Unity's SceneManager.LoadScene() function.

- **Marker Info**

```
using UnityEngine;
using TMPro;
using Vuforia;

Unity Script (15 asset references) | 0 references
public class MarkerInfo : MonoBehaviour
{
    public GameObject animalModel;
    public GameObject descriptionBoxUI;
    public TextMeshProUGUI descriptionText;
    [TextArea]
    public string animalDescription;

    private ObserverBehaviour observer;

    Unity Message | 0 references
    void Start()
    {
        observer = GetComponent<ObserverBehaviour>();
        if (observer)
        {
            observer.OnTargetStatusChanged += OnTargetStatusChanged;
        }

        if (animalModel != null)
            animalModel.SetActive(false);

        if (descriptionBoxUI != null)
            descriptionBoxUI.SetActive(false);
    }

    Unity Message | 0 references
    private void OnDestroy()
    {
        if (observer)
        {
            observer.OnTargetStatusChanged -= OnTargetStatusChanged;
        }
    }

    2 references
    private void OnTargetStatusChanged(ObserverBehaviour behaviour, TargetStatus status)
    {
        bool isVisible = status.Status == Status.TRACKED || status.Status == Status.EXTENDED_TRACKED;

        if (animalModel != null)
            animalModel.SetActive(isVisible);

        if (descriptionBoxUI != null)
            descriptionBoxUI.SetActive(isVisible);

        if (descriptionText != null && isVisible)
            descriptionText.text = animalDescription;


    }
}
```

Figure 4.17 *Code for Marker Info*

Figure 4.17 displays the MarkerInfo script, which controls the presentation and behaviour of augmented reality (AR) material when a certain picture marker is identified using Vuforia in Unity. This script, which is attached to a marker GameObject, controls the appearance of a 3D animal model and an accompanying UI description box that shows information about the animal. When the marker is tracked by the AR camera, whether in TRACKED or EXTENDED_TRACKED mode, the script activates both the model and the description UI, as well as changing the description text to a predetermined animal description. If tracking fails, the items are concealed again to ensure an immersive and responsive AR experience. The usage of ObserverBehaviour assures that the script responds dynamically to the marker's tracking state, resulting in an interactive and educational AR application.

- **Flashcard**

```
using UnityEngine;
using Vuforia;

Unity Script (20 asset references) | 0 references
public class FlashcardDetector : MonoBehaviour
{
    private ObserverBehaviour observer;

    private bool hasDetected = false;

    Unity Message | 0 references
    void Start()
    {
        observer = GetComponent<ObserverBehaviour>();
        if (observer)
        {
            observer.OnTargetStatusChanged += OnTargetStatusChanged;
        }
    }

    1 reference
    void OnTargetStatusChanged(ObserverBehaviour behaviour, TargetStatus status)
    {
        if (!hasDetected && status.Status == Status.TRACKED)
        {
            hasDetected = true;

            // Pass the detected target name to the RiddleGameManager
            RiddleGameManager manager = FindObjectOfType<RiddleGameManager>();
            if (manager != null)
            {
                manager.CheckAnswer(gameObject.name);
            }
        }

        // Reset when target is lost
        if (status.Status == Status.NO_POSE)
        {
            hasDetected = false;
        }
    }
}
```

Figure 4.18 *Code for Flashcard*

Figure 4.18 presents the FlashcardDetector script, which is essential for detecting AR image targets and activating interactions in a flashcard-based riddle game created in Unity using Vuforia. This script, which is attached to specific image targets, uses the ObserverBehaviour component to monitor changes in the marker's tracking state. When a marker is successfully detected (Status.TRACKED) for the first time, it sets a flag (hasDetected) to prevent further detections and communicates the name of the detected GameObject to the RiddleGameManager using the CheckAnswer method. This technique allows the game to verify that the right flashcard (response) was scanned. When the marker is gone, the detection flag is reset (Status.NO_POSE), allowing the target to be recognised in future contacts. This script allows for real-time, marker-based answer validation in an exciting AR riddle game.

- **Flashcard RiddleGame**

Figure 4.19 *Code for Flashcard riddle game*

The main controller for controlling the flow of a marker-based augmented reality riddle game in Unity is the RiddleGameManager script, shown in Figure 4.19. The game lifecycle is managed by this script, which also starts the game, shows riddles, verifies answers, updates scores, and controls user interface feedback. Players must scan the correct image to find the target name and a question to solve each riddle, which is kept in a list of riddle objects. One riddle at a time is displayed at the beginning of the game, and the player must react by scanning the matching picture marker. Before going on to the next riddle, the CheckAnswer technique updates the score and shows real-time visual feedback (green for correct,

red for incorrect) and a countdown after comparing the scanned target's name to the right response. By turning off inputs during transitions and providing a restart option at the end of the game, the script guarantees a seamless and captivating experience. Together with FlashcardDetector, this element produces an engaging and educational augmented reality game.

- **3D animal object Zoom in and Zoom out function**

```
using UnityEngine;

Unity Script (15 asset references) | 0 references
public class ARObjectManipulator : MonoBehaviour
{
    private Vector3 initialScale;
    private Transform parentTarget;

    [Header("Zoom Settings")]
    public float minScaleFactor = 0.5f; // 50% of original
    public float maxScaleFactor = 1.5f; // 150% of original
    public float zoomSpeed = 0.005f;

    Unity Message | 0 references
    void Start()
    {
        initialScale = transform.localScale;

        // Store the original parent (usually the image target)
        parentTarget = transform.parent;
    }

    Unity Message | 0 references
    void Update()
    {
        // Make sure it stays anchored to the image target (local position and rotation stay constant)
        if (parentTarget != null)
        {
            transform.localPosition = transform.localPosition; // Optional: can clamp here if drifting
            transform.localRotation = Quaternion.identity;
        }

        if (Input.touchCount == 2)
        {
            Touch touch0 = Input.GetTouch(0);
            Touch touch1 = Input.GetTouch(1);

            Vector2 touch0PrevPos = touch0.position - touch0.deltaPosition;
            Vector2 touch1PrevPos = touch1.position - touch1.deltaPosition;

            float prevMagnitude = (touch0PrevPos - touch1PrevPos).magnitude;
            float currentMagnitude = (touch0.position - touch1.position).magnitude;

            float difference = currentMagnitude - prevMagnitude;

            float scaleFactor = 1 + difference * zoomSpeed;
            Vector3 newScale = transform.localScale * scaleFactor;

            float min = initialScale.x * minScaleFactor;
            float max = initialScale.x * maxScaleFactor;

            newScale.x = Mathf.Clamp(newScale.x, min, max);
            newScale.y = Mathf.Clamp(newScale.y, min, max);
            newScale.z = Mathf.Clamp(newScale.z, min, max);

            transform.localScale = newScale;
        }
    }
}
```

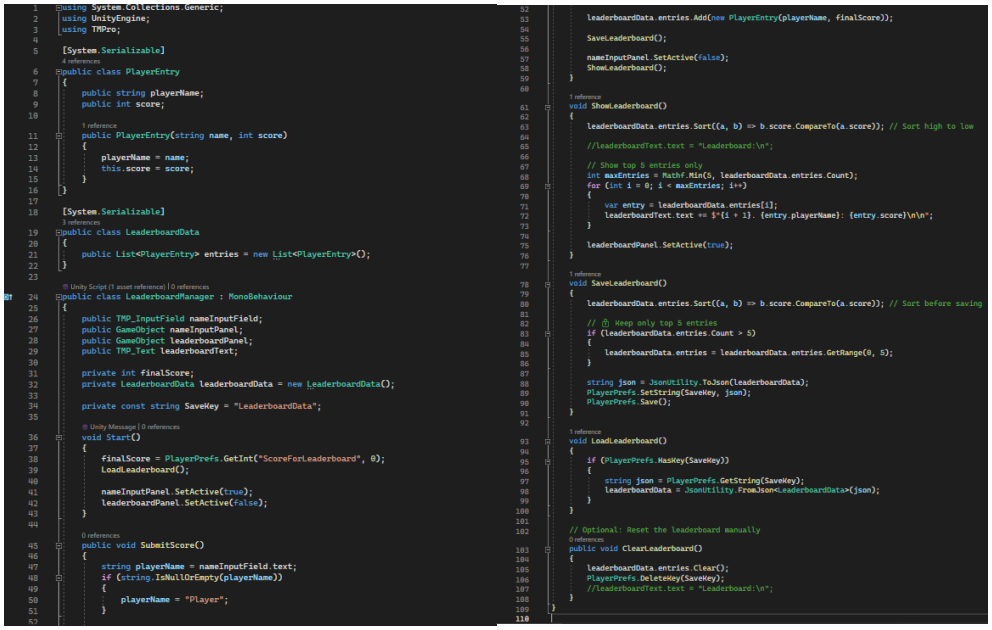
Figure 4.20 *Code for AR Object manipulator*

Based on this Figure 4.20, ARObjectManipulator script is a Unity C# component developed to enable pinch-to-zoom interaction for 3D objects within an augmented reality (AR) application. This functionality is particularly important for improving user experience and engagement, especially in mobile AR environments where touch gestures are commonly used. The script ensures that the object remains anchored to its original image target by maintaining a constant local position and rotation relative to its parent object. This is achieved by capturing the parent transform during the Start() method and continuously updating the object's local position and rotation in the Update() method.

In terms of interaction, the script listens for two-finger touch input to detect pinch gestures. When such input is detected, it calculates the distance between the two touch points both in the current frame and the previous one to

determine whether the user is zooming in or out. Based on the change in distance, a scaling factor is computed and applied to the object's local scale. To maintain control over the zoom level, the script uses predefined minimum and maximum scale limits, ensuring that the object does not become too small or excessively large. The zoomSpeed variable is used to fine-tune the responsiveness of the scaling action. Overall, this script provides an effective method for enabling intuitive interaction with AR content, enhancing both usability and the overall immersive experience of the application.

- **Leaderboard and Exit application**



```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;

Unity Script (1 asset reference) | 0 references
public class ExitApp : MonoBehaviour
{
    0 references
    public void ExitApplication()
    {
        Application.Quit();

#if UNITY_EDITOR
        UnityEditor.EditorApplication.isPlaying = false;
#endif
    }
}
```

Figure 4.21 *Code for Leaderboard and Exit application*

Based on Figure 4.12, it shows script creates a local leaderboard system for an AR educational application, utilising PlayerPrefs for permanent data storage. It allows users to submit their names and final scores from "ScoreForLeaderboard" and shows the top five results. The PlayerEntry class saves

each player's name and score, whereas LeaderboardData keeps track of all entries. After submission, scores are sorted in descending order, and only the top five are saved and shown using TextMeshPro UI components. The script handles input, toggles the leaderboard display, and has an option to clear the leaderboard. This design improves user engagement by offering real-time score monitoring and competitive feedback, which encourages repeat involvement. It is especially appropriate for educational settings where users aged 12 and above may benefit from interactive AR learning.

When invoked, the ExitApp script (Figure 4.21) offers a quick and easy method to end the program, usually through a UI button in a Unity project. ExitApplication(), the only public method it has, calls Application. If the application is operating on a built-in platform, such as Windows or Android, use Quit() to end it. It incorporates a conditional compilation block (#if UNITY_EDITOR) that disables play mode by setting UnityEditor to make sure the feature also functions when development is taking place inside the Unity Editor. Playing to false for EditorApplication. Developers may test the exit feature in the editor without having to create the application thanks to this. The script may be readily integrated into an escape button in the user interface and is helpful in mobile or augmented reality apps when users want a quick method to quit the program.

4.3.10 AR Markers

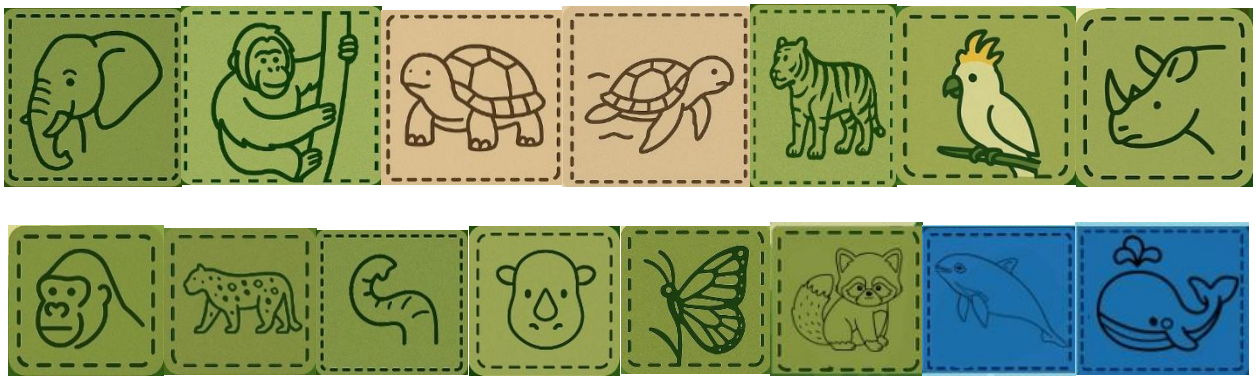


Figure 4.22 *AR Marker for EcoLyfeAR*

ChatGPT's image-generating features were used to create the pictures shown in Figure 4.22. For this project, 15 separate Augmented Reality (AR) models representing various endangered animals were created and included. A distinct picture identifier, produced and saved in the Vuforia database, is linked

to each AR model. Users may activate the associated augmented reality experience by scanning these marks, which operate as visual triggers.

To make the experience more immersive, the AR system will play the sound of the specific animal and display the corresponding 3D animal model when a marker is scanned. The AR interface also offers educational material, such as an interesting fact about the species and a synopsis of the primary reasons for its extinction. By encouraging a deeper knowledge of endangered species and the significance of environmental protection, this interactive method aims to engage people in a more meaningful way.

4.3.11 AR Flashcard Markers

Figure 4.23 *AR Flashcard Marker for EcoLyfeAR*

In Figure 4.23, it shows flashcard marker in the EcoLyfeAR application is designed as an interactive mini quiz game that encourages users to actively engage with environmental content through Augmented Reality (AR). Unlike traditional flashcards, this feature combines physical cards with digital interaction, where users are presented with quiz questions within the app and are required to identify the correct flashcard that corresponds to the answer. Upon scanning the correct flashcard using the AR camera, the app verifies the response and awards a score, promoting a fun and educational experience. This gamified approach not only reinforces knowledge retention but also encourages critical thinking and visual recognition. By integrating AR with a scoring mechanism, the flashcard function transforms passive learning into an immersive and motivating activity, making environmental education more

appealing and effective, particularly for younger users.

4.4 Summary

The EcoLyfeAR mobile application was created primarily to enhance environmental consciousness among users of all ages, with an emphasis on educational value. This chapter covers the tools and platforms utilised during development, such as Unity and Vuforia, as well as the core capabilities included within the application. The final design of the user interface is also shown, with a clean and user-friendly structure for simple navigation. Programming languages like C# are frequently used to teach the concepts behind AR interactions. Finally, the AR markers created to activate environmental material, such as endangered species and habitat environments, are gathered and highlighted.

CHAPTER 5: TESTING AND EVALUATION

5.1 Introduction

This chapter describes the testing and assessment procedure used to assure the functionality, dependability, and efficacy of the EcoLyfeAR application. As a mobile augmented reality (AR) solution developed to raise environmental awareness through interactive booklet and flashcards, it was critical to ensure that the system met its intended goals and performed quickly across several settings. The testing process included both functional and non-functional testing, with a focus on usability, performance, compatibility, and satisfaction among users. The results and feedback were analysed to determine EcoLyfeAR's strengths, limits, and opportunities for growth, ensuring that its users had an engaging and educational experience.

5.2 Application Testing

Application testing was carried out to ensure that all EcoLyfeAR system components worked properly and offered a consistent user experience. The testing was separated into four categories: functional testing, compatibility testing, performance testing, and user acceptance testing. Each test was intended to check certain components of the system, ranging from fundamental functioning to general usability.

5.2.1 Interface Testing

Interface testing ensures seamless functionality across all user interface elements. A user-friendly interface facilitates navigation across a program. The user interface of an application should be simple, easily understood, familiar, responsive, consistent, attractive, and efficient. The task requires users to assess the overall aesthetics of the booklet and application.

5.2.2 Programming Testing

The EcoLyfeAR Mobile Application was developed using the C# programming language. Codes are thoroughly checked to eliminate mistakes and warnings. Testing programming during development is

more efficient as problems can be promptly addressed. To test this, run the program immediately after adding new scripts or features. Unity will issue warnings if it detects errors in the code or application.

5.2.4 Functional Testing

Functional testing focused on ensuring that EcoLyfeAR's key features performed properly. This includes testing.

Flashcard and booklet Recognition: Ensuring that the AR camera correctly recognises each flashcard as well as booklet and displays the appropriate 3D model or video.

- AR Content Display: Ensuring that the relevant 3D object or video displays on the screen and aligns properly with the flashcard and booklet.
- Quiz Feature: Ensures that the quiz is activated following content playing, collects user replies, properly calculates points, and monitors completion time.
- Navigation and user interface: Test all buttons, navigation flows, and screen transitions for responsiveness and usability.

All key features passed the test cases, and any small defects discovered were fixed during the debugging stage.

5.2.4.1 Test Cases

Table 5.1 *Test Case 1*

Module Name: View Start Screen								
Test Objectives: To test if the user can view the Start Screen								
Test ID	Test Case	Input Data	Expected Result	Actual Result	Pass/Fail	Severity of Defect	Summary of Defect	Comments
1	TC- 1	User enter the application	The screen displays the Start screen of the application	The screen displays the Start screen of the application	Pass	None	None	-

Table 5.2 *Test Case 2*

Module Name: View Credit Screen								
Test Objectives: To test if the user can view the Credit screen								
Test ID	Test Case	Input Data	Expected Result	Actual Result	Pass/Fail	Severity of Defect	Summary of Defect	Comments
2	TC-2	User clicks the Credit button	The screen displays the credit screen of the application	The screen displays the credit screen of the application	Pass	None	None	-

Table 5.3 *Test Case 3*

Module Name: View Main Menu								
Test Objectives: To test if the user can view the Main Menu								
Test ID	Test Case	Input Data	Expected Result	Actual Result	Pass/Fail	Severity of Defect	Summary of Defect	Comments
3	TC-3	User clicks the Start button	The screen displays the Main Menu screen of the application	The screen displays the Main Menu screen of the application	Pass	None	None	-

Table 5.4 *Test Case 4*

Module Name: View Tutorial								
Test Objectives: To test if the user can view the Tutorial								
Test ID	Test Case	Input Data	Expected Result	Actual Result	Pass/Fail	Severity of Defect	Summary of Defect	Comments
4	TC-4	User clicks the Tutorial Screen of the application	The screen displays the Tutorial screen of the application	The screen displays the Tutorial screen of the application	Pass	None	None	-

Table 5.5 *Test Case 5*

Module Name: Start Quiz and show leaderboard								
Test Objectives: To test if the user can view and answering the Quiz as well as user can view leaderboard.								
Test ID	Test Case	Input Data	Expected Result	Actual Result	Pass/Fail	Severity of Defect	Summary of Defect	Comments
5	TC-5	User clicks the Quiz button	The screen displays the quiz of the application and users can start answering the quiz and time will start and at the ending scene user will input their name to save their score in the leaderboard.	The screen displays the quiz of the application and users can start answering the quiz and time will start and at the ending scene user will input their name to save their score in the leaderboard.	Pass	None	None	-

Table 5.6 *Test Case 6*

Module Name: Select the correct answer in Quiz								
Test Objectives: To test if the user can select the correct answer in Quiz								
Test ID	Test Case	Input Data	Expected Result	Actual Result	Pass/Fail	Severity of Defect	Summary of Defect	Comments
6	TC-6	User clicks the correct answer in Quiz	The ”Correct” panel is displayed, and score is increased by 40	The ”Correct” panel is displayed, and score is increased by 40	Pass	None	None	-

Table 5.7 *Test Case 7*

Module Name: Select the incorrect answer in Quiz
Test Objectives: To Test if the user can select the incorrect answer in Quiz

Test ID	Test Case	Input Data	Expected Result	Actual Result	Pass/Fail	Severity of Defect	Summary of Defect	Comments
7	TC-7	User clicks the incorrect answer in Quiz	The ”Wrong” panel is displayed, and Score is decreased by 10	The ”Wrong” panel is displayed, and Score is decreased by 10	Pass	None	None	-

Table 5.8 *Test Case 8*

Module Name: Select Settings and adjust volume for BGM and SFX								
Test Objectives: To test if the user can select Settings and adjust volume for BGM and SFX								
Test ID	Test Case	Input Data	Expected Result	Actual Result	Pass/Fail	Severity of Defect	Summary of Defect	Comments
8	TC-8	User clicks the Settings button	Settings screen is displayed, and users can adjust the volume for BGM and SFX	Settings screen is displayed, and users can adjust the volume for BGM and SFX	Pass	None	None	-

Table 5.9 *Test Case 9*

Module Name: Scan using AR Booklet Option								
Test Objectives: To test if the 3D object, video AR and description appear with animal sound								
Test ID	Test Case	Input Data	Expected Result	Actual Result	Pass/Fail	Severity of Defect	Summary of Defect	Comments
9	TC-9	User clicks the AR booklet button	AR function will work by appearing 3D object with description and animal	AR function will work by appearing 3D object with description and animal	Pass	None	None	-

			sound and video will play at certain images	sound and video will play at certain images				

Table 5.10 *Test Case 10*

Module Name: AR can zoom in and out								
Test Objectives: To test if the 3D object can zoom in and out								
Test ID	Test Case	Input Data	Expected Result	Actual Result	Pass/Fail	Severity of Defect	Summary of Defect	Comments
10	TC-10	User pinch the 3D object to zoom in and out	3D object can Zoom in and out	3D object can Zoom in and out	Pass	None	None	-

Table 5.11 *Test Case 11*

Module Name: Select AR Flashcard								
Test Objectives: To test if the user can scan and play the mini games								
Test ID	Test Case	Input Data	Expected Result	Actual Result	Pass/Fail	Severity of Defect	Summary of Defect	Comments
11	TC-11	User will scan the flashcard	User can scan the flashcard and will gain score and 3D object will appear	User can scan the flashcard and will gain score and 3D object will appear	Pass	None	None	-

Table 5.12 *Test Case 12*

Module Name: Exit the Application								
Test Objectives: To test if the user can exit the application								
Test ID	Test Case	Input Data	Expected Result	Actual Result	Pass/Fail	Severity of Defect	Summary of Defect	Comments

12	TC-12	User clicks Exit button in the Start screen	The application close	The application close	Pass	None	None	-

5.3 Usability Testing

A usability survey based on System Usability Scale (SUS) is created with Google Form (refer to appendix C). A total of 42 respondents tested the application and fill in the survey afterwards. The process of user testing is carried out throughout the span of a week (2nd June – 7th June 2025) to evaluate the usability and functionality of the EcoLyfeAR mobile application, booklet and flashcard. The downloadable contents and links for the project was published on the Itch.io platform. Both links for the Itch.io and survey are distributed to the public on WhatsApp, Facebook, X and Instagram for online user testing while physical user testing are conducted individually by meeting in person (refer to Appendix D).

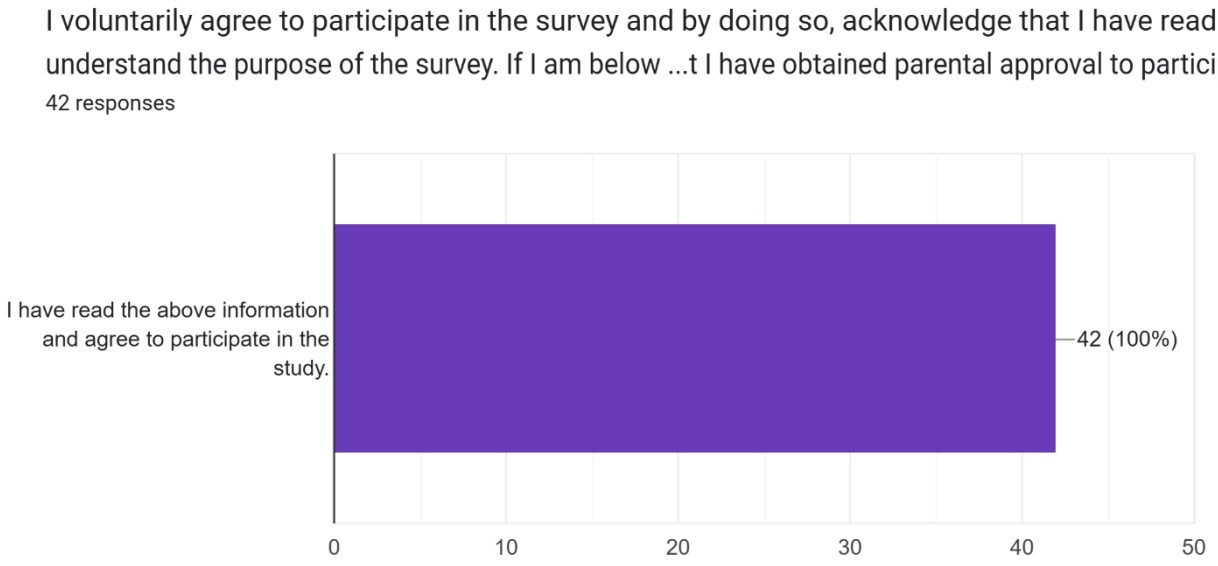


Figure 5.1 *Respondent's consent*

Figure 5.1 illustrates the consent status of the respondents who participated in the usability testing of the EcoLyfeAR application, booklet, and flashcards. Prior to completing the survey, all participants were required to provide informed consent, ensuring that they voluntarily agreed to participate and understood

the purpose of the study. The consent was obtained through a pre-survey section embedded in the Google Form. As shown in the figure, 100% of the respondents provided their consent to participate in the evaluation. This step was crucial in maintaining ethical research standards and protecting participant rights throughout the user testing process.

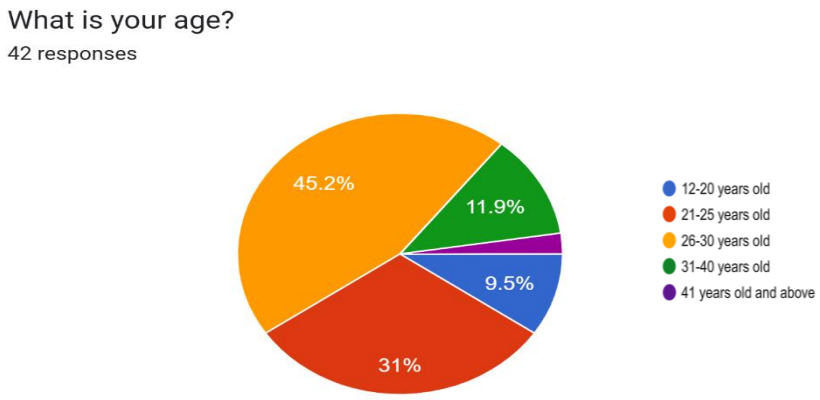


Figure 5.2 *Respondent's age*

The pie chart in Figure 5.2 illustrates the age distribution of 42 survey respondents in five age categories. The largest group, with 45.2% of the participants, is between the ages of 26 and 30, with 31% aged 21 to 25. Respondents aged 31-40 years account for 11.9%, while those aged 12-20 years make up 9.5%. The smallest category, 41 and older, accounts for a modest proportion of responders. This distribution indicates that the bulk of users that interact with the survey or application are in their mid-20s to early 30s, demonstrating a significant interest from young adults in this demographic.

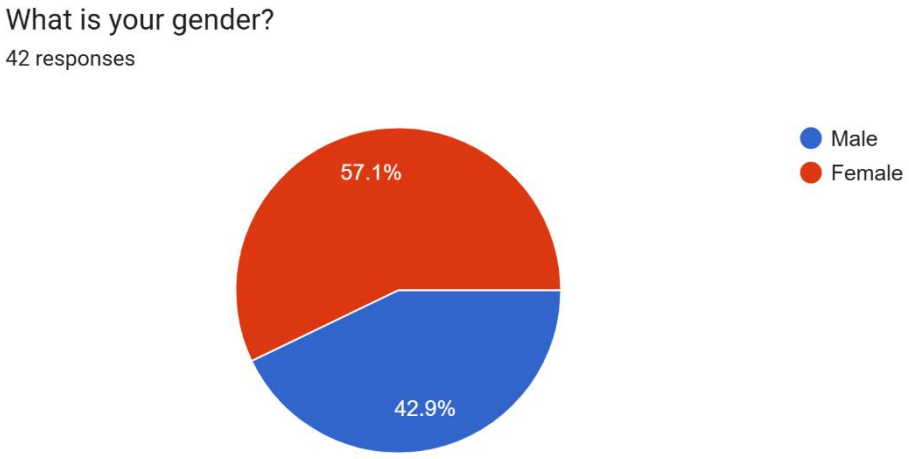


Figure 5.3 *Respondent's gender*

Figure 5.3 illustrates the gender distribution of the 42 respondents who participated in the user testing of the EcoLyfeAR application. Based on the chart, 57.1% of the respondents identified as female, while 42.9% identified as male. This shows a higher participation rate among female users during the usability evaluation. Including users of both genders in the testing process ensures that the feedback gathered reflects a broader range of user experiences, preferences, and interaction patterns. This gender distribution contributes to assessing the inclusivity of the application's interface, content, and overall usability across different user demographics.

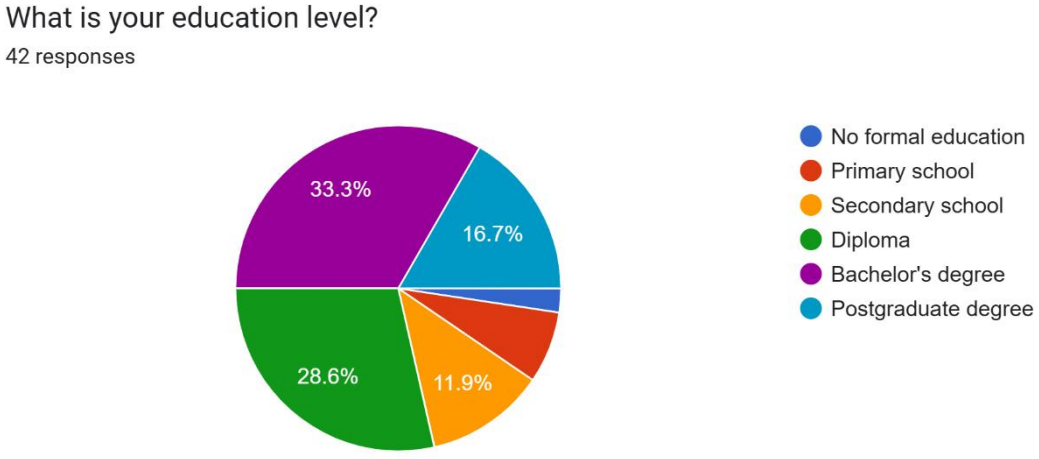


Figure 5.4 *Respondent's education level*

The survey respondents' educational attainment is shown in Figure 5.4. The data shows that degree-level students made up the biggest percentage of responders, at 33.3%. After that, 28.6% of respondents had a diploma, 16.7% had a postgraduate degree, and 11.9% had completed secondary school. This suggests that most users have a background in higher education, which is in line with EcoLyfeAR's target market, which consists of people who are somewhat environmentally and digitally literate. Feedback on the app's educational impact, UI navigation, and difficulty of material may be interpreted with the help of this demographic profile.

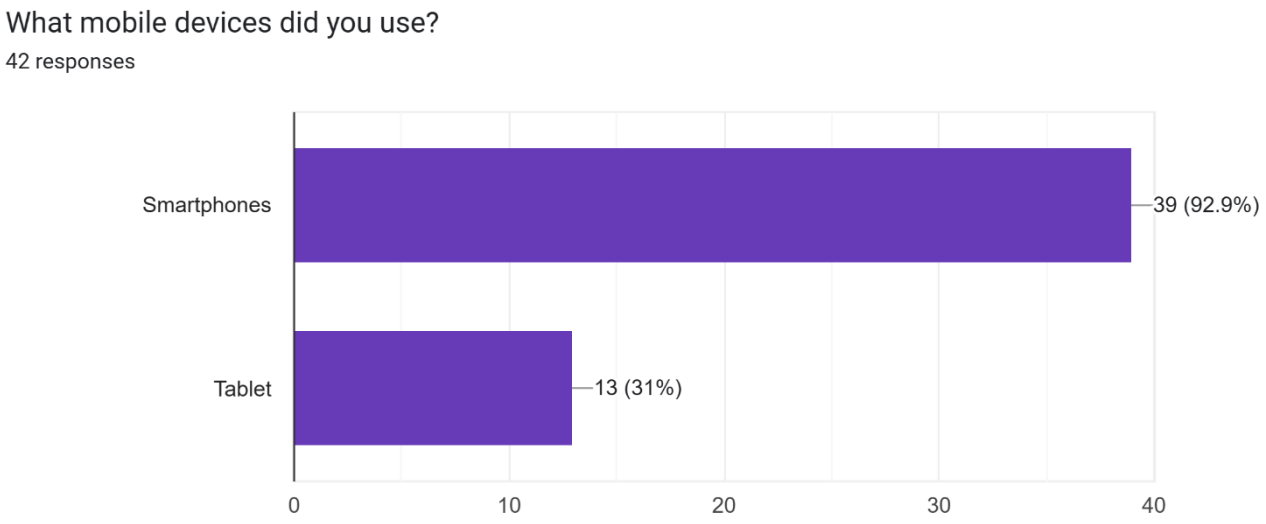


Figure 5.5 *Respondent's mobile type*

Respondents' mobile device types during the EcoLyfeAR application testing are shown in Figure 5.5. Only 31% of respondents utilised tablets (13 respondent), compared to 92.9% (39 respondent) who used smartphones, according to the statistics. According to this survey, users like and can access the application most easily on smartphones, which makes them the main device used to engage with it. Because of this, the app should be largely optimised for smartphone use, with screen responsiveness, interface design, and augmented reality features adapted to smaller devices. Tablet support is still

helpful, but according to customer preferences, it is not the primary issue.

Interface of EcoLyfeAR

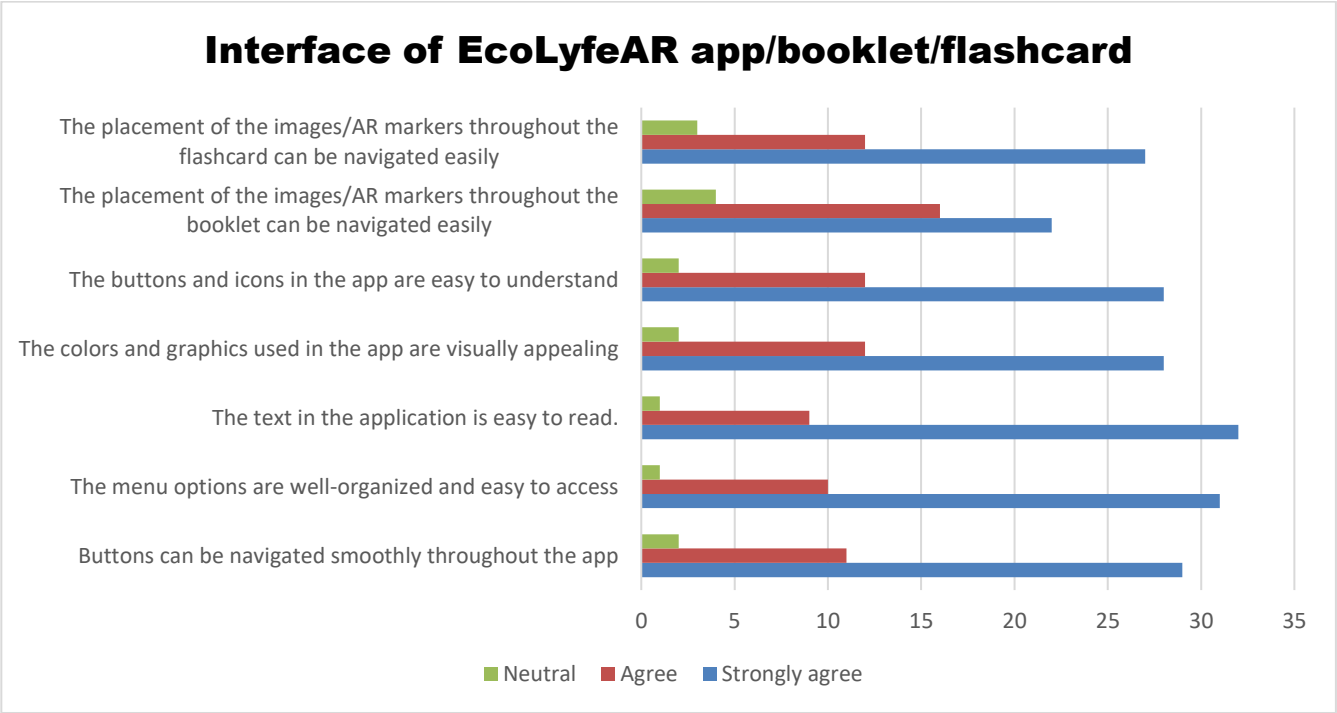


Figure 5.6 *Interface of EcoLyfeAR app/booklet/flashcard*

Respondents' responses on the EcoLyfeAR app, booklet, and flashcard's interface design are shown in Figure 5.6. According to the study, the majority of users thought the interface was very visually appealing and easy to use. A sizable portion of respondents firmly agreed that the application's text is readable and that its buttons and icons are simple and easy to use. The assertion of a seamless navigation experience was further supported by the description of the menu selections as being well-structured and easily accessible.

Although some users chose "Agree" instead of "Strongly Agree," the comments were nonetheless favourable regarding the positioning and visibility of AR markers in the booklet and flashcards. This might indicate that although the implementation is largely successful, there might be a few little details that could be improved, such the placement of the markers or instructions for scanning. Overall, the results in this area show that users are highly satisfied with the EcoLyfeAR system's interface elements in all forms, highlighting its usability and clarity.

Functionality of EcoLyfeAR

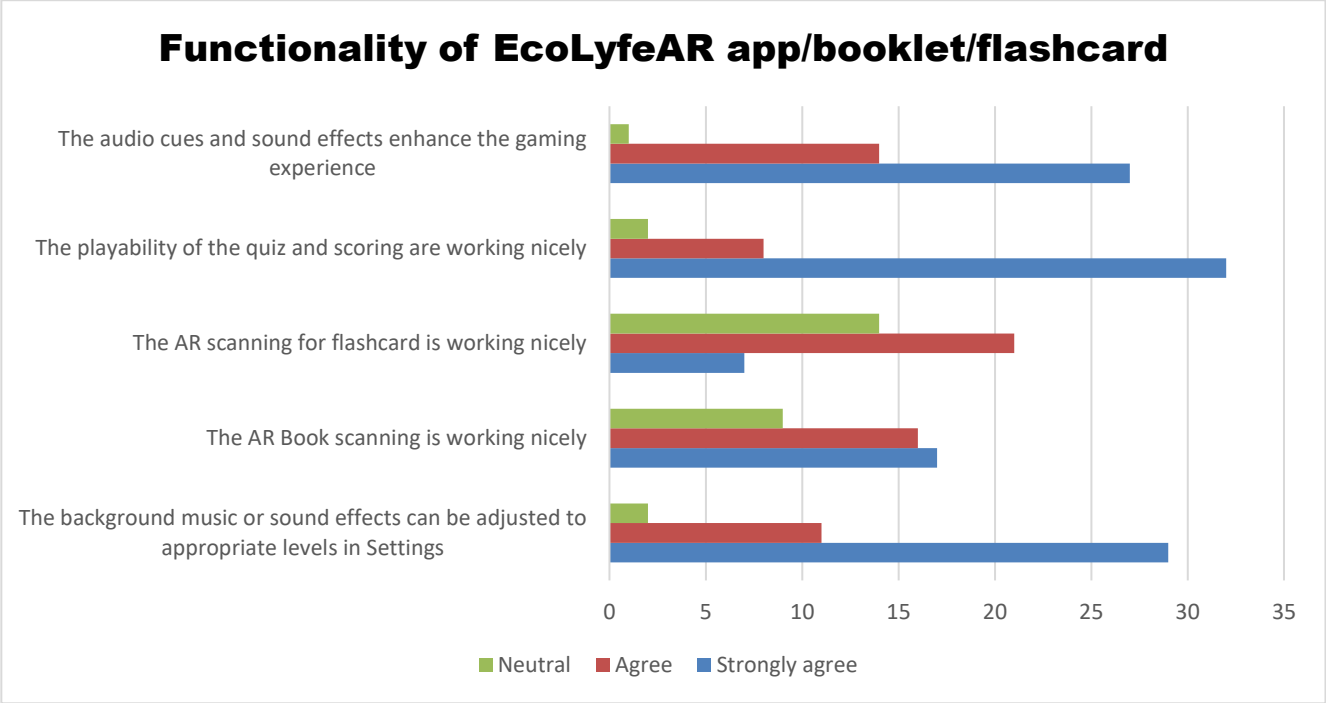


Figure 5.7 *Functionality of EcoLyfeAR app/booklet/flashcard*

Figure 5.7 illustrates the user feedback regarding the functionality of the EcoLyfeAR application, booklet, and flashcards. The chart measures user responses across five key functional aspects, categorized into three levels of agreement: *Neutral*, *Agree*, and *Strongly Agree*. The results indicate that a significant majority of users *strongly agreed* that the core functionalities of the application are working effectively. Specifically, the highest agreement level was observed for "The playability of the quiz and scoring are working nicely" and "The background music or sound effects can be adjusted to appropriate levels in Settings," each receiving nearly 30 responses marked as *Strongly Agree*. Similarly, "The audio cues and sound effects enhance the gaming experience" also received high ratings, reinforcing the importance of audio elements in enhancing user engagement.

The AR-related functionalities showed slightly more varied responses. While "The AR Book scanning is working nicely" had a balanced distribution with a majority in *Strongly Agree* and a considerable number in *Agree*, the response to "The AR scanning for flashcard is working nicely"

showed a higher proportion of *Agree* and *Neutral* responses, suggesting some users may have encountered minor issues or inconsistencies with this feature.

Overall, the chart reflects a positive reception towards the functionality of the EcoLyfeAR components, with most users expressing high satisfaction, particularly in areas related to audio and interactive quiz elements. However, the responses also highlight opportunities for refinement in the flashcard scanning experience to ensure consistent performance.

Overall experience of EcoLyfeAR

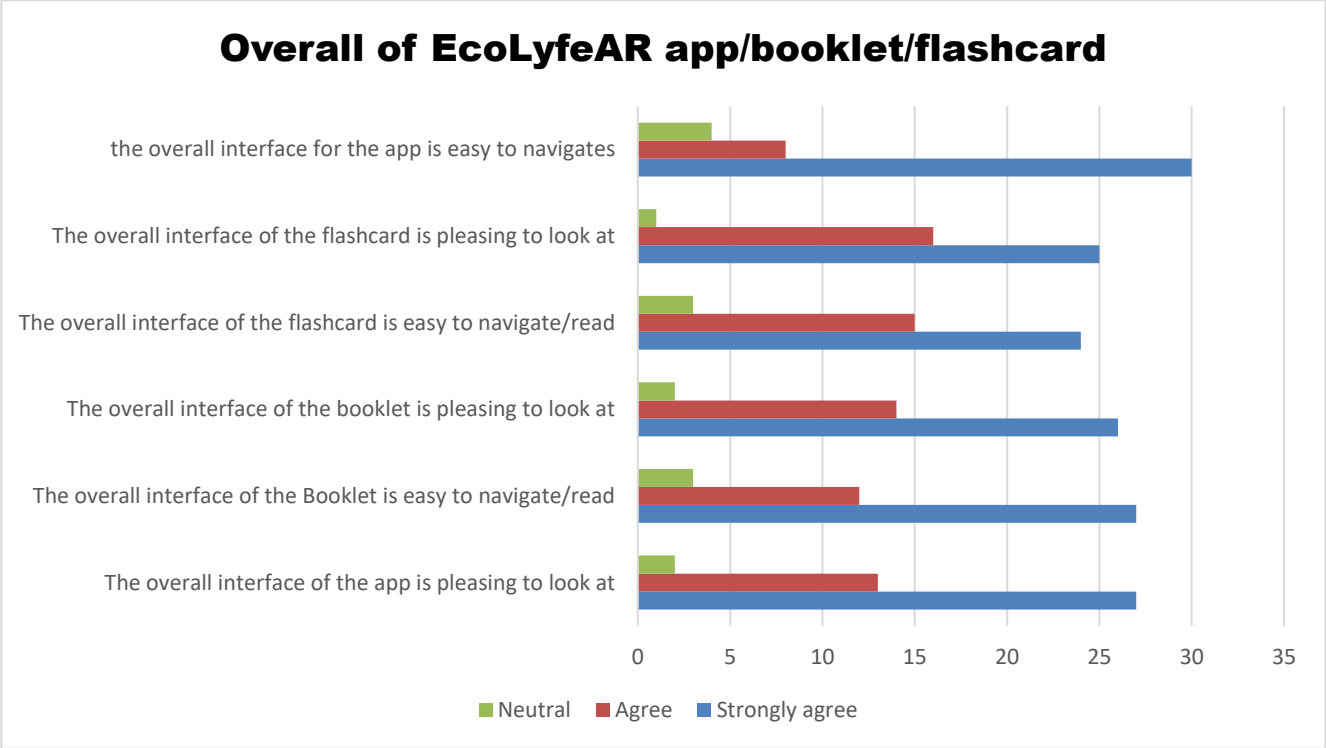


Figure 5.8 *Overall experience of EcoLyfeAR app/booklet/flashcard*

A quick overview of the EcoLyfeAR application, booklet, and flashcard user experience is shown in Figure 5.8. With nearly all of participants strongly agreeing that the interface was simple to use and comprehend for all three components, responses were overwhelmingly positive. Users had a smooth and delightful experience because to the digital app's and printed materials' consistent design and usability.

The booklet and flashcard interfaces improved respondents' learning and engagement since they were simple and easy to use. The findings show that the EcoLyfeAR system effectively provides a seamless and approachable experience, promoting environmental consciousness via interactive and

intuitive design. The efficacy of the project's overall experience is further supported by the small percentage of indifferent or unfavourable comments.

Perception on EcoLyfeAR

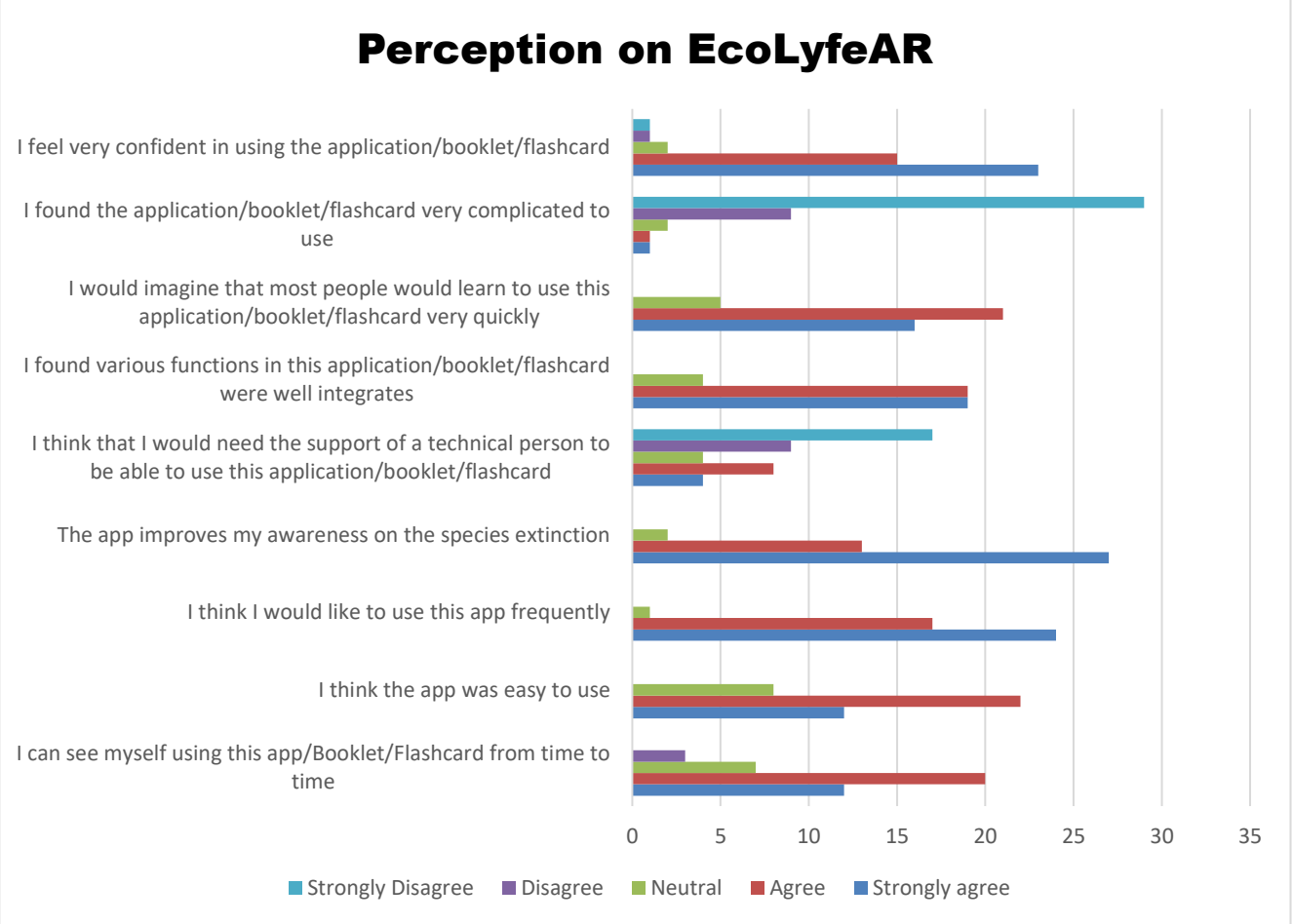


Figure 5.9 *Perception of EcoLyfeAR app/booklet/flashcard*

Based on a number of usability and efficacy criteria, users' opinions on the EcoLyfeAR application, booklet, and flashcard are shown in Figure 5.9. Most respondents were confident in their ability to utilise the tools, and many agreed or strongly agreed that they were simple to use and didn't require technical assistance. This shows how easy it is to use and how widely available the system is. The majority of users also said that the application's features were well-integrated and that others could pick it up fast, highlighting its user-friendly layout. Strong agreement was also expressed on the app's perceived ease of use, which supports the idea that EcoLyfeAR provides a seamless user experience.

Users recognised the EcoLyfeAR products' educational value in addition to their usability, particularly in terms of increasing awareness of species extinction. Significantly more respondents

firmly agreed that the app raised their level of awareness of this problem. Additionally, several participants expressed that they could imagine themselves sometimes utilising the program, indicating a positive propensity towards continuing and regular use. According to these results, EcoLyfeAR not only satisfies functional requirements but also successfully involves users in environmental learning and promotes frequent engagement.

A. Application Usability Testing

The System Usability Scale (SUS) was employed to evaluate the usability and user experience of the EcoLyfeAR application. A total of 42 participants took part in the usability testing after using the app. Each participant responded to the standard 10-item SUS questionnaire to reflect their perceptions of the system's ease of use and overall satisfaction. Table 5.13 below presents the descriptive statistics of the SUS scores collected from the participants. The average SUS score recorded was 68.10, indicating a generally acceptable level of usability. The standard deviation of 14.13 suggests moderate variability in user responses. The lowest score obtained was 45.00, while the highest was 85.00, reflecting a range of user experiences from below average to very positive perceptions of the app's usability.

Table 5.13: *Descriptive statistics of the SUS scores: EcoLyfeAR apps*

Statistic	Value
Count (Number of respondents)	42
Mean SUS Score	68.10
Standard Deviation	14.13
Minimum Score	45.00
Maximum Score	85.00

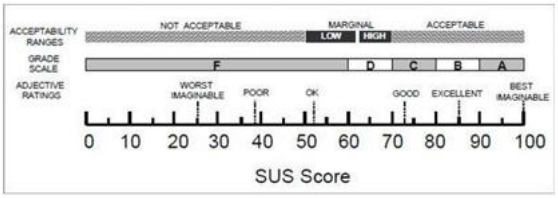


Figure 5.10: *Adjective Rating (Bangor, Kortum, & Miller, 2009).*

According to Bangor et al.'s (2009) SUS adjective rating scale as shown in Figure 7, a score of **68.10** falls within the **"Good"** usability category, suggesting that the application is generally well-accepted by users. The data distribution across SUS categories is shown in Table 5.14.

Table 5.14: *US Adjective Rating and Score*

SUS Adjective Rating	Score Range	Count
Excellent	> 80.3	9
Good	68 – 80.3	20
Poor	51 – 68	5
Awful	< 51	8
Okay	68	0

As shown in Table 5.14, 69% of respondents evaluated the system as Good or Excellent, indicating its efficacy and usefulness for the intended audience. Table 5.14 displays the SUS adjective ratings categorized by score ranges for the EcoLyfeAR application. Out of 42 respondents, 9 rated the app as "Excellent" with scores above 80.3, while 20 respondents considered it "Good" within the 68–80.3 range. A total of 5 participants rated the app as "Poor" (scores between 51 and 68), and 8 rated it as "Awful" with scores below 51. Notably, no respondents selected the "Okay" rating, which corresponds to a score of exactly 68. This distribution suggests a generally favorable perception of the app's usability, though there remains a portion of users with negative experiences.

Pre and Post Quiz Score

Table 5.15 *Pre and Post Quiz score*

Respondent	Pretest quiz result (total Score)	Posttest quiz result (Total score)
1	80	150
2	20	50

3	90	120
4	80	130
5	40	60
6	80	170
7	100	180
8	60	110
9	130	170
10	120	200
11	100	180
12	120	180
13	90	200
14	50	170
15	50	180
16	80	200
17	60	110
18	100	180
19	70	190
20	10	100
21	50	140
22	70	150
23	90	140
24	150	200
25	130	180
26	130	200
27	70	190
28	100	160

29	150	190
30	80	180
31	130	190
32	30	150
33	160	200
34	120	200
35	40	180
36	60	200
37	80	170
38	110	160
39	30	200
40	150	200
41	80	200
42	120	180

Using the results of the participants' pretest and post-test quizzes as shown in Table 5.15, a hypothesis test was carried out to determine how well the EcoLyfeAR application enhanced environmental knowledge. The purpose of the test was to determine whether scores before and after utilising the application, booklet, and flashcard differed in a way that was statistically significant. The activity had no effect on learning outcomes, according to the null hypothesis (H_0), which predicted that mean scores would not change significantly. The alternative hypothesis (H_1), on the other hand, predicted that the pretest and post-test scores would change significantly, suggesting that the EcoLyfeAR learning resources enhanced knowledge.

Since it may be used to compare the performance of the same group before and after an intervention, a paired sample t-test was used for this investigation. The null hypothesis would be rejected in favour of the alternative, indicating that the change in scores is statistically significant, if the test's p-

value was less than the conventional significance level of 0.05. This approach makes it possible to determine objectively if the observed score increases are the result of the EcoLyfeAR tools or are just the result of chance.

t-Test: Paired Two Sample for Means

	Pretest quiz result (total Score)	*Posttest quiz result (Total score)*
Mean	87.14285714	166.4285714
Variance	1440.418118	1408.885017
Observations	42	42
Pearson Correlation	0.559373908	
Hypothesized Mean Difference	0	
df	41	
t Stat	-14.50101072	
P(T<=t) one-tail	4.8692E-18	
t Critical one-tail	1.682878002	
P(T<=t) two-tail	9.7384E-18	
t Critical two-tail	2.01954097	

Figure 5.11 *Paired sample t-test*

Based on Figure 5.11, 42 participants' pre-test and post-test quiz scores were compared using a paired sample t-test, and the findings show a statistically significant increase in knowledge following use of the EcoLyfeAR application. The mean post-test score rose significantly to 166.43 from the mean pretest score of 87.14. Similar variances in the pretest (1440.42) and post-test (1408.89) scores, as well as a somewhat positive Pearson correlation of 0.559 between the two sets of scores, were seen in conjunction with this improvement. With 41 degrees of freedom, the t-statistic was determined to be -14.50, and the two-tailed p-value was 9.74×10^{-18}, both of which are far lower than the generally recognised alpha threshold of 0.05.

We reject the null hypothesis and come to the conclusion that there is a significant difference between the pretest and post-test scores since the t-statistic is greater than the crucial value (±2.02) and the p-value is incredibly tiny. These findings offer strong proof that users' environmental knowledge on species extinction is much improved by the EcoLyfeAR app, booklet, and flashcards. The observed rise

in scores indicates that the instructional goal was successfully satisfied by the learning resources, supporting EcoLyfeAR's usage as a powerful tool for raising environmental awareness on species extinction and comprehension.

Figure 5.12 *Respondent's feedback for Quiz*

According to Figure 5.12, "Yes" responses from all responders to the question, "Did the quiz help you learn about species extinction?" are particularly noteworthy from the user comments. This unanimous reaction demonstrates the EcoLyfeAR application's powerful educational impact. It suggests that each participant thought the quiz element successfully advanced their knowledge of species extinction, which is one of the platform's main goals. This outcome not only shows how well interactive technologies can increase environmental awareness, but it also shows how well EcoLyfeAR can provide instructional information that is impactful, clear, and engaging. The consistent consensus among all participants indicates that the test was informative, well-designed, and usable by a wide range of users, making it a dependable way to impart important conservation information.

Respondents Feedback and suggestions for EcoLyfeAR

Table 5.16 *Respondent's Suggestion*

Suggestions
Tambah hint untuk quiz
Make instruction how to use before play the flashcard
Make more animal and environmental issue for flashcard
Add leaderboard for both quiz and flashcard

Add hint for hard question
Maybe can add leaderboard for the quiz
Tambah jawapan apabila sudah menjawab
Add leaderboard to make it more interactive
Add other species like engdangered plants
More picture of real life animal
Show bgm for AR flashcard
Can include summary quiz at the end
Please fix tne volume settings apply it for quiz bgm so that it can adjust too
Add more videos AR and add puzzle game like that
Can add more music for flashcard AR
Add more fun fames
Add more colors for booklet
Add more AR function for the apps to make more interactive
Give answer feedback after answering the question
Add more flashcard
Add animal more or plant for the app
Add more visual
Add more videos AR
Make more visually appealing for booklet

Based on the data shown in Table 5.16, respondents made a variety of helpful comments targeted at improving the overall functioning and educational impact of the EcoLyfeAR application. A common proposal was to include more diverse topics, especially animal species and environmental challenges, in order to extend the breadth of learning. Participants also suggested adding a leaderboard function to both quizzes and flashcards to increase user engagement through gamification. More hard quiz questions, as well as the chance to examine a summary of results after completing the quiz, were commonly requested. Several respondents emphasised the necessity of having clear instructions before using the flashcards, suggesting that assistance might increase ease of use, particularly for first-time users. Users also

suggested adding AR-based mini-games, new music tracks, visual effects, and animation features to improve the learning experience. Visual changes to the accompanying brochure, such as the use of more brilliant colours, were also recommended. Concerns about audio playing inconsistencies prompted recommendations for changeable volume settings. These proposals together reflect a desire for a more dynamic, user-friendly, and content-rich application that appeals to a broader audience.

Table 5.17 *Respondent's Feedback*

Feedbacks
More interaction for AR
Fun to play this app
Very good application for awareness :)
Its a good application :)
I think this app can help spread awarenees on species awareness
Cute app well done
This app amaze me a lot
Good job
Good can add more games
So far okay just the volume some music loud and some is not
Good
I love this apps
Great user imterface and user experience
Ilike this apps it improve my awareness on species extinction
So far no comment but this app are well made

As indicated in Table 5.17, respondents had a generally good view of the EcoLyfeAR application. Many users acknowledged pleasure with the app's educational goals, notably its capacity to raise awareness about species extinction in an interesting and participatory way. Respondents praised the program as fun, well-designed, and successful at boosting environmental awareness. Positive

remarks like "very good application for awareness" and "great user design and user experience" emphasise the app's ability to communicate its intended message. Users particularly praised the inventive use of augmented reality, which added to the overall attractiveness of the material. However, a few areas of improvement were discovered. Some responders observed discrepancies in audio playback, including substantial loudness differences between flashcards and recommending modifications to ensure audio balance. A minority of users advised increasing the app's functionality to include more games and music to enhance engagement. Despite these small limitations, the bulk of responses emphasised the app's worth as an instructional tool and its potential for future improvement. The findings confirm that EcoLyfeAR is both well-received and effective, with user input acting as the basis for incremental improvement.

5.4 Summary

This chapter focusses on the process of evaluating the EcoLyfeAR application's functionality, usability, and educational efficacy. Testing was conducted in four primary areas: interface, programming, functional, and usability testing. Interface testing evaluated the application's design and navigation, while programming testing verified that the code was error-free. All important elements were proven through functional testing, including AR marker identification, quiz functionality, flashcard scanning, and the presentation of 3D information and films. A total of 12 test cases were described, and all of them passed without error.

The usability assessment includes 42 people who completed the System Usability Scale (SUS) survey between June 2 and 7, 2025. Respondents ranged in age and gender, with the findings indicating great involvement and satisfaction. A paired sample t-test was performed to compare pre- and post-test quiz results, which revealed a substantial gain in knowledge after using the application. The app was found to be educationally beneficial, with a mean pre-test score of 87.14 and a post-test score of 166.43 (p-value < 0.05).

Feedback emphasised visual attractiveness, interesting AR elements, and instructional value. Suggestions for improvement included adding additional AR material, improving audio consistency,

establishing a the scoreboard, and integrating more mini-games and difficult quiz questions. Overall, the findings show that EcoLyfeAR is a useful, interesting, and effective learning tool for raising awareness about species extinctions.

CHAPTER 6: CONCLUSION AND FUTURE WORKS

6.1 Introduction

This chapter wraps up the development and assessment of EcoLyfeAR, an augmented reality-based educational application that uses booklet and interactive flashcards to promote environmental awareness. The chapter summarises the project's primary outcomes, stressing its strengths and usefulness to users. It also identifies possible areas for development and recommends future additions to increase the application's functionality, usability, and effect. These observations are based on the testing and user feedback results from the previous section.

6.2 Achievements

The development and deployment of EcoLyfeAR successfully met the primary objectives outlined at the beginning of the project. The achievements are as follows:

No.	Objectives	Achievements
1.	To design an AR-enhanced booklet with EcoLyfeAR that shows real-time environmental effects that lead to species extinction, making complicated environmental issues accessible and understandable.	An AR-compatible booklet was successfully designed, containing flashcards that visually represent environmental threats such as deforestation, ocean pollution, and climate change. When scanned, each card activates immersive AR content, either a 3D model or a video, clearly illustrating the impact of human activity on species extinction. This visual approach simplified complex environmental concepts,

		making them more relatable and easier for users to understand, especially younger audiences.
2.	To develop EcoLyfeAR's multimodal AR features that enable users to engage with real-time environmental impacts through immersive and interactive content, fostering a deeper understanding of the need for species preservation.	It was accomplished by the incorporation of audio, visual, and spatial aspects into the application. The project used 3D representations of endangered animals, along with educational video narration and background audio, to increase user immersion and provide a multimodal learning experience. Although the AR material did not get real-time updates from environmental data, the carefully chosen situations and images adequately mirrored real-world challenges like as habitat degradation and extinction risks. These elements enabled people to visualise the effects of environmental damage, which strengthened their emotional and cognitive connection to the subject. User comments and testing findings revealed that the

		multimodal experience contributed to a better knowledge of species preservation, suggesting that the goal was attained in both functional and educational areas.
3.	To evaluate the effectiveness of EcoLyfeAR in improving user engagement while enhancing understanding of species extinction.	It was accomplished through the creation and deployment of an interactive AR-based educational tool. Augmented reality was combined with visually appealing information such as 3D animals, video narration, and interactive quizzes to give users with a more immersive and interesting learning experience. The majority of users said the app, flashcards, and booklet were easy to use, visually appealing, and instructive. Feedback from usability and functionality tests revealed that users not only liked engaging with the program, but also got a better understanding of endangered animals and their environments. These results show

		that EcoLyfeAR achieved its goal of enhancing user engagement and successfully communicating knowledge about species extinction in an interactive and accessible fashion.

6.3 Limitations and Constrains

The limitations and constrains of the project that arises during the implementation of the EcoLyfeAR Mobile Application.

Limitations	Comments
The app was optimised for mid-to-high-end Android devices, which limited accessibility for users with older or lower-spec smartphones. Some lag or tracking inaccuracies were observed on devices with low processing power or outdated sensors.	AR performance varied depending on the user's device specifications. Must use newest Android version to get a better result with no lagging.
App is only available for Android platform	This limits accessibility for iOS users, reducing the reach of the app to a broader audience who may use Apple devices.
The application has limited interactive activities, offering only a zooming function for the 3D models and a mini quiz game based on flashcards.	With fewer interactive elements, user engagement may be limited, especially for those seeking a more immersive or dynamic experience. Expanding the range of interactive

	features such as touch-based animations, voice interactions, or additional mini games, could significantly enhance user interest and educational value.

6.4 Future Works

Based on the limits discovered during EcoLyfeAR's, the application should be optimised in the future to support a larger variety of Android devices. The current version works well on mid- to high-end smartphones, which may limit access for those using older or lower-spec handsets. Performance concerns like latency and tracking errors can have a severe impact on the user experience, especially when it comes to AR capabilities. To solve this, future upgrades should prioritise integrating performance scaling tactics such as asset compression, optimised 3D models, and enhanced tracking algorithms to provide consistent performance over a wide range of hardware specifications.

Another significant future aim is to increase platform compatibility by creating an iOS version of the program. Currently, the application is only available to Android users, limiting its reach and potential impact. By supporting iOS devices, the software may reach a larger audience and increase acceptance, particularly among users in educational and environmental awareness settings. Cross-platform compatibility would also be useful for community or institutional deployments in which device types differ greatly.

In terms of interaction, the present program simply has a zooming capability and a flashcard-based mini quiz. While these components provide fundamental engagement, they may not be enough to keep consumers interested over term. Future versions may include more interactive elements such as touch-based animations, sound integration like voice narration, and additional mini-games. These changes would not only boost user engagement, but would also enrich the learning experience by making the information more immersive and interesting, particularly for younger users or non-specialist audiences.

A leaderboard system would also be a useful addition to encourage user engagement and incentive. There is no way to track progress or get competitive feedback in the present edition. A leaderboard might boost replay value and learning retention by promoting healthy competition, rewarding excellent results, and fostering a sense of accomplishment. Finally, the app's accessibility for users with a variety of languages might be enhanced with multilingual support, which would increase its user base and educational impact.

6.5 Conclusion

This chapter provided a comprehensive overview of the achievements, limitations, and future directions for the EcoLyfeAR project. The application successfully met all its initial objectives, demonstrating the effectiveness of augmented reality as a tool for environmental education. Through engaging, multimodal features and interactive flashcards, users were able to learn about the causes and consequences of species extinction in a more immersive way. However, several limitations were identified, including device compatibility issues, limited content scope, and the absence of features such as audio narration and detailed quiz feedback. Based on these observations, a number of future enhancements have been proposed to improve the user experience, educational impact, and accessibility of EcoLyfeAR.

Overall, EcoLyfeAR lays a strong foundation for the integration of AR technology in educational contexts, particularly for raising awareness about environmental challenges and the importance of species preservation.

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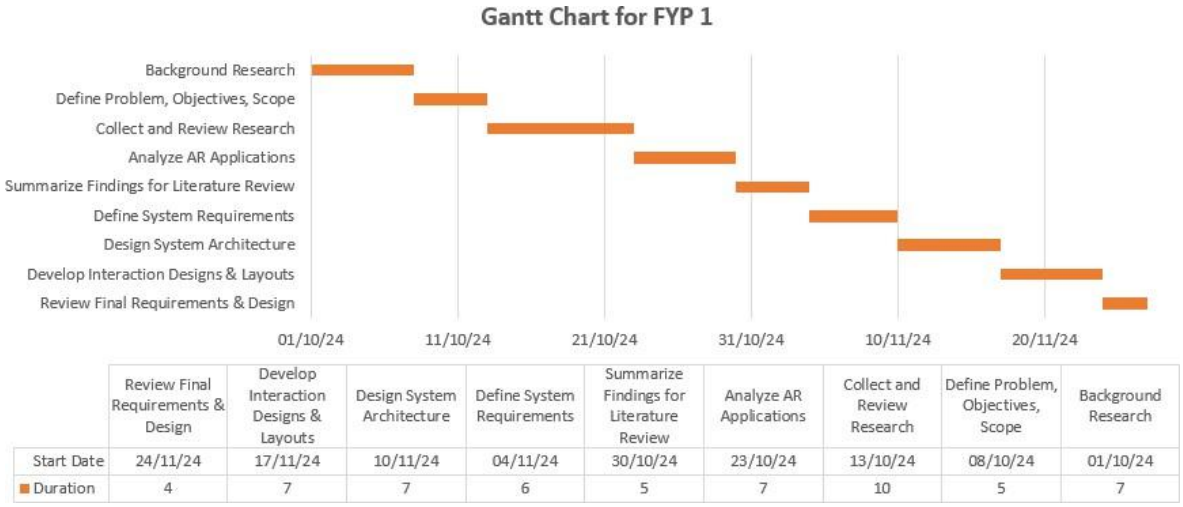
APPENDIX A

Project schedule table for FYP1

Agenda	Date
Submission of the Approved Brief Proposal by Supervisor	14 November 2024
Feedback and Comment from Reviewers	14 November 2024
Submission of Final Full Proposal after amendment	14 November 2024
Submission of Chapter 1	21 November 2024
Submission of Chapter 2	13 December 2024
Submission of Chapter 3	5 January 2024
Submission of FYP 1 Final Report & Paper for assessment	17 January 2025

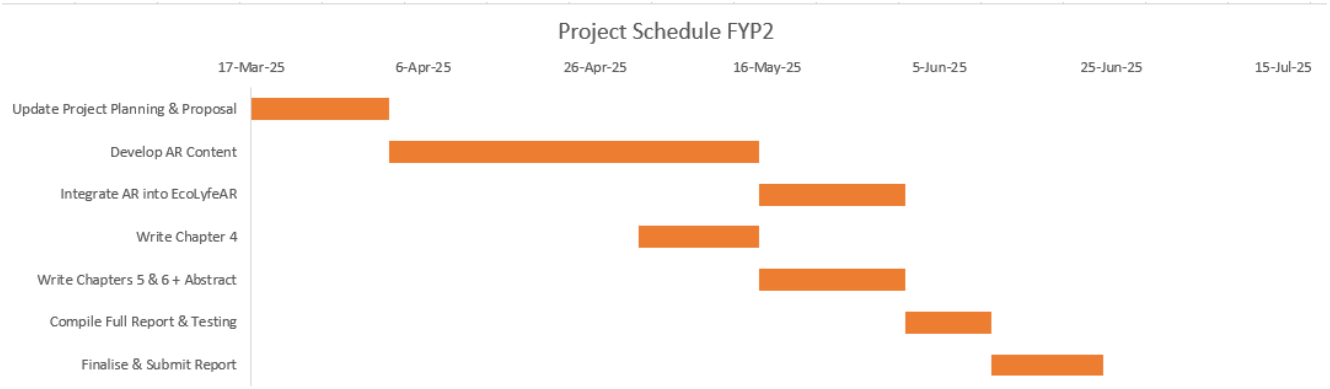
Project schedule table for FYP2

Agenda	Date
Submission of the proposed/revised structure of FYP report, Title and Gantt Chart	1 April 2025
Submission of First Draft for Chapter 4	15 May 2025
Submission of First Draft for Chapter 5, 6 & abstract for paper	31 May 2025
Submission of Draft for FYP2 full report & paper	10 June 2025
Submission of Final Report, Source code, installation kits, user manual & Paper for Assessment	23 June 2025



	Review Final Requirements & Design	Develop Interaction Designs & Layouts	Design System Architecture	Define System Requirements	Summarize Findings for Literature Review	Analyze AR Applications	Collect and Review Research	Define Problem, Objectives, Scope	Background Research
Start Date	24/11/24	17/11/24	10/11/24	04/11/24	30/10/24	23/10/24	13/10/24	08/10/24	01/10/24
Duration	4	7	7	6	5	7	10	5	7

Gantt Chart for Project Schedule FYP 1



	Finalise & Submit Report	Compile Full Report & Testing	Write Chapters 5 & 6 + Abstract	Write Chapter 4	Integrate AR into EcoLyfeAR	Develop AR Content	Update Project Planning & Proposal
Start Date	11-Jun-25	1-Jun-25	15-May-25	1-May-25	15-May-25	2-Apr-25	17-Mar-25
Duration (Days)	13	10	17	14	17	43	16

Gantt Chart for Project Schedule FYP 2

APPENDIX B

Data Collection Materials (Google Form)

EcoLyfeAR: *Immersive Technology for Environmental Education on Species Extinction Survey*

Hi! my name is Mariatul Shamin Binti Mahadar. I am a final year undergraduate student from Multimedia Computing of Faculty of Computer Science and Information Technology (FCSIT), University Malaysia Sarawak (UNIMAS). For your information, the main objective of the project to design an AR-enhanced booklet that shows real-time environmental effects that lead to species extinction, making complicated environmental issues accessible and understandable. Thus, this survey is done to better understand to usability of the mobile application that I Proposed which named EcoLyfeAR.

I would like to invite you to participate in this research project. Your participation is greatly appreciated. There are 5 sections in this survey form which predict that would take about 10 minutes to complete.

Section 1 : Demographics
Section 2 : Awareness and interest in environmental issues
section 3 : Feedback on EcoLyfeAR Concept
section 4 : User Experience and Design
Section 5 : Overall Feedback and Suggestions

The response results will put in writing and presented as part of my project. Please note that the CONFIDENTIALLY of your response is assured. All the information will not be shared and only used for academic purpose.

Your kindly response and time are valuable and most appreciated.

Take care and stay safe. Thank you in advanced.

//

Hai! nama saya Mariatul Shamin Binti Mahadar. Saya merupakan pelajar tahun akhir sarjana muda dari Pengkomputeran Multimedia Fakulti Sains Komputer dan Teknologi Maklumat (FCSIT), Universiti Malaysia Sarawak (UNIMAS). Untuk makluman anda, objektif utama projek untuk mereka bentuk buku kecil yang dipertingkatkan AR yang menunjukkan kesan alam sekitar masa nyata yang membawa kepada kepupusan spesies, menjadikan isu alam sekitar yang rumit boleh diakses dan difahami. Justeru, tinjauan ini dilakukan untuk lebih memahami kebolehgunaan aplikasi mudah alih yang saya Cadangkan yang dinamakan EcoLyfeAR.

Saya ingin menjemput anda untuk mengambil bahagian dalam projek penyelidikan ini. Penyertaan anda amat kami hargai. Terdapat 5 bahagian dalam borang tinjauan ini yang meramalkan bahawa akan mengambil masa kira-kira 10 minit untuk disiapkan.

Bahagian 1 : Demografi

Bahagian 2 : Kesedaran dan Kepentingan dalam Isu Alam Sekitar
Bahagian 3 : Maklum Balas tentang Konsep EcoLyfeAR
Bahagian 4 : Pengalaman Pengguna dan Keutamaan Reka Bentuk
Bahagian 5 : Maklum Balas dan Cadangan Keseluruhan

Keputusan respons akan dimasukkan secara bertulis dan dibentangkan sebagai sebahagian daripada projek saya. Sila ambil perhatian bahawa secara SULIT jawapan anda adalah terjamin. Semua maklumat tidak akan dikongsi dan hanya digunakan untuk tujuan akademik.

Maklum balas dan masa anda adalah berharga dan amat dihargai.

Berhati-hati dan kekal selamat. Terima kasih.

For any enquiries, please email:
Mariatul Shamin Binti Mahadar : 79972@siswa.unimas.my

* Indicates required question

Data Collection Official Letter

Fakulti Sains Komputer dan Teknologi Maklumat

Faculty of Computer Science and Information Technology

UNIMAS/NC-19.03/04-32 Jld. 2 (40)

6 Disember 2024

Kepada Sesiapa Yang Berkenaan

Tuan/Puan

Kerja Lapangan Pelajar Tahun Akhir dari Universiti Malaysia Sarawak
- **Mariatul Shamin binti Mahadar**

Dengan segala hormatnya perkara di atas adalah dirujuk.

Sukacita dimaklumkan bahawa pelajar berikut akan mengumpul maklumat untuk projek beliau.

Berikut adalah butir-butir pelajar:

Nama Penuh	:	Mariatul Shamin binti Mahadar
No. Matrik	:	79972
No. Kad Pengenalan	:	000229130568
Program	:	Pengkomputeran Multimedia
Tahun Pengajian	:	4
Tajuk Projek	:	*EcoLyfeAR : Immersive Technology for Environmental Education on Species Extinction*
Penyelia	:	Ts. Dr Suriati Khartini binti Jali
Emel	:	jskhartini@unimas.my
Telefon	:	082 – 592647

Sehubungan itu, sukacita kiranya pihak tuan/puan dapat memberikan kerjasama kepada pelajar berkenaan untuk menyalurkan maklumat yang diperlukan bagi memenuhi syarat kursus. Segala maklumat yang diperolehi akan hanya digunakan untuk tujuan akademik semata-mata dan akan dijamin kerahsiaannya.

Ini adalah sebagai makluman kepada pihak tuan dan sekiranya ada sebarang pertanyaan, sila hubungi penyelia pelajar tersebut.

Sekian, terima kasih.

Siti Lydiawati binti Sahmat
Penolong Pendaftar Kanan

s.k. - **Timbalan Dekan, Prasiswazah,** FSKTM

1. I have read and understood the statement above. I consent to the use of my information throughout this study *
Saya telah membaca dan memahami kenyataan di atas. Saya bersetuju di atas penggunaan maklumat yang diberikan sepanjang penyelidikan ini

Mark only one oval.

- ◯ Yes

Section 1: Demographics

Please provide your personal information // *Sila sertakan maklumat peribadi anda*

2. 1. What is your age range? *
Apakah julat umur anda?

Mark only one oval.

- ◯ Under 18 years old
- ◯ 18 - 24 years old
- ◯ 25 - 34 years old
- ◯ 35 - 44 years old
- ◯ 45+ years old

3. 2. What is your gender? *
Apakah jantina anda?

Mark only one oval.

- ◯ Male
- ◯ Female

4. 3. What is your highest level of education? *
Apakah tahap pendidikan tertinggi anda?

Mark only one oval.

- ◯ Primary school
- ◯ Secondary school
- ◯ College/University
- ◯ Postgraduate
- ◯ Other: _____

5. 4. Are you familiar with augmented reality (AR) technology? *
Adakah anda biasa dengan teknologi realiti tambahan (AR)?

Mark only one oval.

- ◯ Yes
- ◯ No

6. 5. Have you used AR applications before? *
Adakah anda pernah menggunakan aplikasi AR sebelum ini?

Mark only one oval.

- ◯ Yes
- ◯ No

Section 2: Awareness and Interest in Environmental Issues

7. 6. Are you aware of the issue of species extinction? *
Adakah anda sedar tentang isu kepupusan spesies?

Mark only one oval.

- ◯ Yes
- ◯ No
- ◯ Maybe

8. 7. How important do you think it is to raise awareness about species extinction? *
Pada pendapat anda, sejauh manakah pentingnya untuk meningkatkan kesedaran tentang kepupusan spesies?

Mark only one oval.

	1	2	3	4	5	
Not	◯	◯	◯	◯	◯	Very Important

12. 11. Do you find the idea of combining AR and educational booklets appealing? *
Adakah anda mendapati idea untuk menggabungkan AR dan buku kecil pendidikan menarik?

Mark only one oval.

	1	2	3	4	5	
Not	◯	◯	◯	◯	◯	Very Appealing

13. 12. How effective do you think 3D visualizations are in understanding complex topics like species extinction? *
Pada pendapat anda, sejauh manakah keberkesanan visualisasi 3D dalam memahami topik yang kompleks seperti kepupusan spesies?

Mark only one oval.

	1	2	3	4	5	
Not	◯	◯	◯	◯	◯	Very Effective

14. 13. Would you prefer quizzes or interactive activities as part of the EcoLyfeAR experience? *
Adakah anda lebih suka kuiz atau aktiviti interaktif sebagai sebahagian daripada pengalaman EcoLyfeAR?

Mark only one oval.

- ◯ Quizzes
- ◯ Interactive activities
- ◯ Both
- ◯ Neither

15. 14. Do you think a tool like EcoLyfeAR could inspire you to participate in conservation efforts? *
Adakah anda fikir alat seperti EcoLyfeAR boleh memberi inspirasi kepada anda untuk mengambil bahagian dalam usaha pemuliharaan?

Mark only one oval.

- ◯ Yes
- ◯ No
- ◯ Maybe

16. 15. How likely are you to recommend EcoLyfeAR to others interested in environmental education? *
Sejauh manakah anda mengesyorkan EcoLyfeAR kepada orang lain yang berminat dalam pendidikan alam sekitar?

Mark only one oval.

	1	2	3	4	5	
Unlil	◯	◯	◯	◯	◯	Very likely

Section 4: User Experience and Design Preferences

17. 16. What device do you typically use for educational apps? *
Apakah peranti yang biasa anda gunakan untuk app pendidikan?

Tick all that apply.

- ☐ Smartphone
- ☐ Tablet
- ☐ Laptop/PC
- ☐ Other: _____

18. 17. How important is ease of navigation in educational tools? *
Sejauh manakah pentingnya kemudahan navigasi dalam alatan pendidikan?

Mark only one oval.

	1	2	3	4	5	
Not	◯	◯	◯	◯	◯	Very important

19. 18. What features would make an AR app like EcoLyfeAR more engaging for you? *
Apakah ciri yang akan menjadikan aplikasi AR seperti EcoLyfeAR lebih menarik untuk anda?

Tick all that apply.

- [ ] Detailed 3D models
- [ ] Audio narration
- [ ] Interactive activities
- [ ] Quizzes
- [ ] Other: _____

20. 19. How visually appealing do you think the app's interface needs to be? *
Sejauh manakah anda rasa antara muka app itu perlu menarik secara visual?

Mark only one oval.

- ◯ AR with Quiz
- ◯ AR, Quiz, and Video
- ◯ AR with Gamification Features (Quiz + Points System)
- ◯ AR, Quiz, Video, and Community Section
- ◯ Other: _____

21. 20. Would you prefer the app to offer multiple language options? *
Adakah anda lebih suka apl itu menawarkan pelbagai pilihan bahasa?

Mark only one oval.

- ◯ Yes
- ◯ No
- ◯ Maybe

Section 5: Overall Feedback and Suggestions

22. 21. What topics should EcoLyfeAR focus on besides species extinction? *
Apakah topik yang perlu difokuskan oleh EcoLyfeAR selain kepupusan spesies?

Tick all that apply.

- ☐ Loss of natural habitats due to urbanization
- ☐ The effects of climate change on ecosystems
- ☐ Impact of plastic pollution on wildlife
- ☐ Conservation of endangered plants
- ☐ Other: _____

23. 22. What concerns or challenges do you foresee with using AR for environmental education? *
Apakah kebimbangan atau cabaran yang anda jangkakan dengan menggunakan AR untuk pendidikan alam sekitar?

Tick all that apply.

- ☐ Accessibility to AR-compatible devices
- ☐ Limited content or coverage of topics
- ☐ Difficulty in understanding AR technology
- ☐ Other: _____

24. 23. How do you think EcoLyfeAR could impact environmental education and conservation awareness in this community? *
Pada pendapat anda, bagaimanakah EcoLyfeAR boleh memberi kesan kepada pendidikan alam sekitar dan kesedaran pemuliharaan dalam komuniti ini?

Tick all that apply.

- [ ] Significantly increase awareness and engagement
- [ ] Inspire younger generations to take action
- [ ] Provide an innovative way to understand complex issues
- [ ] Other: _____

25. 24. Do you have any additional feedback or suggestions for you to see in EcoLyfeAR App? *
Adakah anda mempunyai sebarang maklum balas atau cadangan tambahan untuk anda lihat dalam App EcoLyfeAR?

_____

_____

_____

_____

_____

Thank you for taking the time to complete this survey. Your valuable insights and feedback will greatly contribute to the success of my project on ***EcoLyfeAR: Immersive Technology for Environmental Education on Species Extinction***. Your input is deeply appreciated!

take care and have a nice day :)

APPENDIX C

EcoLyfeAR: Immersive Technology for Environmental Education on Species Extinction

Dear respondent,

My name is Mariatul Shamin Binti Mahadar, a final year student of the Faculty of Computer Science and information Technology, University of Malaysia Sarawak. Under the supervision of Dr. Suriati Khartini Binti Jali, I am conducting an evaluation of my AR application, EcoLyfeAR.

The purpose of this survey is to assess the usability and effectiveness of my final year project in raising awareness about Species extinction. Your feedback is invaluable in helping us understand how well the game achieves its goals and how it can be improved.

The AR apps, booklet and flashcards can be accessed on the following links:

click here

You participation involves completing the attached survey, which should take approximately 10-15 minutes of your time. The survey consists of three sections :

Section 1 : Demographics
Section 2 : User Interface Design and User Experience
Section 3 : Application Usability Scale

Please note that your participation is entirely voluntary, and all responses will kept anonymous. The data collected will be used strictly for the purpose of my final year project and will not be shared.

If you are under 18 years old, please ensure that you have obtained parental approval before participating in the survey.

Thank you in advance for your willingness to contribute to this study. Your participation is highly appreciated.

For any enquiries, please email:
Mariatul Shamin Binti Mahadar : 79972@siswa.unimas.my

* Indicates required question

Data Collection Official Letter

Fakulti Sains Komputer dan Teknologi Maklumat

Faculty of Computer Science and Information Technology

UNIMAS/NC-19.03/04-32 Jld. 2 (40)

6 Disember 2024

Kepada Sesiapa Yang Berkenaan

Tuan/Puan

Kerja Lapangan Pelajar Tahun Akhir dari Universiti Malaysia Sarawak
- **Mariatul Shamin binti Mahadar**

Dengan segala hormatnya perkara di atas adalah dirujuk.

Sukacita dimaklumkan bahawa pelajar berikut akan mengumpul maklumat untuk projek beliau.

Berikut adalah butir-butir pelajar:

Nama Penuh	:	Mariatul Shamin binti Mahadar
No. Matrik	:	79972
No. Kad Pengenalan	:	000229130568
Program	:	Pengkomputeran Multimedia
Tahun Pengajian	:	4
Tajuk Projek	:	*EcoLyfeAR : Immersive Technology for Environmental Education on Species Extinction*
Penyelia	:	Ts. Dr Suriati Khartini binti Jali
Emel	:	jskhartini@unimas.my
Telefon	:	082 – 592647

Sehubungan itu, sukacita kiranya pihak tuan/puan dapat memberikan kerjasama kepada pelajar berkenaan untuk menyalurkan maklumat yang diperlukan bagi memenuhi syarat kursus. Segala maklumat yang diperolehi akan hanya digunakan untuk tujuan akademik semata-mata dan akan dijamin kerahsiaannya.

Ini adalah sebagai makluman kepada pihak tuan dan sekiranya ada sebarang pertanyaan, sila hubungi penyelia pelajar tersebut.

Sekian, terima kasih.

Siti Lydiawati binti Sahmat
Penolong Pendaftar Kanan

s.k. - **Timbalan Dekan, Prasiswazah,** FSKTM

1. I voluntarily agree to participate in the survey and by doing so, acknowledge that I have read and understand the purpose of the survey. If I am below 18 years old, I confirm that I have obtained parental approval to participate. *

Tick all that apply.

- [ ] I have read the above information and agree to participate in the study.

Section 1 : Demographics

2. What is your age? *

Mark only one oval.

- ◯ Under 18 years old
- ◯ 18 - 24 years old
- ◯ 25 - 34 years old
- ◯ 35 - 44 years old
- ◯ 45 years old and above

3. What is your gender? *

Mark only one oval.

- ◯ Male
- ◯ Female

4. What is your education level? *

Mark only one oval.

- ◯ No formal education
- ◯ Primary school
- ◯ Secondary school
- ◯ Diploma
- ◯ Bachelor's degree
- ◯ Postgraduate degree

Section 2A : User interface and User Experience for Application

5. What mobile devices did you use? *

Tick all that apply.

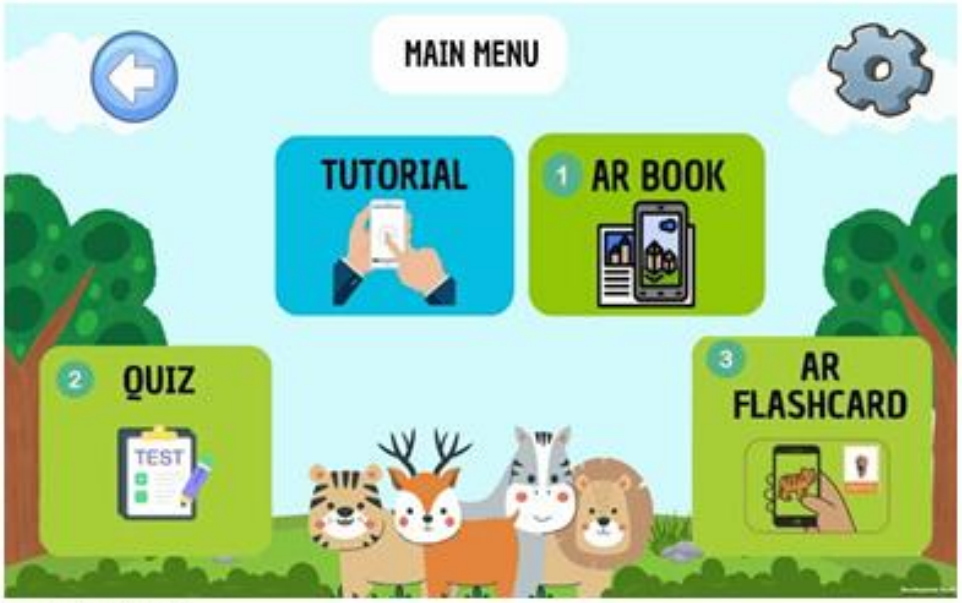
- [ ] Smartphones
- [ ] Tablet
- [ ] Other: _____

6. the overall interface for the app is easy to navigates *

Mark only one oval.

	1	2	3	4	5	
Not	◯	◯	◯	◯	◯	So easy

7. Buttons can be navigated smoothly throughout the app *



Mark only one oval.

	1	2	3	4	5	
Stro	◯	◯	◯	◯	◯	Strongly agree

8. The menu options are well-organized and easy to access *

Mark only one oval.

	1	2	3	4	5	
Stro	◯	◯	◯	◯	◯	Strongly agree

9. The background music or sound effects can be adjusted to appropriate levels in Settings *

Mark only one oval.

	1	2	3	4	5	
Stro	◯	◯	◯	◯	◯	Strongly agree

10. The AR Book scanning is working nicely *

Mark only one oval.

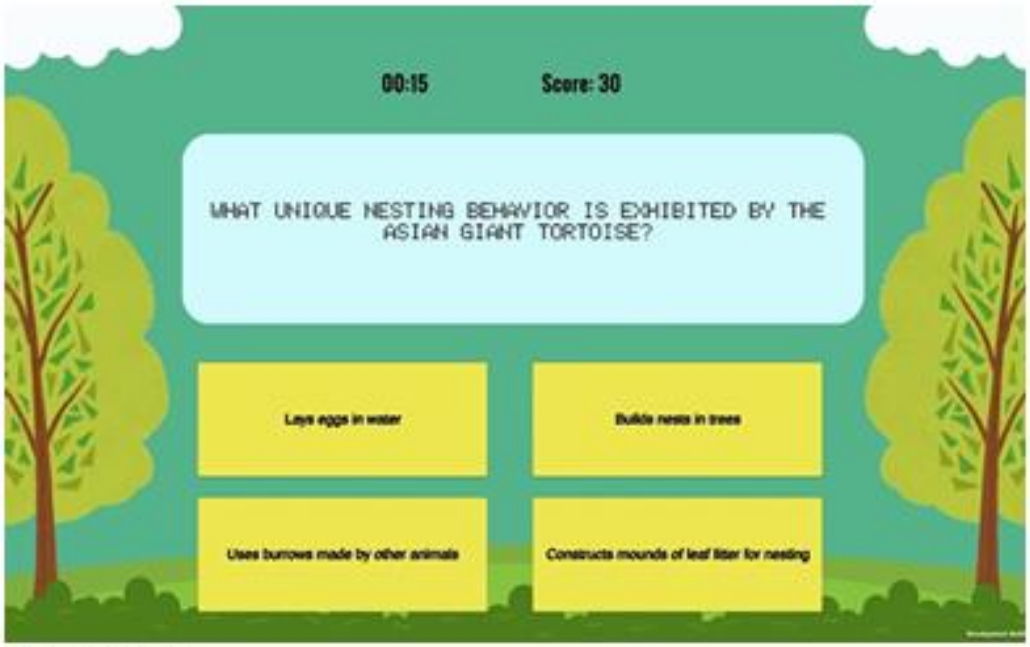
	1	2	3	4	5	
Stro	◯	◯	◯	◯	◯	Strongly agree

11. The AR scanning for flashcard is working nicely *

Mark only one oval.

	1	2	3	4	5	
Stro	◯	◯	◯	◯	◯	Strongly agree

12. The playability of the quiz and scoring are working nicely *



Mark only one oval.

	1	2	3	4	5	
Stro	◯	◯	◯	◯	◯	Strongly agree

13. *

The overall interface of the app is pleasing to look at

Mark only one oval.

	1	2	3	4	5	
Stro	◯	◯	◯	◯	◯	Strongly agree

14. The text in the application is easy to read. *

Mark only one oval.

	1	2	3	4	5	
Stro	◯	◯	◯	◯	◯	Strongly agree

15. The colors and graphics used in the app are visually appealing *

Mark only one oval.

	1	2	3	4	5	
Stro	◯	◯	◯	◯	◯	Strongly agree

16. The buttons and icons in the app are easy to understand *

Mark only one oval.

	1	2	3	4	5	
Stro	◯	◯	◯	◯	◯	Strongly agree

17. The audio cues and sound effects enhance the gaming experience *

Mark only one oval.

	1	2	3	4	5	
Stro	◯	◯	◯	◯	◯	Strongly agree

18. Did the quiz help you learn about species extinction? *

Mark only one oval.

◯ Yes

◯ No

Section 2B : User interface for booklet and flashcard

19. The overall interface of the Booklet is easy to navigate/read *

Mark only one oval.

	1	2	3	4	5	
Stro	◯	◯	◯	◯	◯	Strongly agree

20. The placement of the images/AR markers throughout the booklet can be navigated easily *

Mark only one oval.

	1	2	3	4	5	
Stro	◯	◯	◯	◯	◯	Strongly agree

21. The overall interface of the booklet is pleasing to look at *

Mark only one oval.

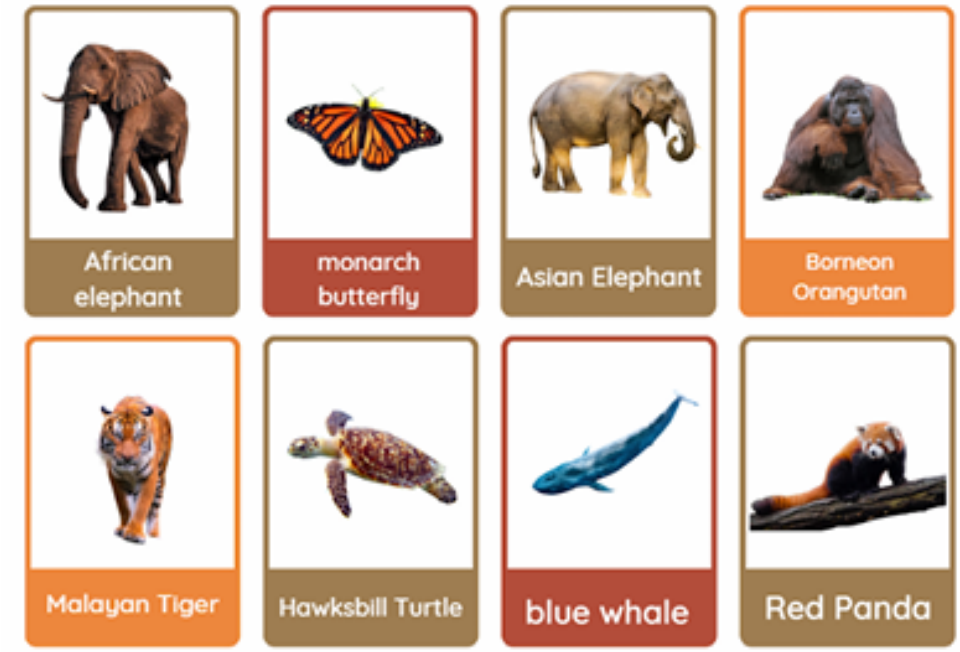
	1	2	3	4	5	
Stro	◯	◯	◯	◯	◯	Strongly agree

22. The overall interface of the flashcard is easy to navigate/read *

Mark only one oval.

	1	2	3	4	5	
Stro	◯	◯	◯	◯	◯	Strongly agree

23. The placement of the images/AR markers throughout the flashcard can be navigated easily *



Mark only one oval.

	1	2	3	4	5	
Stro	◯	◯	◯	◯	◯	Strongly agree

24. The overall interface of the flashcard is pleasing to look at *

Mark only one oval.

	1	2	3	4	5	
Stro	◯	◯	◯	◯	◯	Strongly agree

Section 3 : Usability of the application

25. Pretest quiz result (total Score) *

26. Posttest quiz result (Total score) *

27. I can see myself using this app/Booklet/Flashcard from time to time *

Mark only one oval.

	1	2	3	4	5	
Stro	◯	◯	◯	◯	◯	Strongly agree

28. I think I would like to use this app frequently *

Mark only one oval.

	1	2	3	4	5	
Stro	◯	◯	◯	◯	◯	Strongly agree

29. I think the app was easy to use *

Mark only one oval.

	1	2	3	4	5	
Stro	◯	◯	◯	◯	◯	Strongly agree

30. The app improves my awareness on the species extinction *

Mark only one oval.

	1	2	3	4	5	
Stro	◯	◯	◯	◯	◯	Strongly agree

31. The app, booklet and flashcard are easy to use *

Mark only one oval.

	1	2	3	4	5	
Stro	◯	◯	◯	◯	◯	Strongly agree

32. I think that I would need the support of a technical person to be able to use this application/booklet/flashcard

Mark only one oval.

	1	2	3	4	5	
Stro	◯	◯	◯	◯	◯	Strongly agree

33. I found various functions in this application/booklet/flashcard were well integrates *

Mark only one oval.

	1	2	3	4	5	
Stro	◯	◯	◯	◯	◯	Strongly agree

34. I thought there was too much inconsistency in this application/booklet/flashcard *

Mark only one oval.

	1	2	3	4	5	
Stro	◯	◯	◯	◯	◯	Strongly agree

35. I would imagine that most people would learn to use this application/booklet/flashcard very quickly *

Mark only one oval.

	1	2	3	4	5	
Stro	◯	◯	◯	◯	◯	Strongly agree

36. I found the application/booklet/flashcard very complicated to use *

Mark only one oval.

	1	2	3	4	5	
Stro	◯	◯	◯	◯	◯	Strongly agree

37. I feel very confident in using the application/booklet/flashcard *

Mark only one oval.

	1	2	3	4	5	
Stro	◯	◯	◯	◯	◯	Strongly agree

38. Do you have any suggestions on how this app/booklet/flashcard can be improved?

39. What did you like in the application? (Fun Gameplay, visually appealling, etc.)

40. What did you dislike in the application? (Unclear instructions, complex application, etc.)

41. In your opinion, what could be improves in the application? (more AR functions, more quizzes, etc.)

42. Any comments or feedback on the game? (more interactions, more information, etc.)

APPENDIX D

User testing by meeting the users