

## **The Development of Augmented Reality (Ar) Based Science Learning Media at MI Yaa Bunayya**

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### **Abstract:**

This study aims to produce an *Augmented Reality* (AR)-based learning media in the science field at MI Yaa Bunayya. The development method in this study uses a modified Thiagarajan 4D model with three stages (*Define, Design, and Develop*). The *Augmented Reality* (AR) learning media, later named the SANDIR Application, was assessed by the reviewer and 10 class V students of MI Yaa Bunayya to find student responses. The instrument used is a *checklist* questionnaire. The data obtained is in the form of qualitative data which is converted into quantitative, analyzed descriptively to determine the quality of the product. The results showed that the SANDIR Application learning media for science subjects that had been developed was based on *reviewers'* assessments with an average score of 33.7, classified as very good (SB). SANDIR application learning media based on student responses has a percentage of 99.13 with a positive value category in helping students' understanding while learning and is included in the very good quality category. Based on the data acquisition results, the SANDIR Application learning media is in accordance with the cognitive development of elementary school-aged children and is suitable for use as a learning resource for fifth grade students of elementary school.

**Keywords:** *augmented reality*; learning media; research of development; science-subject

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## Introduction

In the 4.0 era, it is necessary to implement activities that have distinctive and effective activities in education so that the role of technology can be an alternative to improve learning activities. Technology in Indonesia, based on the level of development in the world according to the *International Telecommunication Union* (ITU) with the *ICT Development Index* (IDI), is ranked 108th out of 167 countries in the world (Sanou, B., 2015). Based on research by the Ministry of Communications and Informatics in 2017, Papua and Maluku are around 9.5% technology users, 4.13% have computers, 11.50% laptops and 27.68% smartphones. This data is supported by the efforts of KEMENKOMINFO and Diskominfo in introducing digital literacy to the people of Papua (Diskominfo, 2022; KEMENKOMINFO, 2022). Based on research from the Ministry of Communication and Informatics in 2018 technology was used for 2.8% of E-learning and 24.5% of playing games. Based on these data, it is necessary to have a distinctive educational development in the city of Jayapura as a form of prevention from inaccuracy in the use of technology, so the Papua Diskominfo through various activities plans to increase digital literacy (Hendrik Rikarsyo Rewapatara, 2022) for education in Papua is able to adapt to technology effectively and efficiently.

Technology is developing rapidly, resulting in educational institutions needing developments in teaching and learning activities. Innovation is the existence of advanced quality education. So teaching and learning activities are expected to lead to a technology base in each academic unit (Sanou, B., 2015). Augmented Reality-based technology media is a unique system and can be applied to the world of education. Augmented Reality (AR) can also be interpreted as a synthesis of virtual and real imagery (Atmajaya, 2017; Dey, 2018; Dieck, 2018; Fraga-Lamas, 2018; Heller, 2021; Osadchyi, 2021; Palmarini, 2018; Rauschnabel, 2022; Reipschlager, 2021; Tkachuk, 2021; Yeung, 2021). The developed AR can be adapted in various dimensions. AR is a technology that can be adapted into a factual knowledge technology that is empirical in nature so that users are able to fully understand its use (Alhaija, 2018; Blanco-Novoa, 2018; Bottani, 2019; Boud dkk., 1999; Chen, 2019; Delgado, 2020; Zhan, 2020).

MI Yaa Bunayya School is an elementary school in Jayapura City. MI Yaa Bunayya in its learning system still uses conservative learning media. It makes students feel bored in the learning process. This problem is in line with Siti Aisah's research which suggests that learning that is carried out using conservative media such as picture media will make students not develop in forming their ideas because they are not able to interact with the media they observe (Asiah, 2014). Increasing learning innovation is necessary because, considering Madrasah Ibtidaiyah students are elementary school-age children who like unique and newest things in their development process.

MI Yaa Bunayya in the learning process has implemented media such as 2D images, the disadvantages of these media are (1) limited information; (2) students cannot interact in real terms; (3) only emphasizes the sensory perception of the eye; (4) less effective in learning activities (Utami, 2018), these problems require the need to introduce more attractive technology as a means of learning activities. Interactive learning using Augmented Reality (AR) technology has never been adapted to Yaa Bunayya madrasah, Jayapura City, so this learning media is a new thing for MI Yaa Bunayya students.

Learning at MI Yaa Bunayya is also experiencing difficulties due to the Covid-19 pandemic. This data aligns with the statement that access to learning and teaching for Papuan students is increasingly limited due to the Covid-19 pandemic. Until now, the problem of the lack of telecommunications services and the limited textbooks continues to plague Papuan children (Fabio Costa, 2020). Then, the Head

of the Papua Regional Education, Library and Archives Office Christian Sohilaht stated that the use of television and radio broadcasts was very important because the internet network in Papua was inadequate. Only 48 percent of the 4,000 high school and vocational schools can carry out online learning (Fabio Costa, 2020).

Based on that, research on AR-based science media is urgently needed. It is because due to limited media and learning facilities that are still not adequate, especially at MI Yaa Bunayya, students find it difficult to understand if it conducted in online learning (Aswani & Aswani, 2022; Awani dkk., 2022; Huzaimah & Amelia, 2021; Iwanaga, 2021; Kurnia dkk., 2022; Sadiyah, 2022; Turmuzi dkk., 2021; Verawati & Ni'mah, 2022). Therefore, activities are needed to visualise the material to make it easier for students to understand learning. AR technology, which incidentally is capable of displaying 3-dimensional objects and animated forms that can be displayed through AR technology, can provide an interesting experience for students. This technology is still minimal in Papua and some do not even know about it, so in this study the form of educational innovation in Papua, even though it is familiar in other places but it is relatively new in Papua.

*Augmented Reality* (AR) is a technology that connects the real and virtual worlds. The development of the virtual world will affect and improve user perception in understanding information from recognized objects. This study was limited to Class V MI and Science Subjects on water cycle materials. The choice of water cycle material in developing this learning media is because the water cycle is a process of natural phenomena that is difficult to observe. Hence, students tend to need help understanding. The application of Augmented Reality-based science media is expected to provide good facilities when learning activities occur so that users can easily understand natural phenomena linked through AR technology to natural phenomena in the form of the water cycle.

AR technology is very necessary because in Papua, it is still relatively difficult to get relevant learning media so this technology is expected to be a practical alternative in increasing understanding of science subjects on water cycle materials. The benefits of visualization and interaction that can be optimized in the world of education are urgently needed to increase understanding in student learning (Bahar, Y., N., 2014; Chusna dkk., 2021; Harini & Pujiriyanto, 2022; Peng, 2018; Permana, 2021). Based on the understanding, the research that will be planned is the development of Augmented Reality (AR)-based science learning media at Madrasah Ibtidaiyah Yaa Bunayya Jayapura City.

## **Research Method**

This study used Research and Development (R&D). The purpose of this study is to produce a product or perfect it and then follow it up by testing the feasibility of a product (Trianto, 2013). This study developed Science Learning Media based on *Augmented Reality* (AR) at Madrasah Ibtidaiyah Yaa Bunayya Jayapura City. The development model in this study is procedural; the procedure is descriptive and follows the applicable syntax to produce a product (Tim Puslitjaknov, 2008). ). The development used in this research are 4-D model (Define, Design, Develop, and Dissemination), or adapted to the 4-P model, namely pendefinisian, perancangan, pengembangan, dan penyebaran (Trianto, 2013), However, it is limited only in Develop stage trials because if a complex trial is carried out, it will take more time and costs.

## **Result and Discussion**

The result of this study is in the form of learning media designed to function on Android cell phones and laptops. This media learning is optimized for the students can learn independently. Media development in the form of an application master has

the file extension ".APK" (application package) and EXE (Executable file) which is then used to install applications on Android phones and Windows OS laptops. An application called SANDIR is presented in several menu options including: AR camera menu, AR video menu, material, games, questions, bibliography and profile. All menus have their respective uses which aim to make it easier for students to study independently.

The AR camera menu consists of 3-dimensional objects that students can use to see the water cycle. It contains an audio menu explaining the water cycle that has been adjusted to 3D objects. 3D objects can also be zoomed in, zoomed out and rotated to provide convenience in observing the water cycle. 3D objects can show real rain and evaporation. The AR Video menu contains video animations explaining the water cycle, where this programming is called Augmented Reality (AR) video playback. The technology belongs to a new technology category with the real video objects. In the video, several options are provided for viewing, namely by zooming in and out as needed. The material menu contains a water cycle that students can easily access. The Game menu contains educational games as companions, learning by playing games and reinforcement in learning the water cycle. The Question menu contains evaluation questions to evaluate students' understanding of the water cycle material. The bibliography menu contains references for making applications. The profile menu contains information about the developer or researcher. The menu used is simply because it makes it easier to use.

The procedure for developing Augmented Reality (AR) learning media uses a 4D model consisting of defining, designing, Developing, and Disseminating. Due to time and ability limitations, the developer did not carry out the Disseminate stage. The procedure for developing learning media is carried out as follows.

### **1. Stage Define**

The Define stage consists of the preliminary-final analysis phase, student character analysis, curriculum analysis and material analysis. The preliminary analysis aims to identify the fundamental problems that cause the need to develop learning tools. The basic problem which needs to be solved is the limitations of water cycle learning media in terms of the flexibility and portability of the devices used and the rapid development of technology. The next stage is the analysis of student characteristics, which aims to determine students' cognitive development level.

At this stage of cognitive development, elementary school-age children can think logically, understand conversational concepts, organize objects into classifications, remember, understand and solve concrete problems and think more dynamically. The analysis phase of student characteristics provides information that will be used in the subject matter preparation. Curriculum analysis is carried out to provide subject matter that will be developed on AR learning media because it is possible that not all subject matter is suitable to be developed on AR learning media. Another factor that is taken into consideration is the percentage of students' mastery of science material and also based on the consideration of the lack of media in the science field, which is recommended by the teacher concerned. Material analysis is carried out so that the material presented in this study is under applicable requirements and can be seen systematically. The materials in the SANDIR Application are as follows:

The water cycle is the continuous circulation of water from the earth to the atmosphere and back to the earth. This water cycle occurs through the process of evaporation, precipitation or deposition, and condensation, following the scheme of the water cycle process on Figure 1.



Figure 1. Scheme of Water Cycle

## 2. Stage Design

The design stage is the planning of the SANDIR Application prototype. The design builds an application consisting of Interface design, AR menu design, game character design, two seasons in the game design, material design in the application, game score design, ground game design, problem design, health point design for characters and monster design in the game. The design has criteria that are easy to operate by hand, attractive and simple design, sustainable use and relevant. The design requires software, hardware, and the characteristics of the users of the software. The following devices are needed:

- a. Hardware requirements meet in building the system
  - 1) Laptop Aspire E1-410 dengan Processor Intel(R) Celeron(R) CPU N2820 @ 2.13GHz (2 CPUs), ~2.1GHz
  - 2) RAM capacity of 4048 MB
  - 3) Harddrive with capacity of 500 GB
  - 4) Camera or webcam 2 Mb Pixel
  - 5) Graphic Card (VGA) Intel(R) HD Graphics
- b. Software requirements meet in building the system
  - 1) Operatin System Windows Pro 10 Ultimate 64 bit
  - 2) Unity 2020.2.7f1 64 bit
  - 3) Autodesk 3DS Max 2014 64 bit
  - 4) CorelDraw X8 64 bit
  - 5) Adobe Animate 2020
  - 6) Android SDK Windows versi 5.0
  - 7) Macromedia Flas 8 pro
  - 8) Adobe Illustrator 2022
  - 9) Adobe Photoshop 2022
- c. Minimum hardware and software requirements meet to run the system
  - 1) Smartphone with minimum Android 4.1 *jelly bean*
  - 2) Camera Smartphone with at least 2 Mb Pixel
  - 3) Laptop operating sytem OS Windows Celeron ram 4 GB

After the preparations have been made, the design is carried out as follows:

- a. Design build application

This step is part of forming a water cycle augmented reality application. 3D files must have the extension \*. fbx, then the animated video is imported into the unity editor, which will later be displayed as augmented reality. The step is important

for building an Android-based AR application because of the coding process, determining markers, texturing, and building\*. apk and EXE in this session. The system to be built is based on Android and Windows OS. The media implementation being developed has the form of a marker with a pattern that has been adjusted by the system, the function of the marker is to identify coordinates to bring up menu objects. There is also an object that appears as a 2D object, namely the Sandir application menu. This step is part of forming a water cycle augmented reality application. 3D files must have the extension \*. fbx, then the animated video is imported into the unity editor, which will later be displayed as augmented reality. The step is important for building an Android-based AR application because of the coding process, determining markers, texturing, and building\*. apk and EXE in this session. The system to be built is based on Android and Windows OS. The media implementation being developed has the form of a marker with a pattern that has been adjusted by the system, the function of the marker is to identify coordinates to bring up menu objects. There is also an object that appears as a 2D object, namely the Sandir application menu.



Figure 2. System design

The first marker is formed from the QR-Code, and the second marker is from the water cycle image. The first marker produces two virtual menus: the Sandir application for Android and the Sandir application for Windows. In *vuforia*, images that will be used as second markers or markers must be converted first in the *vuforia* database to have the *\*.unitypackagesextension* and contain an *xml-config.xml* configuration that allows developers to configure several features in *trackable* and *binary files* containing *trackable databases* using *on-line Target Management System* on the *vuforia* website.

1) *Interface design*

The first display when the media is running is the *splash screen* display. The splash screen hides the *loading* process, so the users do not feel bored waiting. The usual splash screen is identified with the cover. The following is the splash screen display in Figure 3.



Figure 3. Display of *Splash Screen*

The main display of the SANDIR application learning media provides information about its use and is intended for users who will use it. In operating the SANDIR application, the display is also adapted for elementary school-age children. At the top, there is a play menu; if clicked, it will go to the SANDIR application menu. The move from the splash screen to the Sandir application menu uses a script method created using the ActionScript language, which can be seen on Figure 4.



Figure 4. Script of Splash Screen

2) AR menu deisgn

In the second stage, the SANDIR menu display contains the material menu, game menu, question menu, profile menu and bibliography menu. The displayed menu is comprehensive, so students can easily operate this SANDIR learning media. The SANDIR menu display can be seen on Figure 5.

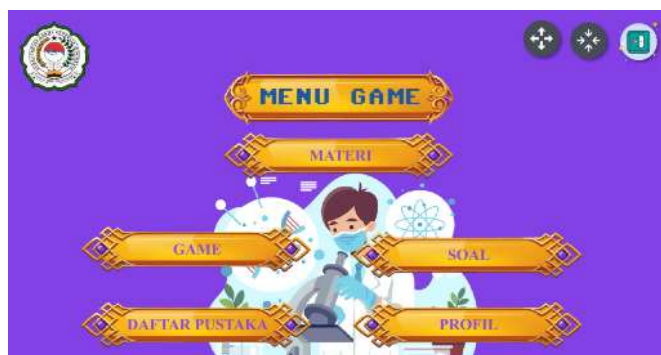


Figure 5. SANDIR menu

The display of the SANDIR application menu in Figure 5, consists of a material menu containing water cycle materials that students can easily access. The Game menu contains educational games as a companion, learning by playing games of the water cycle. The Question menu contains an evaluation to see students' understanding of the water cycle material. The bibliography menu contains references for making applications. The profile menu contains information about the developer or researcher. Sandir uses a script from each application button created using the ActionScript language, which can be seen on Figure 6.

```
on (release) (stopAllSounds();bunyi.stop());  
gotoAndStop('materi', 1);  
}  
on (release) (stopAllSounds();bunyi.stop());  
gotoAndStop('homegame', 1);  
}  
on (release) (stopAllSounds();bunyi.stop());  
gotoAndStop('soal', 1);  
}  
on (release) (stopAllSounds();bunyi.stop());  
gotoAndStop('da', 1);  
}  
on (release) (stopAllSounds();bunyi.stop());  
gotoAndStop('profil', 1);  
}
```

Figure 6. Script Menu of Sandir Application

The next part is a game containing 2D objects, these objects were created previously using a combination of several tools consisting of Adobe Photoshop, Adobe Illustrator and Coreldraw. The 2D objects consist of characters, ground, monsters, backgrounds, Health Points, gates and points. Before the user enters the game, he is asked to answer the questions first, if it is wrong, the user is immediately directed to the warning menu to re-learn and if it is correct, then he will enter the game. The game contains two seasons, spring and winter which will be shown on Figure 7 until 12.



Figure 7. The Beginning of Entering The Game



Figure 8. Question Before Entering The Game

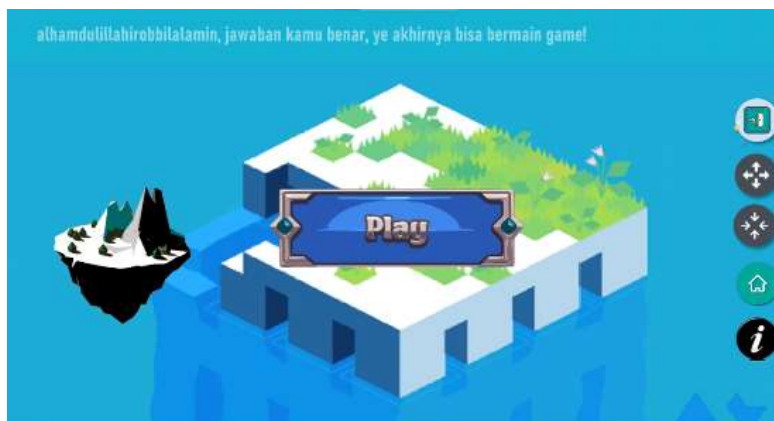


Figure 9. The Display if The Answer is Correct





Figure 10. The Display if The Answer is Incorrect

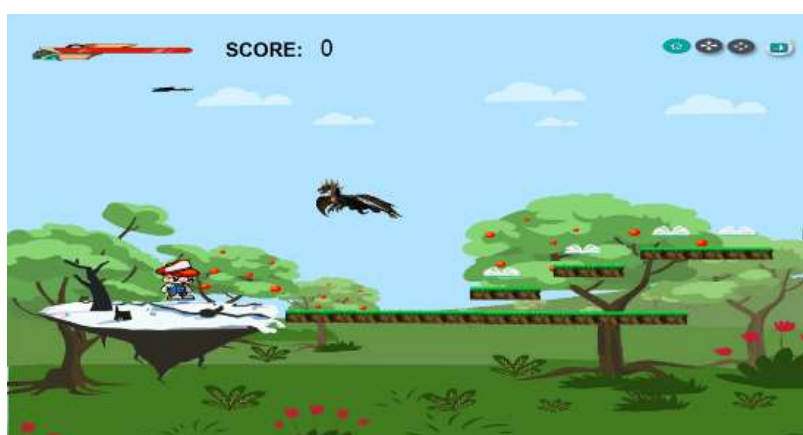


Figure 11. Display of Spring

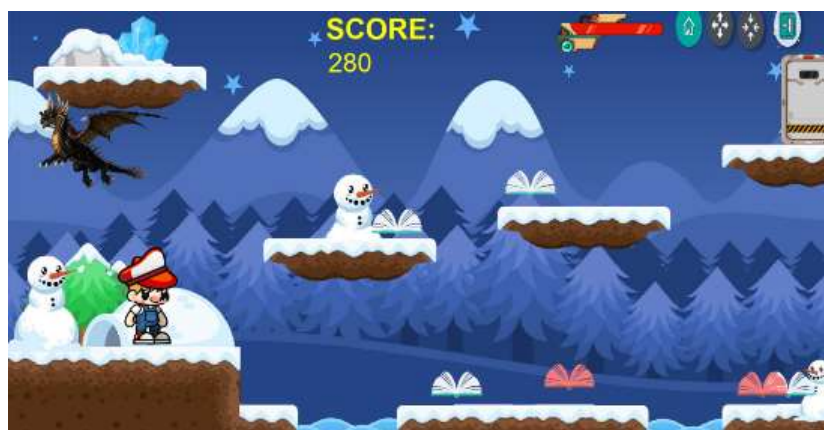


Figure 12. Display of Winter

The next menu function is to return to the main menu. The AR camera menu also uses a script to go to 3D objects, the script used is almost the same, but in the public class method is written `btn_manager`. The method is made so that everything runs smoothly in unifying the script work in each component. The following is a display of AR objects produced by the AR camera, which can be seen on Figure 13.



Figure 13. Object 3D

The design process for the SANDIR application has undergone several revisions. The revision process was carried out, starting with designing layouts, characters, games, presenting the application's interface, materials, and improving the application's display.

### 3. Development Stage

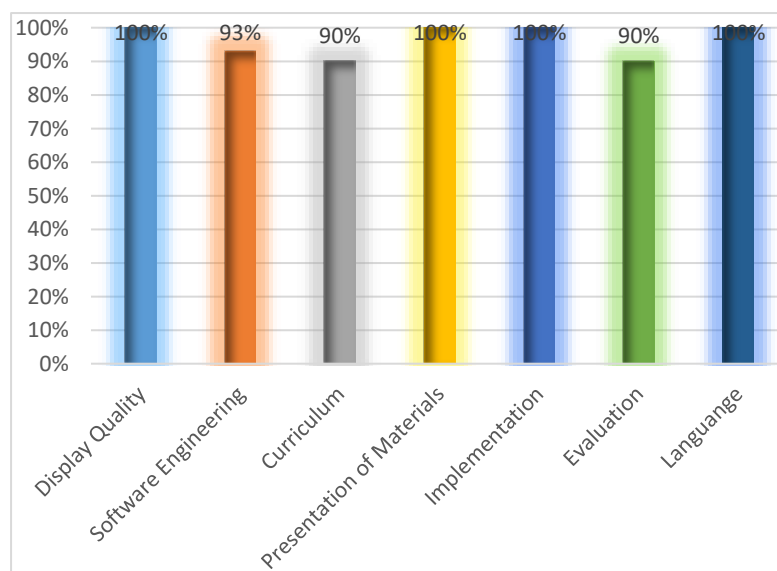
At this stage, the AR learning media products produced are tested first for quality before being tested on students. Reviewers carry out this quality test. One class teacher carries out the assessment. Reviewers have competence in their fields according to the qualifications set by the developer. Hence, reviewers meet the requirements to assess SANDIR application learning media. It is because the SANDIR Application must have good quality and can be accounted for in terms of display quality, software engineering, curriculum, material presentation, implementation, educational games, evaluation and language. The results of the assessment of the product quality of the SANDIR application learning media are as follows:

#### a. Reviewer

Reviewers assess the SANDIR Application from several aspects: display quality, software engineering, curriculum, material presentation, implementation, evaluation, and linguistic aspects. The reviewer has met specific criteria set by the developer. They are considered to have the competence to conduct a SANDIR Application review. The results of the SANDIR Application assessment data by reviewers are in Table 1 and Figure 14.

Table 1. Assessment of SANDIR Application by Reviewer

No	Criteria aspects	Indicator	Score Max	Score Average	Percentage ideal (%)	Quality
1	Aspect of Display quality	1,2,3,4,5	25	5	100%	SB
2	Aspect of software engineering	6,7,8	15	4.7	93%	SB
3	Aspect Curriculum	9,10	10	4.5	90%	SB
4	Aspect of material presentation	11,12,13	15	5	100%	SB
5	Aspect of implementation	14,15	10	5	100%	SB
6	Aspect of evaluation	16,17	10	4.5	90%	SB
7	Aspect of linguistic	18,19	10	5	100%	SB
<b>Total</b>			<b>33.7</b>			
<b>Total Ideal Percentage</b>					<b>96.14%</b>	<b>SB</b>



**Figure 14. Graph of Assessment Result**

Based on Figure 14 above shows that the display quality aspect obtains a percentage of 100%, the software engineering aspect 93%, the curriculum aspect 90%, the material presentation aspect 100%, the implementation aspect 100%, The evaluation aspect 90%, and linguistic aspects obtain 100%. Research on all aspects by reviewers can be seen in table 1, with an average score of 33.7 and obtaining an ideal percentage of 94.57%. Based on these data, it is classified as very good characteristics (SB). The responses given by the reviewers are as follows.

*“Very interesting and suitable for an all-digital era. Moreover, the educational games make learning not monotonous, and it can display two seasons”*

Based on the reviewer's responses, the researcher added the game into two seasons: spring and winter.

#### **b. Limited Trial**

A limited trial was conducted by looking at student responses to the Sandir application learning media product. Students are given the opportunity to assess and provide input. Student assessment includes several aspects, namely the aspect of interest in learning shows that students enjoy learning more because, according to developments, they still like to play while learning. The aspect of ease of understanding material is seen when students are able to complete SANDIR games. The display aspect makes it easier for students to choose menus to interact. Aspects of implementation go well because students can operate the application without any obstacles. The results of the overall response to the SANDIR Application carried out by 10 MI Yaa Bunayya students in Jayapura City produced 99.13% in a positive category in helping them to learn.

#### **Conclusion**

Based on the development study that has been carried out, it produces learning media based on Augmented Reality (AR) for Science Subjects at MI Yaa bunayya, named the SANDIR Application, an acronym for AIR Cycle Science. The development model is procedural and descriptive, shows the steps that must be followed to produce a product using the 4D model. The steps taken are Define,

Design, Develop, and Disseminate. However, this stage is limited to the Develop stage in limited trials so that the final product is obtained in the form of science learning that can be operated on Android cellphones and Windows OS. The results showed that the SANDIR Application learning media for science subjects which had been developed based on reviewers' assessments, had an average score of 33.7 and obtained an ideal percentage of 94.57%. Based on these data, it was classified as very good characteristics (SB). SANDIR Application learning media based on student responses has a percentage of 99.13 with a positive value category in helping students' understanding while learning and is included in the very good quality category. The data acquisition results show that the SANDIR Application learning media is in accordance with the cognitive development of elementary school-aged children and is suitable for use as a learning resource for fifth-grade students of SD/MI.

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