



Design and Build an Application for Introduction to Endemic Indonesian Flora and Fauna Based on Virtual Reality

Aditya Riyadhi*, Ayung Candra Padmasari, Maya Purnama Sari

Multimedia Education, Universitas Pendidikan Indonesia, Indonesia

*Correspondence: E-mail: adityariyadhi@upi.edu

ABSTRACT

Virtual Reality is a technology used in today's application development. Virtual Reality allows users to fully engage in a 3D visual environment and perform various activities. Indonesia has approximately 515 species that are threatened with extinction based on data on the IUCN website. The purpose of this research is to introduce rare biodiversity in Indonesia through a Virtual Reality-based application to reduce extinction rates. In the process of making applications, the authors use the SDLC (Software Development Life Cycle) Waterfall model, which is a software development model with organized and structured stages. SDLC Waterfall stages include needs analysis, planning or design, implementation, and testing, including 3D creation and integration with Unity3D. Testing is applied to the black box testing method. From the trials conducted, this application can run smoothly on computers and laptops with minimal specifications. The results of testing the application involving several respondents with an average percentage value of 87.67% are feasible and effective in making this application an educative media. This application is expected to increase public awareness about Indonesia's natural wealth as well as become an interesting and innovative educational tool.

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1. INTRODUCTION

Indonesia has the highest level of flora and fauna endemism in the world, which means only certain species can be found in Indonesia and cannot be found in other regions. Flora refers to various types of plants or plants, while fauna includes living things such as animals that exist on earth. Although Indonesia is famous for its high biodiversity in the world with fauna wealth second only to Brazil, the sad thing is that the extinction rate in Indonesia is also very high with 583 endangered species (Setiawan, 2019). The threat of biological extinction in Indonesia is a major concern because of its detrimental impact on human life and the environment as a whole, as a result of declining biodiversity. Flora and fauna in Indonesia has approximately 515 species that are threatened with extinction based on data on the International Union for Conservation of Nature (Isti'anah, 2021) and it is likely that the number of threatened species will continue to increase. Factors affecting the threat of biological extinction in Indonesia include climate change, deforestation, infrastructure development, exploitation of natural resources, and damage to habit. Governments and communities have a responsibility to protect and sustain biodiversity by working together to address the threats they face. However, the lack of awareness and interest is quite often a serious obstacle in overcoming the problem. In modern times, books and other written media are still ineffective in increasing people's interest in knowledge even though information is disseminated through these media. There is one example of the implementation of the use of virtual media in modern times to provide information and convey a work about batik in the form of 3D hand motion tracking media in an art gallery (Jeeru et al., 2022). In recent years, there has been an increase and advancement in Virtual Reality technology by combining similar technologies such as Augmented Reality, forming Mixed Reality (Parveau and Adda, 2018). The impact of the combination of VR and AR innovations makes new interactive experiences for users in terms of behavioral, psychological and technological manifestations (Flavián et al., 2019). Therefore, technology is needed that can provide easy access to information and display visual images in three dimensions about endangered species as well as other biodiversity (Gustina et al., 2019).

With Virtual Reality (VR) technology, users can engage in interaction with a three-dimensional virtual world simulated by a computer, so that users can feel as if they are in the environment (Stephen et al., 2016). In principle, Virtual Reality (VR) operates by allowing users to view changing virtual environments with the help of headsets or headphones, and hear realistic-looking sounds with glove, walker, and headset devices. The system also monitors the user's every movement through computer devices (Kim et al., 2021). Virtual Reality (VR) is used as an effective medium to introduce Indonesia's biodiversity (Yang et al. 2019) With VR, users can experience the same as being in the environment created by the application, thus turning on the imagination as if they could see endemic flora and fauna that cannot be seen up close (Aditya and Basri 2019). In recent years, VR technology has developed tremendously. VR produces a digitally created environment and provides a realistic experience for users. Along with the rapid development of technology, VR has been used as a means to introduce batik in a three-dimensional environment. One of the methods used is Normal Mapping, which gives a sense of detail to the displayed object as well as the depth of texture. By using this method, computer performance remains efficient (Harknett et al., 2022). Virtual Reality is used in various fields, such as education, entertainment, and business. In the field of education, VR is used to provide a more interactive and interesting learning experience for practicum learning (Pradiftha, 2020).

Applications for the introduction of endemic flora and fauna in Indonesia can be created using Unity 3D software, a software development platform for creating interactive 3D games and applications. With Unity 3D, developers can create VR applications more easily and quickly, and have complete features to create more interesting and interactive VR experiences. The creation of this application will involve the UI/UX design process, programming, 3D creation of endemic Indonesian flora and fauna using Blender, which is free software for three-dimensional modeling, rendering and rigging (Gustina *et al.*, 2019), and the development of VR systems using Oculust Integration for Unity 3D. In addition, it will also need image resources, along with sound to fill the content of the application. Indonesia's biodiversity can be introduced through the use of VR technology. With the VR application of recognition of endemic flora and fauna of Indonesia, users can experience a more realistic experience in studying and preserving endemic flora and fauna in Indonesia.

The relevant previous research, namely Sakti (2022), shows that the use of VR technology in the introduction of flora and fauna supports children to learn about their environment. Several previous studies have been conducted related to the use of VR applications to introduce flora and fauna, one of which is research conducted by Nida (2020) which makes a VR application of zoo rides. In addition, there was a study conducted by Karundeng *et al.* (2018) regarding the creation of applications to recognize endangered animals in Indonesia using Augmented Reality technology. Based on previous research, it can be concluded that there has been no research using VR applications to recognize endemic flora and fauna in Indonesia (Wheeler *et al.*, 2018). Therefore, researchers are interested in designing an application for the introduction of endemic Indonesian flora and fauna based on Virtual Reality to provide interactive experiences in preserving endemic flora and fauna Indonesia and can contribute to users and the world of education (Anggoro *et al.*, 2016).

2. METHODS

This application development research uses a *waterfall* model with the Software Development Life Cycle (SDLC) method. The SDLC method involves the use of specific methodologies used by application developers to build software systems. SDLC also includes a series of stages, namely planning, analysis, design, implementation, alignment and testing, which are used as patterns in software system development (Mongi *et al.*, 2018). The following are the stages of the SDLC *waterfall* model research method:

2.1 Requirement Gathering and Analysis

This stage is done by collecting functional and non-functional needs from application users. In this case, researchers conducted a survey with a target group of application users and conducted a literature study on endemic flora and fauna of Indonesia. From these surveys and literature studies, information related to the features desired by users, such as the type of endemic flora and fauna of interest, the expected appearance of the user interface, and so on, can be obtained.

2.2 Design

After the analysis phase is complete, researchers design a system design about the application of introduction to endemic Indonesian flora and fauna based on Virtual Reality. At this stage, researchers will create use case diagrams, technical specifications, and

functional specifications. In addition, researchers will design a user interface to make it easier for users to access applications.

2.3 Implementation

At this stage, the entire design will be converted into program code, which will then be organized into modules such as 3D assets, sound assets, and user interfaces. These modules will be combined into one whole system.

2.4 Integration and testing

The modules that have been created at this stage will be combined and tested to verify that the software is made according to the design that has been made. The purpose of this test is to find errors or incompatibilities in functions in the software using the *blackbox* testing method.

3. RESULTS AND DISCUSSION

The application is an application that allows users to get to know various kinds of endemic flora and fauna of Indonesia more interactively and in depth through the use of Virtual Reality (VR) technology. This application is recommended for use on computers with minimum specifications such as Intel i5-4590/AMD Ryzen 5 1500X processors and above, Nvidia GeForce GTX 1070/AMD 500 series GPUs and above, and at least 8GB RAM. In addition, this application is only compatible with Microsoft Windows 10 operating system and requires at least 1x USB 3.0 port. This application can be operated using Virtual Reality devices such as Oculus Quest or HTC Vive.

3.1 System Design

Manufacture application introduction flora and fauna endemic Indonesian based Virtual Reality done with election kind flora and fauna will was especially previously. Design that was between other environment area VR like tree, mountain, bush and rocks. Exist 5 kind Flora and 7 kind fauna endemic Indonesian together name latin that served. After that manufacture user interface use application Adobe Photoshop. Next was 3D models to assets Flora and fauna and detail object another 3D use application Blender. After the User Interface assets, 3D assets and voice assets have been collected, the next step is merging all the assets into a single application unit using Unity3D using the Oculust Integreation help plugin as shown in **Figure 1** below.

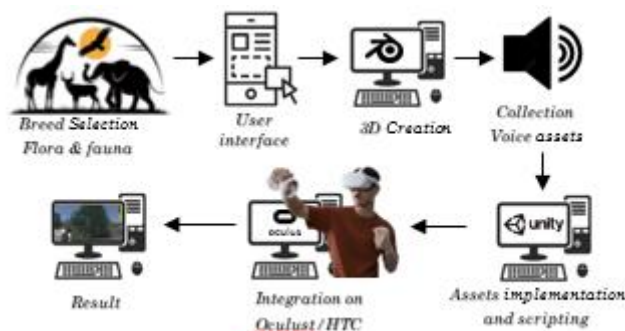


Figure 1. Application system design.

3.1.1 Flowchart Use Case

The following is a Use Case diagram in an application to introduce Indonesia's endemic flora and fauna. To explain each Case function in the diagram above, it can be seen in **Figure 2** and **Table 1** below.

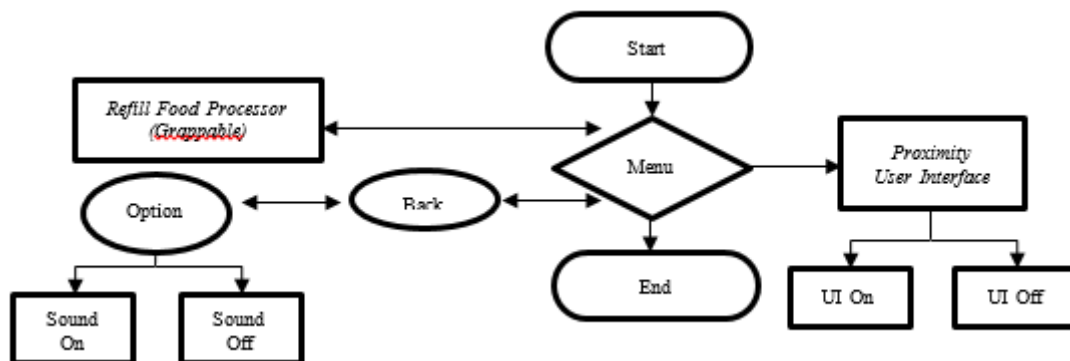


Figure 2. Flowchart use case.

Table 1. Description of use case on the application of introduction to endemic flora and fauna of Indonesia.

No	Use Case	Description
1	Menu	Menu Panel functions to display the pages and functions of the application to be addressed
2	Options	Option button functions to turn the application sound feature on and off
3	Refill Food Processor	Refill Food Processor functions to produce food that will be given to animals. Food in the form of ball objects that can be picked up and thrown at animals (Grappable)
4	Proximity User Interface	This system serves to trigger user interface in order to bring up descriptions of flora and fauna
5	Back	This back button serves to return to the previous scene

3.2. System Implementation Results

The following is the interface of the application for the introduction of endemic flora and fauna of Indonesia based on Virtual Reality, see **Figure 3**.

3.2.1 VR home menu page interface

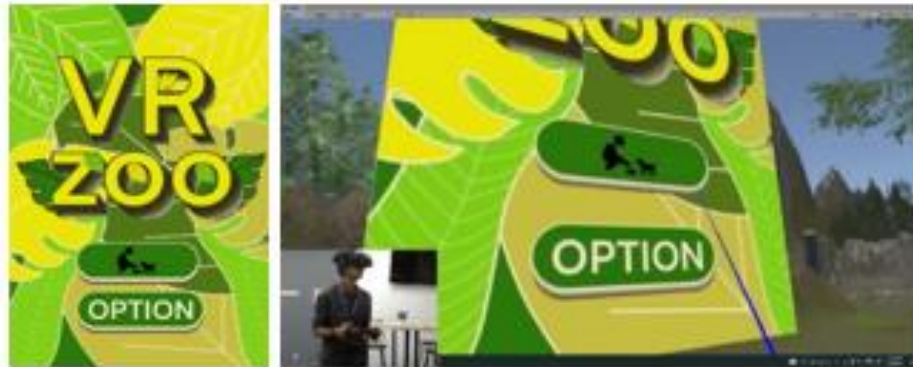


Figure 3. Daily variation in the sedimentation of the sludge at the outlet of the WWTP flocculator.

The main page of the application introduction to endemic flora and fauna of Indonesia is the Start menu page. On this page, users can find the refill food processor button which is useful for generating food objects that can be interacted by fauna, as well as other option buttons.

3.2.2 Option menu page interface

On the application options page of the introduction of endemic flora and fauna of Indonesia, there is a button to enable and disable the sound on the application, and a return option that allows users to return to the previous page. See **Figure 4**.

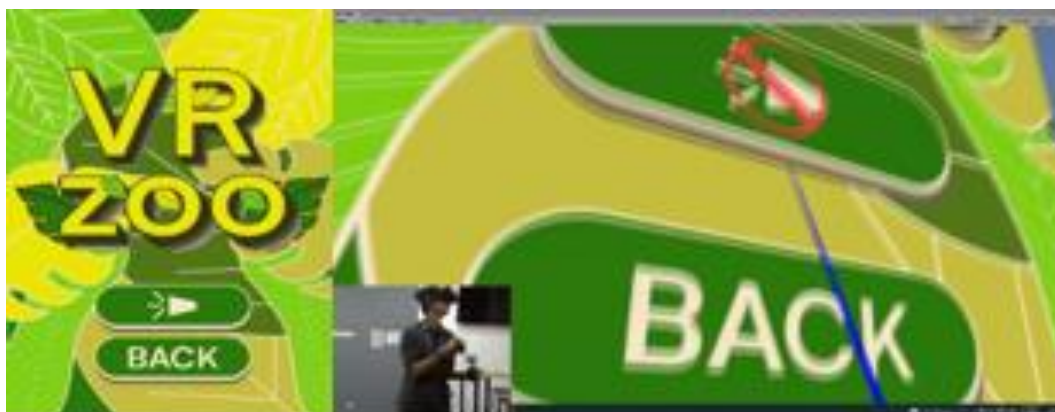


Figure 4. Option page interface.

3.2.3 Fauna page interface

On the page of each animal, the UI will appear when the user is around animals. There are 7 endemic animals of Indonesia with descriptions and Latin names of animals including

arowana fish, Sumatran rhinoceros, Borneo elephant, Komodo dragon, Napoleon fish, Orang utan, and Sumatran tiger. See **Figure 5**.



Figure 5. Fauna explanation page interface.

3.2.4 Flora Page Interface

On the page of every flora just like fauna, the UI will appear when the user is around plants. There are 5 endemic plants of Indonesia with descriptions and Latin names of plants, among them bambu manggong, giant suweg, kasturi mango, giant padma flower, and tree sago rumbia. See **Figure 6**.



Figure 6. Flora explanation page interface.

3.3 Results of 3-Dimensional Object Implementation

At the stage of implementing 3D objects for the development of applications for the introduction of endemic Indonesian flora and fauna, the software used to create 3D objects and their animations is Blender version 3.5. In the development of animation and 3D objects using several stages (Saprilia, 2022), namely:

- 1) Modelling, which is the process of making a mesh of 3D objects be it flora, fauna or other assets such as rocks, mountains, and trees using tools such as uv sphere, circle, cube, plane, cone, cylinder, torus and grid with the technique of modifying the mirror and extrude in Blender.
- 2) Material & Texturing, a process used to produce colors and properties on a 3D mesh. This process relies on interpretation of the original photograph to create original material or similar material so that the colors and textures produced on 3D objects are the same as the original.
- 3) Implement and fix 3D objects in Unity3D, then import objects into the project.

The following are the results of the implementation of making 3D objects in Unity3D and Blender software, namely 3D Environment, and 3D flora and fauna.

The results of the 3D implementation of arowana fish and horned rhinoceros objects in Unity3D software have been successfully integrated with the material and texture of the objects created. See **Figure 7**.



Figure 7. 3D objects arowana fish and Sumatran rhino.

The results of the 3D implementation of Borneo elephant and Sumatran tiger objects in Unity3D software have been successfully integrated with the material and texture of the objects created. See **Figure 8**.



Figure 8. 3D objects Borneo Elephant and Sumatran tiger.

Figure 9 shows the results of the 3D implementation of the object komodo and napoleon fish in the Unity3D software are successfully integrated with the material and texture of the object created.



Figure 9. 3D objects komodo and napoleon fish.

Figure 10 shows the results of the 3D implementation of objects orang utan and bamboo manggong in Unity3D software are successfully integrated with the material and texture of the objects created.



Figure 10. 3D objects orang utan and bamboo manggong.

Figure 11 shows the results of the 3D implementation of objects mango tree and padma raffles flower in Unity3D software have been successfully integrated with the material and texture of the objects created.



Figure 11. 3D objects mango tree kasturi and padma raffles flower.

Figure 12 shows the results of the 3D implementation of sago tree and corpse flower objects in Unity3D software are successfully integrated with the Material and Texture of the objects created.



Figure 12. 3D objects sago tree and corpse flower.

3.4 Results of Virtual Reality Application Implementation

The application Virtual Reality is developed using Unity3D. Before you can use Unity3D's Virtual Reality feature, Oculust Integration must first be installed on your PC. To download Oculust Integration, users can access the Unity website on <https://assetstore.unity.com/packages/tools/integration> and download the extension. Here are the stages of implementation of Virtual Reality in this application.

- 1) 3D objects are imported into Unity3D, The file is shaped (.fbx) and includes textures from all 3D objects.
- 2) The creation of a number of scenes and panels in Unity3D, stored in the assets folder, then each scene and panel is imported user interface assets for each flora, fauna, button, and also assets sound and animation for scripting in Visual Studio software.
- 3) CameraRig, Directional Light, Script Controller and Grappable Oculust Integration are included in the Scene.
- 4) Providing Collider at every Boundary or area that cannot be passed and granting Collider to CameraRig.
- 5) The build process on the Virtual Reality application becomes the last step for the implementation process. App build settings can be set through the file build settings menu. In this settings menu, users can select the scene to build as well as add application icons. Once completed, the application can be built and run on the PC device. The end result of the process will be .exe format

Figure 13 shows the results of the implementation of 3D objects and user interfaces of fauna parts in Unity3D software have been successfully integrated with the provision of Collider and Camera Rig.

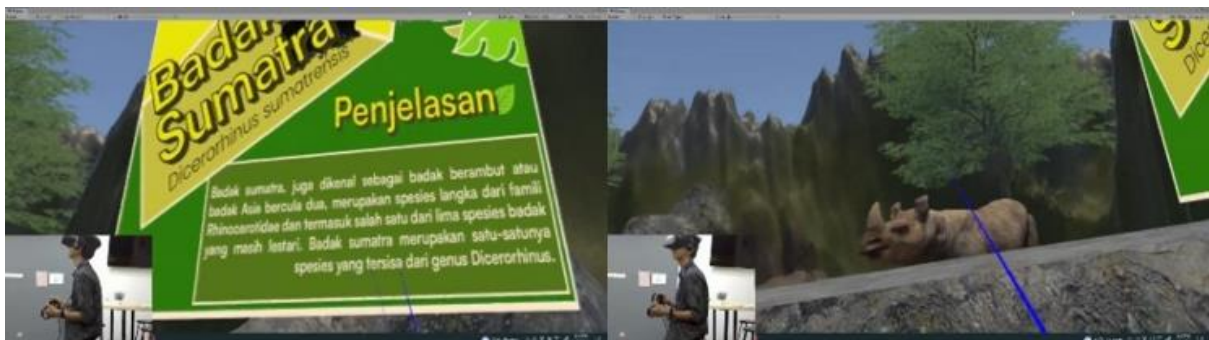


Figure 13. 3D implementation of object and fauna user interface on Virtual Reality.

Figure 14 shows the results of the 3D implementation of objects and user interfaces of the flora section in Unity3D software were successfully integrated with the provision of Collider and Camera Rig.



Figure 14. Implementation of 3D Object and user interface explanation of flora in VR.

3.5 System Testing

After the implementation process is complete, the next step is to test the application to evaluate the performance and functionality of the features that have been implemented. In this study, testing consists of three phases which include testing application functionality, testing on a PC / Computer system, and testing involving users.

3.5.1 Feature Testing

In the feature testing process, testing is carried out on the application using the *black box* testing method. The following table is presented containing the results of feature testing. Based on the results in **Table 2**, it is concluded that the features in the application are successful and function properly in accordance with the designed purpose.

Table 2. Feature testing.

Feature	Description	Result
Menu	Displays the page and functions of the application to be addressed	Succeed
Options	Turn the app's sound feature on and off	Succeed
Refill Food Processor	Producing food to be given to animals. Food in the form of ball objects that can be picked up and thrown at animals (Grappable)	Succeed
Proximity User Interface	Trigger the user interface in order to bring up descriptions of flora and fauna	Succeed
Back	Back to the previous scene	Succeed

3.5.2 PC/Computer Testing

In this section, the application is tested using one computer device and two laptops that have different specifications. The purpose of this test is to evaluate the performance of applications on PCs / Computers and laptops that have different specifications. The test result is on **Table 3** (see equation 1).

Table 3. Computer/laptop testing.

PC/Laptop Type	Specifications	Application		Support Oculust/HTC/ USB3.0
		Installed	Apps running	
Personal Computer	RAM 16 GB Windows 10 Processor Intel Core i7-12700K NVIDIA RTX 3060 GPUs 16GB RAM	✓	✓	✓
MSI GF63 Thin 9RCX	Windows 11 Processor Intel Core i5-9300H GPU NVIDIA GTX 1050 Ti RAM 8 GB	✓	✗	✓
HP Notebook - 15-ba026ax	Windows 10 Processor AMD Quad-Core A10- 9600P GPU AMD Radeon™ R7 M440 Graphics Discrete	✓	✗	✗

From the test results, it was concluded that the application can operate well on computers and laptops that meet the minimum requirements. However, it is important to consider the device's ability to accept the Oculust platform. Therefore, users should check the specifications of the computer or laptop before using this application in order to get an optimal user experience.

3.5.3 Usability Testing

Usability testing was conducted directly by seven respondents using a questionnaire consisting of 16 questions. In this test, the main goal is to measure the level of ease and usability of the software with a unique approach. Through direct interaction with the app, respondents provide their responses through specially designed questionnaires. This questionnaire covers various aspects, from navigation, application functionality, interface appearance, to understanding of workflow. Thus, this test provides an in-depth understanding of the user experience in using the application (Mitre-Ortiz et al., 2022). The test result is on **Table 4**.

Table 4. Recapitulation of usability testing.

Respondents	Question															
	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	P16
Gusti Akbar Maulana	SB	SB	SB	B	SB	SB	SB	SB	B	B	B	B	SB	B	SB	B
Tafa Indra Sukma	B	SB	B	B	B	SB	B	SB	B	B	B	B	B	B	B	B
Abdul Aziz Arrohman	B	B	B	B	B	CB	B	B	B	B	B	B	B	B	B	CB
Ahmad Vishnu Faisal	B	SB	B	SB	SB	SB	B	B	B	B	B	B	SB	B	SB	B
Nabila Anasya Rifqi	SB	B	SB	SB	SB	SB	SB	B	SB	SB	SB	SB	SB	SB	SB	SB
Muhammad Nuriansyah	SB	SB	SB	SB	SB	SB	SB	SB	SB	SB	SB	SB	SB	SB	SB	SB
Thoriq Fadilah Muhammad	B	B	B	CB	SB	SB	SB	B	SB	SB	CB	CB	B	CB	SB	B

Code Description:

- P1 : The application runs smoothly when just run to completion (starting to ending)
- P2 : Applications can be run quickly and optimally
- P3 : Button buttons and pop up menu options work well (main menu, options and such)
- P4 : Features like feeding interaction, proximity UI work well
- P5 : All programs run, no lag and no response
- P6 : Easy to understand gameplay
- P7 : There are studies related to endemic flora and fauna of Indonesia
- P8 : Fun app flow
- P9 : The material of endemic flora and fauna of Indonesia is easy to understand (hint)
- P10 : Is all the material of endemic flora and fauna of Indonesia appropriate
- P11 : Text and image layouts are balanced (easy to reach)
- P12 : Selection of background menu with appropriate application theme
- P13 : Color with appropriate app theme
- P14 : Selection of size and typeface according to the genre of application
- P15 : The appearance in the application according to the theme
- P16 : The application of the display is in accordance with the material needs of endemic flora and fauna of Indonesia
- SB : Excellent (weight 5)
- B : Good (weight 4)
- CB : Good Enough (weight 3)
- K : Less (weight 2)
- SK : Very Less (weight 1)

Percentage of questionnaire results:

$$\text{Percentage} = \frac{\sum \text{Score} \times 100\%}{S_{\text{max}}} \quad (1)$$

In this study respondents numbered 7 people with 16 questions, therefore the **Highest Score (S_{max}) = 5x7 = 35**. This results can be seen on **Table 5**.

Table 5. Results of filling out the usability testing questionnaire.

No	Question	Number of Answers					Total Value	Percentage
		SB(5)	B(4)	CB(3)	K(2)	SK(1)		
1	P1	3	4	0	0	0	31	88,57%
2	P2	4	3	0	0	0	32	91,42%
3	P3	3	4	0	0	0	31	88,57%
4	P4	3	3	1	0	0	30	85,71%
5	P5	5	2	0	0	0	33	94,28%
6	P6	6	0	1	0	0	33	94,28%
7	P7	4	3	0	0	0	32	91,42%
8	P8	3	4	0	0	0	31	88,57%
9	P9	3	4	0	0	0	31	88,57%
10	P10	3	4	0	0	0	31	88,57%
11	P11	2	4	1	0	0	29	82,85%
12	P12	2	4	1	0	0	29	82,85%
13	P13	3	3	0	0	0	27	77,14%
14	P14	2	4	1	0	0	29	82,85%
15	P15	5	2	0	0	0	33	94,28%
16	P16	2	4	1	0	0	29	82,85%
Percentage Average Value								87,67%

After conducting direct testing of users, it was found that the highest percentage on P5, P6, and P15 questions reached 94.28%. These results show that the program runs well, the application flow is easy to understand, and the application display is in accordance with the theme of endemic flora and fauna of Indonesia. However, there is the lowest score on question P13, which is 77.14%. This indicates that users feel less interested in choosing application colors that do not match the theme carried. There is a significant comparison, with almost 20% as evidence that applications still prioritize programming aspects rather than paying enough attention to design aspects. However, overall, the average percentage reached a high number of 87.67%, which shows that this application is effective as an educational tool to introduce endemic flora and fauna in Indonesia.

4. CONCLUSION

Based on the previous explanation, it can be concluded that the application of recognition of endemic Indonesian flora and fauna based on Virtual Reality can be run effectively with an average percentage reaching 87.67% using Unity3D and the Oculust Integration plugin. However, there are some drawbacks to note. First, this application requires PC or computer specifications with a minimum recommendation of an Intel i5-4590/AMD Ryzen 5 processor 1500X and above, Nvidia GeForce GTX 1070/AMD 500 series GPU and above, and at least 8GB of RAM. In addition, this application is only compatible with Microsoft operating systems Windows 10 and above and requires at least 1x USB Port 3.0. Furthermore, this application

can only be operated using Virtual Reality devices such as Oculus Quest or HTC Vive. Although it has gone through the stage of testing features and testing using computers and laptops, which ensures its reliability in carrying out its functions, this application can be developed even better and needs to pay attention to design aspects such as color selection or assets a more attractive look. Nevertheless, this application still has the potential to be an effective learning and education medium in increasing public understanding and awareness of the importance of maintaining the existence of endemic flora and fauna of Indonesia, through the use of Virtual Reality technology.

AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

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