Development of Mobile Butterfly Application- Based Augmented Reality as an Alternative Learning Medium During Post COVID-19

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***Abstract*— Indonesia experienced a COVID-19 pandemic starting in 2020. Limited mobility impacts various sectors, including tourism. Alian Butterfly Park is one of those affected. Alternatives were made to attract visitors, such as developing Augmented Reality applications to educate visitors about the new normal. Previous research developed a similar application, namely butterfly education with Augmented Reality technology, but its implementation still uses markers. It makes the user have to visit in person. This research improves the previous application. The improvement such as adding the interaction in AR butterfly life cycle, a virtual tour to collect butterflies, and the AR object is developed markerless. The application is developed using the agile development method. The application that has been developed is tested on the target user of the application. Testing is done by giving a black box testing. The test method is carried out by the black box testing method on 3 students. From the tests carried out, from a total of 25 test scenarios, there are 23 successful test scenarios and 2 test scenarios that fail due to bugs. The success value of the entire test scenario is 92% and the bugs found are 156 only affect the appearance of the application and do not affect the application critically. In addition, 2 scenarios are successful but are given special note due to environmental factors that can affect the results of the test.**

Keywords*— augmented reality, butterfly, learning media, mobile application

I. INTRODUCTION

Indonesia experienced a COVID-19 pandemic starting in 2020. The pandemic was caused by the SARS-CoV virus, which was initially discovered in Wuhan, China. This virus is growing rapidly so other countries are also affected by this virus, including Indonesia. To prevent infection with the virus, WHO gave orders to all heads of government worldwide to limit outdoor activities [1]. Limited mobility impacts various sectors, including tourism aspect. Alian Butterfly Park is one of those affected. Alian Butterfly Park is a butterfly breeding park tourism object located in Kebumen Regency, Central Java. Alian Butterfly Park also plays a role in butterfly conservation and is an object of public education.

The butterfly park is a tourist spot as well as education for visitors to introduce butterflies. In the butterfly park, there is no exhibition of the existing collection of butterflies but also conservation. Butterflies are animals that play an important role in the ecosystem. Conservation efforts and education about butterflies will improve the ecosystem's health and impact the community's quality of life in general. Scientists have used butterflies as model organisms to study the effects of environmental degradation and climate change. In addition, butterflies also play an essential role as pollinators for various crops [2].

Augmented reality (AR) is a developing technologies that have the potential to be able to deliver interactive experiences [3]. AR is a technology that aims to digitally integrate and expand the user's reality environment by adding layers of digital information [4]. In the context of a pandemic, these two technologies can ensure the safety of tourists by reducing unnecessary mobility. The adoption of the technologies is predicted to be increasingly relevant to the recovery of the travel and tourism sectors affected by COVID-19 [5][6]. Tourism researchers and industry leaders have recognized AR applications as providing potential positive support in tourism since 2000 [7].

Previous research developed a similar application, namely butterfly education with AR technology, but its implementation still uses markers. This makes the user have to make a visit in person [8][9]. The Kupuku AR application is still supplementary, where it only serves to provide added value to visitors who can visit Alian Butterfly Park. In addition, Alian Butterfly Park has recently been temporarily

closed. This causes the Kupuku AR application to be unusable at this time. In addition, the information displayed in the application is also considered less to convey learning about butterflies. There is no information about the life cycle of butterflies, and complete information about the species available at Alian Butterfly Park. Butterfly AR is also not released publicly.

This paper presents the development of the mobile AR application as a butterfly learning medium. It is carried out as an effort to educate visitors about butterflies and their conservation. It is a supporting medium to introduce Alian Butterly Park to visitors. This application is expected to enhance visitor interest.

II. Related Work

The adoption of virtual reality and augmented reality technology is predicted to be increasingly relevant to the recovery of the travel and tourism sector after the COVID-19 pandemic [5]. Augmented reality technology has been widely developed for learning media, including in tourism.

Mathematics learning media with augmented reality developed to help students understand the concept of 3D geometric objects [10]. The application developed is able to understand the concept of students' 3D geometry objects, both students for high school and university [10]. The AR application developed by [4] aims to provide education for child visitors who come to the Alian Butterfly Park. The application developed aims to introduce various collections of butterflies in the garden by means of a scan marker provided around the butterfly garden [8].

The use of AR is not only intended for object recognition but can be a learning supporting tool. Such as research conducted by [6] which implements AR technology to support English learning. AR technology was chosen to support learning because AR technology can increase students' interest and motivation to learn, creating an interactive learning environment [11]. It is used not only for language learning but also for its current development, AR technology is also used to support anatomy learning for medical students [12]. AR technology used for anatomy learning has proven to be acceptable and fun as a medium of learning and teaching for lecturers [12].

AR technology is also widely used to introduce tourism objects[13] [14][15]. AR-based application development is not only used for educational media but also as one of the advantages and promotions of media. Like the app developed by [9]. The developed application aims to introduce butterfly collections and butterfly puzzle games. The AR technology used in this application is only for displaying butterflies, but it still needs further development [9].

Many studies on the use of AR technology as a learning medium have been carried out. This study focuses on the further development of previous research which developed learning media for butterfly recognition [8] by making a media of butterfly life cycle with markerless AR technology. This aims to make it easier for users to recognize the butterfly life cycle as well as butterfly collections without having to visit the Alian Butterfly Park directly.

III. Methods

A. Agile Software Development

Agile Software Development is a software development method. This is also often called Agile Development Methods. The basis of this method is the principle of short-term system development with a rapid rate of adaptation to any changes. The main point of Agile Software Development is teamwork. The methods incorporated in agile emphasize collaboration between members of the agile team [16]. Fig. 1 shows the agile cycle.

In general, there are six core steps in agile. These steps are [16]:

1. Planning
2. Implementation
3. Software test
4. Documentation
5. Deployment
6. Software maintenance

The work process includes the creation of the entire application along with the collection and creation of assets. Furthermore, application integration is carried out in stages and ends with application testing.

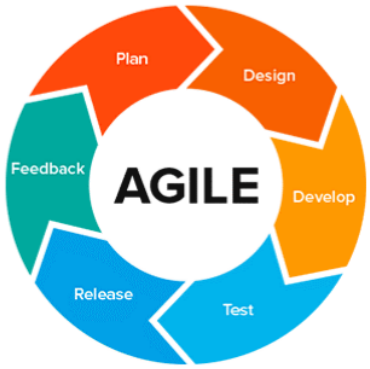

Fig. 1. Agile software development cycle [16].

B. Markerless Augmented Reality

Markerless augmented reality is a technology capable of pairing digital outputs such as 3D models based on real environments. This model is independent of the marker [17]. To perform augmentation, a markerless augmented reality application scans the environment where the user is located and then adds digital elements to the real world. Markerless augmented reality generally scans appropriate environmental features, such as flat surfaces. This object serves as a substitute for using markers as a place to attach digital elements. Because of its flexibility, this markerless technology is usually used for making video games and promotions with virtual object placement formats.

C. System Specification

The application developed has features of Android mobile-based augmented reality. It is a learning media about butterflies and also a promotional media for Alian Butterfly Park. Table I describes the functional specifications or features of the application.

TABLE I. FUNCTIONAL SPECIFICATIONS

Features	Description
Virtual tour	Virtual tour display 360 degree photos as well as navigation and interactivity with butterfly objects
Markerless augmented reality-based butterfly life cycle learning	Learning about the life cycle of butterflies that displays written information about the life cycle of butterflies. 3D models will be displayed for each stage of development using the interactive markerless augmented reality approach
Quiz	Sub features on the butterfly collection book feature. Multiple choice quizzes related to the butterfly life cycle and trivia about butterflies are presented to test the user's understanding of the information presented.
Butterfly collection book with markerless augmented reality feature	Users can view and select 18 butterflies from the collection book, then users can read information about the selected butterflies. Users can then view a 3D model of each butterfly in a physical environment using markerless augmented reality
Virtual interaction of tours and collection books	Users are only granted access to a few species entries in the collection book the first time they use the app. The user must first find and touch the butterfly object in the virtual tour feature to open an entry in the butterfly collection book
Interaction with 3D butterfly model	On the virtual tour and collection of books, there are 3D models of butterflies that move and have animated wings flapping. In the virtual tour, the user can touch the butterfly object to view information about butterflies and open a collection book entry. In the augmented reality feature of collectible books, users can play 3D models by touching the play button.
Interaction with egg 3D model in life cycle learning tool	In the life cycle learning feature, users can interact to press the 3D model of the egg repeatedly to incubate the egg into a caterpillar
Interaction with 3D models of caterpillars in life cycle learning features	In the life cycle learning feature, users can interact with 3D models of caterpillars by 'feeding' the caterpillars with leaves that will appear randomly.
Information about Alian Butterfly Park	Static page containing information about Alian Butterfly Park

IV. RESULTS AND DISCUSSIONS

A. Main Page

Fig. 2 shows the main page of the Alian Butterfly Park application. There are five buttons where users can choose to access the application features.

1. Button to access virtual tour.
2. Button to access AR-based learning lifecycle.
3. Button to access collection books.
4. Button to access the information page.
5. Button to display application settings.

Fig. 2. Main page.

B. Virtual Tour Features

Fig. 3 exhibits a view of a flock of butterflies spawned on a virtual tour. The virtual tour feature has a background component of a sphere that is textured with 360 photos to simulate a visit. Butterflies will appear randomly in a hemispherical area with a certain radius centered on the user's location. The camera icon represents the user on a virtual tour.

Fig. 3. The appearance of a butterfly on a virtual tour.

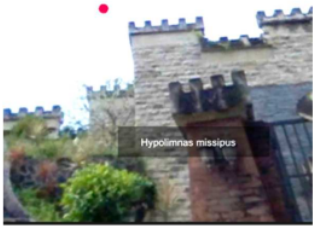

Fig. 4. Interaction results for collecting butterflies.

Fig. 4 shows that the user collects butterflies flying around the user. The application will display butterflies randomly on the screen as shown with red circle and dot, and when the user makes a collection, a pop-up will appear with the name of the species collected.

C. AR-Based Lifecycle Learning Features

This section describes the features of AR-based lifecycle learning. In this feature, users will be provided with information about the life cycle of a butterfly and be able to interact with a 3D model that represents each stage of the butterfly's life cycle.

The life cycle learning feature was developed using markerless augmented reality. The application is equipped with an indicator that will appear every time the device detects a horizontal data field. This serves as a control to be able to place the 3D model. The indicator object is represented as PlacementIndicator name. Fig. 5. presents a view from the PlacementIndicator object.

Fig. 5. Placement object.

Fig. 6 and 7 show a simulation of Augmented Reality-based learning life cycle features. It can be seen that the 3D models of caterpillars and butterflies are displayed on the table surface in the real world. The simulation also demonstrates the workings of the life cycle learning features proposed in the initial design. By pressing the right arrow or left arrow button in front of the 3D model, the user can change the life cycle stage they want to learn.

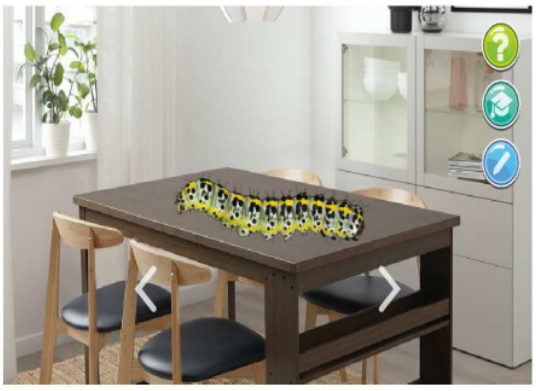

Fig. 6. The butterfly life cycle from a caterpillar.

Fig. 7. Butterfly life cycle.

D. Book Collection

Fig. 8 shows the state before and after the user collects butterflies. The black silhouette of a butterfly will change to a color image of a butterfly when the user successfully collects butterflies during the virtual tour.

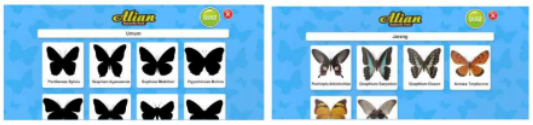

Fig. 8. Book collection.

Fig. 9. shows an information page containing information related to the butterfly selected by the user. There are 18 pages, each containing a description of the butterfly species in Alian Butterfly Park. On the information page, there is a button entitled View in AR. This button will take the user to the Augmented Reality page.

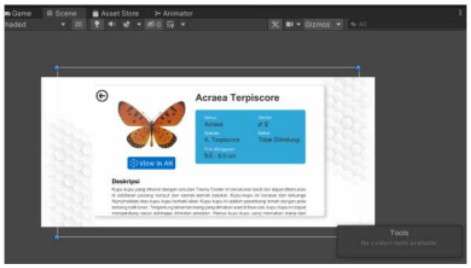

Fig. 9. Page of butterfly information on unity editor.

Fig. 10. AR implementation of collection book.

The results of the AR implementation on the collection book feature are demonstrated in Fig.10. The implementation process is similar to the life cycle learning feature. The user can rotate the butterfly object left and right by pressing the

control button. The user can touch the butterfly to start or stop the wing flapping animation.

E. Blackbox Testing

The black box testing method is a testing method that aims to ensure each feature functionality can run well. Thisa software testing technique focuses on the functional specifications of the software [18]. Black box testing is conducted on respondents who do not know the code structure of the developed application. Testing is done by informing respondents about how the Alian Butterfly Park application works. They were given a brief explanation of the test scenario and also the expected results of the test scenario. Respondents are invited to run the application according to the designed test scenario. The results of the test are then observed and recorded. Suppose it is in accordance with the expected results (Acceptance criteria). In that case, the test scenario is considered successful and if it is not appropriate, it is considered failed.

After the implementation of the application, the design is considered satisfactory. The application is then compiled into a prototype and tested by respondents. Following the division of tasks, the author will only discuss the features' functionality. The test method is carried out by the black box testing method on three students. The evaluation tested 26 scenarios. Based on the test scenarios, 23 successful test scenarios and 2 test scenarios failed due to bugs. The success value of the entire test scenario is 92% and the bugs found are 156 only affect the appearance of the application and do not affect the application critically. Those two scenarios are given special notes due to environmental factors affecting the test results. The black box testing results are depicted in Table II.

TABLE II. BLACKBOX TESTING

Fitur	Total of Scenarios	Success	Fail	Success (%)
AR-Based Life Cycle Learning	10	10	0	100
Virtual Tour Interaction and Collection Book	5	4	1	80
Collection Book	10	9	1	90
Total	25	23	2	92

V. CONCLUSION

We have developed mobile butterfly application-based AR with four main features: virtual tours, AR-based lifecycle learning, collection books, and information pages. For the AR method used, the application utilizes the markerless augmented reality method. The results of the black box method testing on three respondents on AR-based life cycle learning features, collection books, and the interaction between virtual tours and collections of books, with a total of 25 test scenarios worth 92% successful. This is due to discovering a bug that affects the application's appearance.

This application still has shortcomings. Suggestions that can be considered for developing this application for the next version are application development for the IOS operating system so that the application can reach more users. Technically, the code in the application can still be improved and refactored to make the code cleaner, easier to understand and avoid bugs. It is also necessary to improve content on the butterfly information page with more relevant information.

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