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RESEARCH ARTICLE OPEN ACCESS

Development of Augmented Reality Applications as Animal Learning Media for Children

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ABSTRACT
Introducing animals to children *at the elementary school level is expected to provide knowledge about the environment and the ecosystem around them. A survey conducted at Muhammadiyah Ambarketawang 3 Elementary School found it difficult for teachers to present learning resources in class to introduce animals to students. Introducing animals to children requires media depicting their shape, size, and other characteristics. Interactive multimedia is one of the exciting media to introduce animals to children. Learning using multimedia has the advantage of being intuitive, straightforward, informative, exciting, and so on, compared to traditional learning. AR has the potential to create engaging learning experiences. In the case of recognizing animals and their ecosystems, AR has the potential to present virtual animal objects that are projected into the natural environment around children.* This study aims to produce a mobile application with augmented reality technology for animal learning media that is suitable for elementary school children. *The multimedia development lifecycle (MDLC) method is used in developing this application. MDLC has six stages: concept, design, material collection, manufacture, testing, and distribution. The participants in this study were 1st and 2nd-grade students at Muhammadiyah Ambarketawang 3 Elementary School, totaling 20 students. The test results with SEQ show that users can accept this animal learning media AR application with a level of ease of obtaining a score of 6.41 on a scale of 7.*

Keywords -*: Augmented Reality; Introduction to Animals; Multimedia; Learning Media; Children*

I. INTRODUCTION

The education system is a vehicle for a nation to achieve unity and harmony. Learning about animals to children at the elementary school level is expected to provide knowledge about the environment and the ecosystem around them. A survey conducted at Muhammadiyah Ambarketawang 3 Elementary School found it difficult for teachers to present learning resources in class to introduce animals to students. One of the materials that can be introduced to students is the animals of the archipelago. Archipelago animals or animals in Indonesia are animals that live in the territory of Indonesia from Sabang to Merauke. Archipelago animals are typical animals from every region or island in Indonesia [1]. Knowing the wealth of flora and fauna in Indonesia can create a sense of pride in being an Indonesian citizen and participating in the conservation of Indonesian flora and fauna [2].

Introducing animals to children requires media that can clearly depict their shape, size, and other characteristics. Interactive multimedia is one of the exciting media to introduce animals to children. The development of multimedia applications for children's education is popular nowadays [3]. There are many advantages to be gained by developing multimedia applications, such as increasing children's learning performance [4].

Current technological developments occur so quickly. The use of mobile application technology has increased dramatically along with the development of internet penetration and mobile devices. The use of mobile devices is not only by adults but also children [5][6][7]. Learning by using multimedia has the advantage of being intuitive, straightforward, informative, exciting, and so on when compared to traditional learning [8]. Multimedia technology combines text, graphics, audio, video, and animation elements to convey information [9][10]. The intensity of the use of

mobile devices among children has increased significantly during the COVID-19 pandemic.

The current smartphone technology provides various features that can support the installation of various applications for various learning needs. Augmented Reality (AR) is a technology that has recently become popular in education. AR is a technology that combines 2D and 3D virtual objects into a natural environment and then projects these virtual objects in real-time [11]. AR has the potential to create engaging learning experiences [12]. AR applications have been developed in various fields of education, such as interactive calligraphy [13], learning medicinal chemistry [14], thoracoscopic surgery [15], and so on. In the case of the introduction of animals and their ecosystems, AR has the potential to present virtual animal objects that are projected into the natural environment around children. Many applications with various animation types need to be more suitable for children's education. The development of applications suitable for children must pay attention to the characteristics of children as users [16].

Based on the problems regarding teachers' difficulties in presenting learning resources about animals to students, it is necessary to have a solution in the form of ICT-based learning media that can present animal learning objects that approach natural characteristics. This research aims to produce a mobile application with augmented reality technology as a medium to introduce animals to elementary school children.

II. RESEARCH METHOD

A. Participants

The subject of this study was the design of the augmented reality application as a learning medium to get to know animals for the children of SD Muhammadiyah Ambarketwang 3 students. The respondents were students from grades 1 and 2, totaling 20. The sample of respondents was 1 class, each with ten students.

B. Data Collection

Literature review

The literature study was conducted to collect data related to learning content, including the learning curriculum. The literature study was carried out by studying the syllabus and learning plans, especially for mathematics material in grades 1 and 2.

Observation

This stage is to observe how the learning process takes place. Observations were made in each grade 1 and 2 class to know the characteristics of students in using learning technology.

Interview

Interviews were conducted to collect data related to user needs from the content and the application's user interface. Interviews were conducted with homeroom teachers in grades one and grade 2.

Questionnaire

The questionnaire method was carried out to obtain information about children's use of gadgets. In addition, a questionnaire was also carried out to test the quality of the media being developed and whether it meets user needs or not.

C. Research Stages

The stages of this research refer to the multimedia development life cycle (MDLC) method which has 6 stages: concept, design, material collecting, assembly, testing, and distribution. Details of the flow of the stages of this research can be seen in Fig. 1.

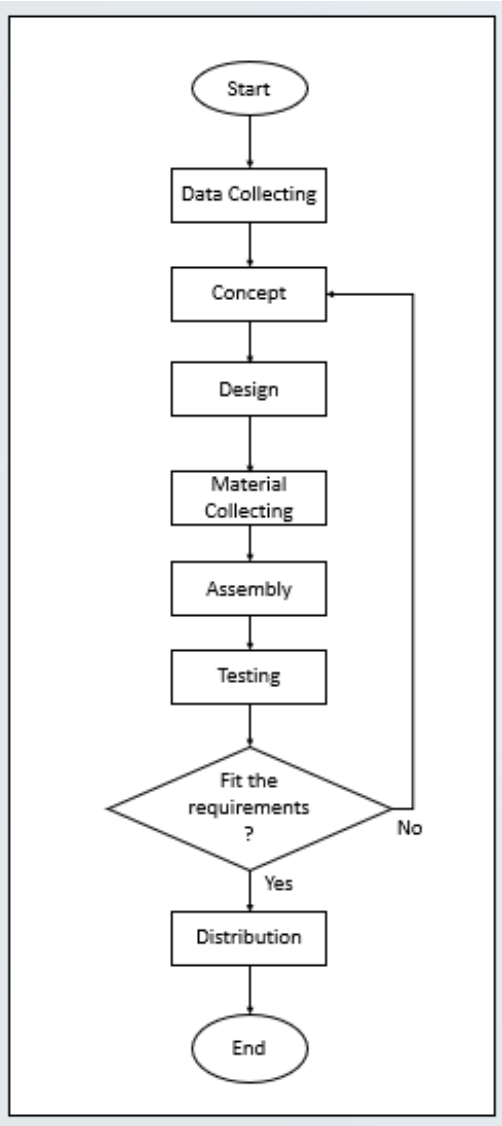

Fig. 1. Research Stages

The research began with data collection and then continued with the six stages of the MDLC method to produce augmented reality applications as a learning medium for children to get to know animals.

Data Collecting

The data needed for the research were collected through literature studies on journals and learning tools, classroom observation, and interviews with teachers and students.

Concept

This stage was carried out to initiate an idea regarding an augmented reality application for animal learning media. This activity is done by analyzing the data resulting from literature studies, observations, and interviews. At this stage, also determine the purpose of the application being developed. This stage will produce requirements specifications, namely functional and non-functional requirements of the augmented reality software for introducing the animals.

Design

After the concept stage is carried out, the next is the application design stage. This stage is to design an augmented reality application as a medium for learning about animals. The design refers to the concept determined in the previous stage. The design stage will produce an application interface design, a 3d object design, and user interface design for augmented reality applications.

Material Collecting

The material collection is the stage for collecting all digital materials (Assets) needed for developing animal learning augmented reality applications. This stage will produce material in the form of images, 3d objects, sounds, and animations needed in the development of animal learning augmented reality applications.

Assembly

The assembly stage is to combine all materials and add program code to produce augmented reality applications for learning animals. The manufacturing stage will be carried out using the unity application. This stage results in an augmented reality application that is ready to be tested.

Testing

The testing phase is the final stage of application development. Tests were carried out to determine whether or not augmented reality applications for learning animals according to user needs. There are two types of testing: media quality and user experience. Media experts, namely teachers, carry out media quality testing. Meanwhile, measuring user experience using this application is done using a single ease question (SEQ) with 20 student respondents. If the results of application testing have met user requirements, the application is ready to be distributed, but if it has not been met, then redesign.

Distribution

Distribution is an activity for distributing applications so that they can be accessed by users easily. The application can be accessed in the form of an app file ready to be installed on the user's Android device.

III. RESULT AND DISCUSSION

A. Concept

AR applications for learning animals are designed with a simple interface that makes it easier for users to study animals. The application has several features: start AR, how to play, material, and exit button. The AR start menu includes a camera view to display animals in a natural environment and several buttons: back, next, stop and pause buttons; the how-to-play menu contains instructions on how to use the AR-Animals Indonesia application, the material menu contains explanatory material from each animal and an exit button at the end of the menu to exit the AR application for animal learning.

Functional requirements

Functional requirements are types of requirements that contain the processes carried out by the system. Functional requirements also include information that must be available and generated by the system. Following are the functional requirements of AR-Animal Indonesia as follows:

1. Applications can display the main menu, which contains Start AR, How to Play, Material, and Exit buttons.
2. Applications can display 3d animal models.
3. Applications can display animals with rotation, scale, and move movements on the model.
4. The Application can display a sound explanation of each animal in the Application.
5. Application has the next, back, pause, and stop buttons for displaying previous and next animal data.
6. The Application has a working back button to display the previous page.
7. The Application can display how to play.
8. Applications can display material pages.
9. The Application can display an exit button from the Application.

Non-Functional requirements

Non-functional requirements are requirements so that the system can run optimally. Non-functional requirements include usability, portability, reliability, and supportability. The non-functional requirements of this AR application to study animals are:

1. The application is easy to use independently by children in elementary grades 1 and 2.
2. The application can run on several Android platforms with a minimum operating system of Android 10.
3. The application is safe and does not require the user's data.
4. Applications can be run without the need for other software support.

B. Design

Use case diagram

Use Case Diagram describes the interaction between application users and AR applications for animal learning. Detailed use case diagrams are shown in Fig. 2.

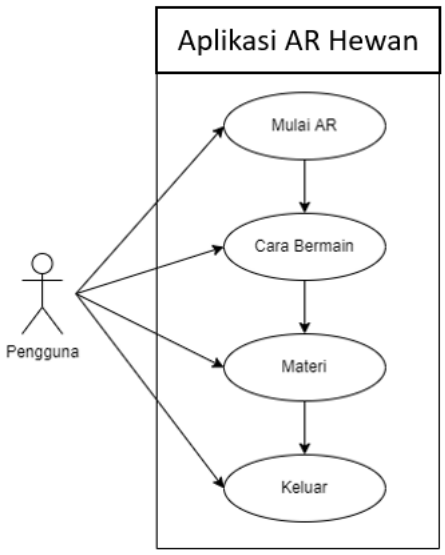

Fig. 2. Use Case Diagram

The use case diagram in Figure 2 shows an interactive relationship between users and AR applications for animal learning. The interaction relationship is that users can access the AR Animal feature, access how to play, access material, and exit the application.

Diagram Activity

Activity diagrams illustrate the flow of user activity and AR applications for learning animals. Fig. 3 below is an activity diagram of the Indonesian Animal Augmented Reality application.

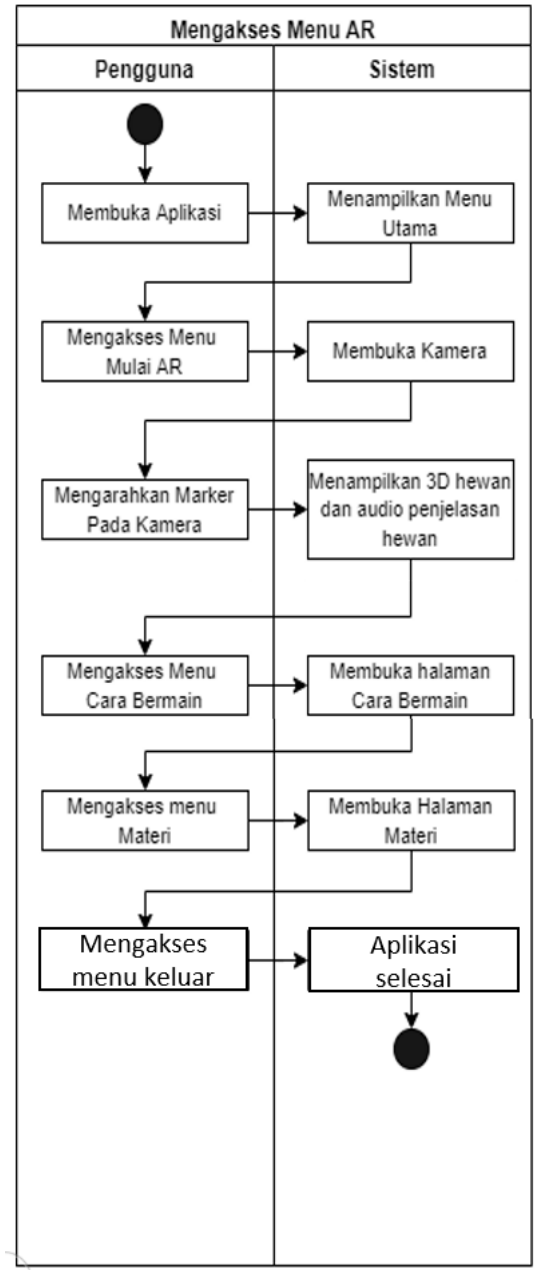

Fig. 3. Activity Diagram

Fig. 3 shows the main flow of activities in animal learning AR applications: Accessing the AR Start Menu, Accessing How to Play, Accessing Materials, and exiting the application.

The activity of starting AR will open the camera on the mobile device and then display the real environment on the mobile screen with the addition of 3d animal objects. The animal view is equipped with scale and rotation features. 3d dimensional animal objects are objects that can move (animated) according to the characteristics and behavior of animals. This display is also equipped with a narration sound that explains the description of the animal. The how-to-play activity will display a page containing instructions for using AR applications for animal learning. The material access activity will display a page containing a textual explanation regarding the description of the animal.

User interface design (wireframe)

Part of this design stage is to design a user interface in the form of a wireframe. This user interface design is made up of rough drawings that describe the layout of the objects. The display is made according to the size of the Android phone screen, which is 375px. Even though this wireframe is a rough drawing, it can be used to define the layout before moving on to the high-fidelity design, the app view. Fig. 4 below is the interface design (wireframe) of animal learning AR applications.

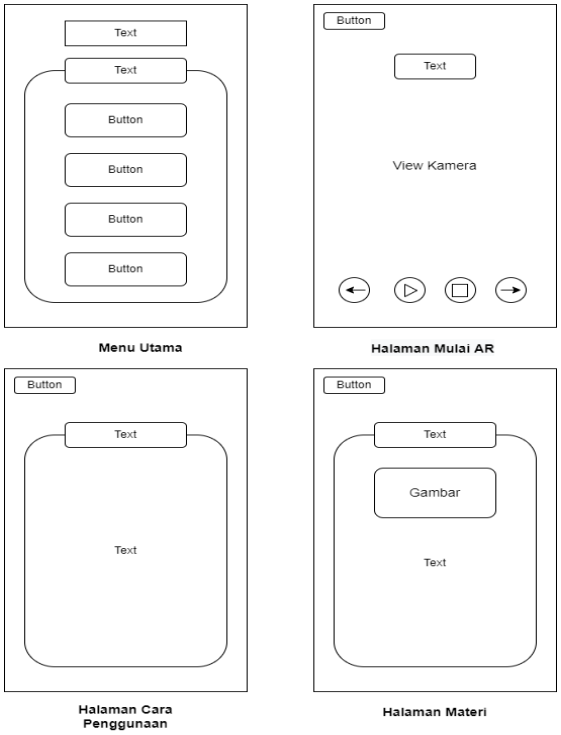

Fig. 4. User Interface Design (Wireframe)

Fig. 4 is the design of the AR application user interface consisting of the main menu page, AR start page, how-to-play page, and materials page. The main menu page has four buttons, namely, start AR, how to use, materials, and exit; the AR start page has four buttons below the camera; namely, the start, stop, right and left arrow buttons, and there is a back button on the top left of the layout, the user's how-to page. There is information from the instructions for use and one back button; the material page explains the animal images' characteristics and one back button.

C. Material Collecting

Material Collecting is the stage of collecting the components needed to develop applications. At this stage determined, 20 types of animals were. The following is animal data which can be seen in Table 1.

Table 1. List of Animals

No	Name
1	Swan
2	Chicken
3	Bear
4	Crocodile
5	Sheep
6	Elephant
7	Mountain Goat
8	Goat
9	Rabbit
10	Buffalo
11	Komodo dragon
12	Cat
13	Horse
14	Turtle
15	Leopards
16	Deer
17	Cow
18	Wolf
19	Camel
20	zebras

Each animal is made into a 3d model with animated movements similar to the animal's behavior. Fig. 5 below is an example of a 3d model of an elephant.

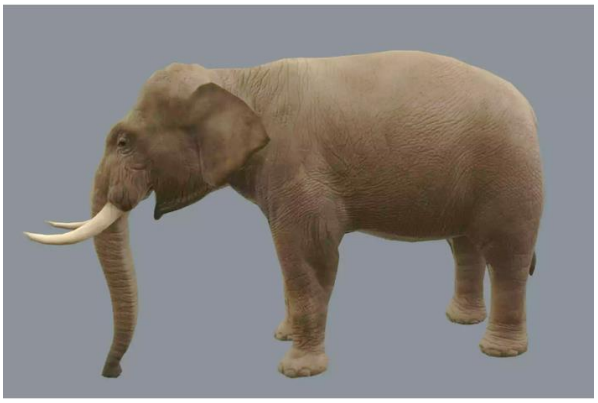

Fig. 5. Example of Elephant's 3d Model

D. Assembly

The development of AR applications to study animals uses markerless technology (without object markers). Applications can incorporate digital 3D animal objects into a real environment captured by the camera and displayed on the cellphone screen. Interface assets are created using image editor software (Photoshop), sound assets are created using the audio editor (Audacity), and 3D assets are created using 3D modeling software (Blender). Merging of all assets and coding is done using unity software.

The AR application for learning animals consists of five pages: the main page, the AR page, the how-to page, the materials page, and the material details page. The main page contains the application's main menu, which functions as a button to display other pages. Fig. 6 below is a screenshot of the main page display.

Fig. 6. Screenshot of Main Page

The AR start page will access the camera on the phone and capture a real environment augmented by a 3d model of the animal and then display it on the phone screen. This view is complemented by a narrated voice explaining the animal's description. There are four interactive buttons: play, pause, next, and previous. The play button displays 3d animal object animation and narration, the pause button stops animating 3d animals, the next button displays the following animal data from 20 animal lists, and the previous button displays previous animal data from 20 animal lists. Fig. 7 below is a screenshot of the AR page display.

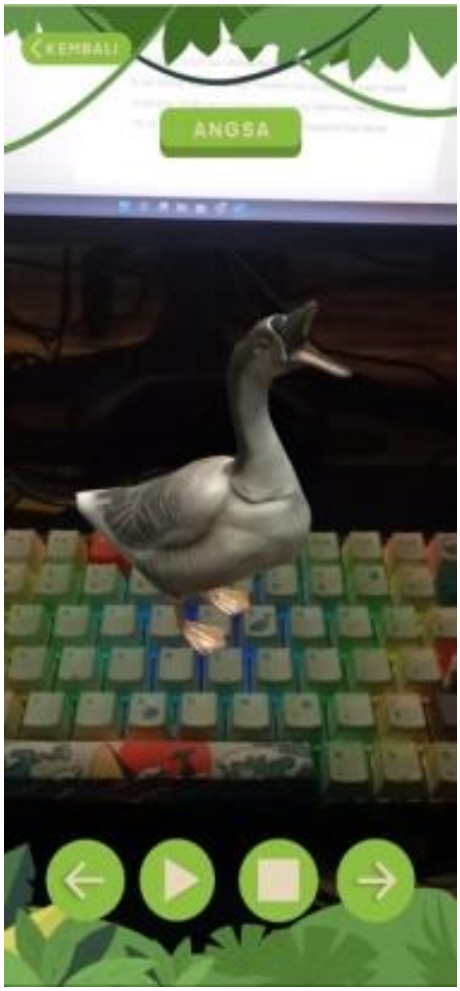

Fig. 7. Screenshot of AR Page

In addition to the two main pages and the AR page, three other pages display how-to-play, materials, and material details. The screenshot of these pages can be seen in Fig. 8 below.

Fig. 8. Screenshot of How-to-play, Material, and Detail Material Page

E. Testing

Tests were carried out to determine whether the animal learning AR application met the user's needs. Testing AR applications for learning animals uses two methods: media quality test and user experience test.

Grade 1 and grade 2 teachers tested the media's quality. 2 teachers installed and ran AR applications for animal learning. The teacher was then asked to respond to the questionnaire statements to measure the media quality level. 11 statements required responses. Responses were given in the form of a Likert scale (1 to 5), which indicated the level of the respondent's approval of each statement. Table 2 below is the result of testing the quality of the media by two teachers.

Table 2. Result of The Media Quality Testing

No	Statement	R1	R2
1	Attractive user interface	4	4
2	Balanced layout	4	4
3	The text is legible	4	4
4	Choosing the right font type	4	5
5	Nice picture skin	4	4
6	The right color combinations and choices	3	4
7	Suit animal 3d models	5	5
8	Voice narration clear explanation	5	5
9	Coverage of sufficient material for learning	4	4
10	The content of the material is in accordance with the learning objectives	4	4
11	Animal 3d model views and explanatory materials accordingly	5	5

R1: Respondent 1
R2: Respondent 2

Based on the results of testing the quality of the media in table 2, respondent 1 gave a response that agreed (4) to 7 statements, neutral (3) to 1 statement, and strongly agreed (5) to 3 statements. Respondent 2 agreed (4) to 7 statements and strongly agreed (5) to 4 statements. These results indicate that AR applications for learning about animals are of good quality and can be used as a medium for learning about animals for children.

The second test determines the user's perceived ease of use of the application. This test used the Single Ease Question (SEQ) method, which 20 elementary school students carried out. Students are asked to perform specific tasks and then provide an assessment. Students must do 12 tasks. The response to the task is a Likert scale of 1 to 7: Very Easy (7), Easy (6), Not Difficult (5), Enough (4), Not Easy (3), Difficult (2), Very Difficult (1). Table 3 below is the result of the SEQ test by 20 students.

Table 3. Result of SEQ Testing

No	Task	Total Score	Avg. Score
1	Displays the main page on the AR application	128	6,4
2	Displays 3d animal models via the Start AR button on the main menu.	122	6,1
3	Rotate the 3d animal model.	124	6,2
4	Scale (enlarge/reduce) the 3d animal model.	124	6,2
5	Make a move on the 3d animal model.	121	6,05
6	Plays/stops the explanation sound of each animal in the application.	128	6,4
7	Pause and stop displaying animal data.	128	6,4
8	Displays the next or previous animal data with the next and previous buttons.	130	6,5
9	Return to the main menu page via the back button	132	6,6
10	Shows how to play page.	133	6,65
11	Display material page.	133	6,65
12	Exit the application.	136	6,8
Total			**76,95**
Average			**6,41**

The test results with the SEQ method in table 3, the AR application for animal learning, obtained a score of 6.41 on a scale of 7. Based on the SEQ ranking percentage, the SEQ score conversion can be seen in Fig. 9 below.

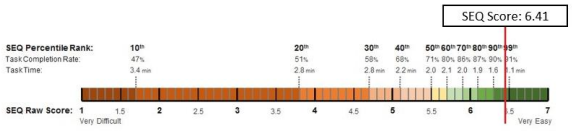

Fig. 9. Convert SEQ Score

Based on the test results, the value is 6.41, included in the percentage of 90% very easy to use. This shows that AR applications for animal learning are acceptable to users and very easy to use.

IV. CONCLUSION

AR applications for animal learning have been successfully developed using the Multimedia Development Lifecycle (MDLC) method. All stages in MDLC (concept, design, material collecting, assembly, testing) have been carried out iteratively to produce applications that meet user needs.

Two teachers, as media experts, have tested the quality of the media. The first teacher gave a response that agreed (4) to 7 statements, neutral (3) to 1 statement, and strongly agreed (5) to 3 statements. The second teacher agreed (4) to 7 statements and strongly agreed (5) to 4 statements. These results indicate that AR applications for learning about animals are of good quality and can be used as a medium for learning about animals for children.

The test results using the Single Ease Question (SEQ) method by 20 students and 12 tasks tested, the AR application for animal learning obtained a score of 6.41. Its shows that the application is acceptable and very easy to use by users.

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