Faculty of Computer Science And Information Technology

Title: Augmented Reality Game Development (Bahasa Iban for Year 1 Students)

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Bachelor of Software Engineering with Honours

2024

DECLARATION

I hereby declare that this Final Year Project report, entitled *"Augmented Reality Game Development (Bahasa Iban for Year 1 Students)"*, is the result of my own independent work carried out during the course of my studies. This project has not been submitted in whole or in part for the award of any degree or diploma at this or any other academic institution. I confirm that all the information, data, analyses, designs, and results presented in this report are original and were developed by me, except where explicit references are provided. Any material derived from the published or unpublished work of others has been acknowledged and cited appropriately. I understand that any violation of this declaration will be considered a serious academic offense.

(NICHOLAS LIM) 17th January 2025

ACKNOWLEDGEMENT

I would like to express my deepest gratitude to my supervisor, Mr. Mohammad Johan bin Khiri, for his valuable guidance, feedback, and encouragement throughout the development of this Final Year Project. I also appreciate the support from our project coordinator, Prof. Dr. Wang Yin Chai and also from my fellow friends who provided insights and motivation during the completion of this project. Their contributions have helped me complete this project successfully.

ABSTRACT

Learning a new language is not easy, especially for young learners. In a classroom environment, students often have to follow the tempo set by the teacher, while each student's level of understanding is different. Not to mention, a traditional teaching method, which sometimes lacks interaction, can affect student engagement and motivation. Consequently, certain pupils may struggle to catch up, ultimately falling behind and conceding defeat. The objective of this project is to create an interactive and engaging Iban language learning application utilizing augmented reality (AR) technology. With this initiative, students are able to study the Iban language at their own pace while following the school curriculum topic without any pressure from other peers. Moreover, the application is accessible via mobile devices, providing students the ability to study at any location and at any time. This application not only helps students who are lagging in class but can also strengthen their understanding of Iban language learning topics.

ABSTRAK

Mempelajari bahasa baharu bukanlah mudah, terutamanya bagi pelajar muda. Dalam persekitaran bilik darjah, pelajar selalunya perlu mengikut tempo yang ditetapkan oleh guru, manakala tahap pemahaman setiap pelajar adalah berbeza. Apatah lagi, semasa menggunakan kaedah pengajaran tradisional yang kurang interaktiviti, ia boleh memberi kesan yang ketara kepada penglibatan dan motivasi pelajar. Akibatnya, sesetengah pelajar mungkin mengalami kesukaran mengejar dan akhirnya ketinggalan dan berputus asa. Justeru, tujuan projek ini adalah untuk membangunkan aplikasi pembelajaran bahasa Iban menggunakan teknologi augmented reality (AR) yang interaktif dan menyeronokkan. Melalui projek ini, pelajar boleh mempelajari bahasa Iban mengikut kadar mereka sendiri, mengikut topik yang diajar di sekolah tanpa perlu berasa tertekan untuk mengejar pelajar lain. Tambahan pula, aplikasi tersebut boleh diakses melalui peranti mudah alih, memberikan pelajar kelonggaran untuk belajar di mana-mana dan pada bila-bila masa. Aplikasi ini bukan sahaja membantu pelajar yang ketinggalan dalam kelas malah dapat mengukuhkan pemahaman mereka tentang topik pembelajaran bahasa Iban.

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CHAPTER 1: INTRODUCTION

1.1 Introduction / Background

At present, Augmented Reality (AR) serves as a transformative educational tool, revolutionizing how students interact with learning resources by integrating digital elements into the physical environment. Unlike traditional teaching methods, which often lack engagement and fail to cater to diverse learning styles, AR provides a multisensory experience that enhances visualization and comprehension by overlaying virtual content onto physical objects, making abstract concepts more tangible. This research underscores AR's ability to boost engagement, retention, and motivation by fostering active participation and creating an immersive learning environment (Pavel et al., 2024). This aligns with Sustainable Development Goal 4 (Quality Education), which advocates for inclusive, equitable, and quality education while promoting lifelong learning opportunities (Lee et al., 2016). Recognizing these benefits, this project aims to develop an Android-based AR application tailored for Year 1 students, facilitating the learning of the Bahasa Iban language and bridging the gap between traditional and innovative education methods.

Bahasa Iban is one of the languages spoken largely in Malaysia, an important element of the Iban people's cultural legacy. Incorporating it into an AR application can aid in early language learning while also maintaining and encouraging the usage of this indigenous language in a modern context. This innovative approach helps bridge the gap between traditional practices and modern technology, ensuring the language remains relevant and actively used in everyday life while fostering a deeper understanding and appreciation of the Iban community's cultural legacy.

One of the current challenges in language learning for young pupils is the lack of engaging and interactive teaching methods. Traditional approaches, such as rote memorization and textbook-based learning, often fail to capture students' attention or cater to their diverse learning styles. Additionally, pupils may struggle with retaining grammar and spelling due to limited opportunities for immersive practice. These challenges can lead to reduced motivation and slower language acquisition, particularly for less widely taught languages like Bahasa Iban.

With that, this project focuses on creating a prototype of an AR application that can aid young students in learning Iban languages, as early exposure is useful in establishing their strong basic language abilities. This AR application will act as an additional tool for the teacher

in a way that makes the learning process more interactive and visually appealing. This application allows the students to experience "learning by doing," engaging the real world with virtual objects and animated characters to develop their language abilities in a hands-on manner.

The game design is being carefully planned to assist teachers in delivering a curriculum that is both age-appropriate and culturally relevant, incorporating basic language abilities that are aligned with the Year 1 Standard-Based English Language Curriculum (SBELC). This initiative makes language acquisition accessible and pleasurable for all kinds of learners by utilizing AR technology, which takes the use of visual and kinaesthetic learning methods. In the end, this interactive experience can improve educational results by boosting motivation, lowering learning anxiety, and cultivating a positive attitude toward language acquisition in young pupils.

This AR-based language application aims not only to enhance early language skills in Bahasa Iban but also to preserve cultural identity by encouraging the use of native languages in the digital age. By combining traditional knowledge with innovative technology, this project serves as a bridge between cultural heritage and modern education, demonstrating the transformative potential of AR in language learning and the preservation of indigenous languages.

1.2 Problem Statement / Research Problem

In many educational settings, traditional teaching methods often lack interactivity, significantly impacting student engagement and motivation. When students are passively receiving information without opportunities for active participation, they can quickly lose interest in the material. The absence of meaningful interactions between students and teachers limits students' ability to clarify doubts, ask questions, and engage in discussions that deepen their understanding. As a result, the teaching process can become one-sided, making it difficult for students to stay motivated and interested in the subject matter.

This issue is particularly evident among Year 1 students learning Bahasa Iban. Many face challenges such as difficulty memorizing new vocabulary, limited comprehension of the language, and a lack of enthusiasm due to unengaging and repetitive teaching styles. These challenges hinder their ability to fully grasp the language at an early stage, which is critical for future language development.

This lack of interactivity has a direct effect on students' academic progress. Students who passively receive information without opportunities for active participation may struggle to keep pace with the curriculum, and their learning outcomes may fall below their potential. Additionally, the gap in communication with teachers hinders timely feedback, which is

essential for students to identify areas where they need to improve and refine their understanding.

Addressing this issue requires a shift toward more interactive and engaging teaching strategies that foster active learning and teacher-student interactions. Implementing interactive elements such as discussions, hands-on activities, and technology-driven tools can enhance engagement and provide a more supportive learning environment. By making lessons more participative, students can stay motivated, progress at a faster rate, and achieve a deeper understanding of the material.

1.3 Aims and Objectives

The proposed project aims to address the challenges faced by young learners in acquiring language skills by leveraging the potential of Augmented Reality (AR). Through the integration of engaging game mechanics and an immersive platform for learning Bahasa Iban grammar and spelling. The objectives of this project are outlined as follows:

- Provide a platform for personalized learning experiences through user-specific progress tracking and adaptive content delivery.
- To develop an AR-based educational game that integrates the digital and physical worlds, presenting Bahasa Iban grammar and spelling interactively and engagingly.
- To evaluate the effectiveness of game mechanics, such as quizzes, in boosting student engagement and motivation to continue practicing, while ensuring the learning experience remains enjoyable and stimulating.

1.4 Scope

The scope of this project is to develop an Augmented Reality (AR) game designed to assist Year 1 students in learning Bahasa Iban grammar and spelling. The system will provide an interactive and gamified learning experience, enhancing student engagement and retention through AR technology. It will focus on grammar and spelling practice by incorporating interactive AR visuals and gamified elements such as quizzes and rankings to encourage active participation.

The target users are Year 1 students, and the application will feature a user-friendly interface tailored to their age group. The system will be accessible on commonly used mobile devices and will support offline accessibility after installation, ensuring that students can use it both in the classroom and at home without requiring a constant internet connection.

However, the system will not cover advanced language learning, teacher performance tracking, or comprehensive curriculum-wide assessments. Instead, it is specifically focused on reinforcing foundational Bahasa Iban grammar and spelling through AR-based interaction.

1.5 Methodology

The software methodology employed in this final year project is Agile. Agile was selected for its adaptability, iterative development methodology, and capacity to accommodate change, which corresponds with the objectives of creating an AR-based instructional game. Agile approaches are highly effective for mobile software development, providing iterative and incremental processes that provide flexibility and adaptive modifications while prioritizing user requirements and swift feedback loops. Each iteration, usually lasting one to four weeks, encompasses steps including requirements collecting, design, implementation, testing, and feedback. This iterative method guarantees progressive software development while integrating regular updates based on real-time feedback, promoting the construction of a user-centered, high-quality result (Rahimian & Ramsin, 2008). Regular feedback from students and educators enables the development team to implement prompt modifications, ensuring the game remains relevant, effective, and engaging.

AGILE METHODOLOGY

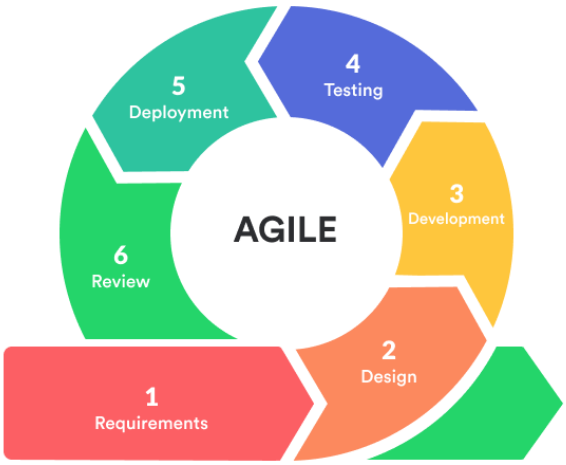


Figure 1. *Agile methodology phases.*

1.5.1 Requirements Phase

In this phase, all initial requirements from stakeholders or end-users will be gathered. Rather than setting strict criteria, Agile articulates them in broad terms, allowing for adaptability and enhancement in later iterations as user needs emerge.

1.5.2 Design Stage

During this phase, a foundational design or prototype will be developed to outline the application's architecture and functionality. Unlike the Waterfall paradigm, Agile design emphasizes minimal initial planning to enable fast modifications. This phase underscores the creation of an initial framework to guide advancement.

1.5.3 Development Stage

During the development phase, coding will transpire in short intervals referred to as sprints. Every sprint produces a small, functional element of the application. Agile's iterative development enables the gradual addition, refinement, and enhancement of features based on input from prior sprints.

1.5.4 Evaluation Stage

The testing procedure is performed consistently throughout each sprint to identify and resolve issues promptly. This phase ensures quality by consistently verifying the functionality of each feature. The developer will also conduct this testing for the teachers and students.

1.5.5 Implementation Phase

Following each sprint in this phase, the latest version of the application will be deployed. This version may represent a full release or an update to a previous iteration, facilitating prompt access to new features for educators and learners, as well as the opportunity to provide feedback.

1.5.6: Review Phase

Following deployment, the results of the sprint will be assessed with the educators, gathering feedback on achievements and opportunities for improvement. This phase enables adjustments before the next sprint, enhancing alignment with user needs and project goals.

1.6 Significance of the Project

This initiative is significant because it offers an innovative and dynamic alternative to conventional language learning methods, which typically depend on rote memorization and passive engagement. The project utilizes Augmented Reality (AR) to establish a dynamic and immersive learning environment that actively engages students and improves their retention of new terminology. The principal advantages of the project are as follows:

a) To enhance students' comprehension and retention of new vocabulary and languages by the utilization of interactive 3D images, including animated objects and situations that illustrate grammar and spelling, so rendering the learning experience more engaging and pleasurable.
b) To promote autonomous discovery by enabling students to interact with the educational content at their own tempo.
c) Simultaneously engaging auditory and visual aspects enhances immersion and facilitates retention in learning.

1.7 Project Schedule

Project title	*Augmented Reality Game Development (Bahasa Iban for year 1 students)*				Week Starting	30-October	6-November	13-November	20-November	27-November	4-December
Activity	**Start**	**End**	**Days**	**Status**	**% Done**						
Full Proposal	30-Oct-24	13-Nov-24	11	In progress	100%						
Chapter 1: Introduction	13-Nov-24	20-Nov-24	6	In progress	100%						
Chapter 2 : Literature Review	20-Nov-24	11-Dec-24	16	Not started	100%						
Chapter 3 : Methodology	11-Dec-24	1-Jan-25	16	Not started	0%						
Chapter 4: Implementation	12-Mar-25	9-Apr-25	21	Not started	0%						
Chapter 5: Testing	9-Apr-25	30-Apr-25	16	Not started	0%						
Chapter 6: Conclusion and Future Work	30-Apr-25	21-May-25	16	Not started	0%						

Figure 2. *Project Schedule.*

1.8 Expected Outcome

The project will deliver a fully operational augmented reality (AR) game tailored to assist Year 1 pupils in acquiring fundamental Bahasa Iban grammar and spelling skills. The system will incorporate interactive learning modules that instruct on fundamental grammar rules and spelling patterns using captivating images and audio.

Furthermore, it will include quizzes to consolidate key topics, enabling students to engage in practice and assess their understanding enjoyably and dynamically. This integration of learning and assessment guarantees a holistic method for understanding Bahasa Iban, rendering grammar and spelling acquisition more entertaining and successful than conventional methods.

Additionally, the system will incorporate a user-friendly interface designed for young learners. The design will emphasize simplicity, enabling students to utilize the app with minimal assistance.

1.9 Thesis Outline

This project will consist of 5 different chapters as shown below:

1.9.1 Chapter 1: Introduction

Chapter 1 provides an introduction and concise outline of the concept for the proposed system. The document includes the project history, problem statement, scope, objectives, concise methodology, project importance, timetable, and anticipated outcomes.

1.9.2 Chapter 2: Literature Review

Chapter 2 contrasts the proposed system with the existing system. This chapter will analyze the strengths and shortcomings of each current system, and the findings will inform the design enhancements of the new system.

1.9.3 Chapter 3: Requirement Analysis and Design

Chapter 3 delineates the methods to be employed in the development of the proposed system. This chapter will provide a detailed discussion of all system needs and specifications. This chapter will also examine the project's system design.

1.9.4 Chapter 4: Implementation

Chapter 4 delineates the implementation process to be employed in the system's development. This chapter will delineate each step undertaken throughout the project's development.

1.9.5 Chapter 5: Testing

Chapter 5 will address the testing conducted following the development of the proposed system throughout the implementation phase. All system testing will be documented as either a pass or a failure.

1.9.6 Chapter 6: Conclusion and Future Work

Chapter 6 presents a concise overview of the whole project upon its completion, along with recommendations for future enhancements.

1.10 Summary

In summary, Chapter 1 highlights the challenges faced by Year 1 students in learning Bahasa Iban, including difficulties with memorization, understanding, and lack of engagement in traditional teaching methods. The project proposes an innovative solution using Augmented Reality (AR) technology to address these issues. This Android-based AR application integrates interactive visual, audio, and gamified elements to make learning experiences with educational content more engaging, aiming to enhance students' understanding, motivation, and retention of Bahasa Iban. Ultimately, this approach promises to deliver a meaningful and enjoyable tailored to young learners.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

A literature review assesses academic sources on a topic, providing a comprehensive overview of existing information. This chapter will examine and evaluate the functionality of five distinct existing systems, all of which are Augmented Reality (AR)-based educational systems specifically designed for language learning, within the language education domain. These systems utilize AR technology to enhance the learning experience by incorporating interactive elements and tangible objects, which aim to engage students in more immersive and effective language acquisition processes. This chapter will compare all current systems by enumerating their functions, strengths, and drawbacks.

2.2 Review of Existing Similar System

Five existing systems will be reviewed to compare and analyze the proposed project. The systems that will be reviewed are:

1. Tangispeak: A Digital Game-Based Language Learning System Using Augmented Reality Technology and Tangible Objects (Ongoro et al., 2023).
2. MOW: Augmented Reality Game to Learn Words in Different Languages (Barreira et al., 2023).
3. VocabulARy: Learning Vocabulary in AR Supported by Keyword Visualizations (Weerasinghe et al., 2022).
4. TARES: A Game-Based Tangible Augmented Reality English Spelling Mastery System (Ongoro et al., 2024).
5. ARbis Pictus: A Study of Language Learning with Augmented Reality (Ibrahim et al., 2018).

2.2.1 Tangispeak: A Digital Game-Based Language Learning System Using Augmented Reality Technology and Tangible Objects

The Tangispeak method was developed to enhance the enjoyment and efficacy of English learning for young children, particularly in Taiwan. It integrates Digital Game-Based Learning (DGBL), Augmented Reality (AR), and physical items to provide an immersive educational atmosphere. DGBL transforms language acquisition into a gamified experience,

whereas AR integrates physical and digital components, enabling children to engage with both tangible and virtual items.

It seeks to diminish screen time and avert health complications such as eye strain by employing actual objects that children can use and interact with. This methodology promotes social engagement and facilitates experiential learning, enhancing children's comprehension of English through both digital and tangible interactions.

The system employs a microcontroller, gameboard, Unity 3D, and Vuforia platforms to develop interactive educational activities. It operates in two phases: letter scrambling and speaking practice. Tangispeak has monitoring capabilities to measure progress, enabling instructors to facilitate children's learning while maintaining a balanced and healthy experience.

Functionality

I. Augmented Reality Content Display

The system employs augmented reality to superimpose 3D graphics or animations over the actual surroundings. When physical items such as flashcards, markers, or toys are scanned with a compatible device, the system displays related digital material, such as a virtual object that represents the vocabulary term. This capability connects abstract concepts with real-world experiences, enhancing engagement and intuitiveness in learning for young learners.

II. Tangible Object Interaction

Tangible objects play a central role in the system by triggering AR content and enabling hands-on interaction. For example, when a learner places a physical card or moves a cube with specific patterns or markers, the system recognizes the object and displays related AR visuals. This feature fosters active participation and enhances the connection between physical actions and virtual outcomes, improving memory retention through kinesthetic engagement.

III. Speech Recognition for Pronunciation

The system includes real-time speech recognition to help learners improve their speaking skills. Learners can pronounce a word, and the system evaluates their pronunciation accuracy, providing immediate feedback. This functionality not only aids in developing correct

pronunciation but also builds confidence in language usage by offering a safe and supportive environment for practice.

Strength and Weaknesses

Strength	**Weaknesses**
It uses several physical objects to make learning more interactive, not just one type of item to scan. This variety helps keep young learners interested by giving them different activities to engage with rather than just repeating the same task.	Since many objects are involved, young learners might focus more on playing with the objects than on learning the language, which could make the lesson less effective.

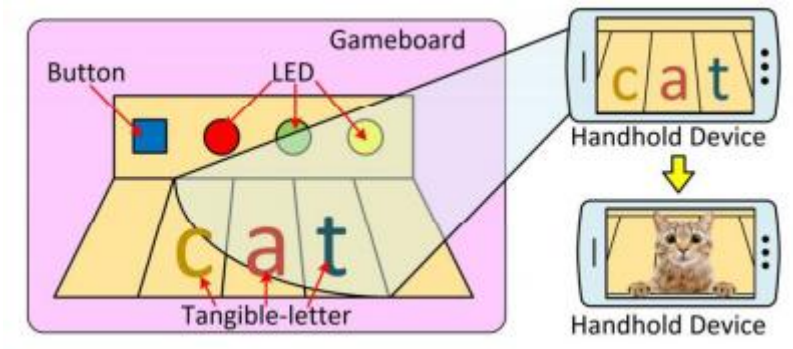


Figure 3. *The overall schematic diagram. (Adapted from Ongoro et al., 2023, Fig. 1).*

Figure 3 depicts the physical interface, comprising 3D wooden alphabet letters in diverse colors, a microprocessor, a Bluetooth module, push buttons, and RGB LED lights. In this configuration, learners position the wooden letters on the gameboard, which interacts with a portable device through the Bluetooth module. This interaction allows the gameboard to provide messages on the accurate placement of letters. Finally, the RGB LED lights on the gameboard offer visual feedback, indicating the precision of the letter placement.

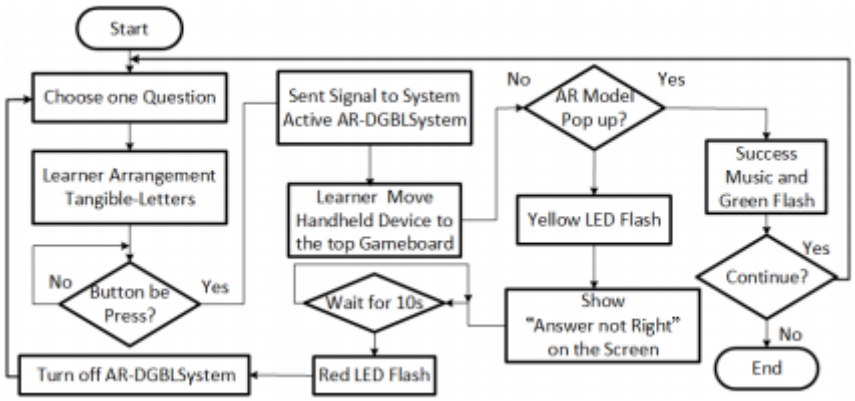


Figure 4. *Lighting code T/R software process diagram. (Adapted from Ongoro et al., 2023, Fig. 3).*

Figure 4 delineates the steps for utilizing Tangispeak. The procedure starts with a welcome interface, succeeded by user registration and authentication login. Users obtain access to particular features of the system based on their roles as learners, teachers, parents, or other stakeholders. Students choose their class level and desired subject, then select a question and organize the relevant letters on the physical gameboard. The scanned letters activate a 3D augmented reality representation displayed on the screen. To augment involvement and motivation, the system offers a progressive evaluation melody, incentives, and constructive suggestions throughout the procedure.

2.2.2 MOW: Augmented Reality Game to Learn Words in Different Languages

In this project, the author explores how digital games, especially AR, can help children learn more effectively. They point out studies showing that games make learning subjects like science and language more engaging than traditional lectures. This led them to create MOW (Matching Object and Words), an AR game that teaches vocabulary through interactive, virtual experiences.

MOW combines AR with traditional methods to help young learners connect with words in an interactive and immersive way. By blending virtual objects with real-world interactions, MOW gives children (5-12 years old) a hands-on way to learn and remember vocabulary.

To see how well MOW works, the authors tested it with children in English classes. Teachers used regular assessments to check vocabulary, comparing game-based learning with traditional lessons. The results showed that MOW made vocabulary learning more engaging and compelling, adding variety to the classroom experience.

Functionality

I. Tangible Object Interaction

MOW leverages tangible objects, such as flashcards, blocks, or toys, to create an engaging and hands-on learning experience. When these objects are scanned or interacted with, the system recognizes them and displays corresponding AR visuals or animations. For instance, placing a flashcard with the word "apple" may trigger the appearance of a 3D apple on the screen. This interaction bridges the physical and digital worlds, allowing learners to manipulate real-world items while enhancing their understanding of vocabulary through immediate visual and contextual feedback. The tactile engagement strengthens memory retention and makes learning more immersive and enjoyable.

II. Audio Pronunciation and Feedback

MOW enhances vocabulary acquisition by providing clear audio pronunciations of words, ensuring learners can hear and mimic correct sounds. Whenever a word is introduced or a tangible object is scanned, the system plays the word aloud, helping learners associate its pronunciation with its visual representation. During activities, the system gives immediate feedback on their responses, using positive reinforcement for correct answers and corrective cues for mistakes. For example, if a learner matches a word to the wrong object, the system might repeat the word, show the correct object, and encourage another attempt. This auditory guidance fosters language skills and boosts learner confidence.

III. Progress Monitoring

MOW incorporates a progress tracking system that records each learner’s activities, tracking metrics such as words learned, game completions, and pronunciation scores. This data is compiled into a user profile that can be accessed by parents or educators to monitor development over time. For example, a parent can review their child's performance and see which categories they excel in or where they face challenges. The system also highlights milestones, such as achieving a certain number of mastered words, motivating learners to continue progressing. This functionality ensures a personalized learning journey, allowing adjustments to be made based on individual strengths and weaknesses.

Strength and Weaknesses

Strength	Weaknesses
Broader language exposure can expose learners to multiple languages within a single platform, which can be beneficial for students in multilingual environments or for promoting language diversity.	Shallow learning objectives as it primarily focuses on vocabulary acquisition without addressing other critical aspects of language learning.

Figure 5. *Examples of template-based markers used in MOW. (Adapted from Barreira et al., 2023, Fig. 1).*

Figure 5 illustrates visual examples of the markers (flashcards) used in the MOW system to trigger AR content. It showcases how different templates can activate AR visuals.

Figure 6. *Game 1 is played with Portuguese (left image) and English (right image) words. (Adapted from Barreira et al., 2023, Fig. 6).*

Figure 6 compares gameplay in the MOW system when used to teach vocabulary in two distinct languages, Portuguese and English. It highlights the system's ability to support multilingual learning by showcasing how the same interactive methods and AR features are applied across different linguistic contexts. This demonstrates MOW's flexibility and potential to cater to diverse language-learning needs in various educational settings.

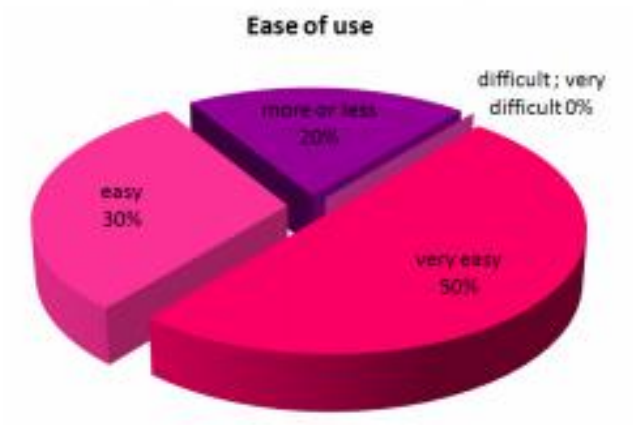


Figure 7. *Children's feedback on the difficulty of using MOW. (Adapted from Barreira et al., 2023, Fig. 8).*

Figure 7 encapsulates user input from youngsters concerning the ease or difficulty of using MOW. The feedback was obtained by requesting students to complete a brief post-game questionnaire on a five-point Likert scale to assess the ease of interaction with MOW.

2.2.3 VocabulARy: Learning Vocabulary in AR Supported by Keyword Visualizations

In this study, the authors examine how AR can make vocabulary learning more dynamic and contextual. They cite studies showing that contextual learning by associating new words with real-world objects improves recall and understanding. This idea prompted VocabulARy, an AR-based vocabulary-learning system that blends keyword visualizations and immersive, object-based interactions.

VocabulARy uses AR to turn everyday environments into dynamic learning environments. The method helps learners associate words with real-world objects by overlaying virtual keywords on physical objects. The goal is to make vocabulary acquisition easier and more fun for young learners and language newbies.

VocabulARy was tested in language classrooms for vocabulary learning and learner motivation. Assessing learning outcomes comparing regular and AR-enhanced sessions helped

teachers compare progress. VocabulARy boosted student engagement and vocabulary retention, delivering a creative and successful alternative to traditional language instruction.

Functionality

I. Gamification and Engagement

There are quizzes, challenges, and games with rewards built into the learning process. This makes practicing vocabulary fun and interactive. This game-like approach encourages students to interact with the AR world more often, which keeps them interested in learning the language.

II. Progress tracking

The system provides real-time feedback and records learners' performance, helping teachers and learners monitor improvements over time. This feature offers valuable insights into learning progress and highlights areas requiring further attention.

III. Memory Enhancement Techniques

Associate vocabulary words with tangible items, utilizing contextual learning principles to enhance memory. By linking new vocabulary to concrete, real-world objects, learners establish significant associations that facilitate memory retention. The technology enhances learning by recurrent interactions with AR annotations, allowing learners to encounter words several times in diverse circumstances.

Strength and Weaknesses

Strength	**Weaknesses**
The ability to input customized vocabulary lists. It allows teachers or learners to tailor the system to specific educational needs, whether for certain topics, proficiency levels, or curricula.	The use of complex visualizations and animations could overwhelm some learners, especially if there are too many details or distractions in the AR environment.

Figure 8. *A participant interacting with VocabulARy during the study. (Adapted from Weerasinghe et al., 2022, Fig. 1).*

Figure 8 depicts a user engaging with the VocabulARy system in a real-world environment, showcasing the practical application of augmented reality (AR) technology. The image illustrates how AR overlays and interactions seamlessly integrate into the learning experience, allowing users to interact with virtual elements superimposed on physical objects.

2.2.4 TARES: A Game-Based Tangible Augmented Reality English Spelling Mastery System

This study examines the potential of game-based learning, augmented reality (AR), and physical interactions to enhance spelling proficiency in youngsters. They emphasize research indicating that the amalgamation of physical things with digital content can improve engagement and educational results. This concept resulted in the creation of TARES, an augmented reality-based, game-oriented spelling system aimed at enhancing the interactivity and enjoyment of spelling practice.

TARES integrates conventional spelling drills with augmented reality and physical objects, transforming spelling practice into an engaging and immersive experience. The method enhances learning by superimposing virtual hints and feedback onto tangible objects, facilitating the association of letter patterns and word structures with real-world elements, and reinforcing spelling through contextualization and active participation. The objective is to render spelling acquisition less tedious and more engaging for young learners.

The efficacy of TARES was examined in educational environments, focussing on its influence on spelling competence and student motivation. The findings indicated that TARES enhanced student engagement and elevated spelling performance, providing an innovative and captivating alternative to traditional spelling training. The study underscores how the

integration of augmented reality, gaming, and physical interactions might improve educational results in spelling proficiency.

Functionality

I. Game-Based Learning

TARES incorporates serious game elements to make learning engaging and fun. It features three difficulty levels tailored to the age of learners (3, 4, and 5-letter words) to progressively enhance spelling skills.

II. Instant Feedback Mechanism

The system provides immediate audio and visual feedback when learners spell words correctly or incorrectly. This includes congratulatory sounds for correct answers and hints for incorrect ones.

III. Customizable Learning Content

The system can accommodate a wide range of words and languages, allowing for flexibility in educational content based on learners' needs.

Strength and Weaknesses

Strength	**Weaknesses**
TARES effectively minimizes screen exposure for preschoolers, addressing concerns about eye strain and cognitive overload associated with prolonged digital device use.	Since this project has a wide focus might mean less in-depth content for any single language.

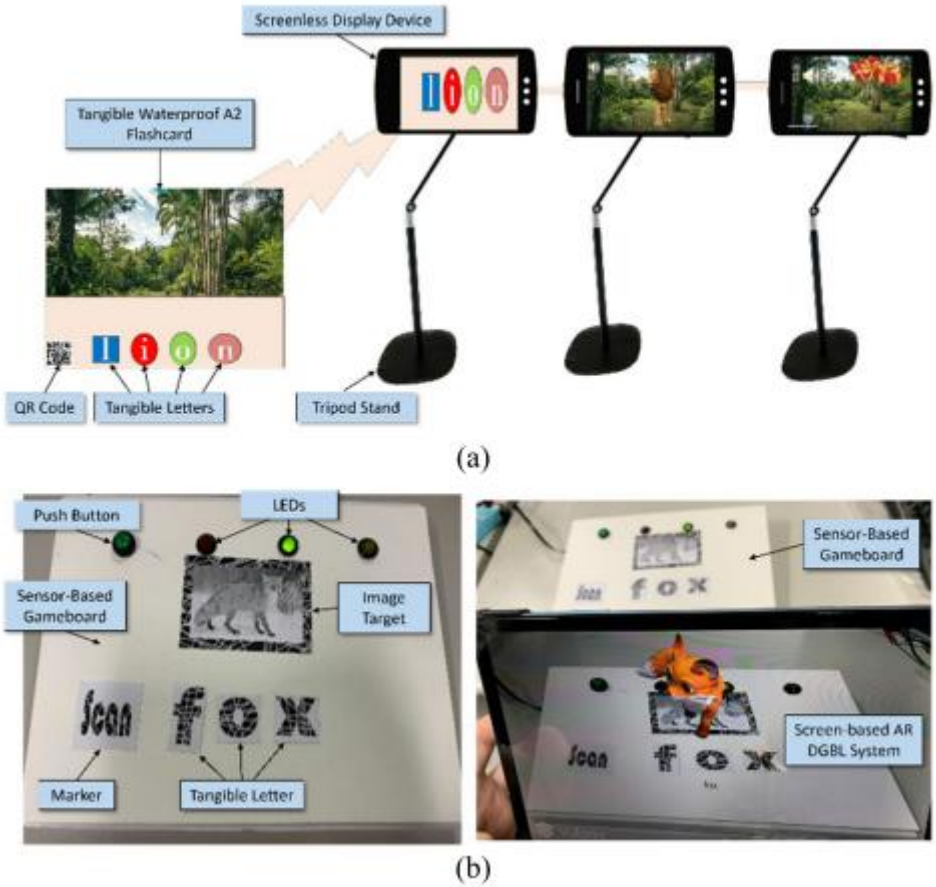


Figure 9. *(a). Proposed TARES system, (b). The early version of the screen-based system. (Adapted from Ongoro et al., 2024, Fig. 2a & 2b).*

Figure 9 compares the proposed TARES system, which is likely to incorporate augmented reality (AR) and tangible objects, with an earlier version that relied solely on a screen interface. The comparison highlights the evolution of the system, emphasizing the integration of interactive elements such as AR and physical objects, which significantly enhance user engagement and functionality compared to the traditional screen-only design.

2.2.5 ARbis Pictus: A Study of Language Learning with Augmented Reality

This study uses augmented reality to make language learning immersive and engaging. The technology helps learners associate new language with concrete experiences by overlaying virtual images and text on real-world items. This strategy uses the brain's ability to link words to visual cues to improve vocabulary acquisition intuitively. The goal is to make language learning more participatory and experiential than rote memorization.

ARbis Pictus was tested for vocabulary retention and student engagement in schools. According to the study, the AR method improved vocabulary comprehension, retention, motivation, and involvement in learning. The study shows that augmented reality can enhance language learning by contextualizing and visualizing words.

Functionality

I. Learning Phases

Structured learning tasks are divided into three phases, where participants learn new vocabulary words in 90-second intervals, followed by distraction tasks and tests.

II. Attention Metrics

Eye-tracking data was collected during the flashcard sessions and head orientation tracking during AR sessions to analyse user engagement and focus on learning materials.

III. Counterbalanced Design

A within-subjects design where participants experienced both learning modalities (AR and flashcards) to control for individual differences.

Strength and Weaknesses

Strength	**Weaknesses**
More scalable in diverse educational situations. Its utilization of AR technology enables adaptability across many educational environments, extending beyond mere word development.	Requires more complex setup and resources to implement, including AR-capable devices and software.

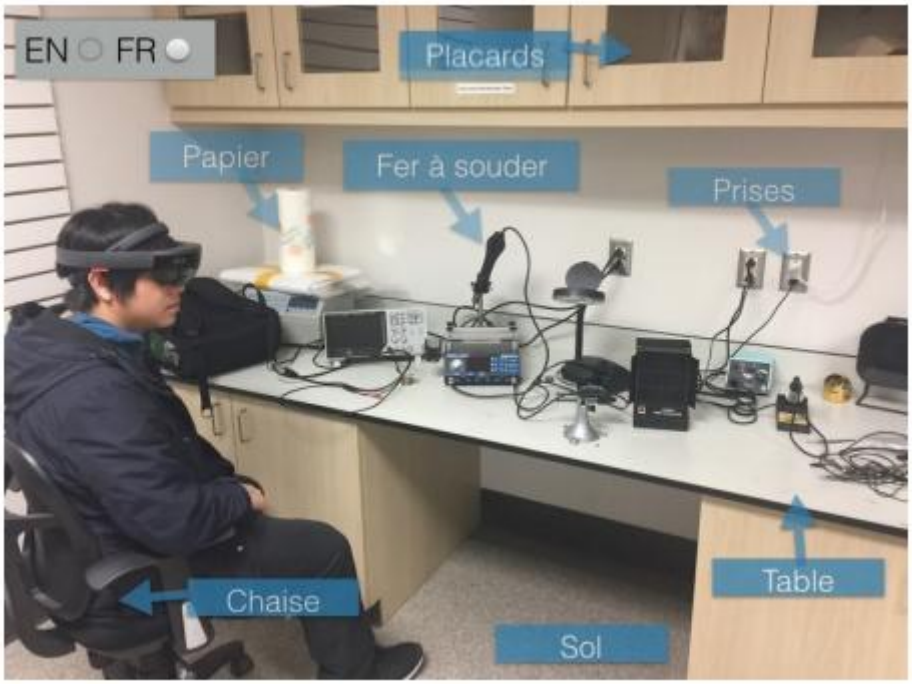


Figure 10. *An illustrative mock-up of a language learner using the Arbis system. (Adapted from Ibrahim et al., 2018, Fig. 1).*

Figure 10 visually represents a user interacting with the ARbis system, highlighting its immersive features (virtual overlays) that seamlessly blend with the real world. It demonstrates how learners engage with these digital elements, illustrating the dynamic interaction between the physical and virtual environments.

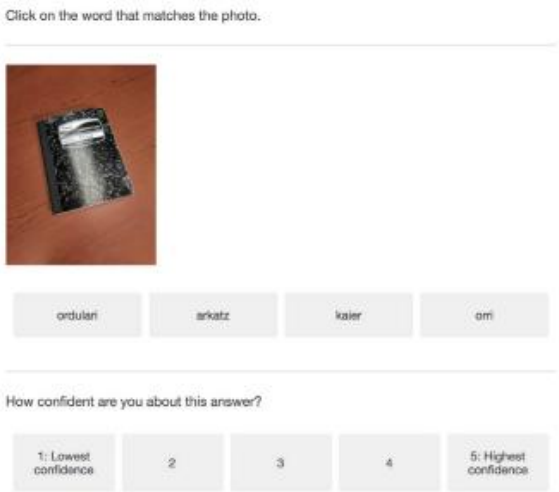


Figure 11. *Format of the Productive Recognition Test. (Adapted from Ibrahim et al., 2018, Fig. 4).*

Figure 11 outlines the test format used in the ARbis study to assess vocabulary recognition, providing a clear depiction of how the test is structured. The figure highlights how

the system evaluates learners' ability to recognize and recall vocabulary, showcasing the interactive nature of the assessment.

2.3 Comparison of The Features in The Reviewed Existing Systems

Table 1. Comparison of features in the review system with the proposed system.

Features	**Tangispeak**	**MOW**	**Vocabulary**	**TARES**	**ARbis Pictus**
Uses Augmented Reality (AR)	Yes	No	Yes	Yes	Yes
Integrates Tangible Objects	Yes	Yes	No	Yes	Yes
Focuses on Vocabulary	Yes	Yes	Yes	No	Yes
Includes Game-Based Learning	Yes	Yes	No	Yes	No
Supports Multisensory Learning	Yes	No	Yes	Yes	Yes

2.4 Conclusion

This chapter reviews five similar AR-based language learning systems and compares them with the proposed system, Augmented Reality Game Development (Bahasa Iban for Year 1 Students). Each system employs different methodologies and features, each with its strengths and limitations. Overall, this review provides a foundation for understanding the current landscape of AR-based language learning systems, setting the stage for developing and refining the proposed system.

CHAPTER 3: REQUIREMENT ANALYSIS AND SYSTEM DESIGN

3.1 Introduction

This chapter highlights the system's specifications and needs, according to the Agile methodology to facilitate a flexible and iterative development process. The adaptability of Agile facilitates ongoing feedback and enhancement, offering it optimal for the development of an interactive learning tool. This chapter addresses requirements analysis to determine the system's functionalities, logical design to produce a coherent architectural framework, and the development of a user-friendly mobile system interface designed for young learners. These aspects combined establish the basis for providing an interesting, augmented reality game that facilitates Year 1 pupils in effectively learning Bahasa Iban.

3.2 Methodology

This system adopts Agile methodology as its project development approach. Agile is a flexible, iterative software development framework emphasizing collaboration, adaptability, and customer feedback. Unlike traditional linear models, Agile focuses on delivering functional components in smaller increments, allowing for continuous evaluation and improvement throughout the development cycle. This iterative approach makes Agile particularly suitable for dynamic and fast-paced environments, where requirements may evolve.

Agile development is organized into iterative cycles called sprints, typically lasting two to four weeks. Each sprint includes planning, design, development, testing, and review activities, ensuring progress aligns with project goals and stakeholder expectations. The Agile process fosters active communication between developers, stakeholders, and end-users to ensure the final product effectively meets user needs. The table below summarizes the activities performed during each phase of an Agile sprint.

3.3 Requirement Analysis

Requirement analysis is a critical phase in the software development lifecycle that serves as the foundation for designing and building a successful system. This stage focuses on identifying, analyzing, and documenting the functional and non-functional requirements of the system to ensure it aligns with the objectives and expectations of stakeholders. For this project, the goal is to develop an augmented reality (AR)-based educational game that facilitates Bahasa Iban language learning for Year 1 students.

In this phase, emphasis is placed on understanding the needs of educators, parents, and school administrators, as well as aligning the game mechanics with the intended learning outcomes. The analysis also considers technical, pedagogical, and usability aspects to ensure the AR game is engaging, accessible, and effective in fostering language acquisition.

The project focuses on covering essential language topics to enhance learning outcomes for Year 1 students. The key topics include grammar, which emphasizes understanding prepositions, active and passive sentence structures, and the proper use of adjectives. Additionally, the project addresses spelling, targeting common challenges faced by students due to social and environmental influences. By incorporating these topics, the AR-based educational game aims to provide a comprehensive and engaging learning experience that supports effective language acquisition.

This section outlines the requirements gathered through stakeholder engagement, such as interviews, surveys, and reviews of educational standards. It also highlights the importance of integrating AR technology with interactive gameplay to create a meaningful and enjoyable learning experience for young students. The project aims to establish a clear and structured foundation for the subsequent design and development phases by systematically analysing these requirements.

3.3.1 Requirement Phase

The requirements for the AR-based educational game were gathered using an interview and questionnaire session. An interview was conducted with a Year 1 Bahasa Iban teacher at Sekolah Kebangsaan Sungai Lamaus, a rural school in a village. A questionnaire was distributed to Year 1 students, with 15 respondents participating, reflecting the low student population typical of the area.

3.3.1.1 Interview

The primary goal of the interview was to gain insights into the teaching and learning practices of Bahasa Iban, particularly for Year 1 students. To achieve this, a semi-structured interview was conducted with a Year 1 Bahasa Iban teacher from Sekolah Kebangsaan Sungai Lamaus, a rural primary school. The interview aimed to explore the teacher's experiences, challenges, and perspectives on current teaching methods, student engagement, and curriculum alignment. This teacher was selected due to their direct involvement in teaching Bahasa Iban to young learners and familiarity with the local context. The data gathered from this session

was essential for understanding the real classroom challenges and for informing the design of the proposed Augmented Reality (AR) game, ensuring it aligns with the students' learning needs and curriculum requirements. The outcome of the interview session is as below:

- Challenges in Learning the Iban Language: Students face difficulty with correct spelling due to the influence of the home environment and social media.
- Lack of Learning Materials: Limited availability of Iban language materials, except from other teachers. Digital training modules are needed as they are more engaging for students.
- Weaknesses of Traditional Learning Methods: Traditional learning methods fail to capture students' interest effectively.
- Effective Teaching Methods: Utilizing digital materials like games created in PowerPoint with hyperlinks excites students and fosters engagement.
- Making Learning Interesting for Students: Tangible and visually appealing materials are key to maintaining student interest.
- Use of Technology in Teaching: Teachers have used technology tools with positive feedback from students, increasing interest and enthusiasm for learning.
- Opinion on Augmented Reality (AR): AR technology helps students understand better, attracts their interest, and creates an enjoyable learning environment.
- AR's Role in Understanding and Interest: AR can enhance understanding and interest in learning the Iban language, achieving educational objectives.
- Response to Interactive Teaching Methods: Interactive methods like quizzes make students more active, engaged, and excited about the topics.
- Complementing Traditional Teaching with AR: AR adds new elements like infographics, sound, and movement, which are absent in traditional methods.
- Syllabus Suggestions for the Project: Grammar (specifically "Bungai Jaku") is recommended as a syllabus focus due to its complexity and breadth.
- Recommended Components for the Project: Quizzes and games to test abilities, provide challenges, and encourage learning through play.

3.3.1.2 Questionnaire

To gather feedback from the target users, a questionnaire was designed and distributed to Year 1 students at Sekolah Kebangsaan Sungai Lamaus. A total of 15 students participated in this data collection activity. The questionnaire aimed to assess students' learning

preferences, their familiarity with digital tools, and their interest in interactive learning methods such as augmented reality (AR). Given the young age of the respondents, the questions were simplified and explained with the help of the teacher to ensure accurate responses. A Likert scale was used to measure students' preferences, perceptions, and feedback.

This section presents graphical representations of the responses collected from the questionnaire. The graphs visually summarize the data, providing insights into trends such as preferred learning methods, familiarity with AR, and interest in gamified educational tools. By analysing these Likert scale-based responses, we can better understand the students' needs and expectations, ensuring that the findings directly inform the design and development of the AR-based Bahasa Iban educational game.

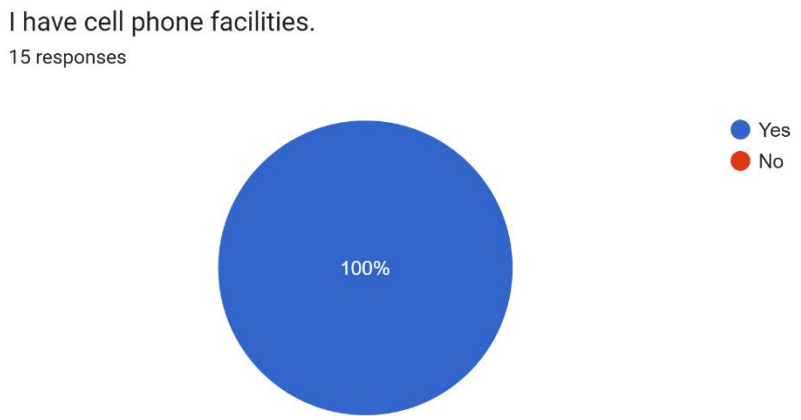


Figure 12: Pie Chart represents the number of students that have cell phone facilities.

Figure 12 represents the percentage of students who have access to cell phone facilities. Most respondents, 85%, reported having cell phones, while 15% indicated they do not. This highlights that most students are well-equipped to utilize mobile-based learning systems, ensuring the feasibility of implementing an AR-based educational game.

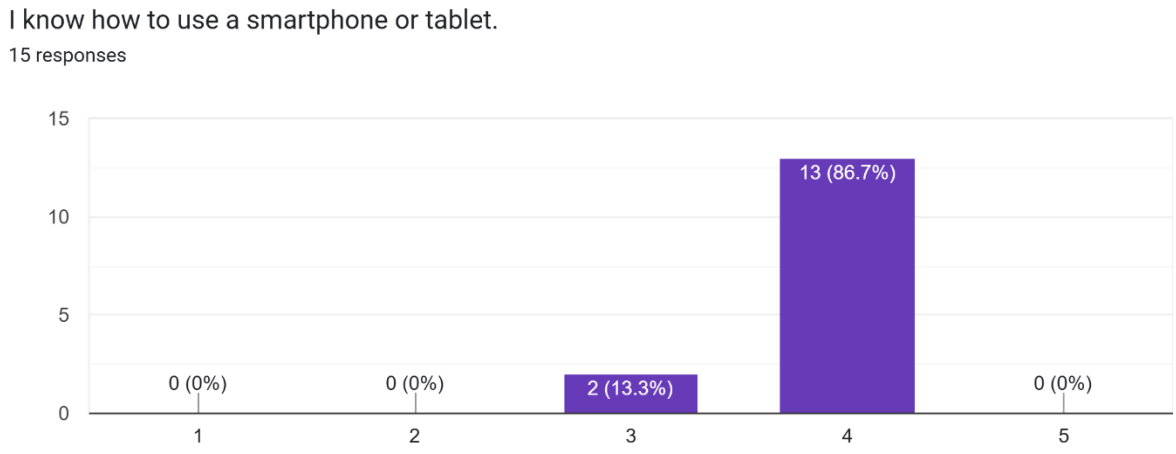


Figure 13: Bar Chart representation of the number of students who know how to use smartphones.

Figure 13 shows the level of familiarity among respondents regarding the use of smartphones or tablets. The majority, 86.7% (13 respondents), rated their familiarity as high, selecting a score of 4. Meanwhile, 13.3% (2 respondents) rated their familiarity slightly lower, selecting a score of 3. No respondents selected scores of 1, 2, or 5. This indicates that most students are proficient in using mobile devices, making them well-prepared to engage with an AR-based educational game on smartphones or tablets.

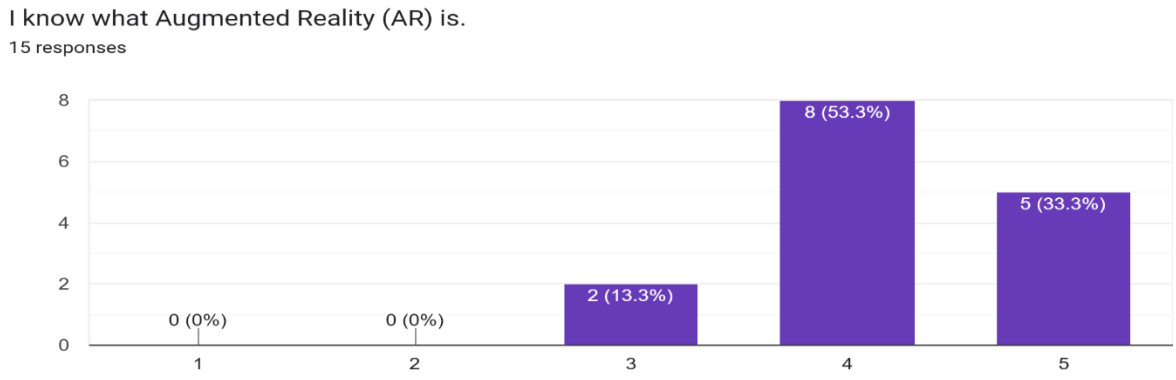


Figure 14: Bar Chart representation of respondents' familiarity with Augmented Reality (AR).

Figure 14 shows the respondents' familiarity with Augmented Reality (AR). The majority, 53.3% (8 respondents), rated their knowledge of AR as 4, while 33.3% (5 respondents) selected the highest score of 5, indicating strong familiarity. Meanwhile, 13.3% (2 respondents) rated their knowledge lower at 3. None of the respondents selected scores of 1 or 2. This data suggests that most respondents are familiar with AR, which is encouraging for integrating AR-based learning materials into the educational game.

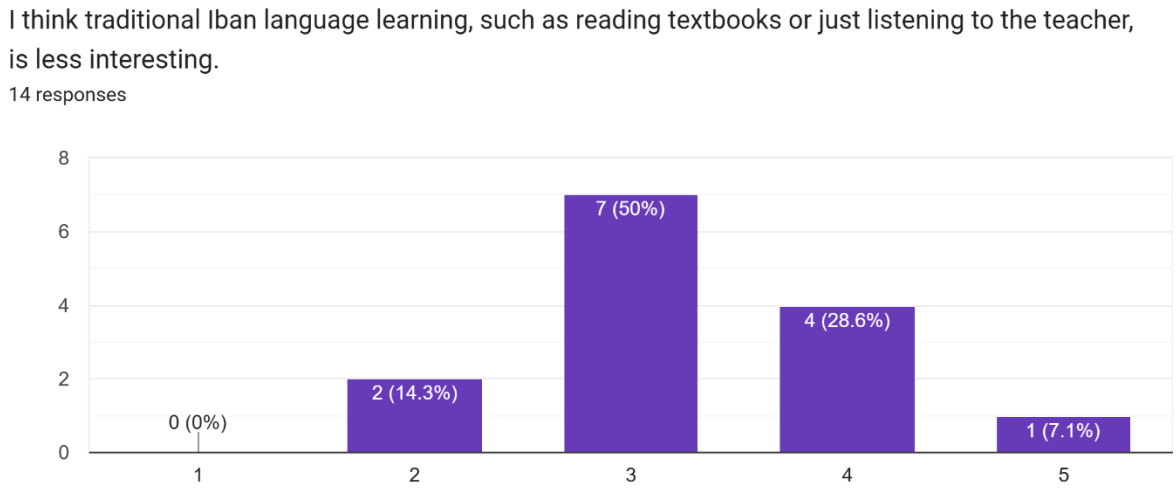


Figure 15: Bar Chart representation of respondents' opinions on traditional Iban language learning methods, such as reading textbooks or listening to the teacher.

Figure 15 illustrates respondents' opinions on traditional Iban language learning methods, such as reading textbooks or listening to the teacher. A small percentage of respondents, 7.1%, rated this method highly with a score of 5. Meanwhile, 28.6% selected a score of 4, and 50% chose a neutral score of 3. A lower 14.3% rated it as less effective with a score of 2, while no respondents selected the lowest score of 1. This data indicates a generally moderate perception of traditional learning methods, suggesting room for improvement through innovative approaches such as AR-based learning.

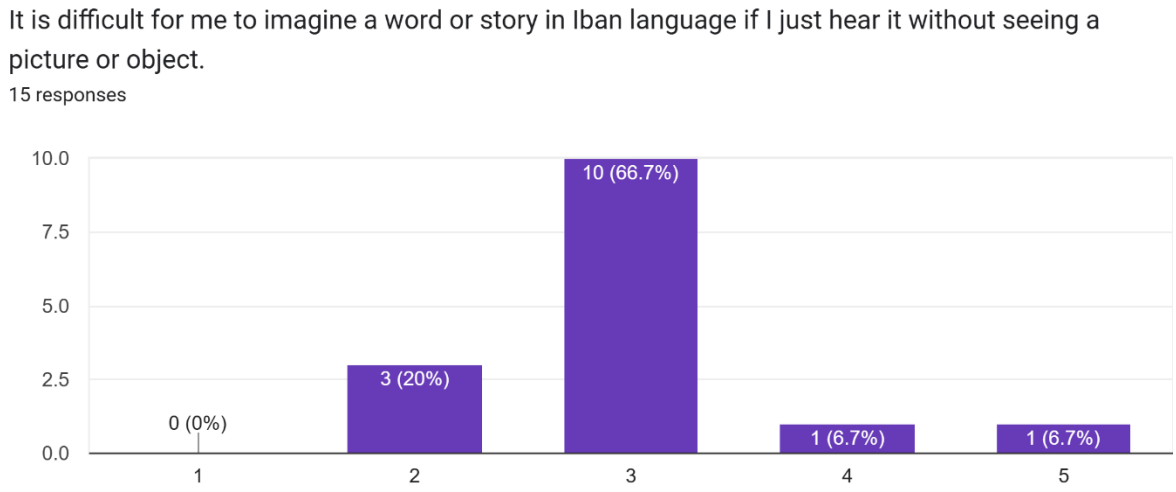


Figure 16: Bar Chart representation of respondents' difficulty in imagining a word or story in the Iban language when they only hear it without seeing a picture or object.

Figure 16 shows respondents' difficulty in imagining a word or story in the Iban language when they only hear it without seeing a picture or object. The majority, 66.7%, selected a neutral score of 3, indicating moderate difficulty. A smaller portion, 20%, rated the difficulty lower with a score of 2, while 6.7% selected scores of 4 and 5, indicating higher levels of difficulty. None of the respondents chose the lowest score of 1. This suggests that most students experience some difficulty in visualizing words or stories without visual aids, highlighting the potential value of incorporating AR visuals in the learning process.

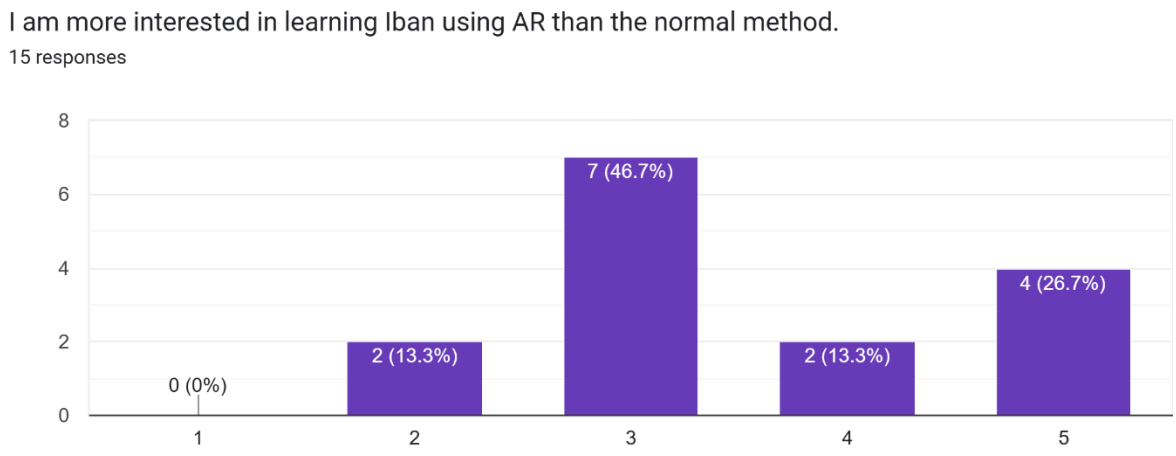


Figure 17: Bar Chart representation of respondents' interest in learning Iban using augmented reality (AR) compared to traditional methods.

Figure 17 illustrates respondents' interest in learning Iban using augmented reality (AR) compared to traditional methods. The majority, 46.7%, selected a neutral score of 3, indicating moderate interest. A smaller proportion, 13.3%, chose scores of 2 and 4, reflecting lower and higher levels of interest, respectively. Meanwhile, 26.7% of respondents expressed strong interest by selecting a score of 5. None of the respondents selected the lowest score of 1. This distribution suggests a general openness to the idea of learning Iban through AR, with a notable portion showing significant enthusiasm for the approach.

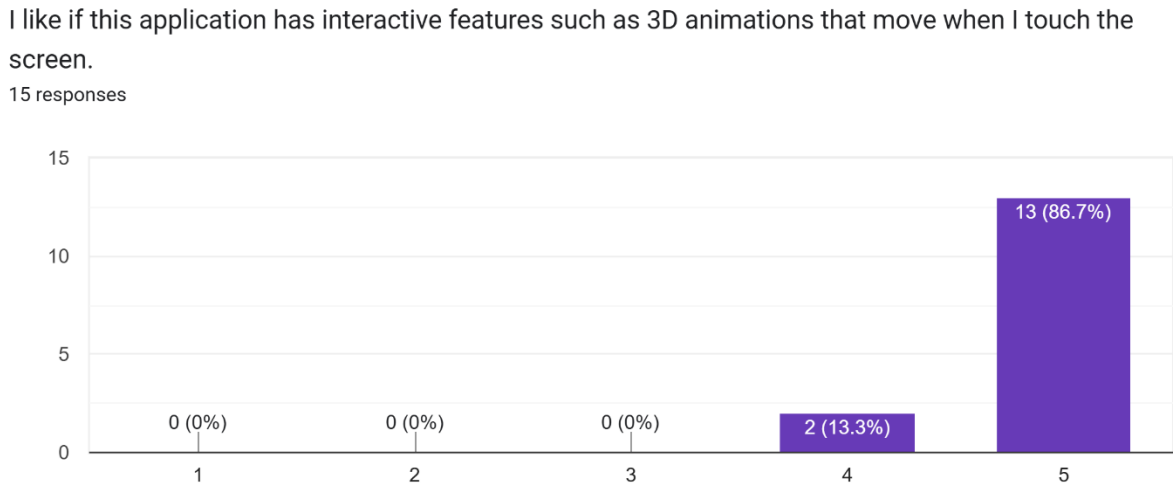


Figure 18: Bar Chart representation of respondents' preferences for interactive features.

Figure 18 illustrates respondents' preferences for interactive features, such as 3D animations that move when touched on the screen. The majority, 86.7%, selected the highest score of 5, indicating a strong preference for such features. A smaller portion, 13.3%, chose a score of 4, reflecting a high level of interest. None of the respondents selected scores of 1, 2, or 3. This overwhelming preference for interactive 3D animations highlights the importance of incorporating such features to enhance user engagement and satisfaction with the system.

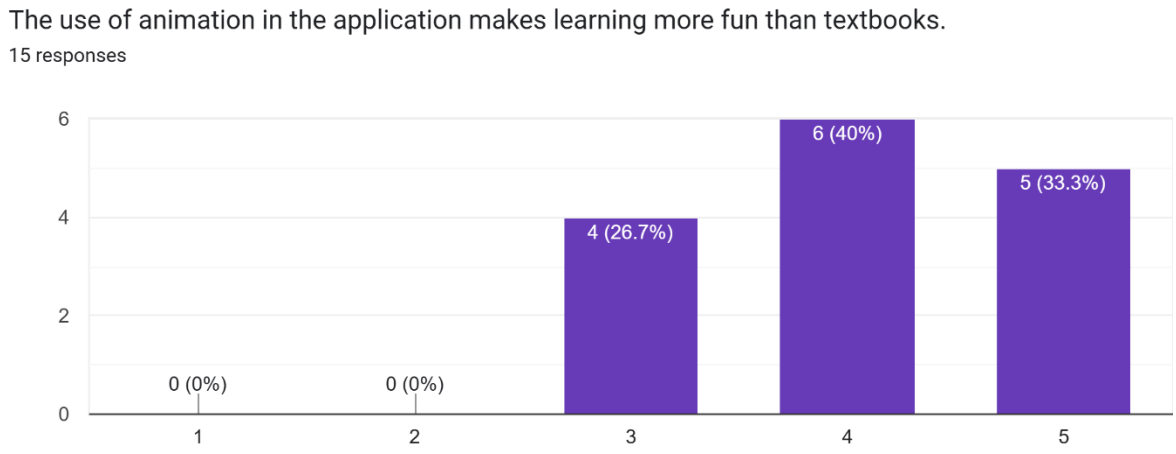


Figure 19: Bar Chart representation of respondents' perceptions of using animation in the system.

Figure 19 illustrates respondents' perceptions of using animation in the system to make learning more enjoyable compared to traditional textbooks. The majority, 40%, selected a score of 4, indicating a high level of agreement. A significant portion, 33.3%, chose the highest score

of 5, reflecting strong agreement. Meanwhile, 26.7% selected a neutral score of 3, suggesting moderate agreement. None of the respondents selected scores of 1 or 2. These results indicate that most respondents find the use of animation in the system a valuable and enjoyable alternative to traditional textbook-based learning.

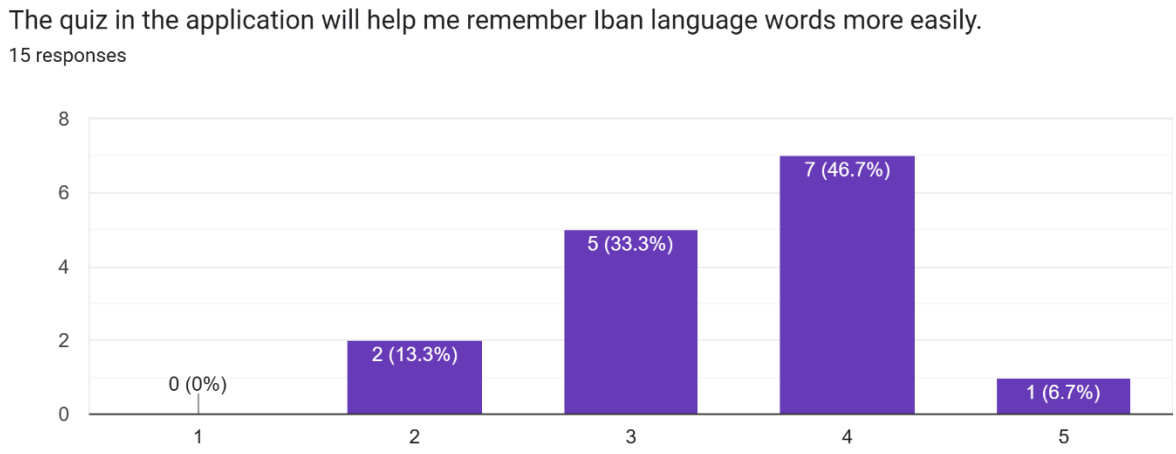


Figure 20: Bar Chart representation of respondents' opinions on whether the quiz feature in the system helps them remember Iban language words more easily.

Figure 20 illustrates respondents' opinions on whether the quiz feature in the system helps them remember Iban language words more easily. The majority, 46.7%, selected a score of 4, indicating a high level of agreement. A significant portion, 33.3%, chose a neutral score of 3, reflecting moderate agreement. Meanwhile, 6.7% selected the highest score of 5, showing strong agreement, and 13.3% chose a score of 2, indicating some disagreement. None of the respondents selected the lowest score of 1. These results suggest that the quiz feature is generally seen as beneficial for aiding memory, although opinions vary in strength.

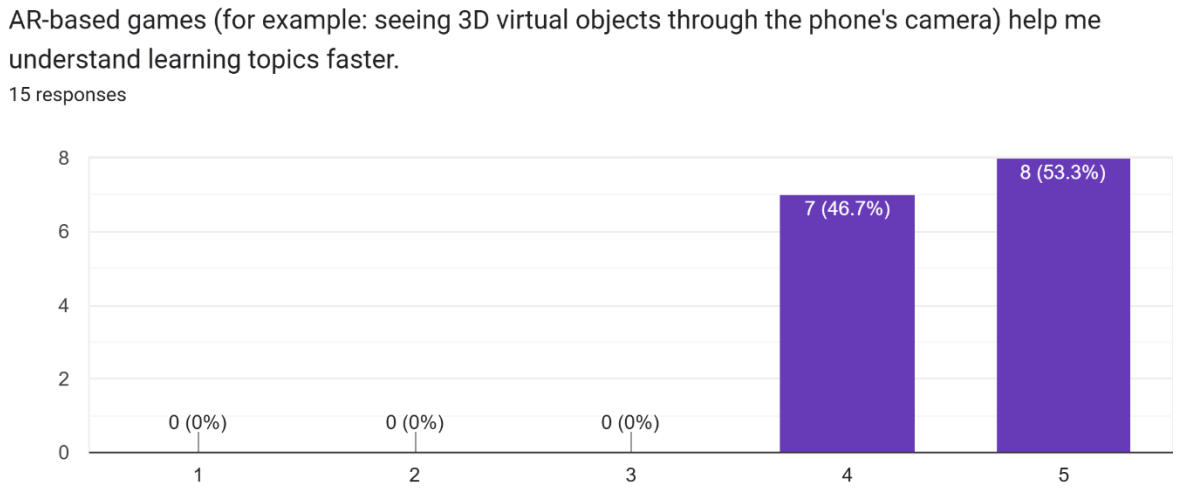


Figure 21: Bar Chart representation of respondents' views on whether AR-based games, such as interacting with 3D virtual objects through a phone's camera, help them understand learning topics faster.

Figure 21 illustrates respondents' views on whether AR-based games, such as interacting with 3D virtual objects through a phone's camera, help them understand learning topics faster. The majority, 53.3%, selected the highest score of 5, indicating strong agreement. A substantial portion, 46.7%, chose a score of 4, reflecting a high level of agreement. None of the respondents selected scores of 1, 2, or 3. These results demonstrate that respondents overwhelmingly perceive AR-based games as an effective tool for accelerating their understanding of learning topics.

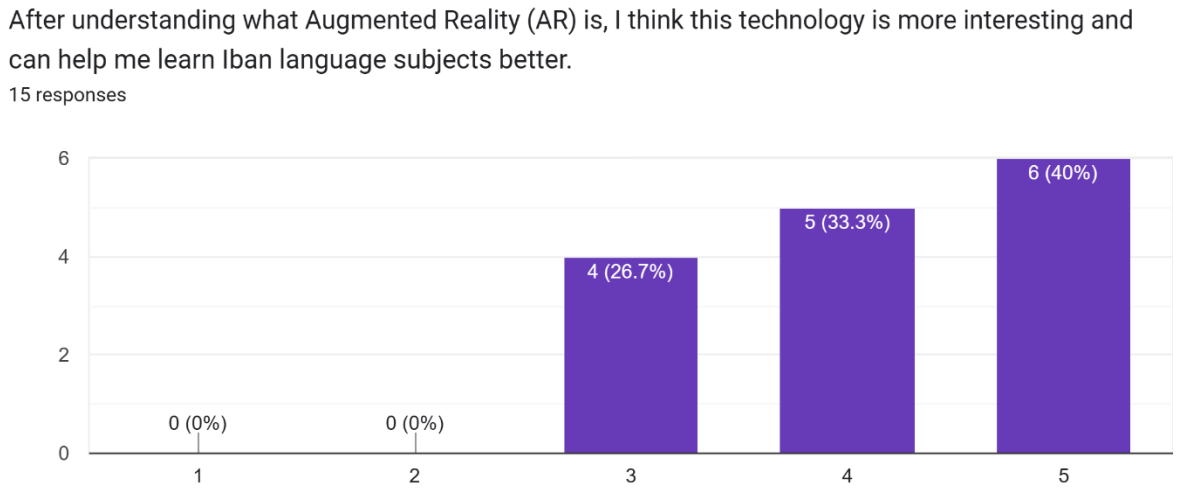


Figure 22: Bar Chart representation of respondents' opinions on whether understanding Augmented Reality (AR) technology makes it more interesting and helpful for learning Iban language subjects.

Figure 22 illustrates respondents' opinions on whether understanding Augmented Reality (AR) technology makes it more interesting and helpful for learning Iban language subjects. The majority, 40%, selected the highest score of 5, indicating strong agreement. A significant portion, 33.3%, chose a score of 4, reflecting a high level of agreement, while 26.7% selected a neutral score of 3, indicating moderate agreement. None of the respondents selected scores of 1 or 2. These results suggest that most respondents find AR technology both engaging and potentially beneficial for enhancing their learning experience in Iban language subjects.

3.3.1.3 Software Requirements

Software Tools	Descriptions
Unity Game Engine	Unity provides a comprehensive development environment with various tools for building interactive mobile systems and integration with AR Foundation to develop Augmented Reality experiences.
Visual Studio	Visual Studio is a popular Integrated Development Environment (IDE) from Microsoft. To be used to write C# scripts, the primary programming language used for scripting functionalities within Unity.

3.3.1.4 Hardware Requirements

A laptop is required to develop the system, and the specifications for the laptop are as follows:

Component	Descriptions
Laptop model	ASUS TUF Gaming FX505DT
Operating system (OS)	Windows 11 64-bit
Central processing unit (CPU)	AMD Ryzen™ 5 3550H
Graphics Processing Unit (GPU)	NVIDIA® GeForce GTX 1650
Random-access memory (RAM)	8GB DDR4

3.3.1.5 Functional Requirements

The Augmented Reality (AR) Game for Bahasa Iban Learning will include the following functional requirements:

1. Augmented Reality (AR) Integration
    - The system will utilize AR technology to create an interactive learning environment.
    - AR will be used to display 3D models and animations that visually represent vocabulary words, reinforcing meaning through immersive interaction.

2. Tangible Object Integration
    - The system will support tangible objects that students can interact with using the device's camera.
    - When scanned, these objects will trigger corresponding AR visuals and audio cues to enhance understanding.
3. Grammar and Spelling-Based Learning
    - The system will focus on Bahasa Iban grammar and spelling acquisition, helping students understand sentence structures and correct word usage.
    - Each grammar rule and spelling exercise will be accompanied by examples, interactive activities, and pronunciation guides to reinforce learning.
4. Game-Based Learning Mechanics
    - The system will incorporate gamification elements such as:
        - Quizzes to test word recognition and spelling.
        - Ranking/Scoring System to encourage engagement and motivation.
        - Progress Tracking to monitor students' improvement over time.
5. Multisensory Learning Support
    - The system will engage multiple senses by combining visual, auditory, and kinesthetic elements:
        - Visual: 3D models and animations of vocabulary words.
        - Auditory: Pronunciations and sound effects.
        - Kinesthetic: Interaction with AR elements and tangible objects.
6. User-Friendly Interface for Young Learners
    - The system will feature a simple and intuitive UI designed for Year 1 students.
    - Navigation will use large buttons, voice instructions, and minimal text, ensuring ease of use.
7. Mobile Device Compatibility

- The application will be optimized for smartphones and tablets, ensuring accessibility for students both in the classroom and at home.

3.3.1.6 Use Case Diagram

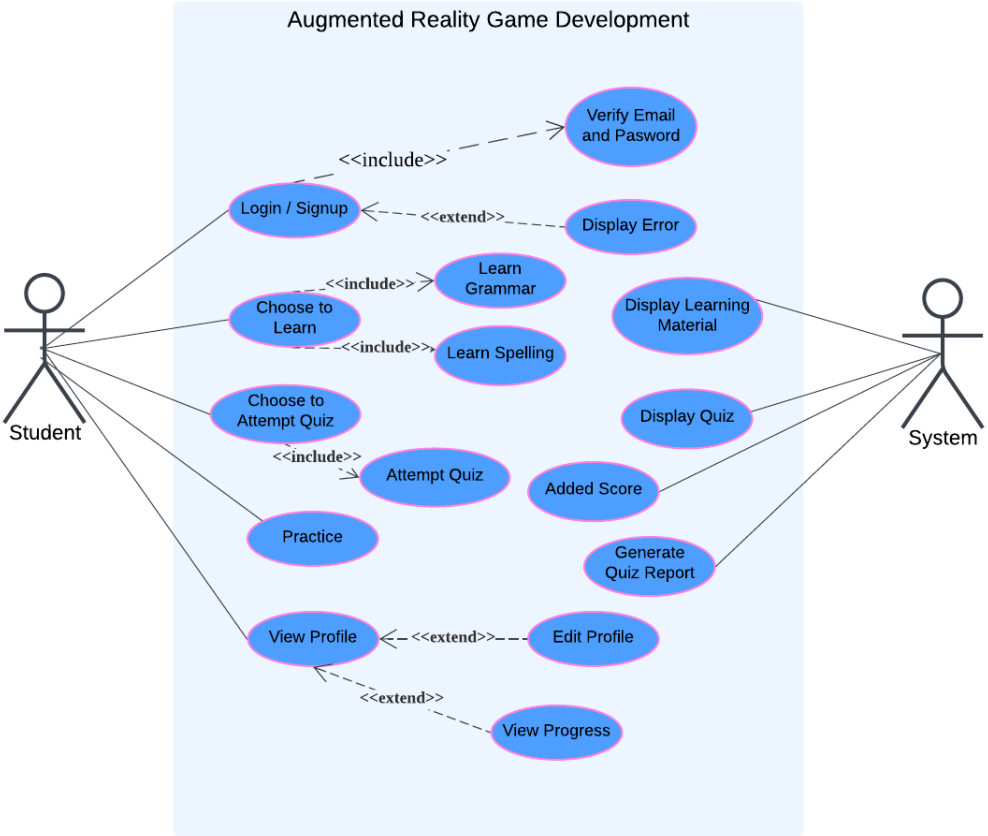


Figure 23: *Use Case Diagram.*

Figure 23 depicts a use case diagram for the Augmented Reality-based instructional game, emphasising the interactions between users and the system. The diagram features two principal actors: the student and the administrator/system manager. The student engages with the system to obtain educational resources, complete assessments, and administer their profile, whilst the administrator supervises content management and system functionality.

The primary use cases encompass "Login/Signup," facilitating user registration or authentication. This use case encompasses the verification of email and password and includes the presentation of an error message if the login credentials are invalid. Students may opt to engage with the "Learn Grammar" and "Learn Spelling" modules, which present educational content in an augmented reality style. The "Choose to Attempt Quiz" use case allows students to do quizzes, presenting questions, updating scores, and generate quiz reports based on their performance.

The diagram also emphasises profile maintenance via the "View Profile" use case, which encompasses "Edit Profile" for updates. Relationships like "include" and "extend" are employed to delineate dependencies and optional functionalities within the system. This use case diagram offers a clear representation of the system's essential functionalities, facilitating a comprehensive knowledge of user interactions and system needs.

3.3.1.6.1 Use Case Descriptions

The use case descriptions serve to systematically outline the functional requirements of the "Augmented Reality Game Development (Bahasa Iban for Year 1 Students)" system. Each use case provides a detailed narrative of how Year 1 students interact with the system to achieve specific learning objectives.

Table 2: *Use Case Descriptions for Signup.*

Use Case:
Sign Up

Brief Description:
The actor creates an account to access the system.

Actor(s):
Students

Pre-condition(s):
1. The actor must give their information to the system correctly.
2. The device used by the actor must connect to the Internet.

Post-condition(s):
The actor successfully signed up for the system.

Main Flow:

Actor's Actions	System Responses
1. The actor launches the system.	The system loads and displays the welcome screen.
2. The actor provides their information to the system.	The system validates the input and prompts for any missing or incorrect details.
3. The actor successfully creates an account.	The system confirms account creation and stores user data.
4. The actor logs in and is redirected to the system homepage.	The system verifies login credentials and grants access to the main interface.
5. The use case ends.	The system is ready for further interactions.

Alternative Flow(s):
-

Exception Flow(s):
The email user insert already exists in the system.
1. The use case begins when the email actor inputted already exists.
2. The system cancels the signup process.
3. The system notifies the actor that the email address already has an account in the system.
4. The use case ends.

Table 3: Use Case Descriptions for Login.

Use Case:
Login

Brief Description:
The actor login to the system.

Actor(s):
Students and the system.

Pre-condition(s):
1. The actor must already have a registered account.
2. The login information such as email address and password inserted by the actor must be correct.
3. The device used must connect to the Internet.

Post-condition(s):
The actor can log in to the system.

Main Flow:

Actor's Actions	System Responses
1. The actor launches the system.	The system loads and displays the login page.
2. The actor inserts their login information.	The system validates the credentials and checks if the input is correct. If incorrect, an error message is displayed.
3. The actor successfully logs in.	The system grants access and redirects the actor to the homepage.

Alternative Flow(s):
The actor forgot their login information:
1. The use case began when the actor forgot their login information.
2. The actor can click the "forgot password?" link from the user interface.
3. A reset password link will be sent to the actor through email.
4. The actor set their new password.

Use case continues to main flow (3).

Exception Flow(s):
The system shows "wrong password or email" to the actor.
1. The use case begins when the system notifies the actor has inserted the wrong password/email.
2. The actor will need to click "ok" and insert their email and password again.

Table 4: *Use Case Descriptions for Choose to Learn.*

Use Case:
Choose to Learn

Brief Description:
The process where the actor selects a learning module, either "Learn Grammar" or "Learn Spelling".

Actor(s):
Students and the system.

Pre-condition(s):
1. The actor has successfully logged into the system.
2. The learning module content is available.

Post-condition(s):
1. The system displays the selected learning module (grammar or spelling).
2. Allow the actor to scan a QR code.

Main Flow:

Actor's Actions	System Responses
1. The student navigates to the "Choose to Learn" screen.	The system displays two options: "Learn Grammar" and "Learn Spelling."
2. The student selects either "Learn Grammar" or "Learn Spelling."	The system processes the selection and loads the appropriate learning module.
3. If "Learn Grammar" is selected:	The system allows the student to choose a grammar topic and prompts them to scan a QR code. Once scanned, grammar learning materials are displayed.
4. If "Learn Spelling" is selected:	The system displays spelling-related activities, such as interactive spelling tasks.

Alternative Flow(s):
-

Exception Flow(s):
-

Table 5: Use Case Descriptions for Learn Grammar.

Use Case:
Learn Grammar

Brief Description:
The student selects and engages with the grammar learning module.

Actor(s):
Students and the system

Pre-condition(s):
1. The student has selected "Learn Grammar" from the "Choose to Learn" screen.
2. Grammar learning materials are available in the system.

Post-condition(s):
The student completes grammar learning activities.

Main Flow:

Actor's Actions	System Responses
1. The student selects the "Learn Grammar" option.	The system loads the grammar learning interface and prompts the student to scan a QR code.
2. The student scans the QR code.	The system recognizes the QR code and displays the corresponding interactive grammar lesson.
3. The student scans all available learning materials for grammar.	The system sequentially loads and displays the scanned grammar materials, allowing the student to interact with them.

Alternative Flow(s):
-

Exception Flow(s):
If the progress data fails to load, the system displays an error message and redirects the student to the main menu.

Table 6: *Use Case Descriptions for Learn Spelling.*

Use Case:
Learn Spelling

Brief Description:
The student selects and engages with the spelling learning module.

Actor(s):
Students and the system.

Pre-condition(s):
1. The student has selected "Learn Spelling" from the "Choose to Learn" screen.
2. Spelling learning materials are available in the system.

Post-condition(s):
The student completes spelling learning activities.

Main Flow:

Actor's Actions	System Responses
1. The student selects the "Learn Spelling" option.	The system loads the spelling learning interface and prompts the student to choose the number of letters for the session.
2. The student selects the number of letters for the spelling session.	The system adjusts the spelling content based on the selected word length and prompts the student to scan a QR code.
3. The student scans the QR code.	The system recognizes the QR code and displays the corresponding interactive spelling lesson.
4. The student scans all available learning materials for spelling.	The system sequentially loads and displays the scanned spelling materials, allowing the student to interact with them.

Alternative Flow(s):
-

Exception Flow(s):
If the progress data fails to load, the system displays an error message and redirects the student to the main menu.

Table 7: Use Case Description for Choose to Answer Quiz.

Use Case:
Choose to Answer Quiz

Brief Description:
The process where the actor selects a quiz module to test their knowledge in either grammar or spelling.

Actor(s):
Students and system.

Pre-condition(s):
1. The actor has completed some learning activities.
2. Quiz content is available in the system.

Post-condition(s):
1. The actor completes a grammar or spelling quiz, and the score is recorded.

Main Flow:

Actor's Actions	System Responses
1. The actor navigates to the "Choose to Answer Quiz" screen.	The system loads the quiz interface and displays five grammar and five spelling quiz questions for the student.
2. The student submits their answers.	The system processes the answers and evaluates them for correctness.
3. The application displays the summary of the quiz attempted.	The system presents a results summary showing the number of correct and incorrect answers along with feedback or scores.

Alternative Flow(s):
If the student answers a question correctly, the system adds the score to their total.

Exception Flow(s):
-

Table 8: Use Case Descriptions for View Profile.

Use Case:
View Profile

Brief Description:
The actor views personal information within the system.

Actor(s):
Students

Pre-condition(s):
The student has logged into their account.

Post-condition(s):
The system displays the student's information.

Main Flow:

Actor's Actions	System Responses
1. The student selects the "View Profile" icon from the homepage.	The system loads the profile interface and prepares to retrieve the student's data.
2. The system retrieves the actor's personal information.	The system queries the database for the student's information.
3. The system displays the student's details, .	The system presents the retrieved information profile screen.

Alternative Flow(s):
-

Exception Flow(s):
-

Table 9: *Use Case Descriptions for Edit Profile.*

Use Case:
Edit Profile

Brief Description:
The actor edits their profile within the system.

Actor(s):
Students

Pre-condition(s):
The student has logged into their account.

Post-condition(s):
The system updates the student's profile.

Main Flow:

Actor's Actions	System Responses
1. The student press the "Edit" button from the profile page.	The system loads the profile interface and prepares to retrieve the student's data.
2. The system displays the updated profile information.	The system presents the retrieved updated information.

Alternative Flow(s):
-

Exception Flow(s):
-

Table 10: Use Case Descriptions for View Progress.

<table>
<tr><td>Use Case:
View Progress</td></tr>
<tr><td>Brief Description:
The actor views their progress within the system.</td></tr>
<tr><td>Actor(s):
Students</td></tr>
<tr><td>Pre-condition(s):
The student has logged into their account.</td></tr>
<tr><td>Post-condition(s):
The system updates the student's progress.</td></tr>
<tr><td>Main Flow:
<table>
<tr><th>Actor's Actions</th><th>System Responses</th></tr>
<tr><td>1. The student press the "Progress" button from the profile page.</td><td>The system loads the profile progress and prepares to retrieve the data.</td></tr>
<tr><td>2. The system displays the student’s progress.</td><td>The system presents the retrieved student’s progress.</td></tr>
</table></td></tr>
<tr><td>Alternative Flow(s):
-</td></tr>
<tr><td>Exception Flow(s):
-</td></tr>
</table>

3.3.2 Design

This phase focuses on converting prioritized user stories into actionable design strategies. Prototypes are developed to visualize the application functionality and aesthetics, providing a foundation for interaction and usability evaluation. Such methods play a crucial role in ensuring that design solutions are aligned with user needs while minimizing development costs and time (Berni & Borgianni, 2020).

3.3.2.1 Flowchart

This part illustrates the traditional learning method's flowchart and the proposed system.

3.3.2.1.1 Traditional Method

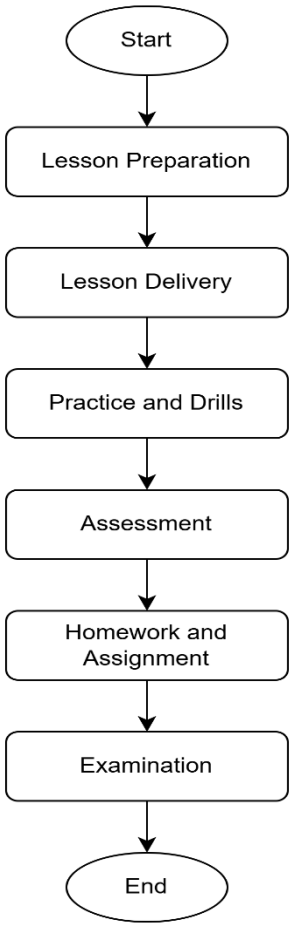


Figure 24: *Flowchart for traditional learning method.*

Figure 24 flowchart illustrates the key steps in a typical teaching and learning process. It starts with lesson preparation, followed by delivering the lecture. Students then engage in practice and drills to apply what they have learned. Next, assessments are conducted to evaluate understanding, and the process concludes with homework assignments for further practice.

3.3.2.1.2 Proposed System

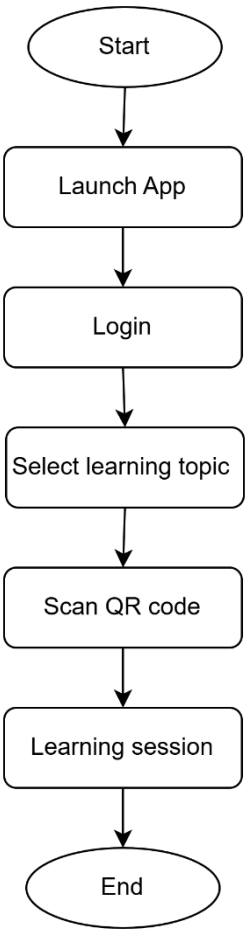


Figure 25: *Flowchart Diagram for proposed system (learning).*

Figure 25 depicts the interaction flow between a learner and the augmented reality (AR) system for a learning session. The process commences with the initiation of the application, designated as the "Start" of the flow. Upon launching the app, the student enters the login phase to have access to personalized features and progress monitoring.

Upon successful login, the student selects a learning topic from the available alternatives, such as grammar or spelling, to advance in their chosen area of study. Subsequently, the learner scans a QR code linked to the chosen educational resource. Upon confirming the QR code, the system directs the user to the learning session, where interactive AR-based instructional material is displayed.

The process culminates with the conclusion of the session, signifying the completion of the engagement. This process guarantees a systematic and accessible method for obtaining educational resources via the AR system.

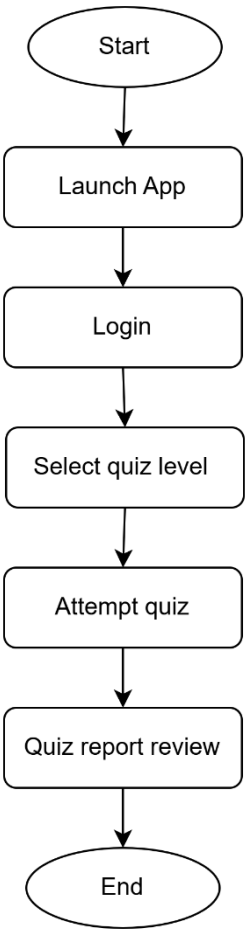


Figure 26: *Flowchart for proposed system (quiz).*

Figure 26 depicts the interaction flow between a student and the augmented reality (AR) system for quiz-based activities. The process commences with the initiation of the application, designated as the "Start" of the flow. Upon activating the application, the learner advances to the login step, guaranteeing safe access to their individualized learning profile.

Upon logging in, the student chooses a quiz level that corresponds to their preferred difficulty or learning advancement. The system thereafter progresses to the attempt quiz step, during which the learner participates in an interactive quiz session. Upon completion of the quiz, the system generates a quiz report review, enabling the student to assess their performance and identify areas for enhancement.

3.3.2.2 System Architecture

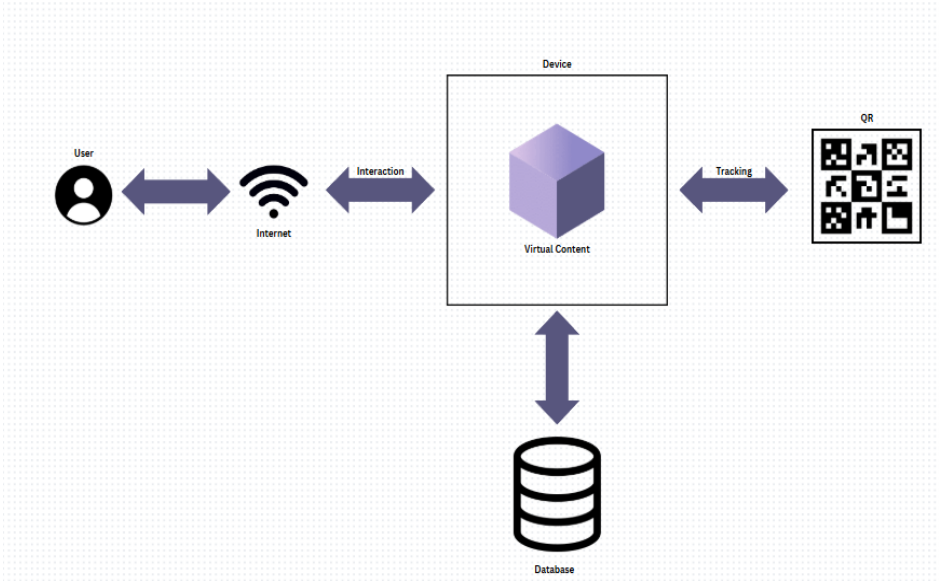


Figure 27: *System Architecture for the proposed system.*

The figure above illustrates the system architecture of an augmented reality (AR) learning application intended for Year 1 pupils. The system's foundation is the device (smartphone or tablet) that supports the application, facilitating the presentation of virtual content via augmented reality. This information is associated with real-world stimuli, such as QR codes, which the device scans to superimpose digital learning resources onto the actual surroundings.

The user-device interaction is enabled via the internet, ensuring connectivity for real-time content updates and synchronization. The gadget serves as a conduit for interactive feedback, enabling the user to interact with educational content, do assessments, and monitor advancement. The technology facilitates ongoing engagement by processing QR code scans to get the associated instructional information and activities stored in the database.

The database functions as the core of the system, including all critical data like user profiles, educational resources, and score records. It interfaces directly with the device to facilitate on-demand material retrieval and preserves user progress for subsequent access. The seamless integration of the database, device, and QR tracking establishes a coherent system that provides an effective and dynamic AR-based learning platform designed for young learners.

3.3.2.3 Sequence Diagram

A sequence diagram illustrates the interactions between the student and the system during the gameplay process. This sequence diagram effectively visualizes the dynamic interactions, helping in understanding the system's flow and functionality.

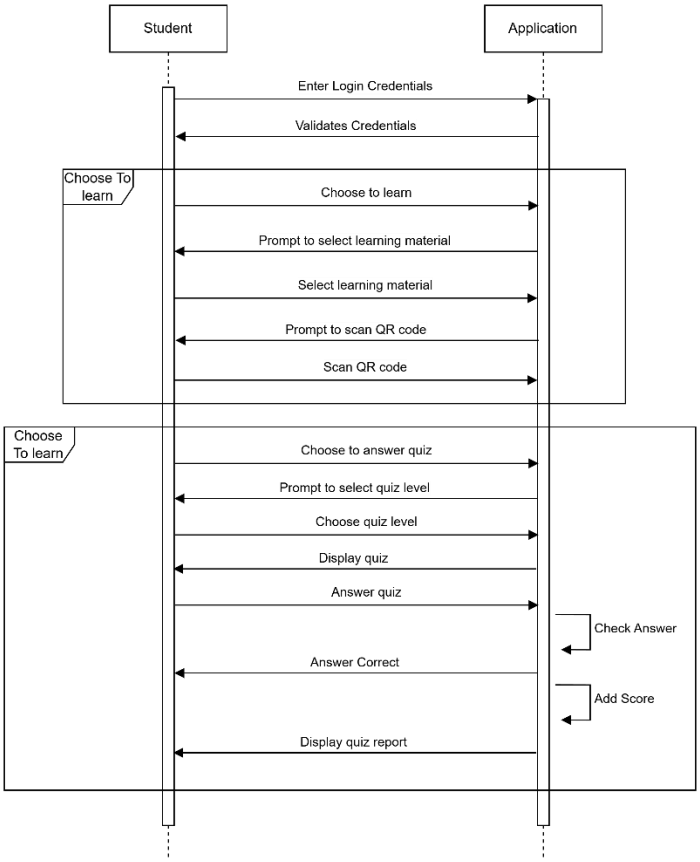


Figure 28: *Sequence Diagram.*

Figure 28 illustrates the interaction between a student and an application in a learning system. The process begins when the student enters their login credentials, which the application validates. Upon successful authentication, the student chooses to learn, prompting the application to provide options for selecting learning materials. The student selects the desired material, and the system prompts them to scan a QR code, which they do.

After accessing the learning material, the student chooses to take a quiz. The application prompts the student to select a quiz level, after which the system displays the quiz. The student answers the quiz, and the application checks the submitted response. If the answer is correct, the application adds the corresponding score. Finally, the system displays the quiz report, summarizing the student's performance. This structured sequence ensures a smooth learning experience, guiding the student from material selection to quiz completion assessment.

3.3.2.4 Activity Diagram

Figure 29 represents the User Login Process using an activity diagram. The process starts when the student launches the application, prompting the system to redirect them to the login page. The student then enters their required login details, after which the system checks if all fields are valid. If any fields are missing or incorrect, the system prompts the student to re-enter the details. Once all fields are correctly entered, the system verifies whether the provided account information is correct. If the credentials are incorrect, an error message is displayed, allowing the student to attempt to log in again. If the credentials are correct, the system successfully redirects the student to the homepage. The process concludes once the student is logged in. This diagram effectively visualizes the authentication flow, ensuring proper validation and error handling before granting access.

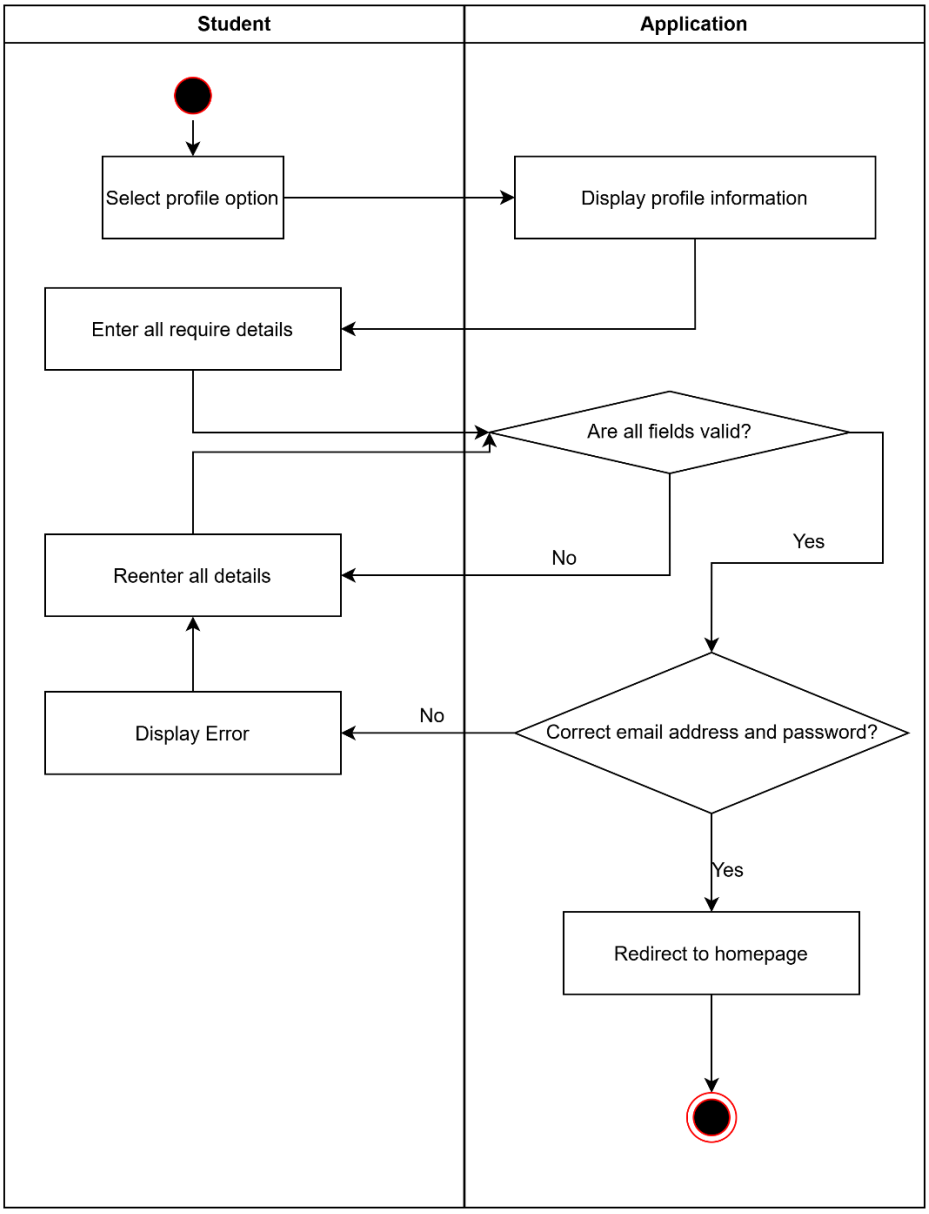


Figure 29: Activity diagram for Login Page.

Figure 30 below illustrates an activity diagram depicting the signup process for a student utilizing an application. The interaction starts with the student initiating the application and clicking the signup link. The application redirects the students to the signup page. The student inputs the necessary information into the form. The application then will verify the fields to confirm that the entries are accurate and comprehensive. Upon validation failure, the student is instructed to re-enter the information. Upon verifying all fields, the system verifies an account associated with the detailed information. If the account is non-existent, the application will save the details in the database, inform the student of the successful account creation, and lead them to the login page. This procedure guarantees a seamless and safe account creation experience while averting duplicate accounts.

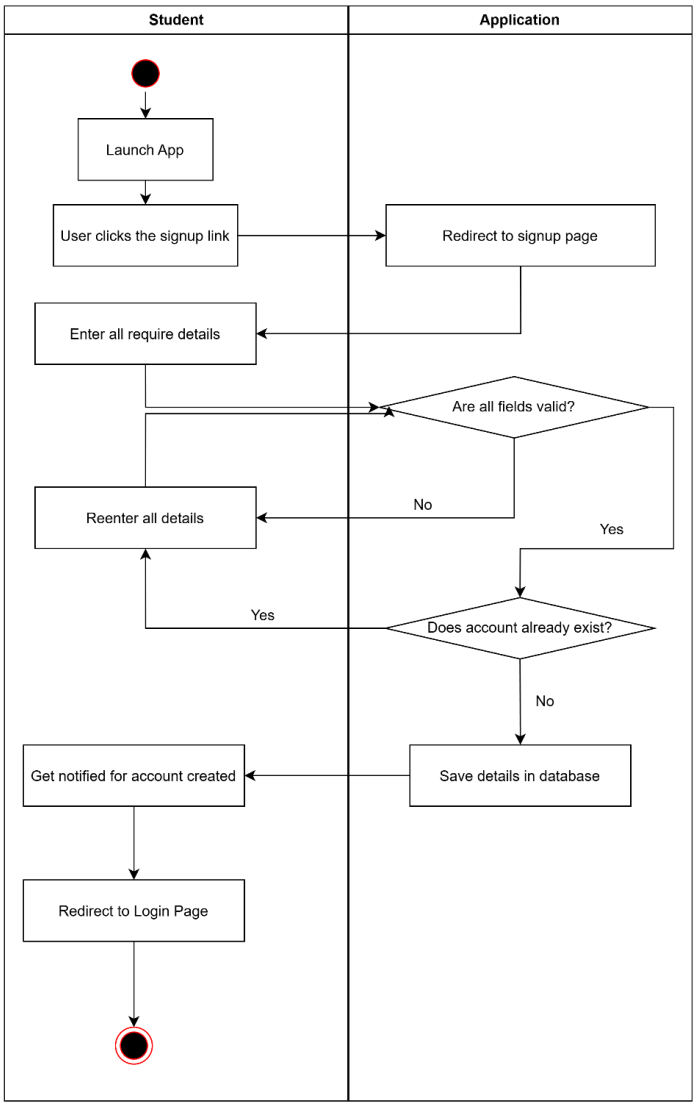


Figure 30: *Activity Diagram for Signup Page.*

Figure 31 below illustrates an activity diagram depicting the interaction between a student and the augmented reality system for learning purposes. The process begins with the student launching the app and selecting the "Learn" option. The system then prompts the student to choose a specific topic they want to learn, such as grammar (covering prepositions, active/passive sentences, and adjectives) or spelling. This step ensures personalized learning, allowing students to focus on areas of interest or need.

After selecting the desired topic, the student scans a QR code associated with the learning material, which the system processes. If the QR code is valid, the corresponding learning material is displayed on the app, enabling the student to engage interactively with the content. This streamlined flow, reflected in the wireframe, ensures an intuitive user experience, empowering students to navigate and access educational topics seamlessly while enhancing their learning through augmented reality.

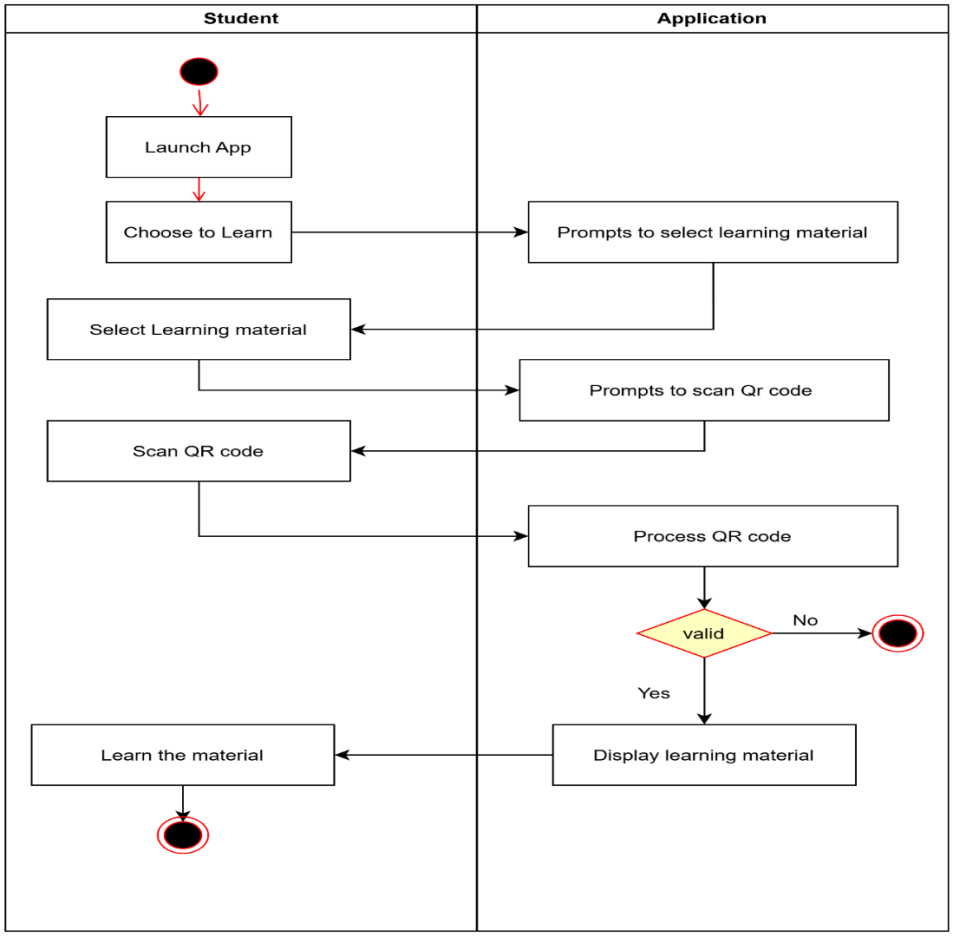


Figure 31: *Activity Diagram for learning option.*

Figure 32 illustrates the activity diagram for a student completing a quiz. The student launches the app, selects "Quiz," chooses a quiz type, and answers the questions. The system validates responses, updates the score for correct answers, and notifies the student. This diagram highlights the streamlined quiz process.

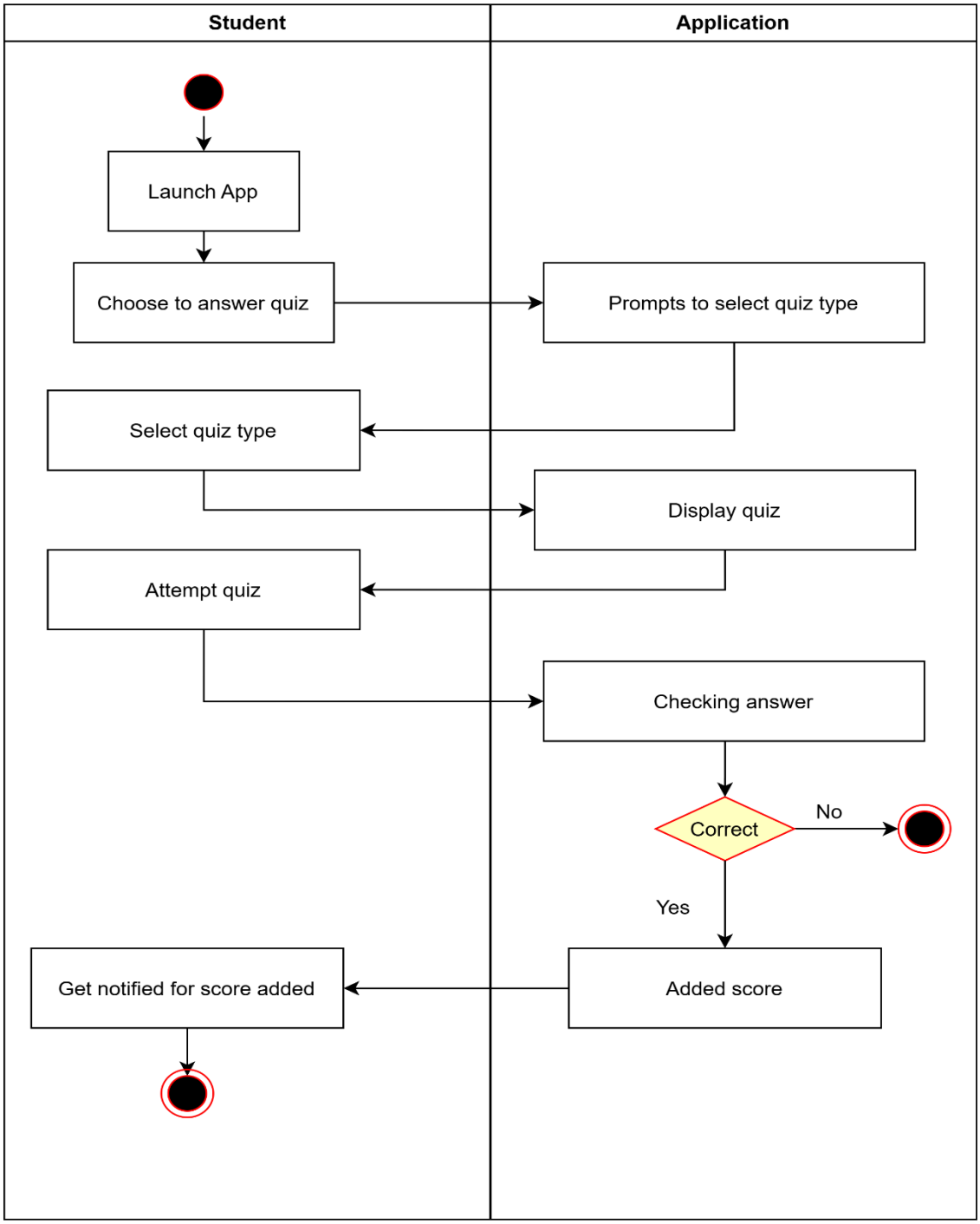


Figure 32: *Activity Diagram for attempt quiz option.*

Figure 33 illustrates the Profile Viewing Process in an activity diagram, divided. The process begins when the student selects the profile option, initiating a request for profile information. The application then retrieves the required profile data from the system. Once the information is successfully retrieved, it is sent back to the student, and the profile details are displayed on the screen. The process concludes when the student views the profile information. This diagram effectively represents the sequence of actions required for accessing and displaying a user's profile in an application.

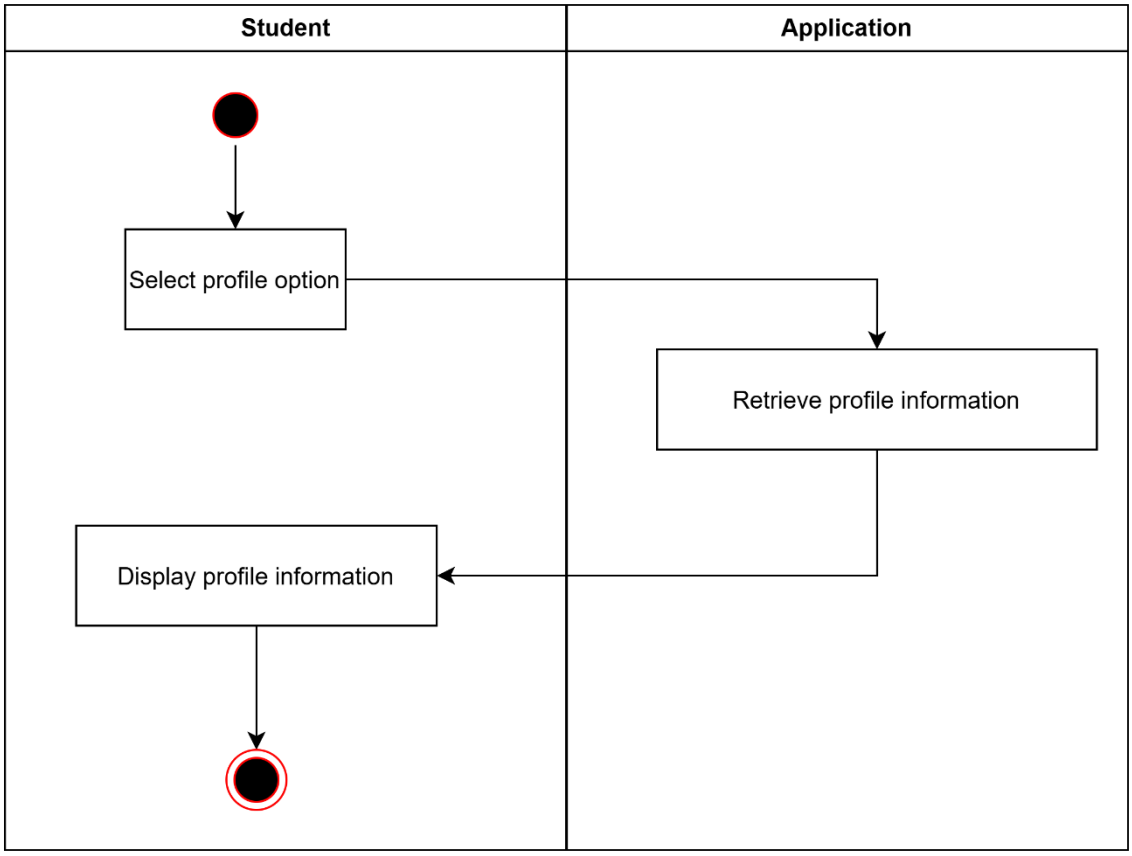


Figure 33: Activity diagram for view profile.

Figure 34 illustrates the Edit Profile Process using an activity diagram. The process begins when the student selects the profile option, followed by choosing the edit profile option. The student then modifies the profile details as required and submits the changes. At this stage, the system validates the submitted information. If the changes are valid, the system updates and saves the profile successfully, displaying a success message. However, if the changes are invalid, an error message is shown, prompting the student to correct the details. The process concludes once the profile is updated, or the student is notified of the errors. This diagram effectively represents the structured sequence of steps required for profile modification while ensuring data integrity.

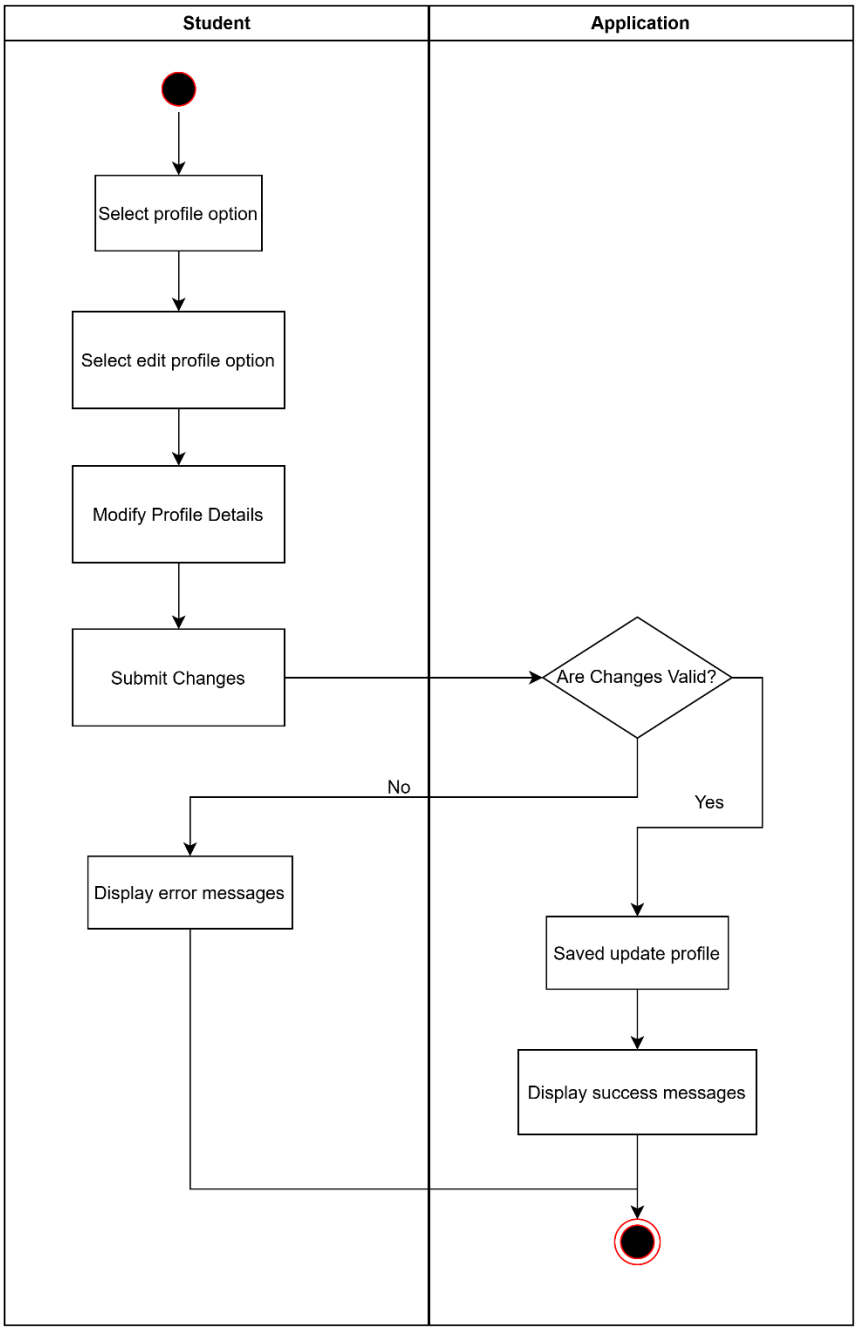


Figure 34: Activity diagram for Edit Profile

3.3.2.5 User Interface

The User Interface (UI) is essential for providing an interesting and user-friendly experience for students. It is crafted to be intuitive, aesthetically pleasing, and engaging, addressing the requirements of young learners. Each interface is designed to facilitate students' navigation through the learning process, featuring explicit instructions and visually differentiated components for enhanced understanding. The integration of augmented reality (AR) and interactive elements enriches the user interface, rendering the learning experience both educational and enjoyable.

3.3.2.5.1 Launch Page

Figure 35: *Launch page for the application.*

Figure 35 shows the application's interface after the student launches the application. The students can press the “BERENGKAH” button to start the app and redirect to the Login page.

3.3.2.5.2 Login Page

Figure 36: *Login page for the application.*

Figure 36 shows the next user interface, which is the login page after the student presses "BERENGKAH" on the launch page. On this page, the student needs to insert the correct email and password that they use for those who have already signed up. Meanwhile, for the students who have not yet signed up, they can select the sign-up link to create an account.

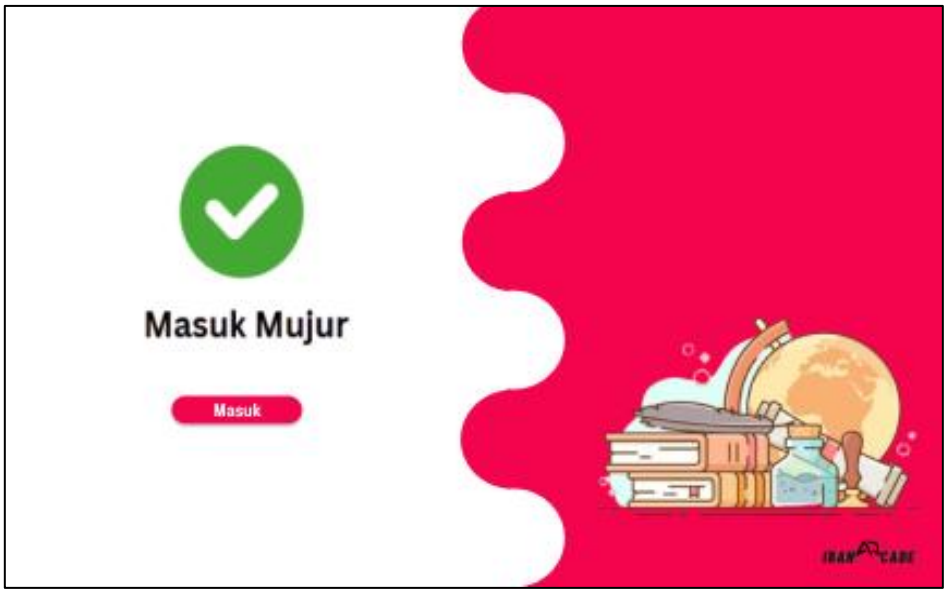


Figure 37: *Successfully login notification.*

After students insert the correct email and password, a pop-up notification as shown above will appear and the user can select "Masuk" to redirect the student to the main page.

Figure 38: *Login fails pop-up notification.*

For another scenario, if the user inserts the wrong email or password, pop-up notifications as shown above would appear on the screen. With that, the student gets to select to re-enter the details "Isi Baru" or to reset the password "Reset password". For the "Isi Baru" button the student will be redirected to the login page to re-enter their details. Meanwhile, for the "Reset Password" button the student receives an email through the email they inserted to reset the password.

3.3.2.5.3 Signup Page

Figure 39: *Signup Page for the application.*

Figure 39 shows the Signup page for students who have not registered. The details needed are the student's name, age, school, email address, and password. After completing all the details, the student can press the “REJISTA” button to register their account.

3.3.2.5.4 Main Page

Figure 40: *Main Page for the application.*

The figure above shows the main page for the application. On this page, the user can select to learn the material, attempt quizzes, or view their profile.

3.3.2.5.5 Learning Page

Figure 41: *Learning Page for the application.*

Figure 41 illustrates the user interface for the learning option selected from the main page. On this page, the student gets to choose either to learn grammar "Jalai Jaku" or spelling "Sepil". For the grammar options, the students will be redirected to Figure 42.

3.3.2.5.6 Grammar Page

Figure 42: *Grammar option Page.*

On this page, students get to choose grammar topics such as prepositions, active/passive sentences, and adjectives. Each selected option will allow the student to scan a QR code that links to specific AR-based content, providing an interactive way to explore the chosen topic.

Figure 43: *QR scanning interface for learning grammar option.*

Figure 43 shows the QR code scanning interface of the augmented reality (AR) learning system. This screen allows the student to scan a QR code associated with specific learning materials or activities. The interface includes a camera viewfinder with visual guides (white brackets) to help the user position the QR code properly within the scanning frame.

Figure 44: *Example of illustration for preposition learning material after scanning.*

Figure 44 displays an example of a visual learning aid for the Iban language, presenting the sentence "Aki benung duduk __ bangku." The illustration shows a man sitting on a chair, supporting the comprehension of the sentence. Students are given four preposition choices "ari," "ba," "nuju," and "dalam" to fill in the blank, with the correct answer being "ba," meaning "on" or "at" in English. If a wrong answer is selected, a "tot" sound will be heard as feedback,

while selecting the correct answer triggers a “Ding” sound. This interactive feature enhances engagement and provides immediate feedback, making the learning experience more enjoyable and effective for young learners.

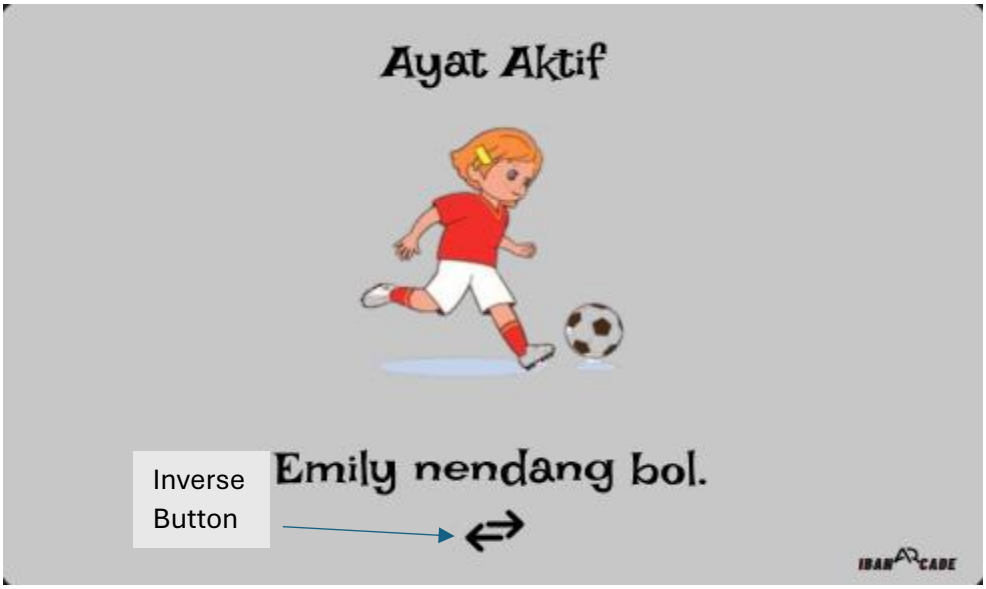


Figure 45: *Example illustration for active sentence learning materials.*

Figure 45 illustrates the interface for students after scanning QR for the Active/Passive Sentences option. In this figure it will display the Active sentences first, then the students can press the inverse button to change the active to passive sentences as shown in Figure 41.

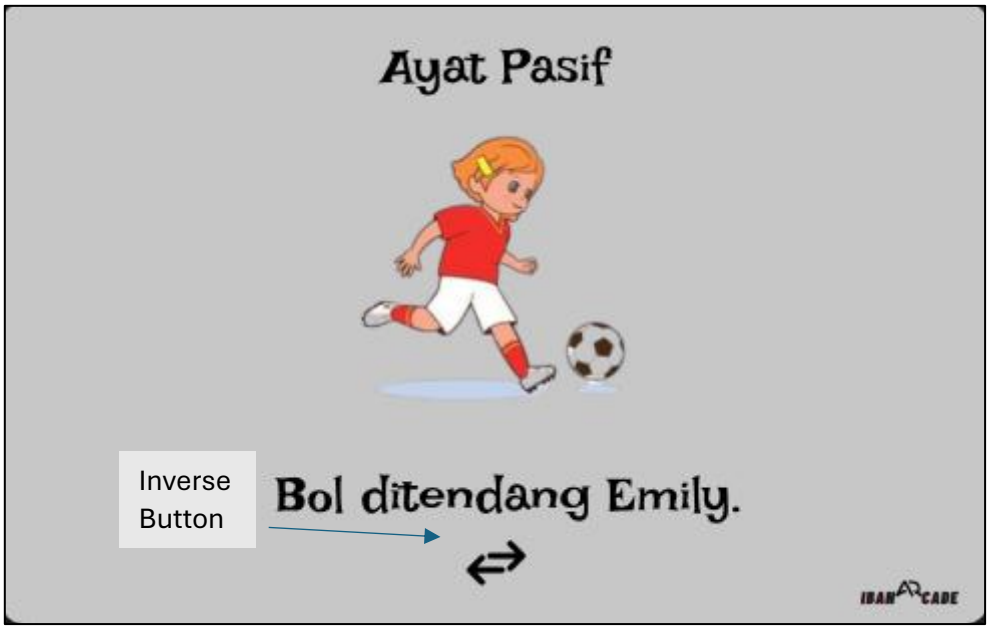


Figure 46: *Example illustration for passive sentence learning materials.*

Figure 46 illustrates the interface for students after scanning QR for the Adjective Sentences option. The illustration shows a big house, supporting the comprehension of the sentence. Students are given four adjective choices "besai," "mit," and "mar" to fill in the blank, with the correct answer being "besai," meaning "big" in English. If a wrong answer is selected, a "tot" sound will be heard as feedback, while selecting the correct answer triggers a "Ding" sound.

Figure 47: *Example illustration of adjective sentence learning materials.*

3.3.2.5.7 Spelling Page

Figure 48: *Selection of number interface.*

Figure 48 illustrates the interface when students choose the spelling option. This page allows students to select the number of letters for spelling words. Upon picking the preferred number of letters, students use the augmented reality (AR) function to scan a QR code associated with their choice, allowing the AR system to produce the corresponding word-spelling learning session.

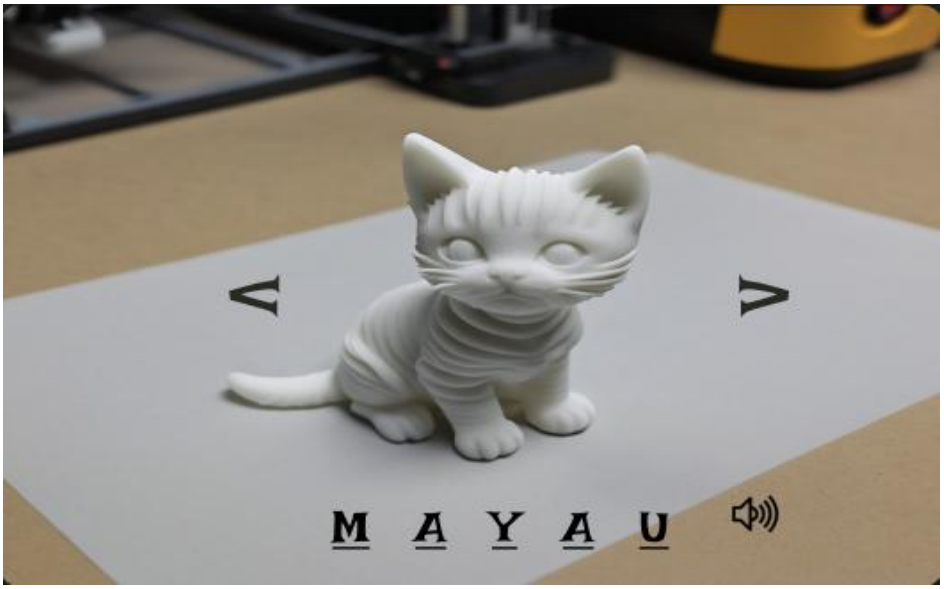


Figure 49: *Illustration of selecting five number of letters.*

The figure above shows the illustration of a cat that consists of five letters in Iban which is “MAYAU”. On this page, the student gets to interact with the model through hand gestures on the screen to rotate the model. Apart from that, the student also can press the speaker button to practice the word pronunciation.

3.3.2.5.8 Quiz Page

Figure 50: *Level option to determine the difficulty of the quiz.*

Figure 50 shows the interface for students selecting the quiz option on the main page. On this page, students get to choose the level of quiz that will determine the difficulty of the question. A higher level will earn more score for each correct answer.

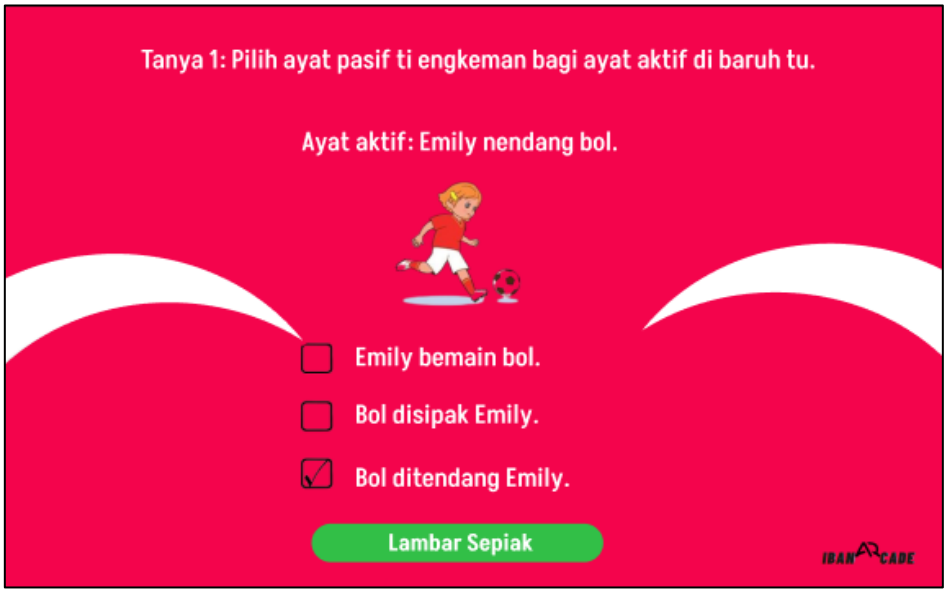


Figure 51: *Example question for level 1.*

Figure 51 illustrates the example question for level 1. On this page, the student got to tick the checkbox for the passive sentences after being given the active sentence above. After choosing their answer the student can press the "Lambar Sepiak" button to proceed to the next question.

Figure 52: *Example of the same question for a quiz with higher-level difficulty.*

Figure 52 illustrates the same question as Figure 46 but for higher-level difficulty. On this page, instead of selecting passive sentences, the students are required to select both active and passive sentences that match the image shown in the questions. If either one of the selected answers is wrong the students will not be given an additional score.

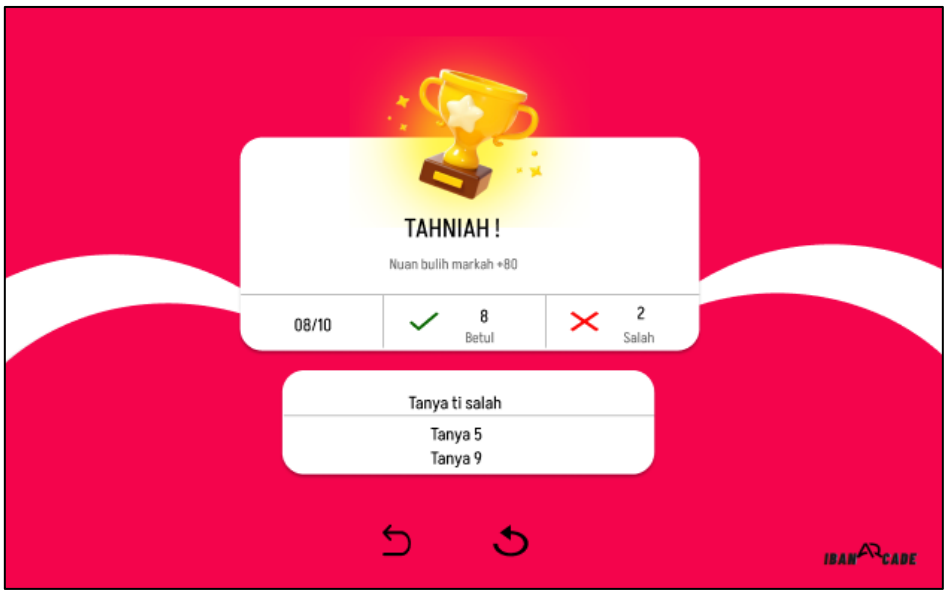


Figure 53: *Summary of quiz attempt.*

Figure 53 illustrates the interface displaying a summary after students complete the quiz. The summary includes the score achieved, and the number of correct and incorrect answers. The summary also highlights the questions answered incorrectly to guide

improvement. Re-attempts button is also included to allow students to retake the quiz and improve their performance.

3.3.2.5.9 View Profile

Figure 54: *Profile Page for the application.*

Moreover, the student also can view their profile by selecting the profile icon on the homepage as shown in Figure 54.

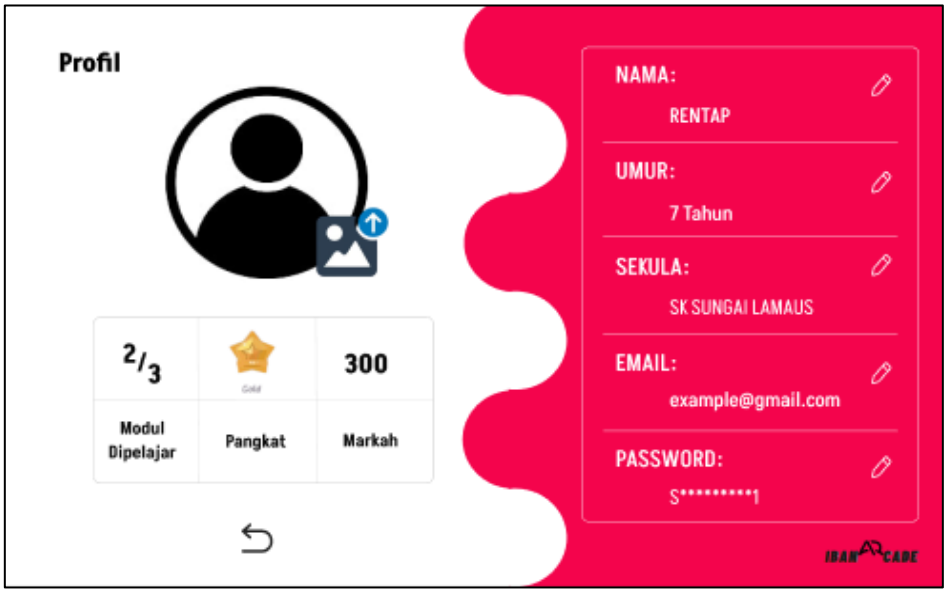


Figure 55: *View Profile Page.*

On the View Profile page (Figure 55), the student can edit their name, age, school, email, and password details. Apart from that, the student can also see their current completed

module, rank, and score on this page. The rank display will be based on their score. The primary purpose of implementing this ranking system is to foster a sense of healthy competition among students, thereby encouraging them to push their boundaries and strive for academic excellence. Additionally, it serves as a motivational tool designed to inspire students to actively engage in their learning journey, cultivate a sense of achievement, and enhance their overall educational experience. By creating an environment where progress and performance are recognized and rewarded, the ranking system aims to elevate students' competitiveness and nurture their intrinsic motivation to learn and grow.

3.3.3 Develop

During this phase, features are compiled and implemented. Development is carried out in short iterations, known as sprints, which allow for quick adaptations based on changing requirements.

3.3.4 Test

In the testing phase, various types of testing will be conducted to ensure the system's reliability and performance.

Test Type	Test Case	Objective	Steps	Expected Result
Unit Testing	Grammar Lesson Interaction	Verify that the system correctly displays the grammar lesson.	1. Select a grammar topic. 2. Scan the QR code. 3. Check if the correct lesson is displayed.	The selected grammar topic is displayed with interactive learning materials.
	Spelling Activity Selection	Verify that the system displays spelling activities correctly based on the word length.	1. Select the number of letters for the spelling session. 2. Scan the QR code for the activity.	The system displays spelling exercises appropriate for the selected word length.

			3. Check if the exercises match the selected word length.	
Regression Testing	Profile Access After Update	Ensure recent updates do not affect the profile page or quiz scores.	1. Update the system or add new features. 2. Access the "View Profile" screen. 3. Check if the quiz scores and rank badges are displayed correctly.	Profile information is displayed accurately without any loss of data.
Performance Testing	System Load During Quiz	Evaluate the system's responsiveness during a quiz session.	1. Start a quiz with grammar and spelling questions. 2. Submit answers and wait for the results. 3. Monitor system response time.	The system responds within an acceptable time frame, displaying results promptly.
Usability Testing	Navigation on the Homepage	Verify ease of navigation on the homepage and module selection.	1. Access the homepage and navigate to "Choose to Learn." 2. Select a	Homepage and learning modules are easy to navigate with clear labels and smooth transitions.

			learning module. 3. Check if options are accessible.	
End-to-End Testing	Full User Flow	Ensure the entire system works seamlessly from account creation to quiz completion.	Create a new account and log in. Select "Learn Grammar" and scan the QR code. Answer the quiz and submit responses. View results.	The full user flow works without errors, with smooth transitions and correct data saving and display.

By incorporating these tests, any potential issues can be identified and addressed at various levels of the development of the system

3.3.5 Deploy

This phase focuses on delivering working features incrementally to end-users to gain valuable feedback.

3.3.6 Review

The review phase encourages regular reflections and evaluations of the development process. Sprint reviews provide an opportunity to showcase completed work, gather feedback, and adjust. This continuous feedback loop is integral to the Agile methodology, fostering a culture of adaptability and continuous improvement throughout the project lifecycle.

3.4 Summary

To conclude, the methodology for the development of the "Augmented Reality Game Development (Bahasa Iban for Year 1 Students)" is discussed, with an emphasis on the Agile Methodology. This approach is chosen for its adaptability and iterative nature, which is ideal

for the project's dynamic requirements. During the requirements phase, both hardware and software needs were thoroughly identified. An interview with the teacher and a survey were conducted among Year 1 students to gather insights into their preferences and expectations for the game, which would guide the design process. The chapter also includes the development of a flowchart and use case diagram to represent the system's overall flow and the interaction of its components, providing a clear framework for the development process. Additionally, the system's high-level architecture demonstrates the integration of AR-enabled devices, QR code tracking, and the central database, enabling real-time updates, content retrieval, and progress monitoring. Wireframes were developed to show the visual arrangement and interactive components of the program, providing a conceptual picture of the user interface and assuring alignment with the educational requirements of Year 1 students.

CHAPTER 4: IMPLEMENTATION

4.1 Introduction

Chapter 4 discusses the implementation of the proposed system. The development of the system consists of five core components: an Android application, an Augmented Reality (AR) engine, 3D assets, a cloud-based backend, and a code editing environment. These components were developed and integrated to fulfil the project's objective, which is to enhance Bahasa Iban language learning for Year 1 students through an interactive AR-based educational game.

The Android application serves as the main platform for users to access AR content. It provides a simple and child-friendly interface where students can scan printed image markers to view corresponding 3D models and hear the pronunciation of the vocabulary in Bahasa Iban. This application was developed using Unity, a powerful game engine that supports cross-platform development and offers seamless integration with AR technologies.

For the AR functionality, Vuforia was used as the primary engine to detect and track image markers. Vuforia allows the application to recognize specific visual markers, such as flashcards, and overlay 3D content on top of them in real-time. When a marker is scanned using the device camera, the system displays a related 3D model along with audio playback to help reinforce the student's understanding of the vocabulary. This combination of visual and auditory elements helps make the learning process more engaging and memorable for young users.

The 3D models displayed in the application were created using Blender, an open-source 3D modelling and animation software. Blender was used to design, animate, and export the models into formats that are compatible with Unity. Each model was tailored to match the vocabulary items featured in the application, ensuring that they were both appropriate and visually appealing for young learners. Attention was given to keeping the models simple and colorful to maintain user interest and encourage interaction.

Firebase was incorporated into the system to provide backend support for user authentication and potential data storage. Although the current version of the application stores user progresses locally, Firebase Authentication is integrated to allow secure login functionality. This creates a foundation for future scalability, where user progress can be stored

in Firebase Cloud Firestore or Realtime Database, enabling cross-device synchronization and additional features such as teacher or parent dashboards for monitoring performance.

Visual Studio Code was used as the primary code editor throughout the development process. It provided a lightweight yet powerful environment for editing C# scripts, JSON configuration files, and Firebase integration code. Its rich ecosystem of extensions, including syntax highlighting, IntelliSense, Git integration, and Firebase tools, enhances productivity and helps ensure clean and organized code management.

To manage the development process and maintain code versions, GitHub has been used as the version control system. GitHub has been utilized as the repository platform to store, track, and back up the project files, ensuring that all development changes are documented and securely maintained throughout the project lifecycle.

Overall, the integration of Unity, Vuforia, Blender, Firebase, and Visual Studio Code forms the backbone of the proposed system. The successful implementation of these technologies demonstrates the potential of AR in improving language learning among early primary school students, particularly through interactive and visual-based experiences that encourage active engagement.

4.2 Environment Setup

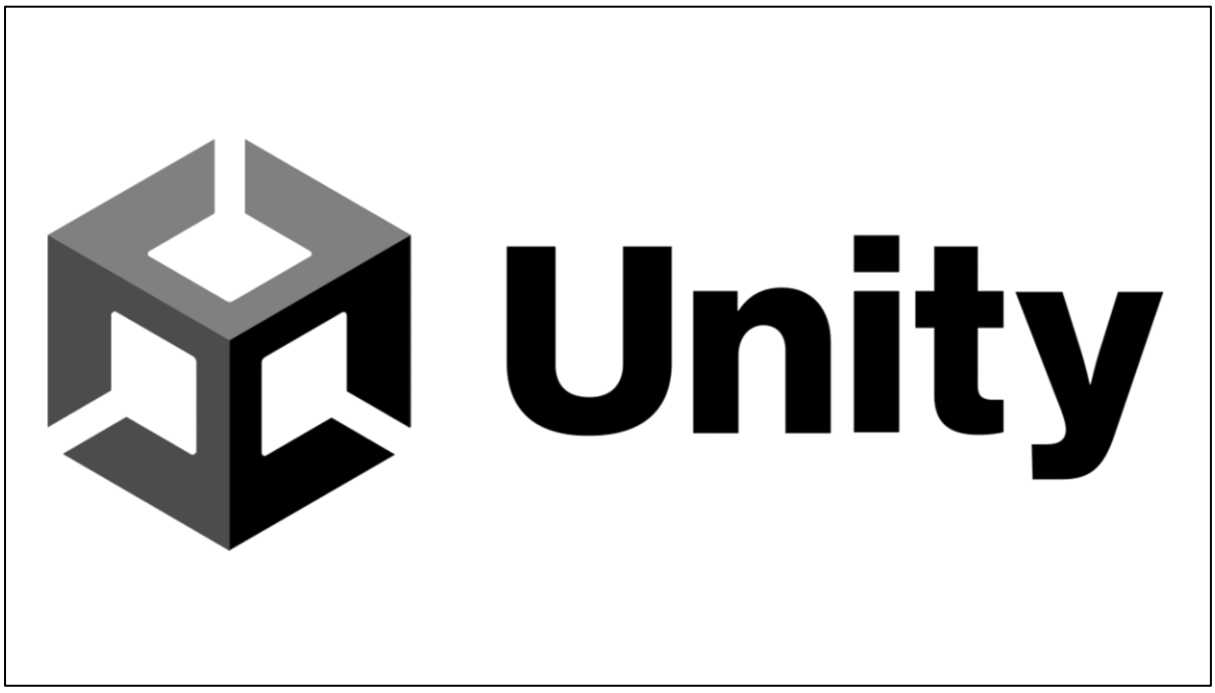


Figure 56: *Unity software.*

Figure 56 shows the Unity. Unity is a cross-platform game engine developed by Unity Technologies, widely used for creating both two-dimensional (2D) and three-dimensional (3D) interactive content. It is known for its powerful features that support game development, simulations, and augmented reality (AR) applications. This project will use Unity as the main platform for building the AR experience in the system. Unity provides a wide range of tools and components such as a user-friendly interface, real-time rendering, physics engine, asset management system, and strong integration support for AR development platforms like Vuforia.

Figure 57: *Vuforia Engine Software.*

Figure 57 shows the Vuforia Engine. Vuforia is an augmented reality software development kit (SDK) for mobile devices that enables the creation of AR applications. It allows apps to recognize and track images and objects in the real world, and to overlay digital content on them. This project will utilize Vuforia to implement marker-based AR features in the system, enabling interactive learning experiences through image tracking. Vuforia offers robust capabilities such as image recognition, object recognition, and model targets, and integrates seamlessly with Unity, making it a popular choice for AR developers.

Figure 58: *Blender software.*

Figure 58 shows the Blender. Blender is a free and open-source 3D computer graphics software used for creating animated films, visual effects, art, 3D-printed models, motion graphics, and interactive 3D applications. It supports the entire 3D pipeline including modelling, rigging, animation, simulation, rendering, compositing, and motion tracking. In this project, Blender will be used to create and edit 3D models which will be imported into Unity for use in the AR application. Blender offers features like sculpting tools, UV mapping, texturing, and a wide range of export formats, making it highly suitable for preparing 3D assets for Unity.

Figure 59: *Visual Studio.*

Figure 59 shows the Visual Studio Code. Visual Studio Code (VS Code) is a lightweight, yet powerful source code editor developed by Microsoft. It is widely used by developers across various platforms for writing, editing, and debugging code. In this project, Visual Studio Code will be used primarily for scripting and editing code files related to the system, such as JSON configuration files, C# scripts, or web-based components. VS Code

offers a wide range of features including IntelliSense for code completion, built-in Git integration, a powerful debugging environment, and an extensive marketplace for extensions that enhance development productivity and support various programming languages and frameworks.

Figure 60: *Firebase.*

Figure 60 shows the Firebase. Firebase is a comprehensive mobile and web application development platform developed by Google. It provides a variety of cloud-based services that help developers build and manage high-quality applications with ease. In this project, Firebase will be used to implement key backend functionalities such as user authentication and a real-time database for tracking student progress. Firebase offers a suite of powerful features including Authentication, Cloud Fire store, Realtime Database, Cloud Storage, Analytics, and Crash Reporting. Its seamless integration with Unity allows for secure data management and user interaction tracking, which is essential for delivering a personalized and interactive learning experience within the augmented reality game application.

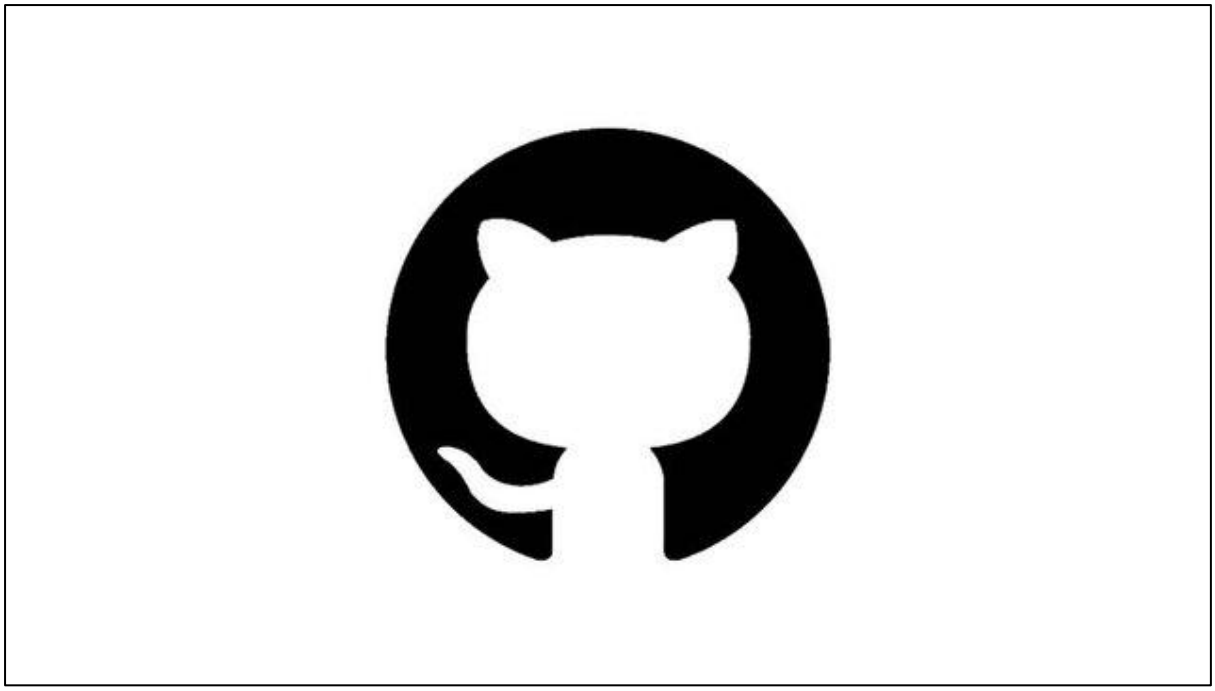


Figure 61: *GitHub.*

Figure 61 shows the GitHub platform**.** GitHub is a widely used platform for version control and collaborative software development, built around Git. It allows developers to host and review code, manage projects, and collaborate with other team members efficiently. In this project, GitHub is used to manage the source code for the augmented reality game application, ensuring proper version tracking, team collaboration, and code backup. Its integration with development tools such as Unity and Visual Studio Code enables seamless commits, branching, and pull requests. This not only enhances team productivity but also provides a structured workflow for tracking development progress and maintaining the integrity of the project codebase throughout the lifecycle of the final year project.

4.3 Mechanism of Image Target Detection in AR

In this project, the core computer vision technique utilized is 2D image target detection and tracking, which forms the basis for marker-based augmented reality (AR).

The process begins with the AR system capturing a live video feed from the device's camera. Each frame of this video feed is analysed in real time to detect and extract distinctive visual features from the environment. These features typically include edges, corners, and textured patterns that uniquely represent the physical image target, such as a page from a book used in this project. To reliably identify these points of interest under varying conditions, like different lighting or partial occlusion, the system employs feature detection algorithms such as

ORB (Oriented FAST and Rotated BRIEF) and BRISK (Binary Robust Invariant Scalable Keypoints). These algorithms are chosen for their ability to efficiently detect and describe image features while maintaining computational speed suitable for mobile devices (Kose et al., 2021).

Once features are extracted from the live camera frames, the system performs feature matching by comparing these live features to pre-stored features from the reference image target. This matching process determines whether the target image is present in the current scene by finding enough matching key points between the two sets. Accurate and fast feature matching is critical to distinguish the target from other objects or patterns, directly impacting the seamlessness and responsiveness of the AR experience. To optimize performance on mobile devices, lightweight deep learning models or optimized descriptors are often integrated to speed up matching without sacrificing accuracy (Shin et al., 2022).

After successfully detecting the image target via feature matching, the system proceeds with pose estimation. Pose estimation calculates the exact position and orientation of the target in three-dimensional space by determining six degrees of freedom (6DoF): translation along the X, Y, and Z axes, and rotation in roll, pitch, and yaw. This spatial information enables the AR system to anchor virtual content, such as educational 3D models and text prompts, directly onto the physical image target. As the student slides the slide bar on the device, pose estimation continuously updates in real time, keeping virtual elements precisely aligned with the target. This alignment is essential to creating a convincing and immersive AR experience (Liu et al., 2020).

This real-time image recognition and pose tracking capability serves as the foundation for many practical AR applications, particularly in education. In this project, this technology enables Year 1 students to engage with Bahasa Iban vocabulary by scanning physical images that trigger an interactive model. The robustness of the image tracking ensures smooth and reliable interaction. Furthermore, modern AR frameworks such as ARKit and ARCore enhance tracking stability and responsiveness by combining visual data with inertial sensor inputs. Although challenges such as motion blur, lighting variations, and occlusion can affect performance, ongoing advances in computer vision algorithms and sensor fusion techniques continue to improve the reliability of AR, making it a powerful tool for educational purposes (Zhang et al., 2023).

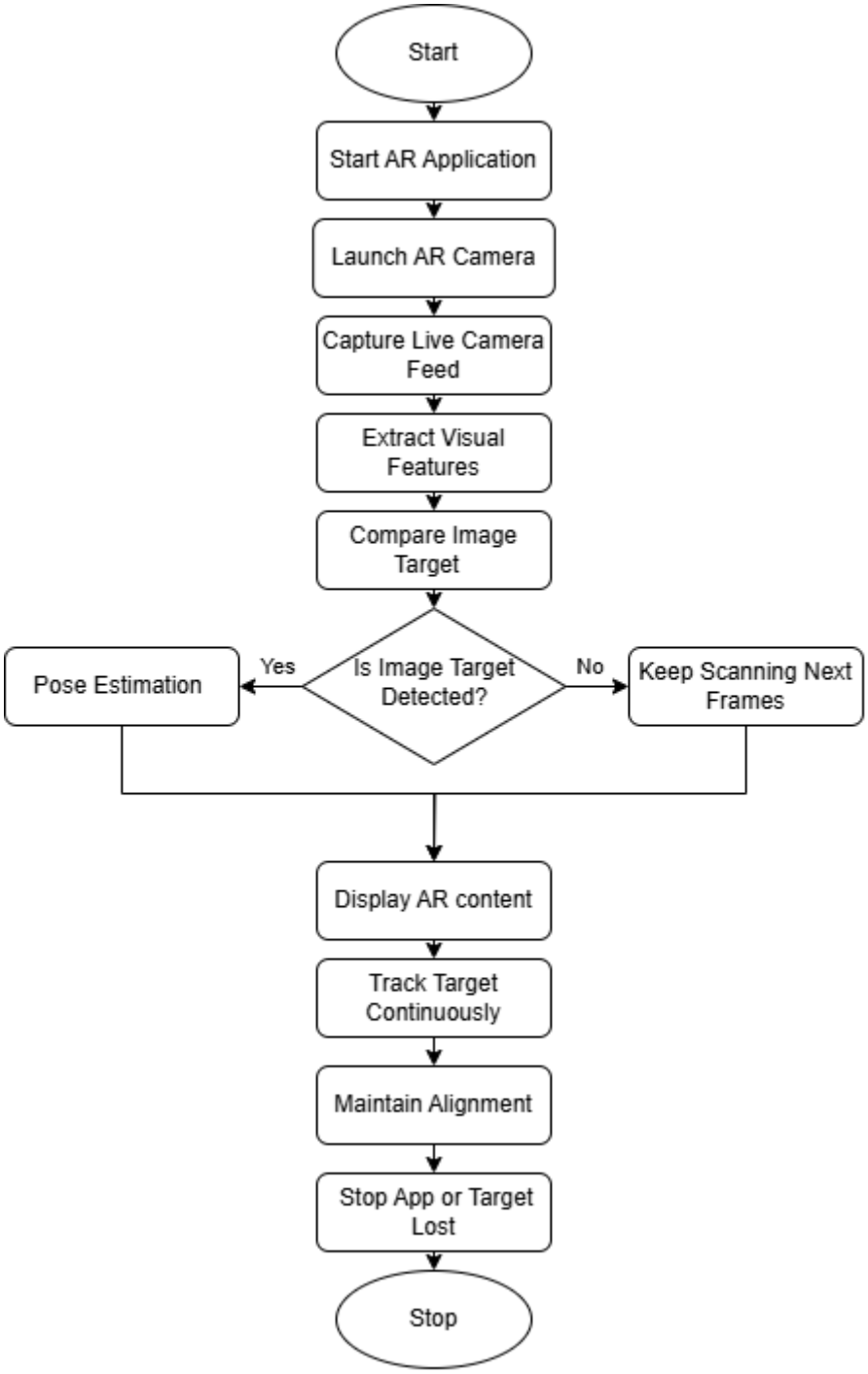


Figure 62: *Flowchart Image Target Detection.*

4.4 AR Recognition and Model Display in the Application

4.4.1 AR Recognition using Vuforia

In this project, Vuforia Engine is used as the primary Augmented Reality (AR) framework to implement image-based recognition. Vuforia enables the application to detect and track specific image targets such as book containing Bahasa Iban vocabulary by comparing them to a database of known images.

From the student's perspective, the recognition process is simple and intuitive. When the AR mode is activated, student point their device's camera at a physical book. Vuforia processes the live camera feed in real time, identifies the image based on distinctive visual features, and confirms a match with the database. Recognition is automatic and instant once the correct image is in view.

Behind the scenes, these image targets are pre-configured using the Vuforia Target Manager. Images are uploaded, processed, and compiled into a downloadable image database, which is then integrated into the Unity project. This database allows the AR system to identify which image target has been scanned and triggers the associated digital content.

By leveraging Vuforia, the application creates an interactive bridge between physical printed materials and digital learning content, enhancing the engagement and motivation of young learners.

4.4.2 Calling and Displaying the AR Model

Once Vuforia successfully detects an image target, the application calls and displays a digital model include the user interface element directly on top of the image target. These models include 3D objects, visual animations and audio clips (e.g., word pronunciation) related to the content.

In Unity, each image target acts as a parent object as shown in figure 63, and the corresponding canvas to display the UI element and AR model are assigned as a child object. This means that when the image is recognized, the child (3D model or UI element) becomes visible and appears anchored to the image target. If the target is no longer visible (e.g., the camera moves away), the model is hidden automatically to maintain immersion.

	1. ImageTargetMayau (Parent Object) - Act as content holder for all the child objects (Canvas, Game Object and Audio Source).
	2. Canvas (UI element) - Content holder for Spelling text, Scale and Rotate slide bar and also for Audio Button.

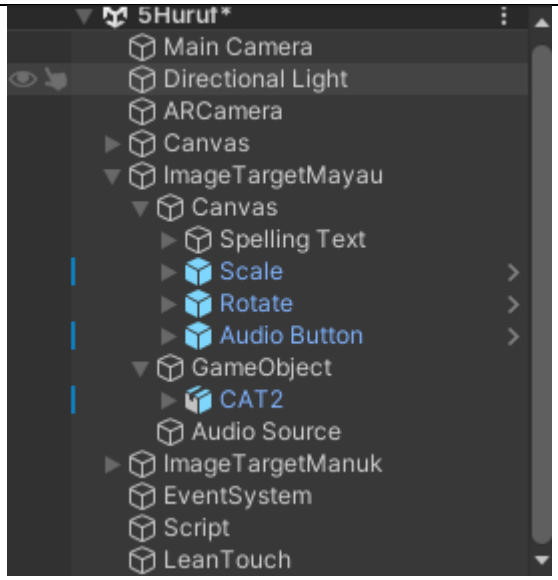
	3. Game Object (3D model) - Content holder for cat model. 4. Audio Source - Holding the audio pronunciation.

Figure 63: *Unity hierarchy structure for the ImageTargetMayau.*

This interaction is handled in real time, with the virtual content appearing automatically once the image target is recognized. For example, scanning an image target of a cat for spelling learning session would trigger the display of a 3D cat model, along with interactive elements such as the word's spelling, an audio button to listen to the pronunciation, and a slide bar that allows students to rotate or scale the model. These interactive features support spelling reinforcement through visual, auditory, and tactile interaction, creating a more engaging and meaningful learning experience for young students.

4.5 AR Marker and 3D Asset Integration

4.5.1 Marker Design

Printed image markers were created using Vuforia's Target Manager, a tool that allows developers to upload and manage image targets used in augmented reality applications. Each image was carefully selected and optimized to ensure high tracking reliability and responsiveness when scanned by the AR system. These printed markers serve as the physical triggers for displaying the corresponding 3D models, spelling text, and audio guidance in the learning environment. By using Vuforia's Target Manager, the system ensures accurate recognition and alignment between the physical images and the virtual content, creating a smooth and immersive AR learning experience for students.

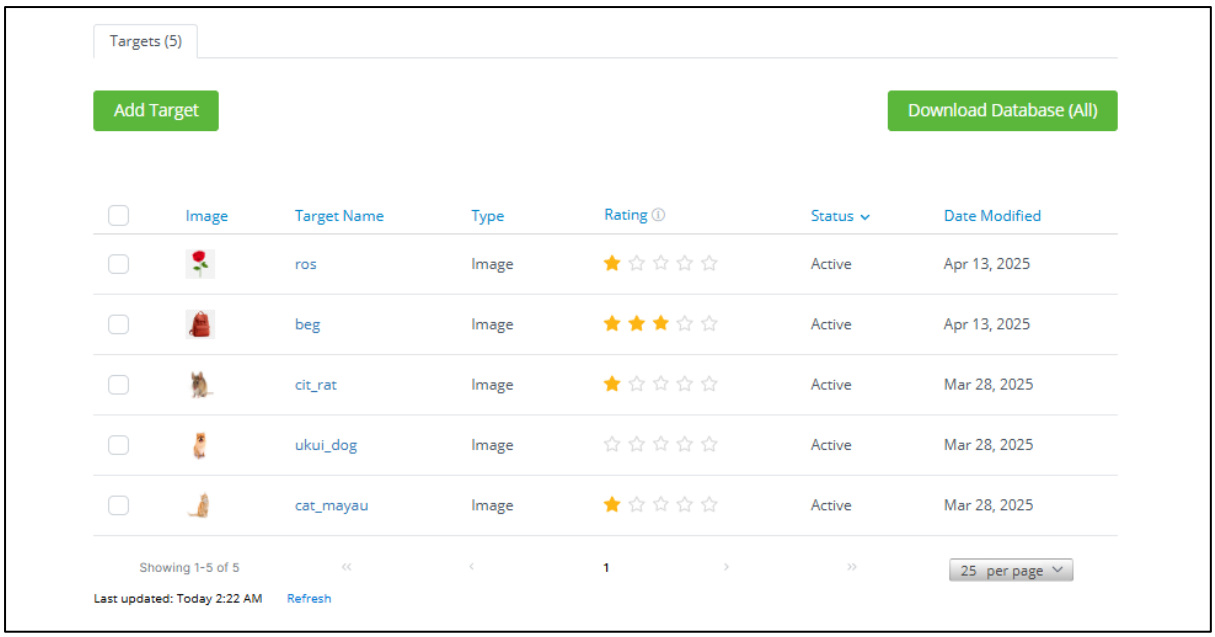


Figure 64: *Image Target in Vuforia Engine.*

4.5.2 3D Model Setup

3D models used in the application were sourced from free repositories, primarily from Sketchfab, a popular platform for high-quality 3D assets. Figure 65 shown the animated dog downloaded in Sketchfab. Once downloaded, the models were imported into Unity, where they were optimized for performance to ensure smooth rendering on mobile devices. Figure 63 shown the adjustments such as scaling, positioning, and animation setup carried out to align the models accurately with their respective image targets. This careful integration of Sketchfab models into Unity ensured that each visual element was both engaging and educational, enhancing the overall AR experience for Year 1 students.

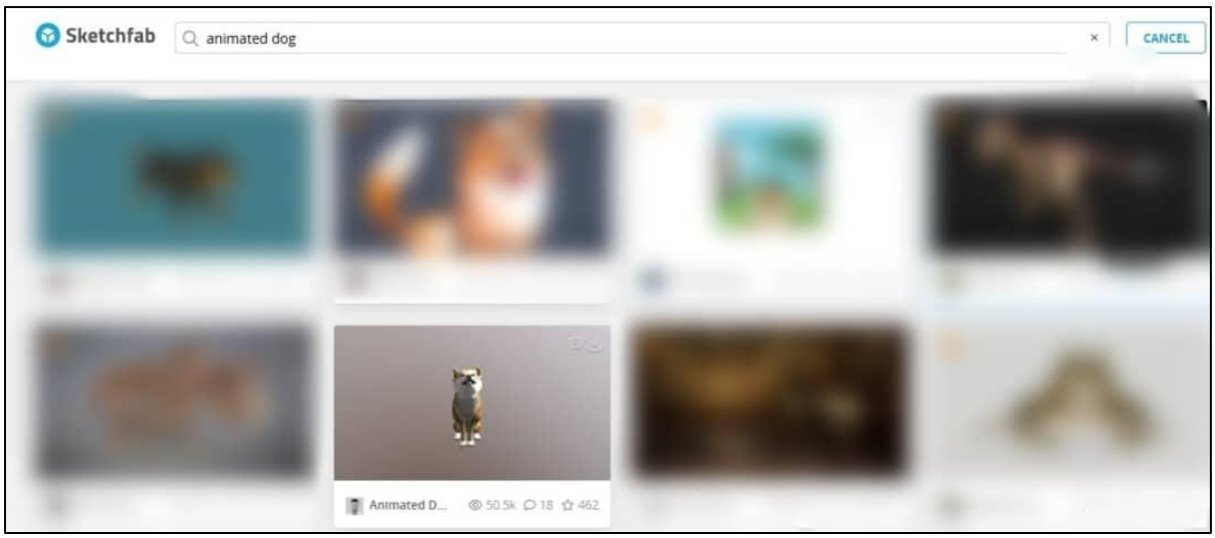


Figure 65: *Animated dog from Sketchfab.*

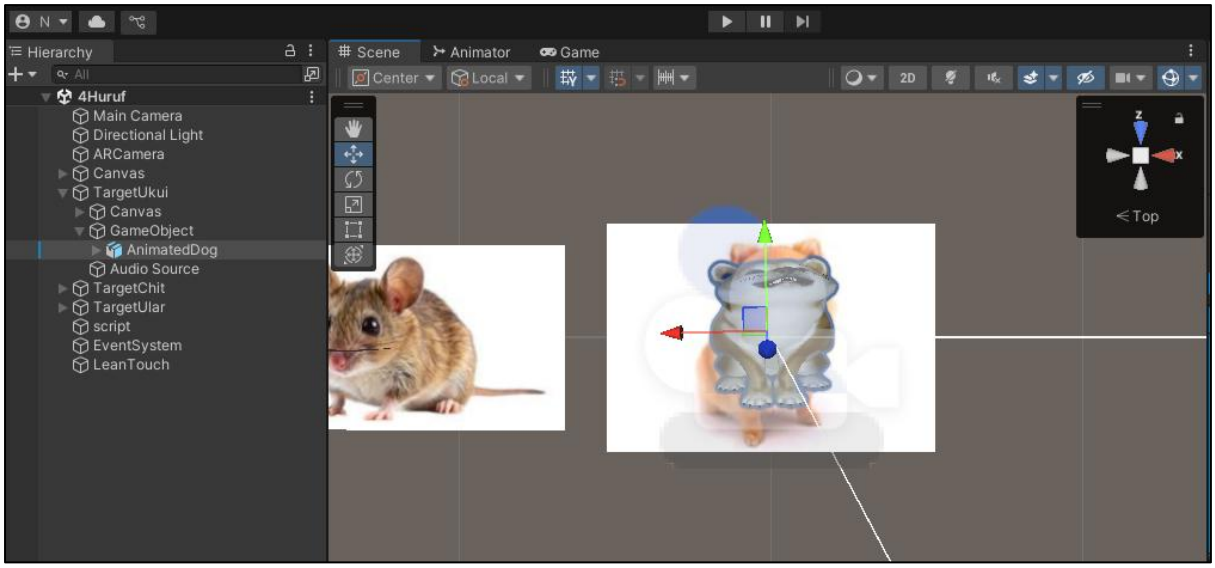


Figure 66: *Scaling, positioning and animation process in Unity.*

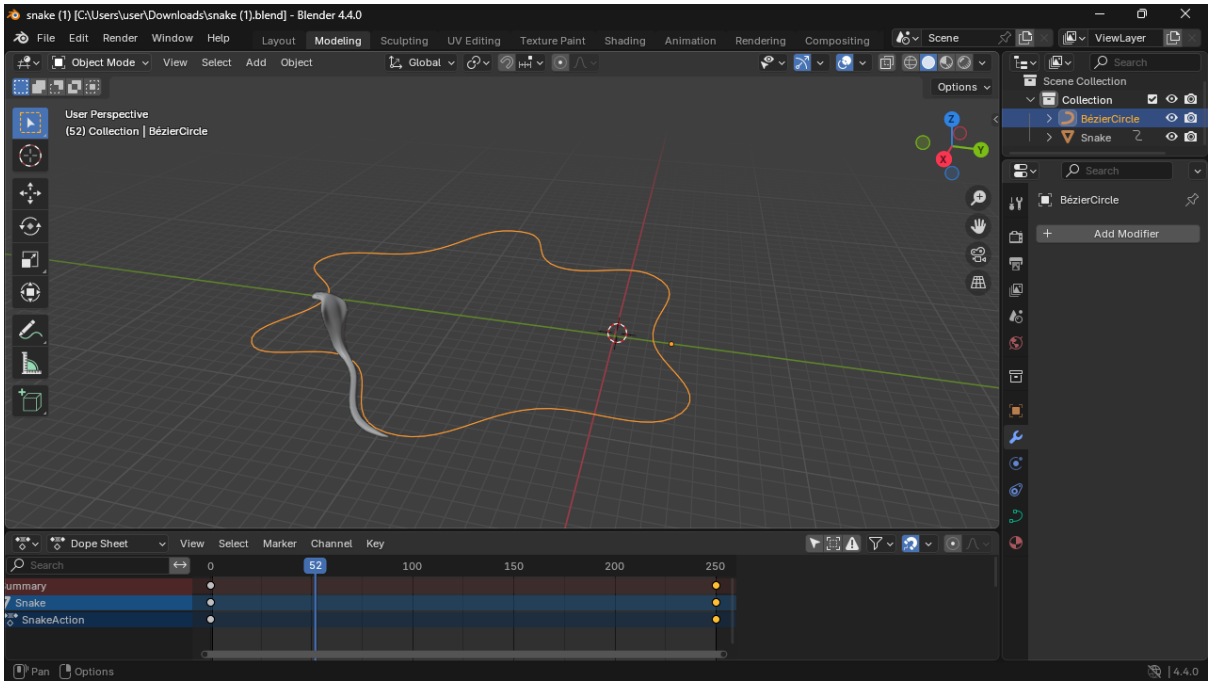


Figure 67: *Modelling progress for snake in Blender.*

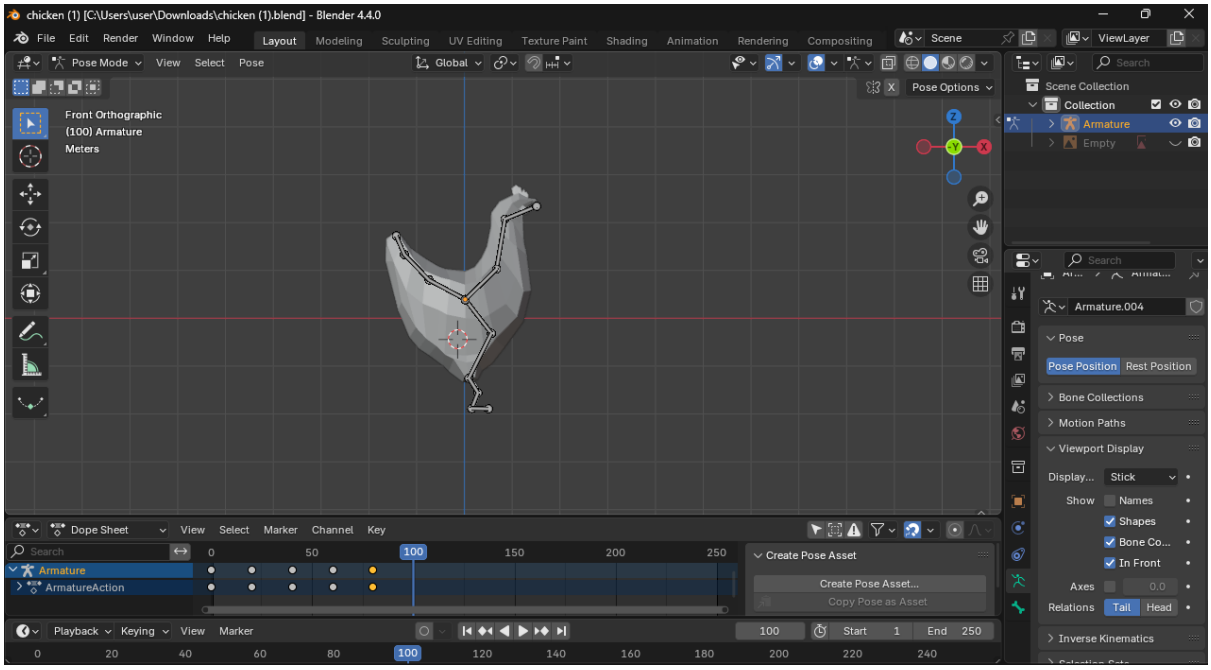


Figure 68: *3D chicken model progress in Blender.*

Figure 67 and Figure 68 show the development progress of 3D modelling using Blender software for the application. These figures highlight the process involved in designing and creating interactive 3D objects that are later integrated into the application. Figure above illustrates the early stage of modelling, where basic shapes and structures are formed to represent key objects such as animals used in vocabulary lessons. This step focuses on

constructing accurate proportions and maintaining a low polygon count to ensure smooth performance on mobile devices.

4.6 Survey

The survey was designed to evaluate two types of learning materials created to teach adjective words, each incorporating a different instructional approach and method of content delivery. The first material consisted of a printed paper with extra examples of adjective words displayed directly on the page. This design aimed to support visual learning through static content that students could easily refer to while reading. In contrast, the second material provided a more interactive experience by introducing an additional image target that students could scan using the application. When scanned, the image target revealed extra examples of adjective words, allowing students to learn through a blend of physical and digital interaction.

Originally, the survey was intended to be conducted with Year 1 students at a school in Miri. However, due to time constraints and the inability to return to the school, UNIMAS students were selected as respondents instead. Both materials were introduced to a group of UNIMAS students in a controlled learning session. The purpose of the survey was to compare the two learning material designs in terms of their impact on learner's understanding of adjective words and to identify which format was more appealing and supportive of their learning needs. Observations during the session, along with survey responses, helped evaluate not only which design the students preferred but also how each design influenced their ability to absorb and retain new vocabulary. This comparison provided meaningful insights into the effectiveness of traditional versus augmented learning approaches in language education.

1. **Material A** – A single image used as a scanning marker, with all related information directly displayed on the page.

Jaku Adjektif

Jaku adjektif tauka dikumbai jaku nama, iya nya leka jaku ti nerangka tukuh tauka gaya sesebengkah utai, tauka orang. Iya dikena nyadi penerang pasal jaku nama lalu meri penerang ti silik agi pasal iya.

Chunto:

Bup tu tebal.

Tebal nya jaku adjektif ti nerangka tukuh bup.

Ular nya panjai

Panjai nya jaku adjektif ti nerangka tukuh ular.

Jaku adjektif saiz: besai, mit, panjai, pandak, tinggi, baruh.

Jaku adjektif asai ati: gaga, tusah ati, ringat, takut, tekenyit.

Jaku adjektif chara: jampat, laun, mudah, tusah.

Belajar ngena AR

Tau buka IbanARcade ba telipun nuan lalu scan gambar ba baruh.

Figure 69: *Material A for Survey.*

2. **Material B** – A page containing two elements: a picture for scanning and a QR code. The picture provides basic information, while the QR code links students to additional learning content for a more in-depth understanding.

Figure 70: *Material B for Survey.*

After using both learning materials, students were asked to indicate their preferred method for learning adjective words. Out of the ten students involved in the study, seven chose Material B, which featured both a picture and a scannable image target that revealed additional examples through augmented reality. This result indicates that the integration of visual

elements with interactive components, such as scanning for more content, was perceived as more engaging and informative by the majority of students. The findings suggest that Material B provided a more dynamic learning experience, allowing students to explore content beyond what was presented on paper. In conclusion, the experiment demonstrated a clear preference for the second learning material, highlighting the effectiveness of combining traditional visuals with interactive technology. The added access to extended information through the AR feature not only enhanced engagement but also contributed to a deeper understanding of the language content. This outcome supports the idea that incorporating multiple learning elements, especially interactive digital tools, can significantly improve both student interest and learning outcomes when teaching concepts such as adjectives.

4.7 User Interface Design

An Android application has been developed to connect the user with the system. The explanation of the User Interface (UI) design of the Android application will be discussed in this section.

4.7.1 Launching Page

Figure 71: *Logo*

When the application is launched, figure 71 a splash screen featuring the "IbanArcade" logo is displayed prominently. The logo symbolizes the core purpose of the app: an engaging, arcade-style platform for learning the Iban language. It blends playful and educational elements to appeal to young learners, with a vibrant colour scheme and game-like typography that reflects the fun and interactive nature of the app. The inclusion of the word "Arcade" emphasizes that learning Iban through this app is not only educational but also game-oriented,

motivating students to explore language through immersive play. This logo reinforces the app's branding and sets the tone for a culturally rich and enjoyable user experience right from the start.

4.7.2 Main Page

Figure 72: *Main Page*

After the launch screen, users are directed to figure 72, which is the main page of the application, which serves as the central navigation point of the IbanArcade learning experience. The interface features a clean and culturally themed layout, with the IbanArcade logo prominently displayed at the center of the screen. Below the logo is a large, easy-to-tap button labeled "Berengkah", which means "Start" in the Iban language. This button initiates the learning journey and leads the user to the LoginPage. The background consists of a vibrant red and white color scheme, chosen to evoke both energy and clarity, making the interface appealing to young learners while maintaining simplicity. The use of local language and minimalistic design reflects the app's goal of combining cultural identity with intuitive gameplay.

4.7.3 Login and Signup

Figure 73: *Login Page*

Figure 73 shows the Login Page of the IbanArcade application. This screen provides students with a secure and straightforward way to access their personal learning progress. The interface includes two input fields: one for the email address and another for the password. When the user enters their credentials and taps the “MASUK” button, the app authenticates the input using Firebase Authentication. If the login is successful, the student is redirected to the main dashboard. If the user has not yet registered, a "Register" button is provided below the login form, allowing new students to create an account. This ensures that only authenticated users can track their learning activities, and that each user has a personalized experience within the app.

Figure 74: *Signup Page.*

Figure 74 illustrates the Signup Page of the IbanArcade application, where new users can create their accounts to begin using the system. The registration form includes fields for the student's name, age, school name, email, and password. These fields are essential for creating a personalized learning profile and for tracking progress specific to each student. Upon completing the form and tapping the "Register" button, the information is submitted and processed through Firebase Authentication and Firestore Database. If the registration is successful, the student is automatically logged in and redirected to the main page. This feature ensures that user data is securely stored and that learners have a unique account tied to their educational background.

Figure 75: *Account Verification Page.*

Figure 75 illustrates the email verification notification screen in the AR language learning application. Presented in the Iban language, the message prompts users to confirm their email address, stating that a verification link has been sent to the provided Gmail address. This step ensures account authenticity before allowing access to the application. A "MASUK" button is also provided, which redirects users to the login page after they have verified their email, offering a smooth and guided user experience.

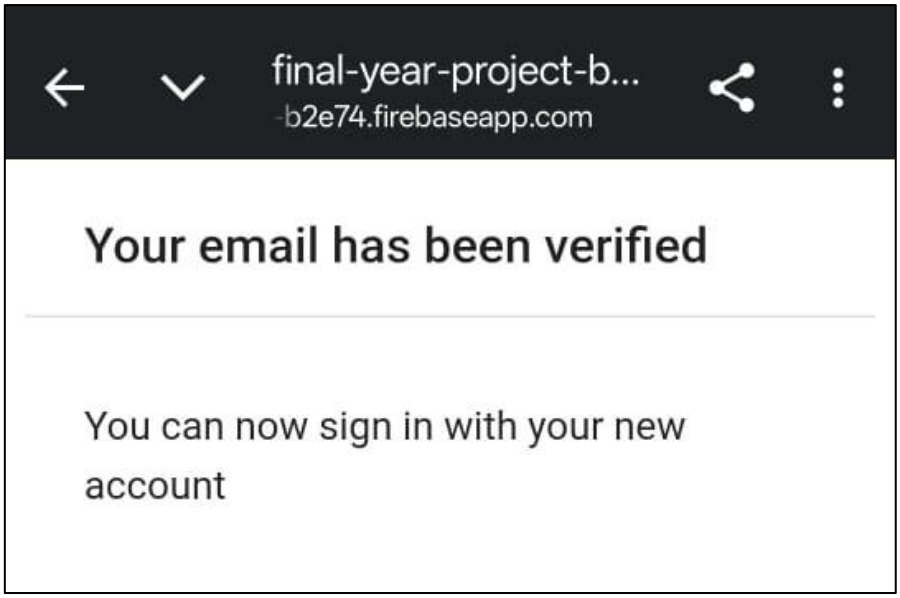


Figure 76: *Email verification.*

Figure 76 illustrates the email verification from user perspective. Once verify the email verification the students now can sign up in the application. If the students not yet verify the email, they unable to sign up the application.

4.7.4 Main Menu Page.

1. Profile Button - Allows student to view the information.
2. Logout Button - Bring the students to login page
3. Learning Button - Redirect students to learning option.
4. Quiz Button - Allows student to attempt quiz.
5. Practice Button -Allow student to attempt practice material.

Figure 77: *Main Menu page.*

Figure 77 displays the Homepage of the IbanArcade application, which serves as the central hub for navigating the learning experience. Upon successful login, students are directed to this screen where they can choose between three options: “Learn”, “Quiz” or “Practice”. The

“Learn” button allows students to enter the educational module where they can explore Iban vocabulary and grammar through AR interactions. The “Quiz” button leads them to assessment activities designed to test their knowledge based on what they have previously learned. Meanwhile, the “Practice” button allows students to scan image target for exercise materials.

4.7.5 Learning Selection Screen

1. Grammar Button - Redirect students to grammar learning material.
2. Spelling Button - Redirect students to spelling learning material.
3. Back Button - Redirect students to Main Menu.

Figure 78: *Learning Selection Page.*

Figure 78 shows the Learning Selection Page, which appears when a student selects the “Learn” button from the homepage. On this screen, students are given a choice between two main learning modules: Grammar or Spelling. Each option is represented by a clearly labelled button. This page allows students to direct their focus based on their current learning objectives, whether they want to improve grammar rules or focus on spelling through interactive AR elements. This separation of content ensures a more structured and manageable learning experience for Year 1 students.

Figure 79: *Grammar selection option.*

Figure 79 shown the grammar selection option consists of “JAKU PENEMPAT” (Preposition), “JAKU ADJEKTIF” (Adjective) and “AYAT AKTIF/PASIF” (Active/Passive Sentence). Each selection will the allows the students to use the camera feature to scan assigned Image Target for each learning option in the book. This will allow the student to view the learning material with the present of AR technology shown in figure below.

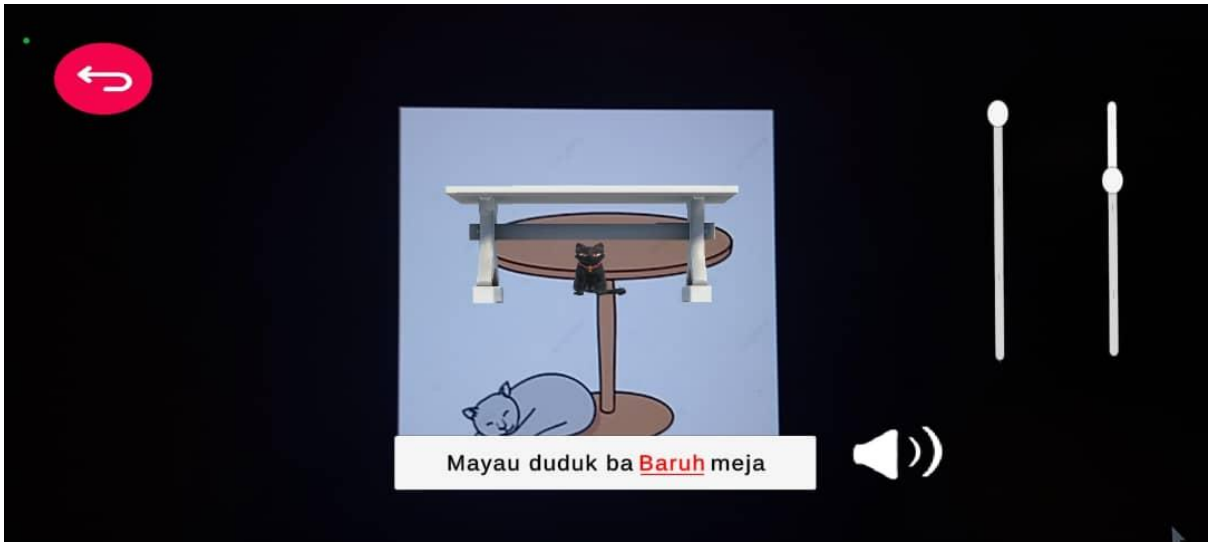


Figure 80: *Preposition Interface (Under).*

Figure 80 illustrates the augmented reality (AR) interface for learning prepositions in the Iban language within the educational game application. In this example, a 3D model of a black cat (mayau) is shown positioned under a table, visually representing the preposition "baruh," which means "under." The sentence displayed on the screen, "Mayau duduk ba Baruh meja," helps learners understand the spatial relationship by combining text with a corresponding visual cue. The highlighted word "Baruh" reinforces the target vocabulary. Additional features include a speaker icon for audio playback, allowing students to hear correct pronunciation, and a back button for easy navigation, making the learning experience more interactive and engaging for young users. Figures 81 and 82 shown below illustrate additional examples of prepositions, specifically focusing on "above" and "beside".

Figure 81: *Preposition interface (above).*

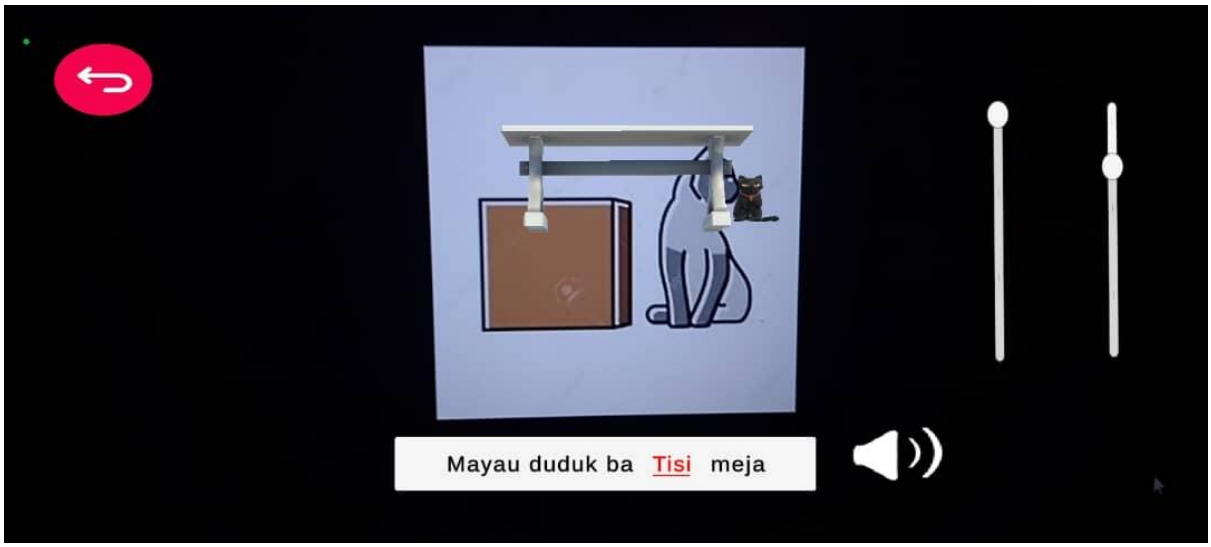


Figure 82: *Preposition Interface (Beside).*

Figure 83 and 84 below illustrates an interactive scene from the application for adjective learning material. For example, figure 82 showcasing a 3D model of a house accompanied by an Iban language sentence: *"Rumah Pengajar amat Besai"*. This translates to *"The teacher's house is very big"*. The interface includes label guides such as *Utai* for the subject and *Tukuh* for the behaviour, which support students in learning proper articulation. A sound icon is also present, allowing users to hear the sentence read aloud, reinforcing auditory learning. This immersive setup demonstrates how AR technology can make abstract language concepts more tangible and engaging.

Figure 83: *Adjective Interface (House).*

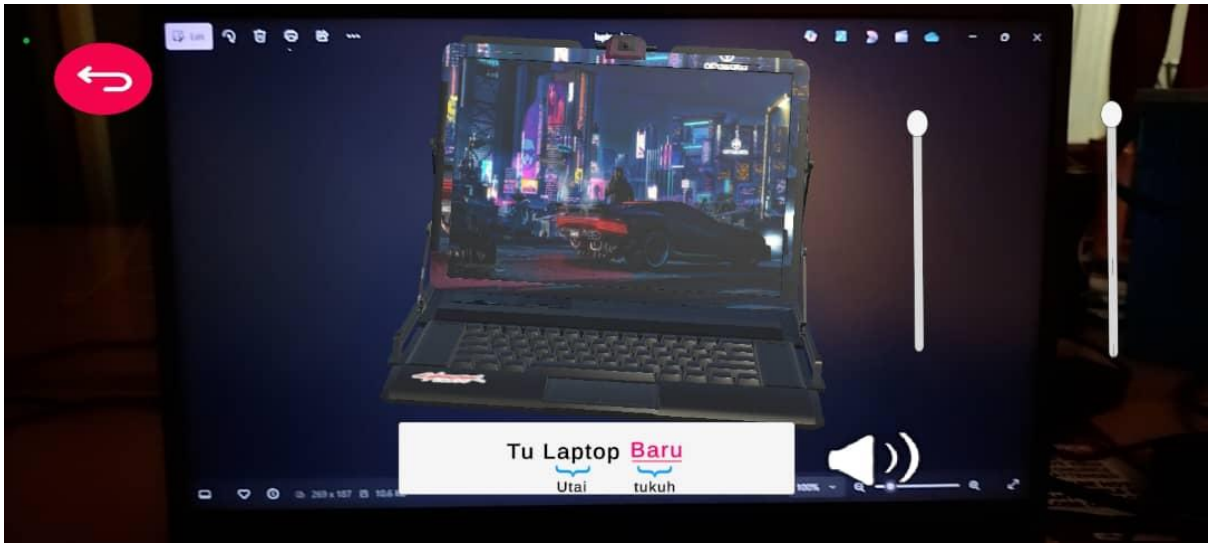


Figure 84: *Adjective Interface (Laptop).*

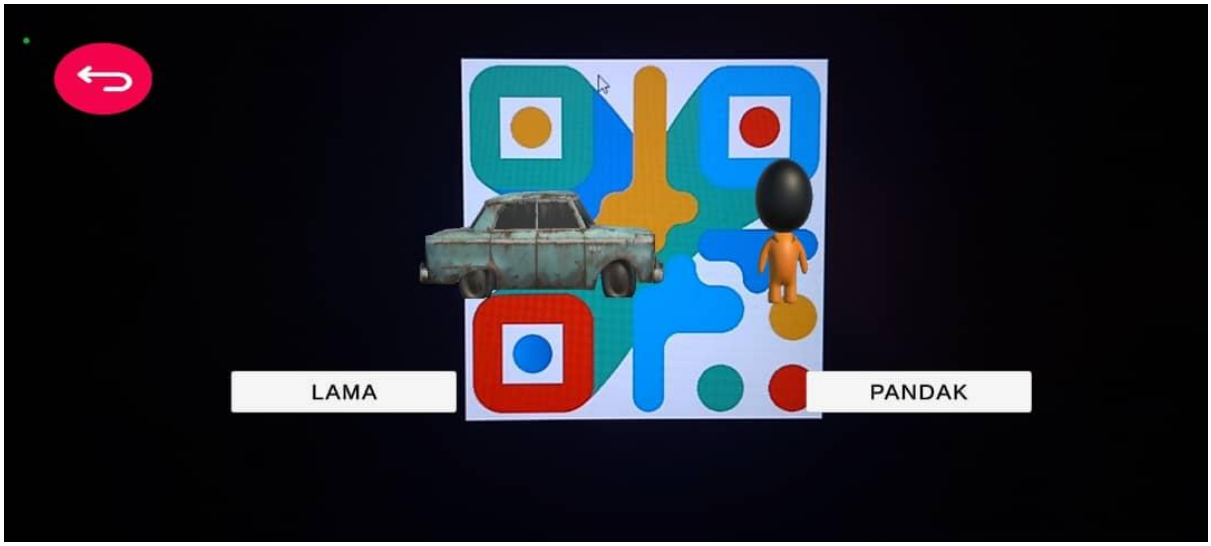


Figure 85: *Multiple adjective models in one AR scene, used to compare traditional and interactive learning materials for teaching descriptive words.*

Figure 85 showcases the multiple adjective models displayed within a single AR scene, developed as part of a comparative study on adjective learning materials. This interactive model was activated by scanning a designated image target, revealing various 3D objects labelled with descriptive adjectives. Designed to support the second instructional approach from the survey, this AR-based material aimed to enhance vocabulary acquisition through immersive and visual learning.

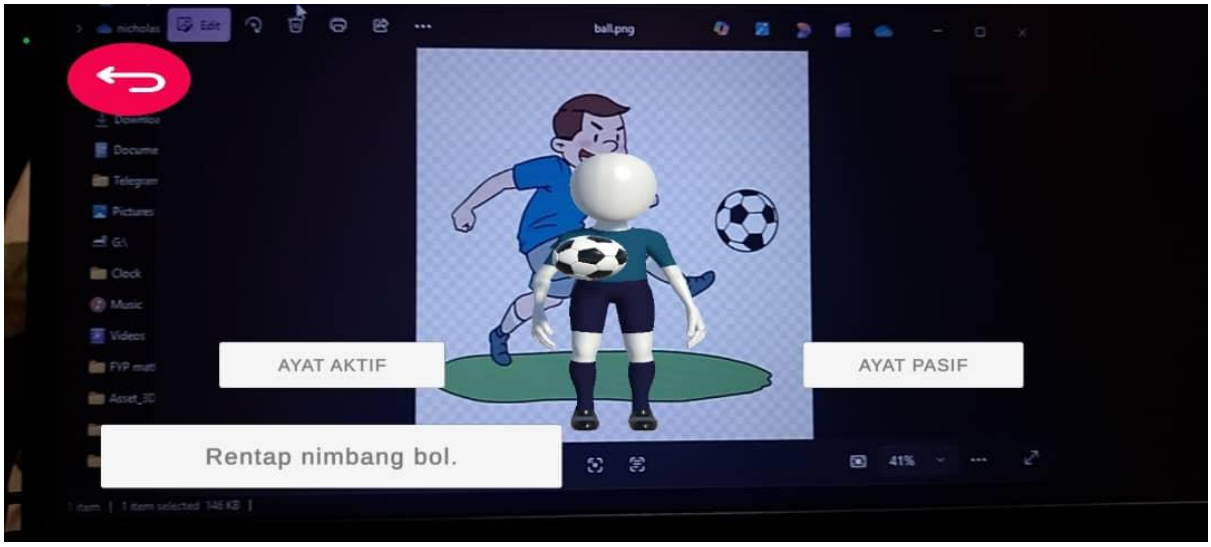


Figure 86: *Active sentence interface.*

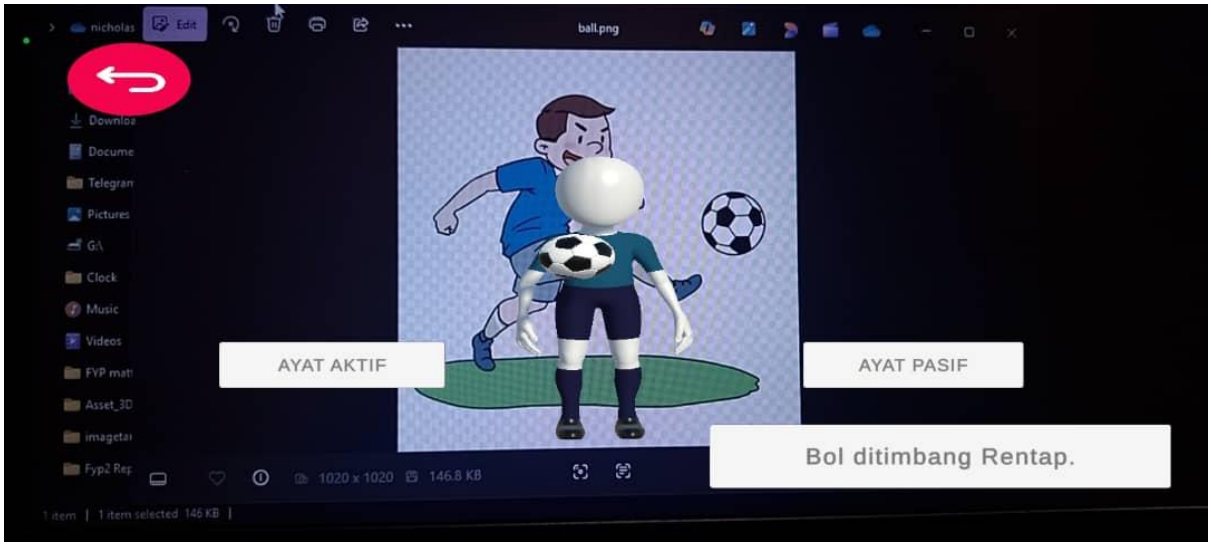


Figure 87: *Passive sentence interface .*

Figure 86 and figure 87 illustrates the learning interface of the 3D model, which is designed to help students understand the difference between active and passive sentences in Bahasa Iban. The interface displays an augmented reality scene where a 3D model character

with animation is positioned in front of an image showing a football action. Two buttons are labelled "AYAT AKTIF" (Active Sentence) and "AYAT PASIF" (Passive Sentence), placed on either side of the character.

When the user clicks on either button, the application will display the correct sentence based on the selected type. For instance, choosing "AYAT AKTIF" will show the active sentence related to the action in the scene along with an audio cue, while selecting "AYAT PASIF" will present the passive version. This interactive learning feature helps students visualize and better understand sentence structures through real-life scenarios, making the learning experience more engaging and effective.

4.7.6 Spelling Selection page and Spelling Game Screen

Figure 88: *Spelling Selection page.*

Figure 88 displays the Spelling Selection Page, which appears after a student selects the "Spelling" option from the Learning Option Page. On this screen, students are prompted to choose the number of words they would like to learn, with options to select 3, 4, or 5 words. This flexibility allows students to tailor their learning experience based on their comfort level and desired progress, offering a manageable number of words for each session. The page is designed with intuitive buttons for easy selection, ensuring a seamless and engaging experience as students explore new vocabulary and improve their spelling skills through interactive AR elements.

The Spelling Game Screen is where students engage with the selected number of words, whether 3, 4, or 5, based on their earlier choice. Each word is presented in an interactive AR

environment, displaying an animated model alongside the word itself. Students can see the word floating in 3D space, accompanied by a voiceover that pronounces the word and provides a guide on how to spell it. This visual and auditory combination enhances the learning experience, allowing students to focus on the word's structure and pronunciation engagingly and interactively. The screen adapts to the number of words chosen, ensuring a personalized and manageable learning session for the students.

1. Back Button – Allow students to redirect to learning selection pages.
2. Word spelling - Show correct spelling of the model.
3. Audio Playback – Spelling pronunciation.
4. Rotate slider – Allow students to rotate the model.
5. Scale slider – Allow students to resize the model scale.

Figure 89: *Spelling scene for three letter word (beg).*

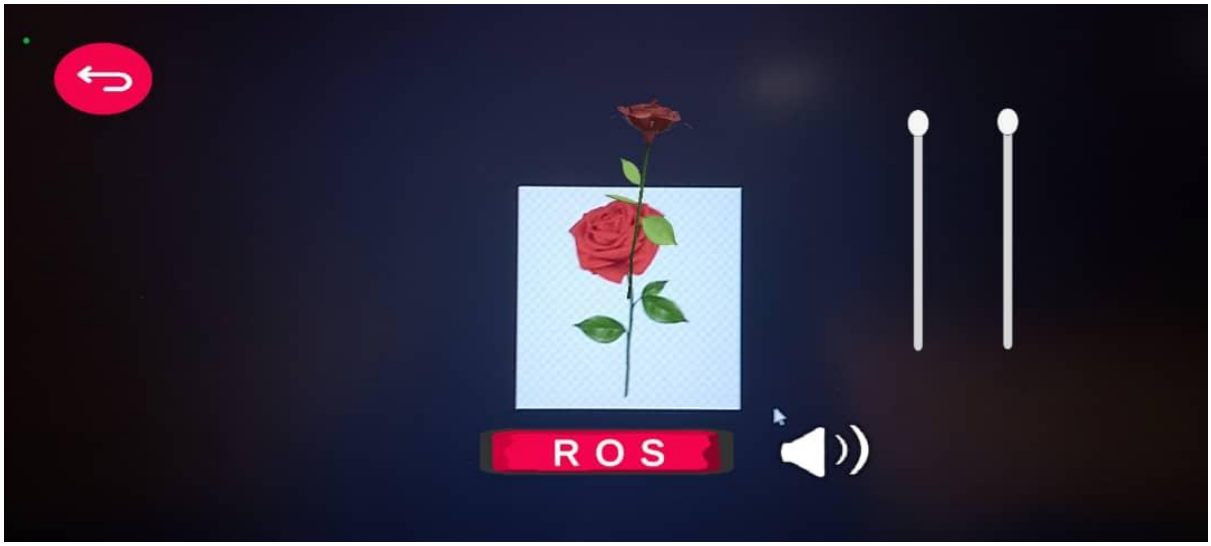


Figure 90: *Flower spelling scene.*

Figure 89 and 90 showcases the Spelling Game Screen for a 3-word selection. The three-letter words are displayed on this screen alongside their corresponding 3D model. The word itself is shown clearly, and an audio playback guides how to pronounce and spell each word, reinforcing the connection between the letters and their sounds. This interactive approach helps students focus on one word at a time while engaging with both visual and auditory elements, making the learning experience more dynamic and effective. The three-letter setup offers a balanced challenge for Year 1 students, allowing them to concentrate on a manageable set of vocabulary.

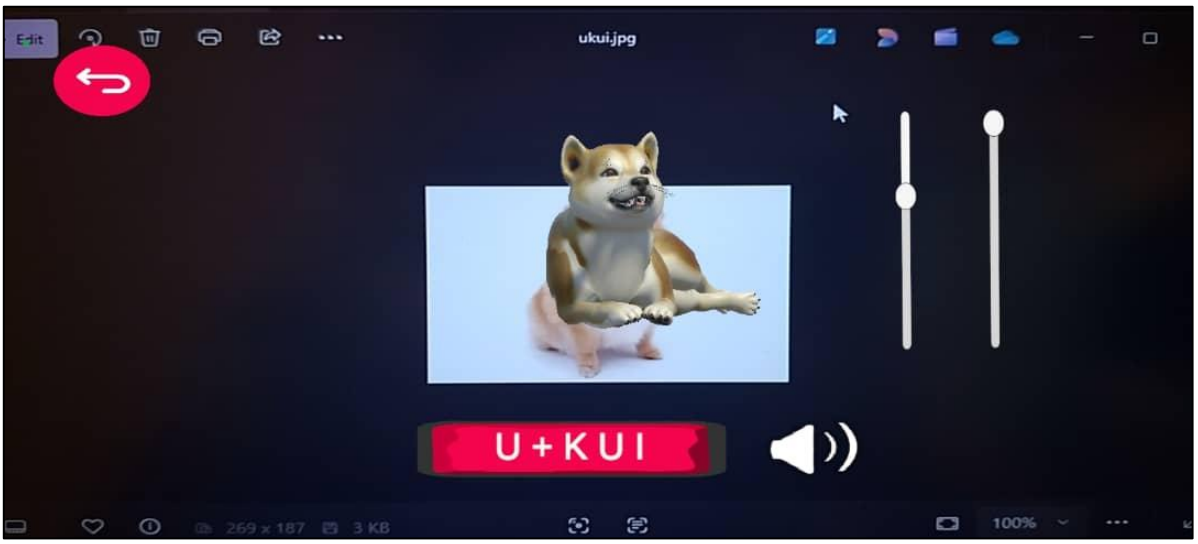


Figure 91: *Four-letter word spelling scene (dog).*

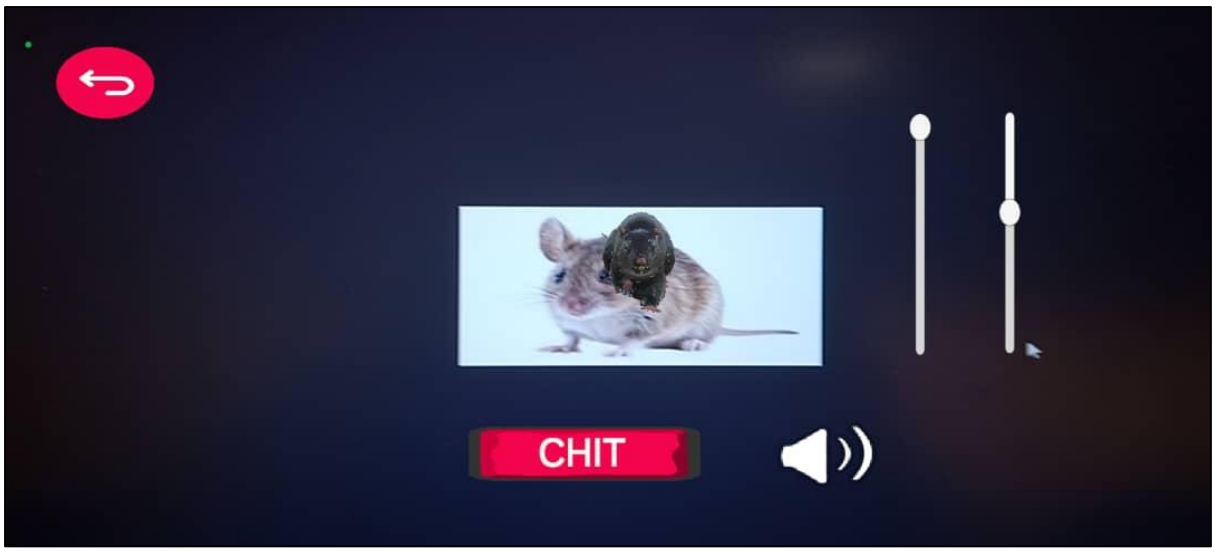


Figure 92: *Rat spelling scene.*

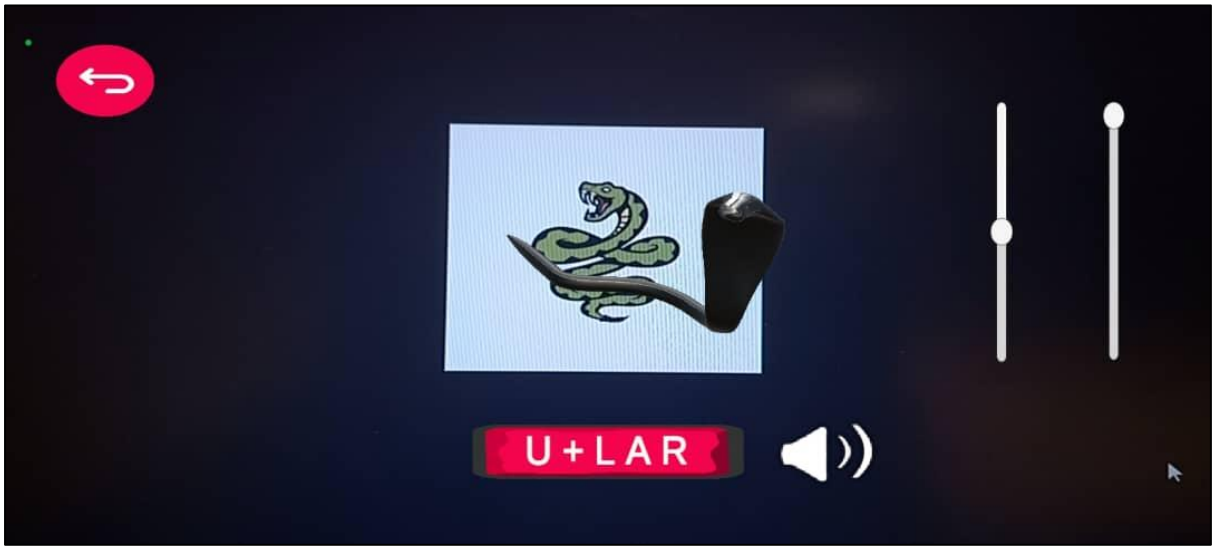


Figure 93: *Snake spelling scene.*

Figure 91 until figure 93 illustrates the Spelling Game Screen for a four-letter word selection. Same as three-letter spelling scene once the correct image target scanned and detected, the corresponding animated 3D model appears, along with the spelling of the word and an accompanying voiceover that pronounces and spells the word.

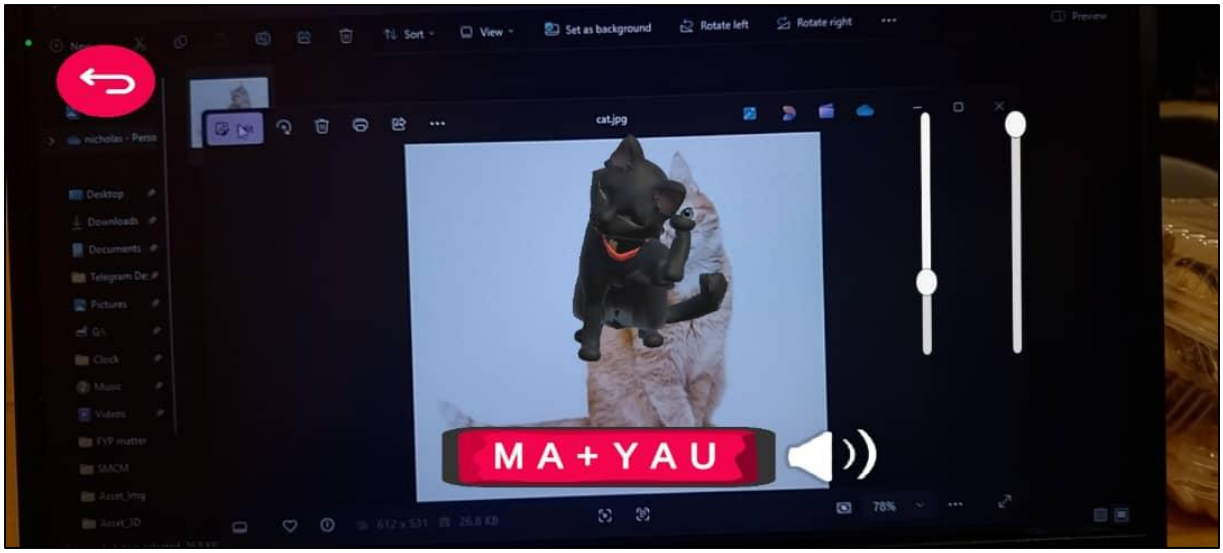


Figure 94: *Five-letter word game scene (cat).*

Figure 95: *Chicken spelling scene.*

Figure 94 and figure 95 displays the Spelling Game Screen for a five-letter word selection. The interaction functions the same as in three-letter spelling scene, where students scan an image target to reveal the animated 3D model, spelling, and voiceover for each word, providing an engaging AR learning experience.

4.7.7 Quiz Level Selection Interface.

Figure 96: *Quiz level selection page.*

Figure 96 illustrates the quiz level selection screen in the application, where students can choose the desired difficulty level before starting a quiz. The interface allows students to select from three available levels, each marked by numbered red buttons (1, 2, and 3). Each level consists of 5 questions that assess the student understanding of grammar and spelling based on the previous learning material. As the level increases, the complexity of the questions also rises, by removing the hint for the question providing a gradual learning curve suited to the student's progress. This feature allows the students to test their knowledge at their own pace.

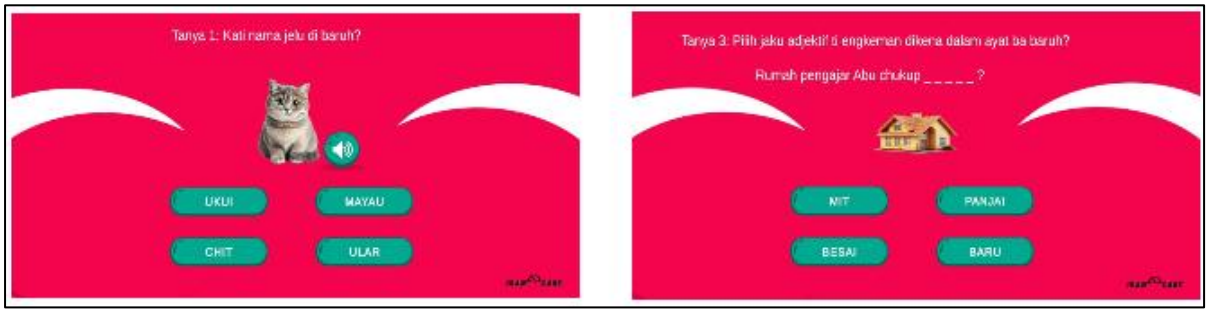


Figure 97: *Example of quiz questions.*

Figure 97 illustrates the example of quiz questions presented in the application. The question shown is a multiple-choice question (MCQ), where students are required to select the correct answer from several given options. To enhance the learning experience, the application includes sound effects that provide immediate feedback such as playing a correct sound when the right answer is selected and a wrong sound for incorrect choices and only then it will

proceed to the next question. This audio feedback helps reinforce learning by guiding students toward the correct usage of grammar and spelling. The MCQ format, combined with interactive sound cues, creates an engaging and responsive environment that supports active learning for young learners.

	1. Back Button - Redirect students to level selection page.
	2. Re-attempt Button - Allow students to re-attempt quiz.

Figure 98: *Result page.*

Figure 98 illustrates the result page displayed after a user completes a quiz attempt in the application. This page shows the student's total score, providing immediate feedback on their performance. It helps learners reflect on their understanding of the material covered in the quiz. The interface also includes two buttons: a back button that allows student to go back to level selection page, and a re-attempt button that enables them to retake the quiz for further practice. This feature encourages repeated learning and gives students the opportunity to improve their scores and reinforce their knowledge through additional attempts.

4.7.8 Practice Interface.

Figure 99: *Practice scene example.*

Figure 99 illustrates the practice interface of the application, where students are given the opportunity to answer the practice question then scan and identify the correct answer using multiple real-world image target. In this example, a 3D dog model is displayed on the screen as part of the correct response. For this scene, I have included a celebratory animation with confetti popping up, a success audio cue playing in the background along with a 3D dog model when the student successfully scanned the correct answer. This positive reinforcement is designed to motivate and reward students for their accuracy, making the learning experience more enjoyable. The combination of visual, audio, and interactive elements in the practice interface enhances student participation and helps reinforce through an immersive learning.

4.7.9 Profile Screen

Figure 100 illustrates the profile page of the application, which allows students to view and manage their personal information. When an online student clicks the Profile icon on the main menu, they are directed to this screen, where key details such as their name, age, school, and email and password are displayed. The profile data is retrieved from the Firebase Realtime Database, ensuring that all information remains accurate and up to date. To enhance usability, the interface includes an Edit button that enables users to update their profile and save changes in real time. Additionally, a Back button is provided for easy navigation, and a Progress button allows users to view their quiz progress, giving them insights into their learning achievements. This personalized and interactive profile page strengthens user engagement and supports a seamless educational experience.

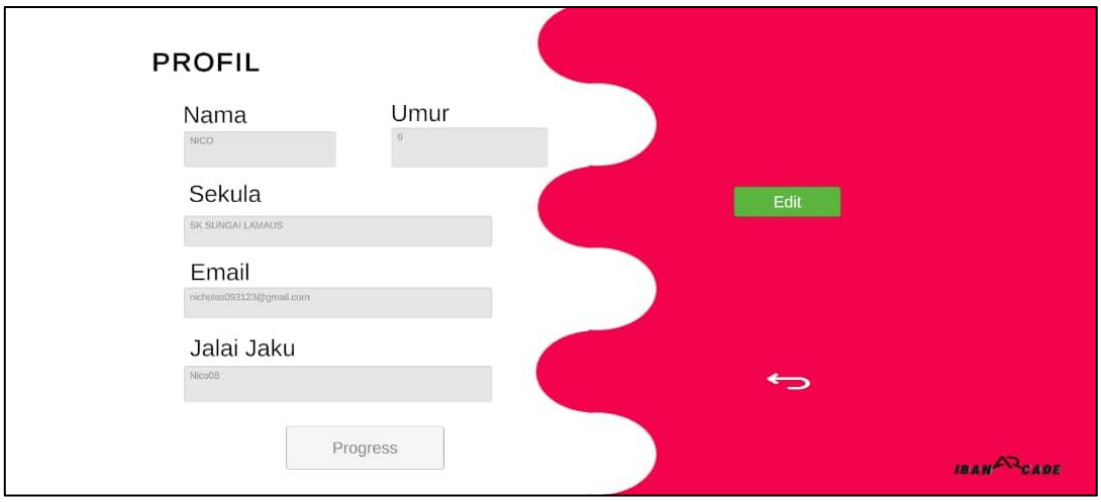


Figure 100: *Profile Page.*

Figure 101 illustrates the progress panel within the application, which displays each student's quiz completion status across different levels. This interface offers a clear summary, where completed levels are marked with a tick icon and incomplete or unattempt levels are shown with a cross icon. Aligned with the objective of providing a platform for personalized learning experiences, this feature enables user-specific progress tracking that adapts to individual learning journeys. By visually representing achievements, the progress panel not only helps students monitor their learning but also encourages consistent engagement and goal setting as they strive to complete all quiz levels.

Figure 101: *Progress Panel Interface.*

4.8 Code Snippet

```
protected virtual void OnTrackingFound()
{
    if (mObserverBehaviour)
        SetComponentsEnabled(true);

    OnTargetFound?.Invoke();
}
```

Figure 102: *OnTrackingFound() method to show AR model when image target is detected.*

This code snippet from Visual Studio Code, as shown in figure 102, defines the OnTrackingFound() method from the DefaultObserverEventHandler script. This method is called automatically when the image target is successfully detected by the AR camera. The line SetComponentsEnabled(true) enables all relevant components on the 3D model and its child objects, effectively making the AR content visible in the scene. Additionally, OnTargetFound?.Invoke() is used to trigger any custom Unity events linked through the Inspector, such as playing pronunciation audio or triggering character animations when the target is found. This method contributes to delivering an interactive and responsive learning experience in the AR application.

```
protected virtual void OnTrackingLost()
{
    if (mObserverBehaviour)
        SetComponentsEnabled(false);

    OnTargetLost?.Invoke();
}
```

Figure 103: *OnTrackingLost() method to hide AR model when image target is lost.*

Figure 103 show the method is triggered when the image target is no longer detected (for example, if the camera is moved away or the target goes out of view). It disables the components of the model using SetComponentsEnabled(false), effectively hiding the AR content from the scene. This ensures that the 3D model only appears when its corresponding marker is visible in the real world. The OnTargetLost?.Invoke() function allows additional actions to occur when the marker is lost.

```
void SetComponentsEnabled(bool enable)
{
    var components = VuforiaRuntimeUtilities.GetComponentsInChildrenExcluding<Component, DefaultObserverEventHandler>(gameObject);
    foreach (var component in components)
    {
        switch (component)
        {
            case Renderer rendererComponent:
                rendererComponent.enabled = enable;
                break;
            case Collider colliderComponent:
                colliderComponent.enabled = enable;
                break;
            case Canvas canvasComponent:
                canvasComponent.enabled = enable;
                break;
            case RuntimeMeshRenderingBehaviour runtimeMeshComponent:
                runtimeMeshComponent.enabled = enable;
                break;
        }
    }
}
```

Figure 104: *SetComponentsEnabled() method to enable or disable model components based on tracking status.*

Figure 104 shows the SetComponentsEnabled() method, which is responsible for enabling or disabling the visual and interactive components of all child objects under the Image Target, excluding the script itself. When the enable parameter is set to true (typically called from OnTrackingFound()), it activates components such as mesh renderers, colliders, and UI canvases, making the AR content visible and interactive. Conversely, when enable is false (triggered from OnTrackingLost()), these components are hidden. This functionality ensures a smooth and consistent AR experience, where content is only displayed when the corresponding image target is actively tracked by the AR camera.

The three code snippets work together to control the visibility of AR content based on the image target's tracking status. When the image target is detected by the AR camera, OnTrackingFound() is called to display the 3D model by enabling its components. If the image target is no longer detected, OnTrackingLost() is triggered to hide the model by disabling those same components. Both methods rely on the shared SetComponentsEnabled() function, which activates or deactivates visual and interactive elements like renderers, colliders, and canvases. This ensures that AR content is only visible when the image target is present, providing a responsive and immersive learning experience.

4.9 Summary

This chapter presented the technical implementation of the AR application. The system was developed with a focus on user engagement, educational value, and mobile AR interaction. All core components such as the user interface (UI), AR marker tracking and 3D content delivery successfully integrated.

To evaluate the effectiveness of the AR-based learning material, a comparative survey was conducted among Year 1 students. After interacting with two types of learning materials one traditional and one enhanced with AR students were asked to indicate their preference. Out of ten students, seven preferred Material B, which included both an image and a scannable target that revealed additional examples through augmented reality. This result highlights the value of combining traditional visuals with interactive features, as students found the AR-enhanced material more engaging and informative. The interactive scanning experience allowed students to explore extended content beyond what was presented on paper, contributing to a deeper understanding of the topic. These findings, suggest that integrating interactive digital tools like AR can significantly boost student interest and learning outcomes, especially for abstract concepts like adjectives.

Besides, the project utilized the Vuforia Engine to deliver AR functionality. Vuforia enabled robust image target detection and tracking, making it possible to overlay 3D educational content on physical markers in real time. Its seamless integration with the Unity game engine and proven reliability made it a suitable choice for this mobile-based learning application. Vuforia's capabilities ensured that the AR content remained accurately aligned with the printed materials, providing a smooth and immersive learning experience.

Overall, the successful integration of technical components, survey validation, and AR technology demonstrates the potential of augmented reality to enrich Iban language learning for early learners.

CHAPTER 5: TESTING

5.1 Introduction

Chapter 5 discusses the testing process conducted on the Augmented Reality Game Development (Bahasa Iban for Year 1 Students) system. Multiple types of testing were carried out to ensure that the system performs according to its intended design and meets the expected user experience for Year 1 students. These testing types include functional testing, non-functional testing, and user testing. The user testing was conducted at SK Sungai Lamaus, a rural school with limited student enrolment. Due to the small number of students, only 15 Year 1 students participated in the testing session, which was held for one hour. Despite the short duration and limited number of participants, the session provided valuable feedback on the system's usability, effectiveness, and engagement. Each type of testing played a critical role in verifying the reliability, functionality, and educational value of the AR game for young learners in a rural education setting.

5.2 Functional Testing

Functional testing was performed to ensure that all features developed in the AR game application work as expected based on the initial requirements. Below are shown all the functional tests for the project.

Table 11: *Login Module.*

Test Case Description: To verify that the login-related functionalities of the AR-based educational game operate as intended. **Testing Objective:** To ensure that all login features, including authentication, session handling, and logout, function correctly within the Bahasa Iban AR educational game. **Remarks:**							
Test Case ID	**Test Scenario**	**Test Steps**	**Test Data**	**Expected Result**	**Actual Result**	**Status**	**Severity**
Func_01	Verify Login Function	1. Launch the app 2. Tap "Login" 3. Enter valid email and password 4. Tap "Login"	Registered email and password	User is authenticated and navigated to the main menu	User is authenticated and logged in	✅ Pass	High
Func_02	Verify Login with Invalid Data	1. Launch the app 2. Enter incorrect login credentials 3. Tap "Login"	Invalid email or password	Error message appears: "Invalid login credentials"	Error message displayed as expected	✅ Pass	Medium
Func_03	Verify "Remember Me" Feature	1. Launch the app 2. Check "Remember Me" 3. Login 4. Reopen app	Valid credentials + checkbox ticked	User remains logged in on next app launch	User remains logged in	✅ Pass	Low

Func_04	Logout	1. Login 2. Tap "Logout" from main menu	-	User is logged out and redirected to login screen	Redirects to login screen after logout	✅ Pass	Medium

Table 12: *Signup Module.*

Test Case Description: To verify that the sign-up functionalities of the AR-based educational game operate as intended. **Testing Objective:** To ensure that all user registration features, including data validation and account creation, function correctly within the Bahasa Iban AR educational game. **Remarks:**							
Test Case ID	**Test Scenario**	**Test Steps**	**Test Data**	**Expected Result**	**Actual Result**	**Status**	**Severity**
Func_05	Verify Sign Up Function	1. Launch the app 2. Tap "Register" 3. Enter user details 4. Tap "Sign Up"	Name, Age, School, Email, Password	User is registered and taken to the main menu	User successfully registered and redirected	✅ Pass	Medium
Func_06	Verify Validation on Incomplete Form	1. Launch the app 2. Tap "Register" 3. Leave one or more fields empty 4. Tap "Sign Up"	Missing one or more fields	User is shown an error: "All fields must be filled out"	Error message displayed when field is empty	✅ Pass	High

Table 13: *Profile Module.*

Test Case Description: To verify that the profile-related functionalities of the AR-based educational game operate as intended. **Testing Objective:** To ensure that users can accurately view and update their personal profile information (such as name, age, school, and email) within the Bahasa Iban AR educational game. **Remarks:**							
Test Case ID	**Test Scenario**	**Test Steps**	**Test Data**	**Expected Result**	**Actual Result**	**Status**	**Severity**
Func_07	View Profile Information	1. Login 2. Tap "Profile" button on main menu	-	User profile details (Name, Age, School, Email) displayed	Profile data is shown correctly	✅ Pass	Medium
Func_08	Edit Profile Information	1. Login 2. Tap "Profile" 3. Edit name/age/school 4. Tap "Save"	Updated profile data	Changes are saved and displayed correctly	Changes reflected after saving	✅ Pass	Medium

Table 14: *AR Marker Module.*

Test Case Description: To verify that the application correctly detects and responds to AR markers. **Testing Objective:** To ensure that AR markers trigger the correct educational content without lag, visual glitches, or tracking issues. **Remarks:**							
Test Case ID	**Test Scenario**	**Test Steps**	**Test Data**	**Expected Result**	**Actual Result**	**Status**	**Severity**
Func_09	Verify AR Marker Scanning	1. Launch the app 2. Select Learning Mode 3. Open AR camera 4. Scan a valid marker	Valid AR marker	3D content or learning UI appears with no lag	Content appears correctly with no lag	✅ Pass	Medium
Func_10	Scan Invalid Marker	1. Open AR camera 2. Scan image that is not a registered marker	Invalid image	No content appears, and no crash occurs	No content appears; app remains stable	✅ Pass	Medium

Table 15: *Audio Playback Module.*

Test Case Description: To verify that the voice/sound features in the learning content work correctly. **Testing Objective:** To ensure that pronunciation audio plays clearly and matches the display model in the AR interface. **Remarks:**							
Test Case ID	**Test Scenario**	**Test Steps**	**Test Data**	**Expected Result**	**Actual Result**	**Status**	**Severity**
Func_11	Verify Pronunciation Playback	1. Scan marker 2. Tap sound icon on displayed word	Word with audio	Clear and accurate audio plays for selected word	Audio plays correctly	✅ Pass	Medium

Table 16: *Quiz Module.*

Test Case Description: To verify that the quiz functionality including answering questions and result display works as expected. **Testing Objective:** To ensure that the quiz system correctly registers user answers and shows accurate scores. **Remarks:**							
Test Case ID	**Test Scenario**	**Test Steps**	**Test Data**	**Expected Result**	**Actual Result**	**Status**	**Severity**
Func_12	Start and Answer Quiz	1. Open quiz 2. Select answer 3. Proceed to next question	Multiple-choice quiz	Answer is registered; next question loads smoothly	Works as expected	✅ Pass	Medium
Func_13	Quiz Score Display	1. Finish quiz. 2. View result screen	Quiz answer	Final score is displayed accurately	Score shown correctly	✅ Pass	Medium

Table 17: *Navigation Module.*

Test Case Description: To verify that the profile-related functionalities of the AR-based educational game operate as intended. **Testing Objective:** To ensure that users can accurately view and update their personal profile information (such as name, age, school, and email) within the Bahasa Iban AR educational game. **Remarks:**							
Test Case ID	**Test Scenario**	**Test Steps**	**Test Data**	**Expected Result**	**Actual Result**	**Status**	**Severity**
Func_19	Navigate Between Menus	1. Open app 2. Tap Main Menu buttons (Profile, Learn, Quiz, Logout)	-	Navigates to correct screen	All navigation works as expected	✅ Pass	Medium
Func_20	Back Button Functionality	1. Navigate to subpage 2. Tap back button	-	Returns to previous screen	Functions correctly	✅ Pass	Medium

5.3 Non-functional Testing

Non-functional testing was conducted to evaluate the overall performance, stability, and user experience of the application beyond its core functionalities. This type of testing ensures the system performs reliably under various conditions and provides a smooth, user-friendly experience for Year 1 students. The non-functional tests included reliability testing, which verified the system's consistency during repeated use across modules such as login, signup, profile management, AR marker detection, quizzes, and screen navigation. Usability testing focused on assessing how intuitive and accessible the interface is for young learners, including the ease of navigation, interaction flow, and clarity of features such as quizzes and profile editing. Meanwhile, efficiency testing evaluated the system's performance in terms of AR content loading speed, app responsiveness, and resource usage like battery consumption. These tests were essential to ensure that the application runs smoothly used in rural settings and remains responsive and stable.

5.3.1 Reliability Testing

In this section, reliability testing was conducted to ensure that the Bahasa Iban AR-based educational game performs consistently and remains stable during repeated use, confirming it can handle typical user interactions without errors or crashes.

Table 18: *Reliability Testing of Login Module.*

Test Case Description: To verify the stability of the login process during repeated authentication attempts. **Testing Objective:** Ensure the login system functions reliably under frequent use, handling multiple login /logouts attempts without failure or delay. Remarks:							
Test Case ID	**Test Scenario**	**Test Steps**	**Test Data**	**Expected Result**	**Actual Result**	**Status**	**Severity**
R01	Multiple login attempts	1. Open app.2. Enter valid credentials repeatedly (5 times in a row).3. Log in and out each time.	Valid email & password	Successful login/logout every time	No failures or delays across repeated login attempts	✅ Pass	Medium

Table 19: *Reliability Testing of Signup module.*

Test Case Description: To verify the application's behaviour during multiple sign-up attempts and invalid input scenarios. **Testing Objective:** Ensure the sign-up process consistently handles valid and invalid entries without crashing or losing responsiveness. Remarks:							
Test Case ID	**Test Scenario**	**Test Steps**	**Test Data**	**Expected Result**	**Actual Result**	**Status**	**Severity**
R02	Repeated sign-up attempts	1. Try signing up with various valid/invalid entries repeatedly. 2. Check error handling.	New email and missing fields	Correct validations triggered and no crashes occur	All error messages shown appropriately; no crashes	✅ Pass	Medium

Table 20: *Reliability Testing of Profile Module.*

Test Case Description: To verify that profile updates (e.g., name and avatar changes) persist accurately after multiple edits and logins. **Testing Objective:** Ensure user profile data remains stable and is stored and retrieved correctly across multiple save and login cycles. Remarks:							
Test Case ID	**Test Scenario**	**Test Steps**	**Test Data**	**Expected Result**	**Actual Result**	**Status**	**Severity**
R03	Profile save stability	1.Edit profile. 2.Save 3.Log out/in 4.Repeat multiple times	Profile updates	Data persists after multiple edits	Profile info saved and persisted successfully	✅ Pass	High

Table 21: *Reliability Testing of AR Marker Module.*

Test Case Description: To test AR content stability and performance across various mobile devices with different specifications. **Testing Objective:** Ensure that AR markers load smoothly and consistently on multiple devices without lag, crashes, or visual glitches. Remarks:							
Test Case ID	**Test Scenario**	**Test Steps**	**Test Data**	**Expected Result**	**Actual Result**	**Status**	**Severity**
R04	AR marker on multiple devices	Scan 5 markers on different mobile phones under same conditions	iPhone, OPPO, Nubia	AR loads smoothly with no crash	Smooth rendering across all tested devices	✅ Pass	Medium

Table 22: *Reliability Testing of Quiz Module.*

Test Case Description: To verify the accuracy and consistency of quiz result calculations over multiple attempts. **Testing Objective:** Ensure quiz scoring remains correct, and results are reliably displayed after each attempt, regardless of user performance. Remarks:							
Test Case ID	**Test Scenario**	**Test Steps**	**Test Data**	**Expected Result**	**Actual Result**	**Status**	**Severity**
R03	Quiz result reliability	Take quizzes multiple times with different answers	Multiple quiz attempts	Correct scores every time	Score calculated consistently	✅ Pass	Medium

Table 23: *Reliability Testing of Navigation Module.*

Test Case Description: To verify app stability during continuous navigation between screens and features. **Testing Objective:** Ensure that repeated scene transitions (e.g., Main menu, learning option, profile, quiz) do not cause performance issues or crashes. Remarks:							
Test Case ID	**Test Scenario**	**Test Steps**	**Test Data**	**Expected Result**	**Actual Result**	**Status**	**Severity**
R06	Continuous screen transitions	Switch between scenes (Main Menu → Profile → Quiz → Learn) for 10 minutes continuously	None	App transitions without freezing or crashing	All transitions remain smooth	✅ Pass	Medium

5.3.2 Usability Testing

Table 24: *Usability Testing.*

Test Case Description: To evaluate the user-friendliness of the AR-based educational game interface and interactions. It focuses on the ease of navigation, clarity of instructions and accessibility of features. **Testing Objective:** To assess whether the application is intuitive and easy to use for its target audience, ensuring that users can effectively interact with the system. Remarks:							
Test Case ID	**Test Scenario**	**Test Steps**	**Test Data**	**Expected Result**	**Actual Result**	**Status (Pass/Fail)**	**Severity**
Usab_01	Verify UI navigation	1. Launch the application. 2. Access the main menu. 3. Tap on the “Learning” mode. 4. Navigate back to the menu. 5. Tap on the “Quiz” mode.	Button clicks	Easy switching between modes without lag or error.	Easy switching	✅ Pass	Low
Usab_02	Verify profile accessibility	1. Launch the application. 2. Log in with a user account. 3. Tap on the profile icon or menu. 4. Select "Edit Profile" option.	Profile settings	Profile menu loads properly and displays editable fields.	Profile menu loads properly	✅ Pass	Low

Usab_03	Verify quiz flow	1. Launch the application. 2. Navigate to the quiz section from the main menu. 3. Answer 5 questions consecutively using the UI options. 4. Observe automatic transition to the results screen after the last question.	Quiz questions	The quiz progresses smoothly with no submit button; after the 5th answer, results are automatically displayed.	The quiz progresses run smoothly.	✅ Pass	Medium

5.3.3 Efficiency Testing

Table 25: *Efficiency Testing.*

Test Case Description: Testing the performance of the AR-based educational game in terms of its resource efficiency, including load time, AR content rendering speed, and battery consumption. **Testing Objective:** To measure the responsiveness of the application, ensuring that it loads quickly, renders AR content smoothly, and operates efficiently in terms of battery consumption and system resources. Remarks:							
Test Case ID	**Test Scenario**	**Test Steps**	**Test Data**	**Expected Result**	**Actual Result**	**Status (Pass/Fail)**	**Severity**
Eff_01	Test AR rendering speed	1. Launch the application. 2. Scan an AR marker. 3. Observe the rendering speed of AR content. 4. Repeat with 5 different AR markers.	AR marker images (pre-defined)	The AR content should load within 2 seconds of scanning the marker with no noticeable lag.	AR content rendered smoothly within 2 seconds on all tested devices.	✅ Pass	Low

Eff_02	Test AR rendering speed	1. Close the application. 2. Re-launch the application. 3. Measure the time taken for the main menu to load and be interactive.	None (Timing measurement tool used)	The application should load the main menu within 3 seconds, and all menu items should be interactive immediately after loading.	The main menu loaded within 3 seconds, and all menu items became interactive immediately after launch.	✅ Pass	Low
Eff_03	Test battery consumption during AR use	1. Fully charge the device. 2. Launch the application and use the AR feature for 30 minutes. 3. Measure battery consumption after 30 minutes.	Device battery percentage before and after testing	Battery consumption should not exceed 10% after 30 minutes of use	Battery consumption was 8% after 30 minutes of AR usage on all devices tested.	✅ Pass	Medium
Eff_04	Test responsiveness	1. Launch the application.	Pre-selected AR markers for	The application should respond quickly and without	The application remained responsive with no	✅ Pass	Low

	during interaction	2. Scan an AR marker. 3. Interact with the displayed AR content by rotating and moving the device. 4. Observe the responsiveness.	interaction such rotating the 3D model	lag, even when the user moves or rotates the device.	noticeable lag during interaction with the AR content.		

5.3.4 Visual representation of test Result

Test Case: Load Testing for AR on different mobile phones.

Description: Install the application on different phones.

Screenshot:

Figure 105: *Testing the app across different smartphones.*

Test Case: Profile save stability

Description: Tests if user profile details are saved correctly and remain stable after navigation.

Screenshot:

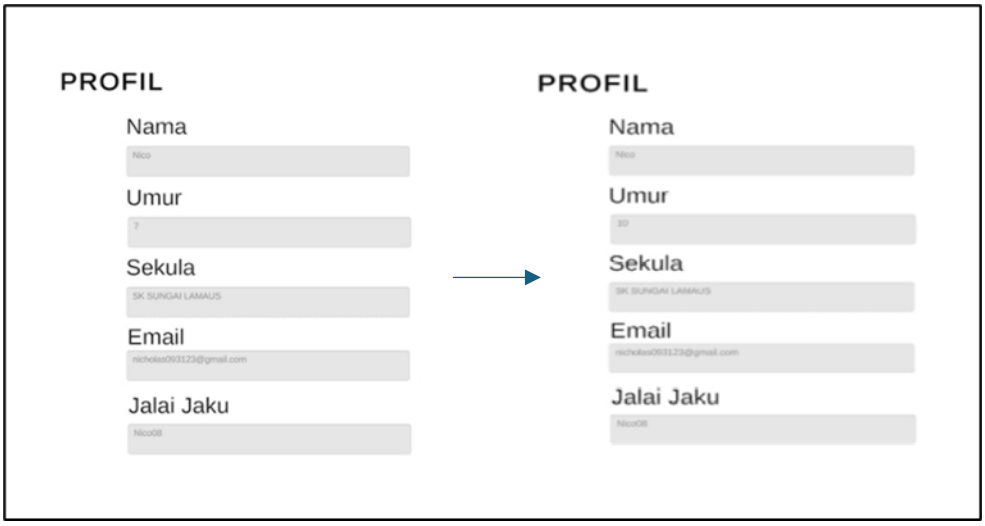
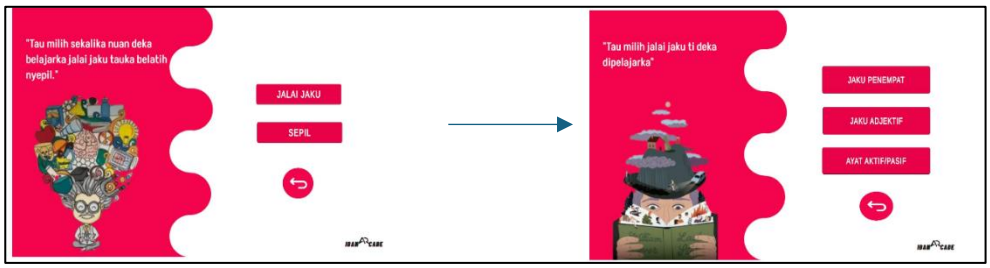
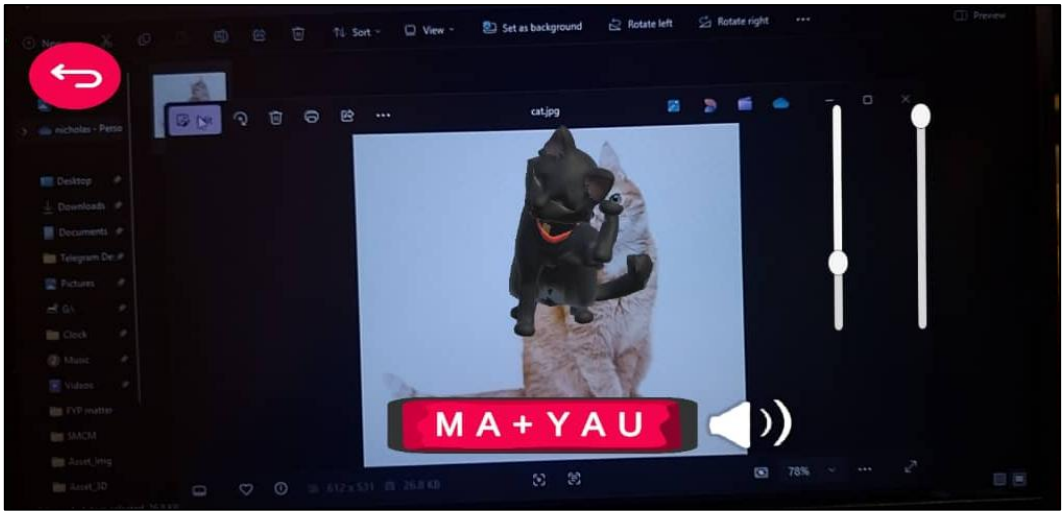
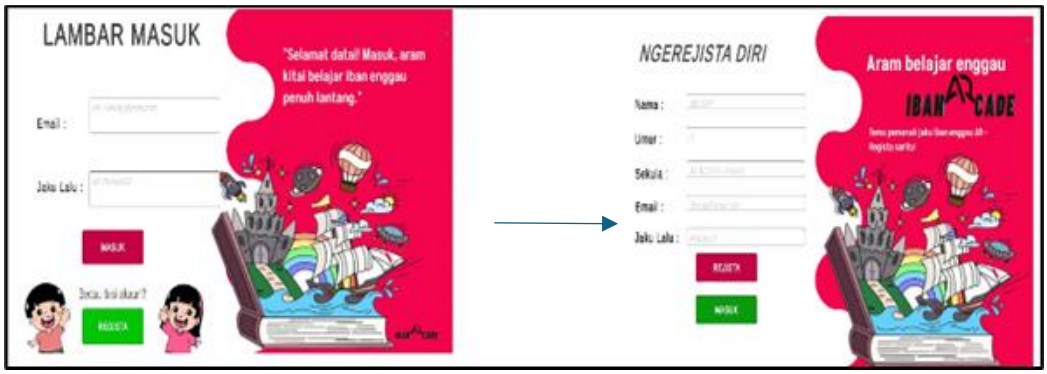


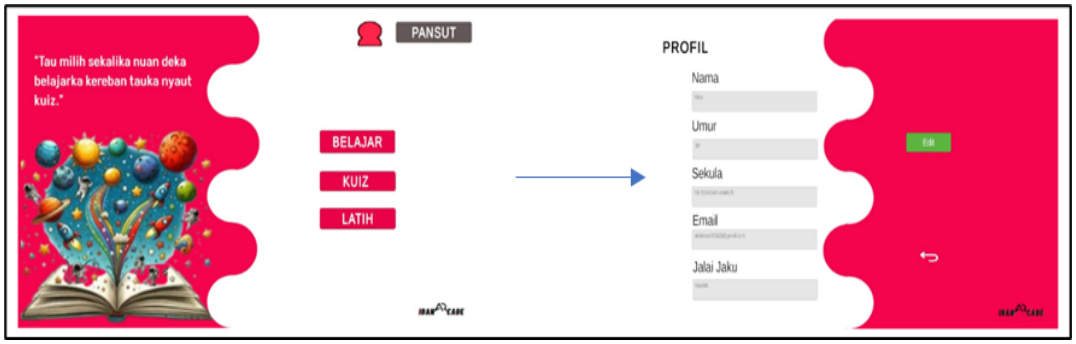
Figure 106: *Profile Update – Changing Age Information (7yo to 10yo)*

Test Case: Verify AR Marker scanning.
Description: Checks if the AR marker is detected and displays the correct content.
Screenshot: ***Figure 107:*** *Validates marker detection and activates relevant AR elements.*

Test Case: Verify Learning Option Selection.
Description: Verifies that learning categories can be selected and content loads properly.
Screenshot:  ***Figure 108:*** *Tests category selection to confirm proper content loading.*

Test Case: Verify Voice in the Learning Material.
Description: Ensures audio pronunciation plays when interacting with learning items.
Screenshot:  ***Figure 109:*** *Audio pronunciation is triggered upon interaction with learning items.*

Test Case: Verify UI navigation.
Description: Confirms that users can navigate between screens without issues.
Screenshot:  ***Figure 110:*** *Confirms smooth navigation between the Login and Register screens without any issues.*

Test Case: Verify profile accessibility.
Description: Tests if the profile page opens correctly from the main menu.
Screenshot:  ***Figure 111:*** *User Profile Screen Displayed After Selecting the Profile Icon from the Main Menu.*

Test Case: Verify quiz flow.
Description: Checks the full quiz flow from question display to result screen.
Screenshot: ***Figure 112:*** *Quiz Flow Showing Two Questions and Result Summary.*

Test Case: AR rendering speed
Description: Tests how fast and smoothly AR content appears after scanning a marker.
Screenshot: ***Figure 113:*** *Tests AR rendering speed, ensuring 3D content appears smoothly within 500–800 milliseconds after scanning the marker.*

Test Case: Quiz responsiveness
Description: Checks how quickly the app responds to answer selections and question transitions.
Screenshot: **Figure 114:** Verifies quiz responsiveness, ensuring instant feedback and result page display in under a second after answer selection.

5.4 User Testing

User testing is the process of evaluating how effectively students can interact with an application by observing them performing specific tasks in a natural and realistic environment. For this project, user testing was conducted to assess the usability, engagement, and overall learning experience offered by the AR-based application. The primary goal was to determine whether the system is intuitive, age-appropriate, and suitable for Year 1 students, particularly those with limited exposure to digital learning tools. By allowing students to interact freely with the game, the testing aimed to reveal whether the interface was easy to navigate, the features were accessible, and the learning content was effectively delivered through augmented reality. This approach helps identify areas for improvement and ensures that the application meets the expectations and needs of its young users before being widely implemented.

5.4.1 User Acceptance Testing

User Acceptance Testing (UAT) is a critical phase where the end users validate whether the developed system meets their needs and performs as expected in a real-world environment. In this project, UAT was conducted to ensure that the AR-based educational game functions correctly and delivers a smooth learning experience for Year 1 students before full deployment. This testing was carried out after the completion of functional, integration, and system testing to confirm the system's readiness from the user's perspective.

The UAT session involved a total of 15 students from SK Sungai Lamaus, a rural primary school. Before interacting with the application, students were first given a pre-test consisting of questions to assess their initial understanding of the selected Bahasa Iban vocabulary. After engaging with the AR-based game, the same students were given a post-test containing identical questions to evaluate any improvement in their learning. Both the pre-test and post-test were conducted within a 10-minute time limit to maintain consistency. Following the testing session, students' feedback was initially collected using a structured printed questionnaire, which was later converted into a Google Form to generate visual representations such as graphs for easier analysis of the results. The responses provided valuable insights into the system's usability, stability, and effectiveness in enhancing language learning. A sample of the pre-test questions and full UAT responses are included in Appendix C.

5.4.1.1 User Demographic

A total of 13 questions in the questionnaire were asked to year 1 students including their personal information and their past experience of using AR applications. Figure 115 depicts the results related to the age of the students. Since this project was specifically targeted at Year 1 students, the results show that 100% of the respondents were indeed Year 1 students. Meanwhile, Figure 116 presents the results regarding the student's previous experiences with AR applications. All the students responded that they had never used an AR application before. This indicates that the AR application developed in this project would serve as their first exposure to AR technology, making it important to ensure that the application is intuitive, user-friendly and engaging for them.

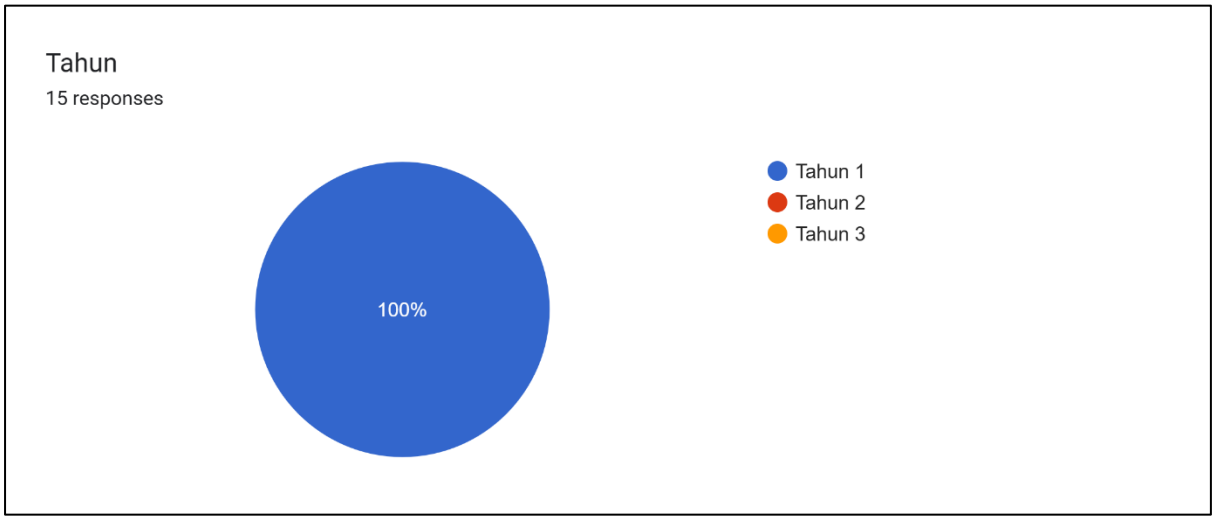


Figure 115: *Result of age.*

Figure 116: *Result of using AR experience.*

5.4.1.2 Analysis of the Usability Testing

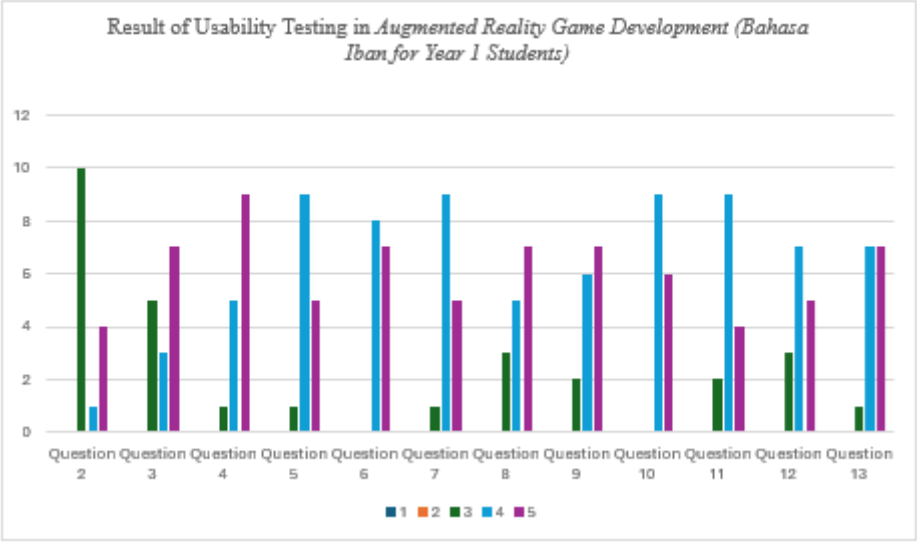


Figure 117: *Result Usability Testing.*

List of questions stated as below:

Soalan 2: Saya dapat menavigasi keseluruhan aplikasi AR dengan mudah.

Soalan 3: Saya dapat mengimbas penanda AR (cth: kad imbas/kertas) dengan mudah.

Soalan 4: Saya dapat melihat kandungan AR 3D (cth: model, perkataan atau animasi) dengan jelas dan tepat.

Soalan 5: Kandungan pembelajaran Bahasa Iban dipaparkan dengan jelas dalam aplikasi AR ini.

Soalan 6: Saya dapat memahami dan menyelesaikan kuiz yang disediakan dalam aplikasi.

Soalan 7: Kuiz dalam aplikasi ini membantu meningkatkan penglibatan (**boost engagement**) saya untuk terus belajar.

Soalan 8: Keupayaan untuk mengulang semula kandungan dalam aplikasi ini membantu saya belajar dengan lebih selesa mengikut tahap pemahaman saya.

Soalan 9: Kandungan pembelajaran dalam aplikasi ini membantu saya memahami kosa kata dan tatabahasa Bahasa Iban dengan lebih baik.

Soalan 10: Reka bentuk keseluruhan (warna, bunyi, animasi) aplikasi AR menyeronokkan dan sesuai untuk pembelajaran.

Soalan 11: Aplikasi AR ini membuatkan saya lebih berminat untuk belajar Bahasa Iban berbanding sebelum ini.

Soalan 12: Saya merasakan pembelajaran menggunakan AR ini lebih **menarik** berbanding kaedah tradisional seperti buku teks dan papan putih?

Soalan 13: Saya merasakan terdapat perubahan positif dalam cara saya belajar selepas menggunakan aplikasi AR berbanding cara pembelajaran tradisional.

Figure 118: *User Acceptance Testing questions.*

Figure 117 presents the usability testing results based on a 13-item Likert-scale questionnaire, where students rated each statement from 1 (Very Disagree) to 5 (Very Agree). The results were analysed by focusing on the top three most selected ratings for each question to identify overall trends and student perceptions.

The Likert-scale questionnaire evaluated student's experience with the AR learning application across 13 questions. For navigation (Q2), responses were mixed, with some students finding it easy while others needed more guidance. Scanning AR markers (Q3) and viewing 3D content (Q4) were generally rated as easy and clear. Students also found the Bahasa Iban content understandable (Q5) and were able to complete quizzes without major issues (Q6). The quiz feature (Q7) helped increase learning interest for most students.

Students appreciated being able to repeat content (Q8), and many felt the app improved their understanding of vocabulary and grammar (Q9). Design elements like colours, sounds, and animations (Q10) were well received. The majority agreed that the app increased their learning interest (Q11), was more enjoyable than traditional methods (Q12), and helped improve their learning performance (Q13). Overall, feedback was positive, showing that the app is user-friendly, engaging, and effective for language learning.

5.5 Summary

In this chapter, various tests were conducted to ensure that the developed augmented reality (AR) learning application functions as intended. These tests included functional, non-functional, usability, and performance evaluations. Functional testing verified that all core features such as AR marker detection, 3D content display, quizzes, and navigation worked correctly, while non-functional testing focused on usability, reliability, and efficiency across different devices.

User acceptance testing was also carried out with Year 1 students to assess the application's suitability for the intended audience. Feedback gathered through Likert-scale questionnaires indicated that most students found the app easy to use, engaging, and helpful for learning Bahasa Iban. All feedback and suggestions obtained during the testing phase will be considered for further improvement, ensuring the application is refined and ready for broader use in educational settings.

CHAPTER 6: CONCLUSION AND FUTURE WORK

6.1 Introduction

Chapter 6 concludes the development of the Augmented Reality Game Development (Bahasa Iban for Year 1 Students) project. This chapter discusses the achievements and contributions of the project in relation to its initial objectives. It also highlights key features that were successfully implemented throughout the development process. Following the evaluation and testing described in the previous chapter, the limitations of the system are outlined and discussed. These limitations provide insight into areas for improvement and serve as a foundation for potential future enhancements.

6.2 Project Achievement

This project aims to enhance the learning of Bahasa Iban among Year 1 students by using an augmented reality-based educational game. Through the use of AR technology, students can interact with learning content in a more engaging and immersive way, making abstract concepts like grammar and spelling easier to understand. The application allows students to scan a downloadable AR marker using a mobile device to trigger interactive learning scenes. Progress is tracked individually, allowing each student to learn at their own pace. The system also evaluates student responses through quizzes, providing instant feedback and motivational elements to encourage continued learning. The objectives of the AR-based educational game are described in the following table.

Table 26: Objective and achievement of the project.

Objective	Achievement
Provide a platform for personalized learning experiences through user-specific progress tracking and adaptive content delivery.	Successfully implemented a user profile system with individualized progress tracking. The app adapts content based on each student's progress, allowing for a more tailored and effective learning journey.
To develop an AR-based educational game that integrates the digital and physical worlds, presenting Bahasa Iban grammar and spelling interactively and engagingly.	Developed and launched a functional AR-based educational game that overlays digital learning content in enhancing engagement by connecting digital interaction with real-world elements.
To evaluate the effectiveness of game mechanics, such as quizzes, in boosting student engagement and motivation to continue practicing, while ensuring the learning experience remains enjoyable and stimulating.	Evaluation results showed increased student engagement and enjoyment, with quizzes and interactive tasks positively influencing learning motivation and continued use. Feedback from users indicated improved understanding of Bahasa Iban grammar and spelling.

6.3 Contribution

This project contributes significantly to the field of educational technology by introducing an innovative, gamified approach to language learning through the use of mobile augmented reality (AR). Specifically, it focuses on the preservation and learning of an indigenous language, Bahasa Iban, which is often underrepresented in mainstream educational tools. By leveraging AR, the application creates immersive and interactive learning experiences that engage students far more effectively than traditional classroom methods. The game-based format, combined with visual and auditory elements, helps to reinforce language concepts such as grammar and spelling in a way that is both enjoyable and educational.

Additionally, the project has particular value for rural and underserved communities, where access to educational materials is often limited. By delivering the app via mobile devices, it becomes more accessible to students in remote areas. Usability testing with Year 1 students confirmed that the app was intuitive, effective and well-received, with most students

finding it easy to use, enjoyable and helpful in supporting their language learning. Functional and non-functional testing further confirmed the app's reliability, performance and educational value. This is in line with broader efforts to bridge the digital divide and promote inclusive education, ensuring that students in less connected areas can still benefit from modern learning technologies. Overall, the project represents a shift from traditional rote learning methods to a more interactive, technology-driven approach. By integrating emerging technologies such as AR, it demonstrates how digital tools can transform the educational experience, making learning more engaging, personalized, and effective especially for young learners.

6.4 Project Limitation

Despite its achievements, several limitations were encountered:

1. **Limited Multimedia Elements**: To manage scope and focus, the game primarily included visual and textual elements. Features such as narration, or voice recognition for pronunciation support were not fully implemented, which may reduce the learning experience for auditory learners.
2. **Limited Vocabulary Sets**: Due to time and resource constraints, the current version of the application includes only a basic set of Bahasa Iban vocabulary. Additional content could not be implemented within the project timeframe.
3. **User Testing Scope**: Due to time and location constraints, user testing was conducted with a small sample size. While initial feedback was positive, a broader evaluation with more students and educators would provide more comprehensive insights into the effectiveness and usability of the system.
4. **3D Model Development Constraints**: Creating AR-compatible 3D models using Blender was time-consuming, particularly since it was a new tool for the developer. Additionally, the selection of suitable and culturally relevant 3D models from free sources was limited, which affected the variety and representation of certain vocabulary items.
5. **Requires Internet Connection:** Another key limitation of the project is that the application cannot be used without an internet connection. This is mainly due to the use of Firebase Authentication and Realtime Database. The login system requires internet access to verify user credentials, meaning first-time or logged-out users cannot access the app offline. Additionally, the progress tracking feature relies on Firebase Realtime Database to store and retrieve learning data, which also requires an active connection.

6.5 Future Work

To further enhance engagement, the app could integrate interactive storytelling or dialogue-based learning, allowing students to make choices and explore language through immersive scenarios. Artificial intelligence (AI) could also be implemented to offer real-time pronunciation feedback, chatbot-based conversation practice, or intelligent virtual assistants that guide students through lessons and quizzes.

Additionally, expanding the platform to support teacher accounts and administrative tools would allow educators to monitor student progress, assign tasks, and adjust lesson plans based on class performance. This would turn the application into a more comprehensive and scalable classroom resource.

Future versions may also include support for multiple indigenous or local languages, broadening the app's cultural impact and usefulness in diverse educational settings. Combined with offline functionality and improved accessibility, these enhancements would make the application a more powerful tool for inclusive and engaging language learning.

6.6 Conclusion

In conclusion, the development of an Augmented Reality Game for Iban Language learning successfully achieved its core objective by delivering engaging and interactive education tailored for Year 1 students. Through the integration of AR technology, this project demonstrates how digital tools can enhance language learning by making learning materials more tangible and enjoyable. The implemented features such as progress tracking, interactive 3D content, and quiz-based assessment contribute to a more meaningful learning experience, especially in supporting the understanding of Iban Language grammar and spelling.

Despite its achievements, the project faced limitations such as limited content, lack of offline access, and minimal multimedia elements. These highlight areas for future enhancement, including expanded content, teacher support, AI-based learning tools, and offline functionality. Overall, the project lays a strong foundation for modernizing language education through inclusive and culturally relevant technology.

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Appendix A

Interview

Interview Date: 30 December 2024, 7.00 am

Interview Location: Sekolah Kebangsaan Sungai Lamaus

Interviewee: [Mr. Martin] (Bahasa Iban Teacher)

Age: 24 Tahun

Origin: Sibu, Sarawak

Position: Guru Bahasa Iban Sekolah Kebangsaan Sungai Lamaus

Interviewer: [Nicholas Lim]

1. What are the main challenges students face when learning the Iban language?

The challenge that I can notice is in terms of Iban language spelling. Students are often confused with the correct spelling due to the influence of home and social media.

---

2. Is the lack of learning materials one of the challenges? If so, what kind of materials are needed?

Yes. It is difficult to get materials for Iban language subjects, if not from other Iban language teachers. Lack of learning materials such as training modules in digital form. Because it is more interesting for students to learn.

---

3. What are the weaknesses of learning the traditional way?

In my opinion, the weakness of traditional learning is that it cannot attract students' interest.

---

4. What is the most effective teaching method for the Iban language, based on the teacher's experience?

The most effective teaching method is to use existing materials. Something that can be seen as digital stuff. For example, materials in the form of games in power point and hyperlinks. With that, the students will feel excited to learn the topics.

---

5. How do teachers ensure that learning the Iban language becomes interesting for students?

Produce tangible materials, things that can be touched and seen.

---

6. Do teachers ever use technology tools in teaching the Iban language? If so, how was the experience?

Yes ever. Positive reception from the students. They are more interested in learning because they are excited to see the learning materials.

---

7. What is the teacher's opinion about the use of technology such as augmented reality (AR) in learning Iban?

In my opinion, the use of technology such as augmented reality really helps students understand better, helps attract students' interest, and makes the learning atmosphere more enjoyable.

---

8. In the teacher's opinion, what are the pros and cons of using technology tools in the learning process?

The advantage of learning is more interesting and helps them learn faster because students can see the learning material for themselves.

The bad thing is that students will misuse it if they are not monitored when used outside the study room.

---

9. Do teachers think technology like AR can help students better understand and be interested in learning the Iban language?

Yes, I agree with that statement. AR was created to make things more interesting. Especially learning in the study room. AR can attract students' interest and be able to achieve learning objectives.

---

10. Do teachers agree to use AR technology in the learning process?

Yes, agree.

---

11. How do students usually respond to interactive teaching methods such as quizzes?

The students became more active than usual. They became more excited about the topic that had been asked.

---

12. In the teacher's opinion, how can AR complement existing traditional teaching methods?

By creating elements that do not exist in traditional methods such as infographics, sound and movement in learning materials.

---

13. What syllabus do you think can be included in this project?

The syllabus that I think can be included in this project is grammar. Because there are many breakdowns under "Bungai Jaku" (Grammar).

---

14. What components do you think should be included in this project?

Components in the form of quizzes and games to test students' abilities. Play while learning. With that, this component can make them feel more challenged and at the same time want to solve the challenge.

---

15. Are teachers ready to switch to a more modern and interactive teaching approach if given the opportunity?

Yes, I like augmented reality. If required or required to switch, I am ready.

Appendix B

Questionnaire

Nama Pelajar: _____

Tahun: _____

Sila bulatkan jawapan anda.

Link video: https://youtu.be/nFsUq-kcI4U?si=eGG_hg5rxG3QpMEe

Saya mempunyai telefon bimbit.

YA	TIDAK

1. Saya tahu bagaimana menggunakan telefon pintar atau tablet.

1	2	3	4	5
Sangat Tidak Setuju	Tidak Setuju	Kurang Pasti	Setuju	Sangat Setuju

2. Saya tahu apa itu Augmented Reality (AR).

1	2	3	4	5
Sangat Tidak Setuju	Tidak Setuju	Kurang Pasti	Setuju	Sangat Setuju

3. Saya rasa pembelajaran Bahasa Iban secara tradisional, seperti membaca buku teks atau mendengar guru sahaja, kurang menarik.

1	2	3	4	5
Sangat Tidak Setuju	Tidak Setuju	Kurang Pasti	Setuju	Sangat Setuju

4. Saya sukar untuk membayangkan sesuatu perkataan atau cerita dalam Bahasa Iban jika hanya mendengarnya tanpa melihat gambar atau objek.

1 Sangat Tidak Setuju	2 Tidak Setuju	3 Kurang Pasti	4 Setuju	5 Sangat Setuju

5. Saya lebih berminat belajar Bahasa Iban menggunakan AR berbanding kaedah biasa.

1 Sangat Tidak Setuju	2 Tidak Setuju	3 Kurang Pasti	4 Setuju	5 Sangat Setuju

6. Saya suka jika aplikasi ini mempunyai ciri-ciri interaktif seperti animasi 3D yang bergerak apabila saya menyentuh skrin.

1 Sangat Tidak Setuju	2 Tidak Setuju	3 Kurang Pasti	4 Setuju	5 Sangat Setuju

7. Penggunaan animasi dalam aplikasi menjadikan pembelajaran lebih menyeronokkan berbanding buku teks.

1 Sangat Tidak Setuju	2 Tidak Setuju	3 Kurang Pasti	4 Setuju	5 Sangat Setuju

8. Kuiz di dalam aplikasi akan membantu saya mengingati perkataan Bahasa Iban dengan lebih mudah.

1 Sangat Tidak Setuju	2 Tidak Setuju	3 Kurang Pasti	4 Setuju	5 Sangat Setuju

9. Permainan berbentuk AR (contohnya: melihat objek maya 3D melalui kamera telefon) membantu saya memahami topik pembelajaran dengan lebih cepat.

1 Sangat Tidak Setuju	2 Tidak Setuju	3 Kurang Pasti	4 Setuju	5 Sangat Setuju

10. Setelah memahami apa itu Augmented Reality (AR), saya rasa teknologi ini lebih menarik dan dapat membantu saya mempelajari matapelajaran Bahasa Iban dengan lebih mudah.

1 Sangat Tidak Setuju	2 Tidak Setuju	3 Kurang Pasti	4 Setuju	5 Sangat Setuju

User Acceptance Test Questionnaire

User Acceptance Testing

This form is designed to collect feedback from users who have interacted with the AR (Augmented Reality) Language Learning Game developed for this Final Year Project. The purpose of this User Acceptance Testing (UAT) is to evaluate the overall functionality, usability, and satisfaction level of the system from the user's perspective. Your responses will help identify any issues and ensure the system meets user needs and expectations before final deployment.

Participants will be asked to rate various aspects of the application, such as ease of use, clarity of instructions, visual appeal, responsiveness, and overall user experience. There will also be a section for open-ended feedback to suggest improvements or report any issues encountered during use.

Your honest feedback is highly appreciated and will contribute to the successful refinement of the project. All responses will remain confidential and will be used solely for academic and improvement purposes.

* Indicates required question

1. Nama *

2. Tahun *

Mark only one oval.

- Tahun 1
- Tahun 2
- Tahun 3

https://docs.google.com/forms/d/1yFqneqt5oM_vNj1oz-aq-dBkvEwQaphkN4d7yodj2sU/edit?ts=684ed67c 1/9

3. Pernahkah anda menggunakan aplikasi atau permainan berasaskan AR sebelum ini? *

Mark only one oval.

- Ya
- Tidak

4. Jika Ya, sila nyatakan nama aplikasi

5. Saya dapat menavigasi keseluruhan aplikasi AR dengan mudah *

Mark only one oval.

	1	2	3	4	5	
San						Sangat Setuju

6. Jika Pilihan anda 1 dan 2, sila nyatakan nama sebab

7. Saya dapat mengimbas penanda AR (cth: kad imbas/kertas) dengan mudah *

Mark only one oval.

	1	2	3	4	5	
San						Sangat Setuju

8. Jika Pilihan anda 1 dan 2, sila nyatakan nama sebab

9. Saya dapat melihat kandungan AR 3D (cth: model, perkataan atau animasi) dengan jelas dan tepat. *

Mark only one oval.

	1	2	3	4	5	
San	◯	◯	◯	◯	◯	Sangat Setuju

10. Jika Pilihan anda 1 dan 2, sila nyatakan nama sebab

11. Kandungan pembelajaran Bahasa Iban dipaparkan dengan jelas dalam aplikasi AR ini. *

Mark only one oval.

	1	2	3	4	5	
San	◯	◯	◯	◯	◯	Sangat Setuju

12. Jika Pilihan anda 1 dan 2, sila nyatakan nama sebab

13. Saya dapat memahami dan menyelesaikan kuiz yang disediakan dalam aplikasi. *

Mark only one oval.

	1	2	3	4	5	
San	◯	◯	◯	◯	◯	Sangat Setuju

14. Jika Pilihan anda 1 dan 2, sila nyatakan nama sebab

15. Kuiz dalam aplikasi ini membantu meningkatkan penglibatan (**boost engagement**) saya untuk terus belajar. *

Mark only one oval.

	1	2	3	4	5	
San	◯	◯	◯	◯	◯	Sangat Setuju

16. Jika Pilihan anda 1 dan 2, sila nyatakan nama sebab

17. Keupayaan untuk mengulang semula kandungan dalam aplikasi ini membantu saya belajar dengan lebih selesa mengikut tahap pemahaman saya. *

Mark only one oval.

	1	2	3	4	5	
San	◯	◯	◯	◯	◯	Sangat Setuju

18. Jika Pilihan anda 1 dan 2, sila nyatakan nama sebab

19. Kandungan pembelajaran dalam aplikasi ini membantu saya memahami kosa kata dan tatabahasa Bahasa Iban dengan lebih baik. *

Mark only one oval.

	1	2	3	4	5	
San	◯	◯	◯	◯	◯	Sangat Setuju

20. Jika Pilihan anda 1 dan 2, sila nyatakan nama sebab

21. Reka bentuk keseluruhan (warna, bunyi, animasi) aplikasi AR menyeronokkan dan sesuai untuk pembelajaran. *

Mark only one oval.

	1	2	3	4	5	
San	◯	◯	◯	◯	◯	Sangat Setuju

22. Jika Pilihan anda 1 dan 2, sila nyatakan nama sebab

23. Aplikasi AR ini membuatkan saya lebih berminat untuk belajar Bahasa Iban berbanding sebelum ini. *

Mark only one oval.

	1	2	3	4	5	
San	◯	◯	◯	◯	◯	Sangat Setuju

24. Jika Pilihan anda 1 dan 2, sila nyatakan nama sebab

25. Saya merasakan pembelajaran menggunakan AR ini lebih **menarik** berbanding kaedah tradisional seperti buku teks dan papan putih? *

Mark only one oval.

	1	2	3	4	5	
San	◯	◯	◯	◯	◯	Sangat Setuju

26. Jika Pilihan anda 1 dan 2, sila nyatakan nama sebab

27. Saya merasakan terdapat perubahan positif dalam cara saya belajar selepas menggunakan aplikasi AR berbanding cara pembelajaran tradisional. *

Mark only one oval.

	1	2	3	4	5	
San	◯	◯	◯	◯	◯	Sangat Setuju

28. Jika Pilihan anda 1 dan 2, sila nyatakan nama sebab

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Appendix C

Proof of Interview and Questionnaire

Figure 119: *Questionnaire session.*

Figure 120: *Interview session with Mr. Martin.*

Survey proof

Figure 121: *Students actively engaged in a survey comparing two different learning material designs.*

User Testing Proof

Figure 122: *Students interacting with the developed AR-based educational application.*

Pre-test Questions

Nama: _____ **Tahun:_____**

1. Beri nama **GAMBAR** ba baruh tu.

_____	_____
_____	_____
_____	

2. Isi **JAKU PENEMPAT** ti engkeman kena gambar ba baruh.

 _____	 _____
 _____	

3. Gariska gambar ngagai **JAKU ADJEKTIF** ti engkeman.

- Besai
- Panjai
- Lama
- Pandak

4. Tukar **AYAT AKTIF** di baruh ngagai **AYAT PASIF** ti betul.

- Rentap nendang bol.

_____

- Kumang macha bup.

_____

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