




Design of Virtual Reality Zoos Through Internet of Things (IoT) for Student Learning about Wild Animals



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ABSTRACT

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One of the functions of the Zoo is educational tourism. However, the obstacle when they are at the Zoo is that visitors rarely see animals moving freely and do not see the overall shape of the animal's body because some animals are dangerous and cannot be touched carelessly. In addition, the information presented on the information boards is minimal. With these problems, an idea emerged to create a system that could help as an educational medium, especially for school students, in an exciting way. This research aims to develop a Virtual Reality (VR) zoo with an Internet of Things (IoT) approach as an educational medium for recognizing wild animals. This VR is embedded in the YouTube application as a medium for running it so that students can use an Android-based smartphone; wild animal objects will appear in 3D animation and sound, along with information about wild animals. This research is development research using the Multimedia Development Life Cycle (MDLC) model. This application was tested on five smartphone users with the Android operating system. Based on the test results, the application system can run on several mobile devices using Android from Version 5.1.1 to Android 11. The IoT-based VR zoo application was successfully built to become an alternative for students and tourists who want to see and interact with wild animals up close. Future researchers are expected to be able to analyze this VR application on students' understanding of the concepts of the material being taught.

1. INTRODUCTION

With the fast development of technology information, people have changed Lots of methods of Work via the Internet [1]. In some years Lastly, VR has increased rapidly, showing characteristics and its application in various fields such as Education, Health, and entertainment [2, 3]. However, VR still is Lots used for entertainment. Although VR is not Lots used in Education. This own potency is big in Education applications [4]. It is a possible learner for simulating experiences and training processes to help increase understanding.

Virtual Reality (VR) and the Internet of Things (IoT) are two very important technology several years final [5, 6]. At VR and IoT, we understand future possibilities with combined second technology. At the moment, a few researchers applying VR to the education sector [7, 2]. Virtual Reality is a new medium that delivers moderate information development moments [8]. Before the existence of Virtual Reality, media delivery information usually only utilizes audio and visual media, and yet makes use of the movement sensor, so that the media is more static and only Can enjoy in a manner One direction [9, 10]. Development technology moment This possible A more interaction well and more real between a medium with human.

Virtual Reality (VR) is enabling technology to the user's own similar experience with the real world through digital simulation. Superiority VR technology is can increase experience in various user fields like education, entertainment,

and business. For example, VR technology can be used to make simulation training for employees in the industry certain, like industry aviation and industry health.

The Internet of Things (IoT) is enabling technological devices electronic for connecting via the Internet and exchanging data without mix hand humans. Superiority IoT technology is can increase efficiency and productivity across a wide range of fields like industry, agriculture, and health. For example, IoT technology can be used to automate production processes in factories or collect data on the industry farm. The Internet of Things is a program that can send data through a network without the help of computers and humans. Reluctantly development of the Internet of Things (IoT), then the internet can be utilized for supporting needs learning, among others that with take advantage of the internet for activity learning theory nor practicum and support activity its administrative.

The zoo is a good tourist vehicle to get to know various kinds of animals and is a place for family recreation [11], a lot of visitors want to interact like give eat, take pictures, or even touch the animals in the garden animal Because considered Already benign [12, 13]. Although safe for seen, interacting directly with animals wild too close to raises several impacts negative, like scratched, bitten, or deprived goods default, so interacting directly with the animal wild is a dangerous act [13]. Visitors or travelers difficulty see the shape and behavior of the real animals in the garden animals, for one animals does feel not uncomfortable or stressed because bustling environment visited by tourists, therefore that animal No can

show behavior naturally or tend to be quiet. Researchers have explored the potency of Virtual Reality use for learning aspect cognition primates.

Research results this has to give an outlook about use of technology can enrich animals. Because of the limited environment, in the matter, this ensures the life and well-being of the living animal in maintenance humans and the visitors who want to relate with them. VR makes it possible for more exploration and possibility interaction in a secure virtual space. Coe and Hoy suggest that technology can be used to provide an interactive platform for an animal with visitors in the garden animal. For that need exists a method to replace the form of interaction direct that is the virtualization of animal savages to visitors specifically kids at the school base can interact in a manner safe with the animal wild. Form virtual interaction can make with the virtualization process [14, 15].

Several advantages of Virtual Reality for children can give the experience of fun learning, improve understanding, motivation in self, satisfaction, and engagement and attract attention because VR provides tools that can visualize objects so that possible users for interact with them. See from the advantages and capabilities done Virtual Reality, then Virtual Reality has the potential for utilized as a learning medium [16, 17]. This is because using Virtual Reality learning is felt to be more efficient than theoretical explanations because there is direct visualization. The use of virtual worlds can also be worn as a practical medium until a limitation particular because in a manner preparation easier to be prepared [5, 18].

Develop Virtual Reality with zoo objects to meet the learning needs of elementary school students. One learning that can use Virtual Reality is learning creature life children [19]. The learning material is related to the introduction of animals (fauna). By utilizing Virtual Reality, children not only study animals in theory but can also see animal life more closely and more safely [20]. One material study for a child school based in the city of Surakarta, Indonesia fauna still using books containing pictures 2 dimensions. Student No can see or hear in a manner that directs How animals move and sound. it is naturally not enough interesting Because the animal they are Look No as real compared to with see direct to the garden animal. In the Zoo student can see a manner right away, and students can see How animal move, sound, or even directly interact with every student. But not all elementary school students in Surakarta can go to the zoo easily, the costs that must be paid by the school and parents are certainly not small. In addition to costs, permits and processes and long distances also affect students' willingness to go to the zoo.

This research aims to develop Virtual Reality with an IoT approach to learning animal diversity for elementary school students, which contains an introduction to animal types; wild animals, tame animals, and pets. Making it easier for students to interact virtually and get to know the various types of animals at the Jurug Zoo.

The research method used is the Multimedia Development Life Cycle which consists of six stages, namely concept, design, material collecting, assembly, testing, and distribution. Several studies have shown that MDLC can produce quality multimedia applications.

Based on that, we offer that elementary school students in Surakarta City can be more interested and more efficient in getting to know animals than if they use 2-dimensional picture books [21, 22]. Students also don't need to go to the zoo which costs a lot of money, so the solution is with Virtual Reality, where the learning media previously used books or picture

media. The environment described by Virtual Reality will be made similar to the real world [23], and representative of real conditions according to sensing (visual, audio, tactile).

We hope this app can provide a closer experience with animals than just looking at pictures in a book. This Virtual Reality will later describe the atmosphere of a zoo that contains wild animals complete with information and is developed by adopting an IoT-based approach.

2. LITERATURE REVIEW

2.1 Development and utilization of the Internet of Things (IoT)

IoT technology is developing rapidly. The industrial sector, security systems, and transportation are fields that already use IoT technology in carrying out their activities [24]. IoT has become part of human life because almost all sectors of human life use IoT technology, call it a smart home, all home equipment, starting from gates, and lighting, to water levels, is monitored and users can monitor all home appliances that work automatically [25-27].

The Internet of Things (IoT) is a system consisting of smart devices, including sensors, actuators, and microcontrollers, that make it possible to exchange information and communication in a manner automatically [28]. IoT uses smart devices that can increase the level of optimization activity every day. Equipment is clever including smart home devices, smart classrooms are formed with connect several supporting sensors, actuators, and microcontrollers for communication between equipment [26, 29]. In the world of education, in particular, activity study teaches expected will be more effective If applied deep IoT technology carry out the learning process teach, as successful research explaining IoT can increase the experience of learning for the student. Students in Indonesia in general have a smartphone, which can be utilized as a learning medium [30].

In the world of education, IoT is a possible system for increased convenience in the learning process teaching. An example application of IoT technology is an implementation in smart classrooms [29]. The draft of smart classrooms is to integrate several integrated sensors, actuators, and microcontroller equipment with the portal learning management system [31]. In smart classrooms, all rooms are controlled using technology that runs automatically, namely through IoT, thus during learning it allows the teaching and learning process to be carried out with mobile devices or multimedia devices [32].

2.2 Utilization of Virtual Reality (VR) in the digital age

Virtual Reality, also known as VR, is a computer simulation technology that creates 3-dimensional virtual interactions. By viewing and manipulating content in the virtual environment, the user can become a participant in the virtual space, enabling him to enter a virtual world that is as completely realistic as if he were in the real world [33]; Virtual Reality (VR) is a technology created so that users can interact with an environment that is simulated by a computer or is called a computer-simulated environment. An imitated environment or a representative Virtual Reality experience by adding a combination of sensory simulations (visual, audio, touch) with the help of a computer to a real object by generating a 3-

dimensional (3-D) atmosphere so that it makes the user feel as if he is physically involved [34]. To be able to bring out the real sensation of Virtual Reality, several supporting devices are needed, namely Smartphones and VR Box 3D glasses [35].

A Virtual Reality, or actual reality, basically requires four key elements to be felt optimally, these four elements are 1) Virtual World. The meaning of the virtual world or the virtual world itself is an imaginary or unreal space that is manifested by a medium, the second meaning of the virtual world is a description of a set of objects that are in space and the rules governing related objects. A simple example of a virtual world is in a drama or film performance, where everything happens in a world created by the director or maker of the play or film, more deeply, the world created is then filled with actors, music, and all the sets on stage. Thus making the world that has been made more lively, when someone watches a drama or film, then that person has enjoyed the virtual world of the drama or film. 2) Immersion, Immersion is another key element, namely uniting the user with other realities and other points of view, or simply uniting the user with alternative realities and/or points of view, which can be the same as reality or a real point of view or vice versa, a reality or another different point of view completely different from the original conditions. Immersion can be achieved because there is an understanding that an information medium is said to be valid if everyone who uses it can obtain information without outside influence, this gives the possibility that there is a way to convey information other than something real in two ways, namely capturing information from alternative worlds or see the real world from a different perspective. 3) Sensory Feedback, Sensory Feedback is an essential key in Virtual Reality that distinguishes Virtual Reality from most traditional media, because unlike traditional media which is a one-way delivery of information Virtual Reality allows the user to impact the virtual world according to the user's position, and vice versa the virtual world also make decisions according to the position of the user. 4) Interactivity, Interactivity is the same as sensory feedback because both are essential key in Virtual Reality that distinguishes Virtual Reality from most traditional media, but interactivity places more emphasis on responding to the decisions that users make when facing something. Just like human-to-human interaction, interactivity is used to give Virtual Reality a lively and real impression [18].

Based on field facts that researchers have identified related to the use of Virtual Reality for understanding animals for elementary school students. Previous research and the results of observations on elementary school students, the researchers intend to design an IoT-based Virtual Reality media that can be operated on Android smartphones.

3. METHODOLOGY

The methodology study writer uses Multimedia Development Life Cycle [36]. Development of this multimedia method is done based on six stages namely concept, design, material collecting, assembly, testing, and distribution [37].

At each stage will load things to target for completion, as the stage of concept aims to identify various types and shapes of animals to become an object of Virtual Reality, define specification device that can operate Virtual Reality media, as well determine the analysis need developer product like the

type of software and hardware capabilities for designing Virtual Reality objects. The research procedure can be seen in Figure 1 below.

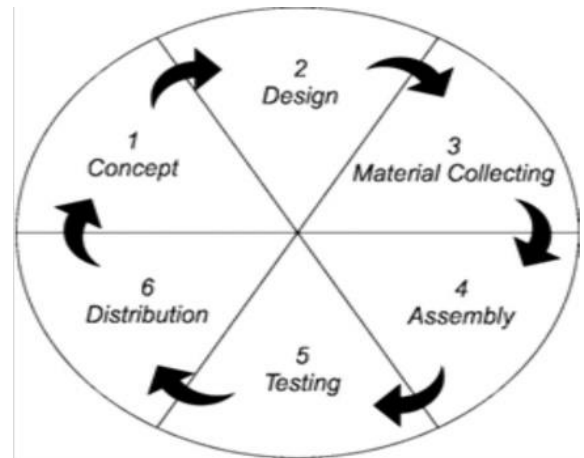


Figure 1. Research procedure

The design stage is making specifications about purposeful media design for creating a framework embodied IoT-based Virtual Reality media work in storyboard form for describe the description of every scene, with include all Virtual Reality objects and links to other scenes and charts flowchart for describing Genre from one scene to another. Researchers create storyboards with the use method of making multimedia storyboards in the form of text.

Furthermore, the third stage of material collecting is the stage of collecting material according to media needs, namely collecting the various materials needed, in this case, the researcher collects photos of objects from various types of animals that exist, takes videos, and various types of sounds that reflect each animal. The collection of animal object materials is carried out directly at the zoo.

After the required objects are collected, in the fourth stage, assembly (manufacture) is to create Virtual Reality objects from various objects to be developed. Making media is based on the design stage that has been made on storyboards, flowcharts, and navigation structures. Researchers make this Virtual Reality media with the help of After Effects software.

Furthermore, in the fifth stage testing is carried out to test whether objects adapted to the Virtual Reality format can operate or not, namely by running the application program and seeing whether there are errors or not. The first stage at this stage is called the alpha testing stage (alpha test) where the test is carried out by the manufacturer or the manufacturer's environment. After passing the alpha test, a beta test that looks at the end users will be carried out.

In the sixth final stage, after it is stated that the product or virtual object being developed is included in the valid category, the product will then be distributed to potential users, namely elementary school students to study material about the diversity of animals in zoos. IoT-based Virtual Reality will be distributed via YouTube in mp4 format.

The data collection technique in this study is observation. Observations were made by visiting and seeing firsthand the condition of the zoo. While observations were made to elementary school teachers and students to find out their needs for Virtual Reality. The tool used in collecting the data uses an instrument in the form of an observation sheet which is used as a reference in making observations.

4. RESULTS AND DISCUSSION

Using the MDLC method produces results study with a step as follows:

4.1 Concept

At the Concept stage planning about object Animals that will be applied to VR applications that will give animation multiple 3D objects Animals listed in the book learning. And there are several effect sounds on each animal that appears as well as the object it is applied to later as if like appear to image target surface. Stages This produces a formula draft namely. The initial concept in making VR is the initial display concept seen in Figure 2 and the concept of animal display displays is shown in Figures 3 and 4.



Figure 2. Start view



Figure 3. Display of horse



Figure 4. Display of crocodile

In addition to determining the VR display concept, a concept regarding the hardware specifications used in making VR is also formulated which can be seen in Table 1.

Table 1. Hardware requirement specifications

Personal Computer or Laptop	Smartphone
The hardware used in this study namely Processor Intel(R) Core (TM) i5-9400F CPU @ 2.90GHz 2.90 GHz, Installed RAM 16,0 GB Device ID22F95C96-7514-4CA5-B067 8A5E1CF4554C Product ID 00331-10000-00001-AA561 System type 64-bit operating system, x64-based processor, display lebar layar 15,6 inchi.	The smartphone used is Smartphone Lenovo Vibe K4 Note which has a Mediatek MT6753 chipset, CPU Octa-core 1,3 GHz Cortex-A53, RAM 3GB and Internal Memory 16GB.

Some of the software used in the VR procedure can be seen in Table 2.

Table 2. Software specifications

Software Used
Microsoft Windows 10
Adobe After Effects
Blender
Youtube.

4.2 Design

At the stage after obtaining the concept then the next step is designing a storyboard and designing navigation structures for animal recognition applications. In this step, there are 2 main stages, namely designing the storyboard and designing the navigation structure.

4.2.1 Design storyboard

In this activity, there are six scenes at the planning storyboard applications to be made are presented in the Table 3 below.

Table 3. Storyboard description

Scene	Information
Scene 1	Loading the main view of the application
Scene 2	Loading the menu display, among others: start, page VR, guidance, and about
Scene 3	The page starts showing scene VR Zoo Contains of 3D animated objects, video, sound, and text
Scene 4	The guide page shows how to use the application.
Scene 5	The about page deals with making apps.

4.2.2 Navigation structure design

In the process of making VR, navigation is also formulated as shown in Figure 5 below.



Figure 5. Navigation structure

4.3 Collecting materials

In this stage, the collection of material related to making animation is obtained from various sources. In the process of designing and developing the Animal Recognition application, the data that has been collected includes images, sounds, and animations, namely:

4.3.1 Picture

Images file that has been collected by the development needs of animal recognition applications. The process of collecting images is done in a way download from internet sources and then editing with the application editing picture. Images file used in making the application consisting of background, and logos with .jpeg extension. Pictures are also obtained from taking directly at the zoo. The shooting process can be seen in Figures 6, 7, and 8.



Figure 6. The process of taking animal pictures I



Figure 7. The process of taking animal pictures II



Figure 8. The process of taking animal pictures III

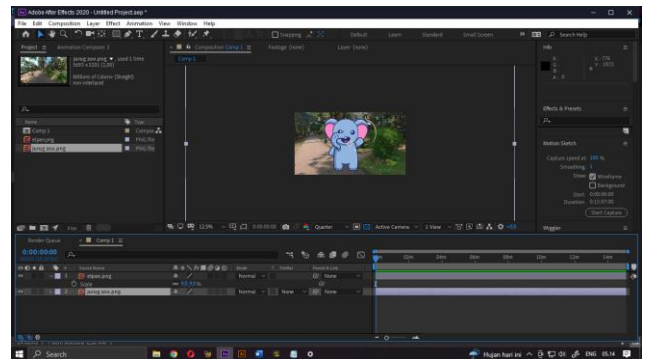


Figure 9. VR integration with buttons

4.3.2 Animation

Designing the application required animation that can make the appearance of this application more attractive. Animation is obtained by downloading on the internet or assets stored in the 3D Unity application. The animation creation process can be seen in Figure 9.

4.3.3 Voice

Use file sound with the MP3 type which is used to fill in animal sounds and background music. The step to collect tone is by downloading on the internet and then modifying with the application editing voice. File used in making the application, namely for animal sounds and background music.

4.4 Assembly

The assembly stage is the stage where all multimedia objects or materials are made. Application development is based on the design stage. In this final project, the author relies on After Effects software to combine animal objects with markers. At this stage the rendering process is carried out, namely the process of combining edits in the form of photos, video, audio, text, and other objects. This process can be seen in Figure 10. The rendering process is the step of combining all objects into a unified whole. Rendering is the final process of creating a graphic (see Figure 11). The result of rendering is output that can be enjoyed (see Figure 12).

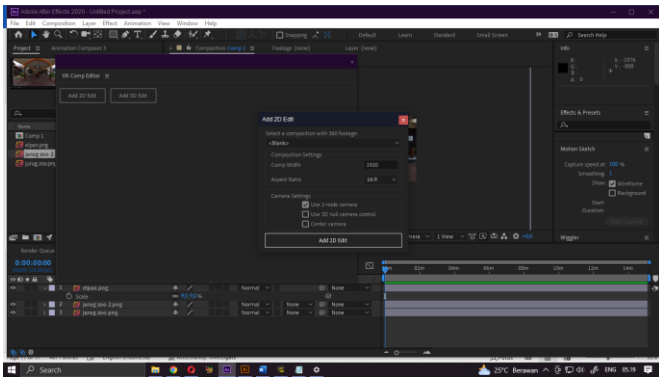


Figure 10. Product rendering process

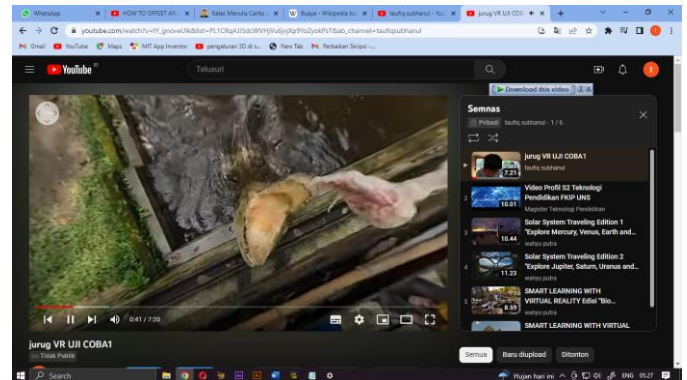


Figure 12. Virtual zoo with IoT approach

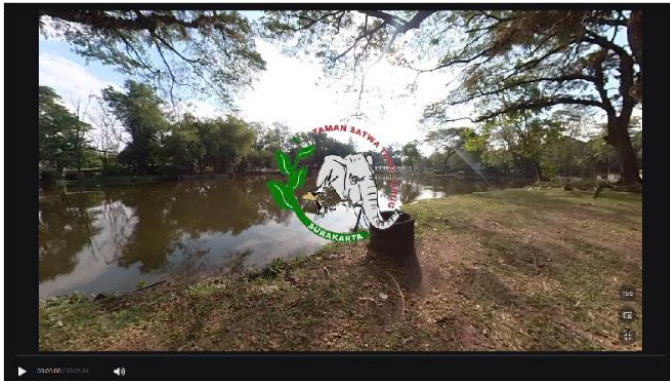


Figure 11. The main view of the application

4.5 Testing

The next step in software design can be seen if it functions as needed or not by alpha testing along with black box testing, starting with installing the application, showing pages, functions, buttons, and sounds obtained from successful test results running smoothly. Following are the results of testing the application design as shown in Table 4.

After the alpha test was performed beta testing. Beta testing is part of non-functional testing. Beta testing is done with a spread-given questionnaire to the respondent. The Likert scale was designed for reassuring respondents to answer at various levels from every grain of the questions contained in the questionnaire [38]. The Linkert scale can be explained in Table 5.

Table 4. Black box testing

No.	Smartphone name	Operating System	RAM	Result
1.	Oppo A57	Android Versi 6.0.1 Mashmallow	4 GB	Valid
2.	Oppo A96	Android versi 11	8 Gb	Valid
3.	Oppo A77	Android Versi 5.1.1	8 Gb	Valid
4.	Samsung Galaxy A73 5G	Android 11	8 Gb	Valid
5.	Samsung Galaxy A52s 5G	Android 11	4 GB	Valid

Table 5. Linkert scale table

Satisfaction Level	Scale
Very Good	4
Good	3
Less Good	2
Bad	1

After conducting the test, the next step is to analyze the test results. For beta testing, the analysis is carried out by calculating the survey results from the questions that have been filled in by the respondents. Where the calculation questionnaire is obtained by the following formula:

$$Y = \frac{\chi}{Ideal\ Score} \times 100\% \quad (1)$$

$$\chi = \sum(NX R) \quad (2)$$

$$Ideal\ Score = \text{the highest Linkert value} \times \text{number of respondents} \quad (3)$$

Description:

Y = value the percentage you are looking for
 x = amount from results multiplication mark every answer with respondent

N = value from every answer

R = amount of respondent

From the calculation of the results so obtained results percentage for every question as shown in Table 6.

Following chart results of beta testing for every question based on results calculations that have been done.

The graphical percentage of VR introduction of wild animals can be seen in Figure 13. From the results beta testing shows That the VR Introduction of wild animals for the student school base obtain an average percentage is 86.5%. Percentage value highest by 95% for evaluation question user friendly and Congeniality of music illustration. Whereas the percentage Lowest with an average of 80% on statements Appropriateness of the use of color and background design and the accuracy of the selection of the type of writing.

Table 6. Percentage results from beta testing

No	Question	Answer				Total Respondents	Results (%)
		1	2	3	4		
1	Appropriateness of the use of color and background design			5	20	25	80%
2	Matching the color of the text with the background			15	10	25	85%
3	The accuracy of the selection of the type of writing			16	9	25	80%
4	user-friendly			2	23	25	95%
5	Animation display suitability			21	4	25	85%
6	The congeniality of music illustration			7	18	25	95%
7	suitability with sound content			5	20	25	85%
8	VR can help that material delivered for children's learning process			10	15	25	85%
9	users can follow existing materials			4	21	25	90%
10	The convenience of using the app as a whole			17	8	25	85%

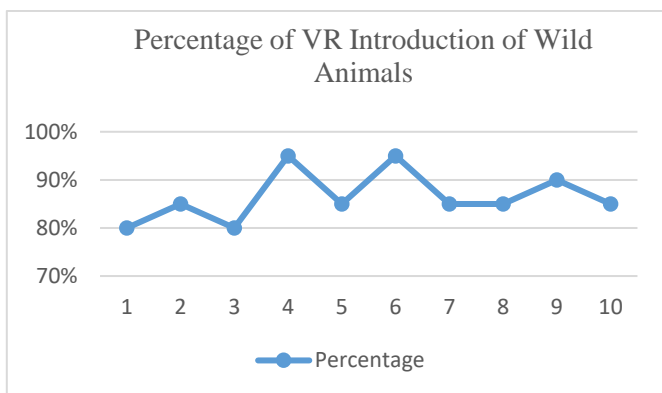


Figure 13. Graphic percentage of VR introduction of wild animals

4.6 Distribution

The distribution stage is the stage where the finished application will be massively deployed or distributed. In the next step, Virtual Zoo is backed up on media with YouTube application mp4 type which other users can use.

5. DISCUSSION

While VR technology is not a new thing, recent technological advances have increased resolution and dramatically reduced the cost of implementing VR materials. Two decades ago, VR had to be played on desktop computers [39]. Nowadays, with their many accelerometers, even mobile smartphones can be used to experience VR [33]. Additionally, VR content can be delivered in a variety of ways, specifically such as Oculus Rift, smartphones, and traditional computers [20, 40]. This research utilizes smartphones in using VR to study wild animals in zoos because they are considered easier, and more flexible and only require additional devices such as virtual glasses. Virtual Reality wild animals in this developed zoo were uploaded into the YouTube application to facilitate

distribution to potential users, namely elementary school students in Surakarta City.

Based on the results of observations made by the author, the majority of visitors to zoos are children, so zoos have great potential as an educational tool to provide information and knowledge related to wild animals, which is one of the materials students must learn in elementary school. However, when visiting the zoo, children are limited to seeing these wild animals more closely for security and safety reasons so they can only see them from a certain distance. Therefore, the use of virtual reality is a solution for children to learn about Wild Animals directly and more closely than in the real world. The results of observations with elementary school teachers and students in elementary schools in the city of Surakarta explain that the majority of students in urban areas already have smartphones so the development of virtual reality also adapts to student's abilities to use them such as smartphone ownership and students' abilities to operate the smartphone.

The use of virtual reality can enhance, motivate, and stimulate students towards certain events and at the same time also allows students to experience learning directly. VR can also be used to simulate subject matter, allowing students to practice without involving risk, and students can focus more and concentrate on what is in the virtual world. The use of VR can display wild animal animations and get a positive response from children as users where children can find out the types of wild animals, the movements of wild animals, the sounds of wild animals, and the habitat of wild animals and can use them easily. Besides that, research this too has capable combines VR and IoT. Kind of thing This conceived for the excellence of each technology can provide a stimulus to give understanding to student students about animal existing beast in the zoo. VR makes virtual worlds feel real [18, 21], and IoT makes it possible for users or students to monitor the real world virtually [41]. Combining the two gives the user the feeling of being somewhere else. Thus, the integration of VR and IoT is natural, because while VR simulation has proven to be an effective educational medium [42] as evidenced by several researchers it has provided insight into the psychological and physiological processes that underlie VR experiences [43, 44]. However, in the process of

implementation use of VR have several barriers where users experience difficulty in operating it. Besides that, there is an effect on experienced side users from the Health side after using VR like dizziness, nausea, and painful eyes. Illustration following show if VR media is developed including in a valid category so it is very possible for distributed to student, as media users [45, 46].



Figure 14. Integration of virtual zoo with IoT

Figure 14 shows the draft base architecture proposed VR service in the article, where VR can be reconstructed from captured images /videos and stored on the sharing server pictures /videos and given to VR users. Virtual Reality (VR) and the Internet of Things (IoT) are two techniques that can be integrated to create a richer and more interactive experience for users. VR makes it possible user for feel a computer-generated environment in form three dimensional and interactive. While IoT is network connected device to the internet and can each other communicate.

In VR and IoT contexts, integration can create more experience realistic and interactive for the user. For example, VR can be used for creating a connected virtual environment with IoT devices in the real world. Users can interact with deep IoT devices in this virtual environment and see the effect of action in the real world.

6. CONCLUSIONS AND RECOMMENDATIONS

This paper has succeeded in demonstrating a Virtual Reality application to make it easier for elementary school students to learn about Wildlife Animals, by creating a virtual learning environment in which there are virtual objects about the concepts and types of wild animals in zoos. Besides that, this VR application also includes several interactive components that can help students understand the subject matter, these components include audio, video, and text. The VR that has been developed has gone through the stages of testing using an Android device, which shows that this VR application is valid and has the potential to be implemented by students.

Finally, some specific suggestions and prospects need to be put forward so that future researchers can further improve and expand research in this field. The next researcher can carry out an analysis of this Virtual Reality application on students' understanding of the concepts of the material being taught. So that it can be seen how effective the use of the virtual environment is in achieving learning outcomes for elementary school students.

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