

BESALIR: Wild Animals Education using Augmented Reality

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ABSTRACT

Learning about wild animals traditionally relies on static books and posters, lacking interactivity and engagement. This paper presents the development of BESALIR - an augmented reality (AR) mobile application using Vuforia to teach elementary students about wild animals. The app name BESALIR is an abbreviation of the Indonesian phrase "Belajar Satwa Liar" meaning Learning Wild Animals. The Multimedia Development Life Cycle methodology guided the design and implementation. Virtual 3D models of animals overlaid on image target markers provided enhanced visualization. Animation and sounds immersed students in the experience. Information pop-ups provided details on each animal species when markers were detected. Quizzes reinforced knowledge retention. Black Box Testing validated requirements during iterative prototyping. Initial user studies indicated increased engagement versus conventional materials. The results demonstrate the potential of AR technology to transform static content into interactive and stimulating educational experiences. BESALIR serves as a practical use case and template for developing engaging AR learning applications.

General Terms

Augmented Reality, Multimedia Development Life Cycle.

Keywords

Augmented Reality, AR, Marker, Marker-based, Multimedia Development Life Cycle, MDLC, 3D, 3D models, Wild animals, Wildlife, Learning media, Elementary school students.

1. INTRODUCTION

Wild animal education in elementary schools has traditionally relied on static media like textbooks and posters. These linear, passive methods can lack interactivity and fail to fully engage all students [1], limiting comprehension of key concepts about wild animals. Prior studies have shown interactive educational technologies can increase student interest, retention, and outcomes by facilitating active learning [2], [3].

Augmented Reality (AR) is an emerging technology that overlays digital information onto the real environment, providing an immersive and stimulating learning experience. AR integrates 3D models, animations, sounds, and multimedia directly into the user's surroundings [4]. In education contexts, AR applications have demonstrated improved learning motivation and outcomes versus traditional methods [5], [6].

This research aims to develop an AR application to create a more interactive way for elementary students to learn about wild animals. The BESALIR mobile app, meaning "Learning Wild Animals" in Indonesian, allows students to view detailed 3D animal models overlaid and animated in their surroundings. Supplemental information on the wild animals is displayed in

pop-ups when corresponding AR markers are detected. The goal is to develop an AR experience that has the potential to increase engagement, interest, and comprehension compared to current static educational materials on wild animals.

2. LITERATURE REVIEW

Relevant prior research was reviewed to establish background context and derive requirements for developing an augmented reality application for interactive wild animal education.

Augmented reality (AR) technology has been applied across many fields, including tourism, archaeology, art, business, manufacturing, education, emergency response, entertainment, and healthcare [4]. Recent studies found AR apps can increase student motivation and engagement compared to traditional teaching methods [6], [7].

Research shows incorporation of interactive digital activities can positively impact learning processes and outcomes [2], [3], [8], [9]. Techniques such as simulations, visualizations, games, and adaptive content can promote active learning and increased engagement versus passive linear methods [1]. Students are able to visualize abstract concepts, receive real-time feedback, and engage multiple senses. Such interactivity enables exploration, discovery, and hands-on learning which resonates with today's digital native students.

Traditional wild animal teaching materials have relied heavily on static books and posters, which can limit interactivity and engagement. However, efforts have emerged to develop more interactive educational resources, particularly for early childhood. For instance, interactive multimedia including videos, games, and activities have been designed to introduce wild animals to young learners [10]. While progress is being made, there remains ample room for growth in leveraging interactive technologies to create customizable, stimulating experiences that transform static wild animal education content. There is a need for applying new interactive technologies to transform wild animal education. AR shows potential to build on these advancements through immersive 3D visualizations adapted to learners' needs and modalities.

Augmented reality shows strong potential to bridge the interactivity gap in wild animal learning materials [5] through 3D visualization, simulations, audio, and contextual data overlays. AR applications can display interactive 3D animal models, animations, and sounds adapted to each species to provide an immersive experience. Quizzes and data pop-ups further engagement. AR technology aligns well with pedagogical needs for customizable, interactive content to stimulate interest in learning about wild animals.

This literature review provided motivation to develop an augmented reality mobile experience for elementary wild animal education, as discussed next in the Methodology

section. AR appears well suited to overcoming current materials limitations through interactive 3D visualizations and simulations.

3. METHODOLOGY

The research employs literature review and observational study to inform the AR application development using the Multimedia Development Life Cycle (MDLC) methodology. MDLC is a method utilized in developing and designing multimedia applications that combine image, sound, video, and other media [11]. This method consists of 6 stages: Concept, Design, Material Collecting, Assembly, Testing, and Distribution [12]. This structured development process enabled creating an engaging augmented reality educational experience within the limitations of available time and resources. The MDLC provided organization and helped avoid common pitfalls in multimedia software projects.

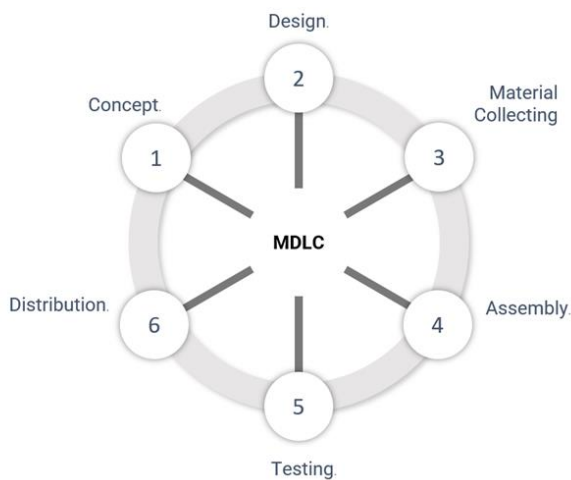


Fig. 1: Multimedia Development Life Cycle Stages

Following are the six stages of MDLC activities carried out:

1. In Concept stage, the needs of users and the purpose of the application are determined. Research is conducted to find out the needs and interests of end users. The results of this research inform the design and development of the application. In this research, the needs analysis found that elementary school students require an interactive and engaging media to learn about wild animals.

2. Design stage plans the overall framework and components of the application. This includes developing storyboards, interface layouts, and navigation flows. The application is designed using Figma and Unity as the development platform for building the 3D models and AR functionality. Vuforia SDK is utilized for handling AR camera controls, image recognition, and target tracking.

3. In Material Collecting, assets such as 3D models, images, audio, animations, and textual information are gathered and created. 3D models of wild animals are obtained from online 3D model marketplaces and created manually. Animal images are compiled from public domain image sources and KORA. Audio clips play animal sounds based on scans in the application. Relevant information on wild animals is collected from books, websites, and domain experts.

4. Assembly integrates all assets into a working prototype following the designs. The 3D models, animations, textures, and behaviors are imported into Unity scenes. User interface controls, menus, and navigation are programmed using C#

scripts. Vuforia capabilities are initialized and image targets linked to AR content.

5. Testing evaluates overall performance and usability using the Black Box Testing method. Black Box Testing verifies that the functional requirements and flows operate as intended without examining internal code structure. Test cases are developed to check all use case scenarios, interface elements, inputs, and expected outputs. Compatibility testing is performed to confirm correct operation on target Android devices. Issues discovered during testing are logged, diagnosed, repaired, and retested until functioning properly.

6. Distribution publishes the completed application for access and installation by end users. The Android application package file is built and uploaded to cloud servers for free public download.

4. RESULT AND DISCUSSION

In the results and discussion section, the authors, following the Multimedia Development Life Cycle (MDLC) methodology and employing Black Box Testing for system evaluation, presents the findings and insights gained from the research.

Compared to the animal recognition AR application developed by [6], BESALIR application focuses specifically on wild animals and provides wild animal sounds and quiz features to reinforce learning, not just 3D models.

4.1 Concept

Please In the Concept stage, the user identification activity was conducted through literature studies and observation to find data about potential users of this Augmented Reality application. From the collected data, this wild animal introduction learning media application is aimed at elementary school students and teachers. Research was conducted to determine the needs and interests of students in grades 1-6 as the target users for the wild animals learning application. The key needs identified were:

1. Interactive 3D models to improve visualization of wild animals' appearance and behaviors
2. Audio of wild animals sounds to associate with the 3D models
3. Information about the wild animals
4. Quizzes and award titles to engage users in active learning

The concept of the application is an interactive learning media for introducing wild animals using Augmented Reality. The application will utilize the smartphone camera to detect wild animal image markers [13] and display 3D models of the wild animals on the smartphone screen. The users require the following software: Minimum Android operating system version Oreo or 8 and supports ARCore.

The purpose of developing this application is to assist elementary school students in learning and understanding various types of wild animals in a more interesting and interactive way using Augmented Reality technology.

4.2 Design

In the Design stage, the application architecture, layout, style, and appearance were defined. User experience (UX) design principles emphasize creating applications that are easy and convenient for users. Research shows that applications designed with UX principles in mind tend to gain higher user acceptance and satisfaction [8]. Following this guidance, user experience design was conducted in this project to ensure an

intuitive and user-friendly interface. Storyboards [14] were created to map out the overall flow and key interactions. A navigation structure [15], [16] diagram was developed to lay out the connections between application screens and how users would navigate the app. This provided a high-level view of the user journey. Flowcharts [17] were then made for each screen to detail the logic and workflow within screens. The flowcharts mapped out conditional logic, decisions, and processing to provide lower-level design detail.

The application consists of five main scenes: Home, Scan, Quiz, Result, and About. The Home screen contains buttons for Play, Quiz, About, and Exit. Play starts the scanning flow, Quiz opens the mini quiz game, About shows application and developer information, and Exit to closes the application. The Scan screen has Home and Info buttons. Home returns to the main screen, while Info brings up a popup with details on the detected animal. If no marker is detected, an alert is shown. The Quiz screen contains a Back button and four multiple choice answer buttons. Back goes to Home, and selecting an answer submits it for the quiz. After finishing the quiz, it advances to the Result screen. The Result screen has buttons to play the quiz again or go Back to Home. It displays a categorical award title based on the number of correct answers. For example, "Wild Animals Beginner" for a lower score or "Wild Animals Expert" for a highest score. A description is shown explaining the meaning of the title awarded.

To enable Augmented Reality, Vuforia SDK was integrated into the Unity project. Image Targets and 3D models were linked and added to the Vuforia database. The camera feed combines real and virtual views. Models were optimized for mobile performance. The design focuses on usability, visuals, and interactive learning. The simplicity allows users to quickly start scanning and learning about wild animals through Augmented Reality.

4.2.1 Storyboard

Storyboards were created to map out the overall user flow and journey in the application. possible.

Table 1. Storyboard

Screen	Description
Home	Contains buttons to start scanning, take quiz, view about, or exit
Scan	Camera view to scan marker which triggers display of a 3D model, text, images, and sounds related to the wild animal associated with that marker
Quiz	Displays quiz questions and multiple choice options
Result	Shows categorical award title based on number of correct answers after completing and description explaining meaning of title
About	Displays credits, version, descriptions, and developer info

4.2.2 Navigation Structure

A navigation structure diagram illustrates the connections between application screens and how users navigate between them.

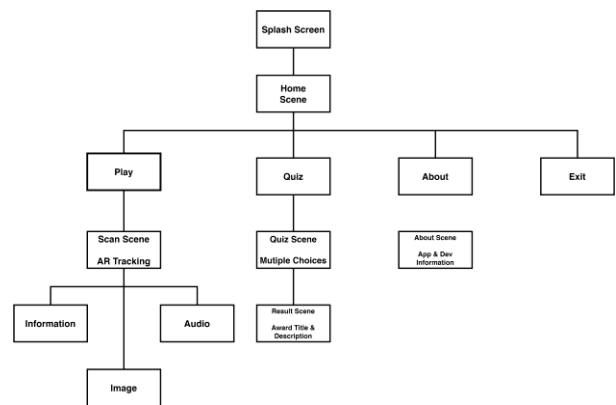


Fig. 2: Navigation Structure

4.2.3 Flowchart

Flowcharts visually depict the step-by-step logic and workflow within each screen of the application.

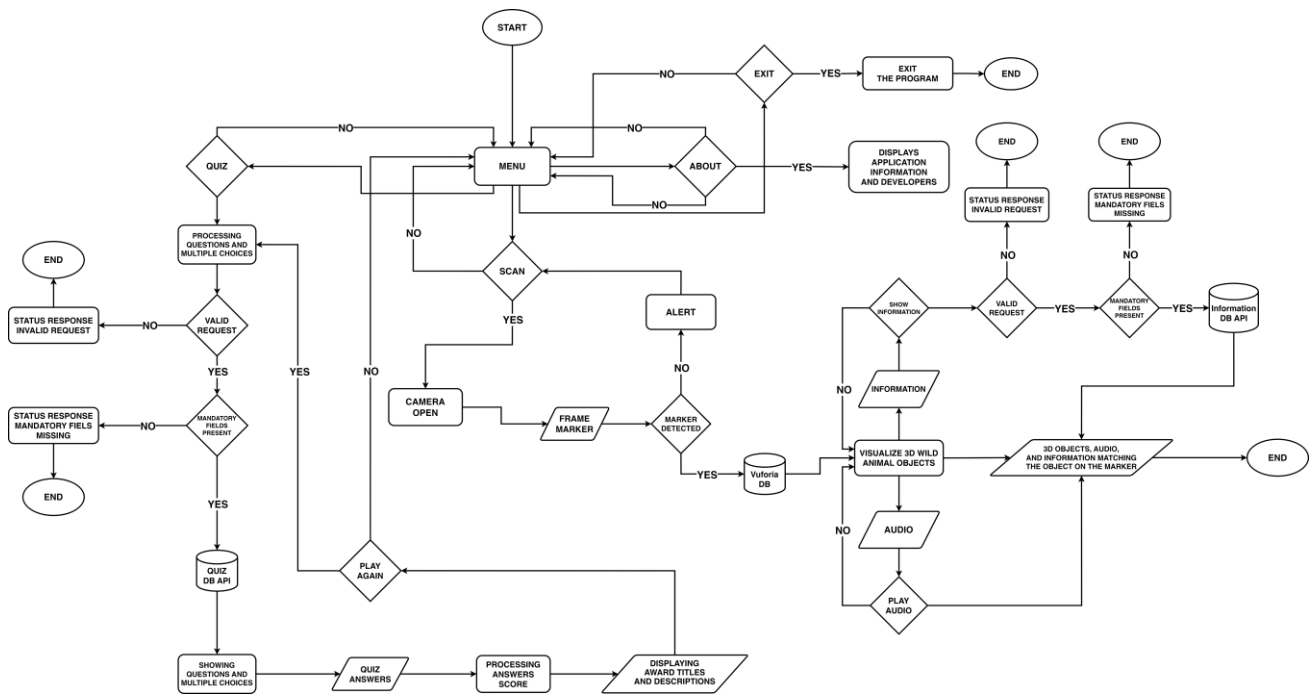


Fig. 3: Flowchart Diagram

4.3 Material Collecting

Material Collecting stage gathered and created the visual, audio, and information assets required for the application. The user interface was designed in Figma to finalize the layouts and flow between screens. Supporting assets including the application logo and QR code were created using CorelDraw and NX.TN. Image editing software Paint.NET was utilized to refine any additional graphics needed. Facts and descriptive information on the animals were collected from educational resources, as well as relevant online sites such as KORA and reference books.

4.4 Assembly

The Assembly stage integrated the assets into a working prototype of the application. The 3D models, images, audio clips, animations, and other visual elements were imported into the Unity project. Each 3D model was configured with the appropriate textures, lighting, and animation behaviors. Colliders were added to enable interaction with the AR camera for placement and environmental occlusion. The Vuforia scripts were initialized to enable image target tracking and detection capabilities.

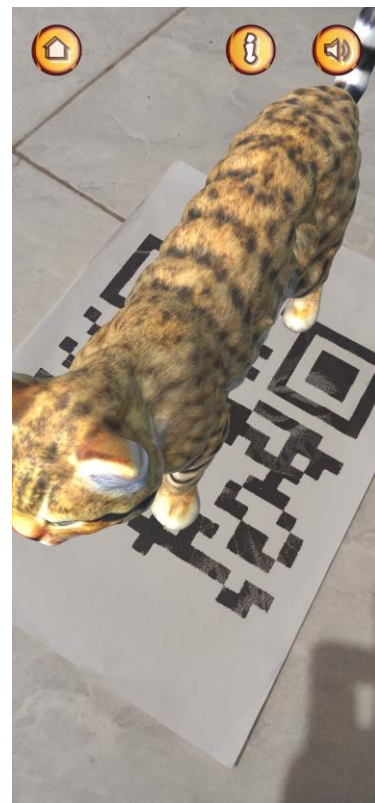


Fig. 4: 3D Visualization of wildcat

The user interface layouts designed in Figma were reconstructed in Unity using canvas objects, panels, buttons, text fields, and other UI components. Navigation flows between screens were coded in C# scripts. Background audio and sound effects were added using Unity's audio system.

An API backend was developed using ExpressJS and NodeJS with a MySQL database to serve the quiz questions, answers, and informative text about the animals. The systems for

retrieving the API data, displaying flashcard content, detecting quiz answers, and calculating scores were programmed in C#.



Fig. 5: Display of BESALIR application and one of its markers

4.5 Testing

Testing stage evaluated the performance and usability of the application prototype. Black Box Testing methodology was utilized as it allows evaluating functions and outputs without examining internal code structure [18], [19].

Comprehensive test cases were developed to simulate real user scenarios and validate that key features performed as intended. Test cases covered critical app functions including marker scanning, 3D model visualization, navigation flows between screens, audio playback, pop-up information display, quiz questions and scoring, and award title calculation.

Any issues discovered during testing were logged, diagnosed to identify root causes, and resolved through iterative code improvements. After fixes were implemented, the concerning features were retested to confirm the bugs were eliminated and intended functionality restored. This process continued until all defined test cases passed and the prototype demonstrated robust performance.

In total, 37 test cases were executed, uncovering 12 defects. The resolved issues included camera feed freezing, incorrect 3D model display, audio sync problems, score miscalculation,

and award title text bugs. Through methodical diagnosis and correction of these deficiencies, all requirements were verified and the prototype prepared for final refinement before distribution. Following are the results of application testing:

Table 2. Unit Testing Results (Black Box Testing)

Units	System Testing	System Reactions	Test Results
Scan	Displays frame markers to the smartphone camera	Shows 3D objects corresponding to the detected marker	Pass ✓
Scan	Presses the Home button	Moves user to the main menu Home scene	Pass ✓
Scan	Presses the Info button	Displays information about wild animals based on the detected marker	Pass ✓
Scan	Presses the Audio button	Plays wild animal sounds based on the detected marker	Pass ✓
Menu	Presses the PLAY button	Moves the user to the Scan scene	Pass ✓
Menu	Presses the QUIZ button	Moves the user to the Quiz scene	Pass ✓
Menu	Presses the ABOUT button	Moves the user to the About scene and displays application information	Pass ✓
Menu	Presses the EXIT button	Closes the application	Pass ✓
Quiz	Presses the correct answer button	Plays a special audio for the correct answer and goes to the next question	Pass ✓
Quiz	Presses the wrong answer button	Plays a special audio for the wrong answer and goes to the next question	Pass ✓
Quiz	Answer all the quiz questions	Moves the user to the Result scene and displays the award title based on the number of scores obtained, along with a descriptive explanation regarding it	Pass ✓

The extensive black box testing validated that key educational elements of the AR experience functioned correctly from the

student perspective. This increases confidence that the augmented reality features will perform reliably to engage and instruct users as intended.

4.6 Distribution

The final polished build of the Android application package (APK) file was generated from the Unity project. The APK file was uploaded to a cloud server to allow users to access and download the application. There is a QR code that links directly to the APK download page.

5. CONCLUSION

This paper presented the development of BESALIR, an augmented reality mobile application using Vuforia to create an interactive learning experience for teaching elementary students about wild animals. The Multimedia Development Life Cycle methodology guided the design and implementation of the app.

The use of 3D animal models, animations, sounds, and pop-up information overlays transformed static educational content into an engaging augmented reality experience that has the potential to increase student motivation and engagement. Further validation through user studies is required to formally demonstrate educational impact.

The research provided a practical template for applying augmented reality to boost interactivity and visualization in education contexts. While focused on wild animal education, the implementation approach could be extended to other subjects and age groups.

In conclusion, this research highlighted the promise of augmented reality to turn static media into immersive experiences that are stimulating and interactive. It serves as an initial proof-of-concept for using augmented reality in engaging education applications.

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