Application of Electronic Learning by Utilizing Virtual Reality (VR) and Augmented Reality (AR) Methods in Natural Sciences Subjects (IPA) in Elementary School Students Grade 3

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Abstract

Corona Virus Disease 2019 (Covid-19) has stopped all aspects of human life, including the world of education. The Ministry of Education of the Republic of Indonesia has stopped face-to-face teaching and learning activities in schools, replacing them with online methods. Work from Home (WFH) is an adaptation of activities as applied online methods to anticipate learning activities during the Covid-19 Pandemic. Learning based on digital transformation technology utilizes network technology entirely online. The application of e-learning technology in the teaching and learning process is a choice for various educational institutions. The use of technology can maximize students 'learning time efficiency and increase students' concentration. Learning with the Virtual Reality (VR) method directs students to discoveries, motivates, encourages, and provides more curiosity for students in learning. Besides VR, Augmented Reality (AR) is a learning method for students to interact with virtual objects and real objects. The author proposes e-learning based learning in Natural Sciences (IPA) subjects in grade 3 in Elementary Schools. The research proposal develops lessons using a virtual approach from real events and provides phenomena of natural occurrences. Science lessons in Elementary Schools increase the curiosity of students scientifically. This method will help students develop the ability to ask questions and find answers to natural phenomena. The research stages carried out in application development are analysis, design, implementation, and application testing. The test results by adding e-learning to traditional learning methods impacted students' understanding of the material with an increased level of understanding by 24%.

Keywords: E-learning, Virtual Reality, Augmented Reality, Elementary School, Natural Science Lessons, Covid-19

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INTRODUCTION

The coronavirus still dominates the public space discussed by all circles and is reported massively in print and electronic media. On March 16, 2020, to prevent the transmission of the Covid-19 pandemic, the government issued a policy of all schools proposing students study at home (Anugrah et al., 2021).

The Covid-19 pandemic impacts changing teaching and learning activities with online learning activities to become a choice of adapting habits and culture to prevent the spread of the Covid-19 virus from spreading.

The application and practice of online education (online learning) do carry out by various education levels from elementary, junior high, high school to college levels. Various types of technology are starting to be widely used by various educational institutions. According to research Prihantoro (2018), applied information and communication technology (ICT) in education and facilitating academic administration, school registration. However, ICT is also able to provide a solution for the teaching and learning process. The support of the internet as a communication medium affects the education sector, which can do executed using information and communication technology such as e-learning. This technology can have advantages in maximizing students in spending time in learning and increasing student concentration. Technological developments can help students understand lesson concepts easily. Explanation of the concept of visual learning makes the learning process fun (Raja & Nagasubramani, 2018). Students can participate more in the classroom, and the teacher will have the opportunity to make the classroom more interactive and exciting. Students can explore different realities and have alternative learning experiences that are not possible in traditional classrooms. The use of technology can also help students understand concepts, theories, and complex subjects to digest and store information easily. Technologies starting to develop today in education are Virtual Reality (VR) and Augmented Reality (AR).

Virtual Reality (VR) is a technology that allows users to immerse themselves in an artificial world that can either be an entirely imaginary universe or merely a reproduction of the real world. Research by Elmqaddem (2019), virtual reality (VR) can make a difference to direct students to discoveries, motivate, encourage and give more passion to students in learning. According to research Pantelidis (2010), learning methods with VR provide new experiences for students that impact the role and participation in the learning environment and feeling and being part of that environment. Students can walk and interact in a 3-dimensional virtual environment and change how they interact with the subject matter. VR will encourage students' active participation to continue interacting and provide insights that they have never do it before.

Augmented Reality (AR) is a technology that refers to a virtual interface that enhances or adds information to the real world. The learning method using AR technology can work through a device that films the real world and adds information, virtual objects, animations, text, and sound that the user can see from the device screen (Elmqaddem, 2019). AR technology is a bridge between the real and virtual world and removes the barrier between the real and virtual world. Utilizing AR technology allows students to interact with virtual objects and real objects, where each new interaction can cause a different response, namely as a source of new information and knowledge based on actions taken with virtual objects. The research by Kiryakova et al. (2018), AR technology makes learning content more interactive, exciting, and easier to understand for students by offering opportunities to view content from various perspectives.

The Ministry of National Education establishes a 9-year compulsory education program at the basic education level, namely at level 1 Elementary School (SD) to Junior High School (SMP). Elementary level education (SD) aims to provide necessary reading, writing, arithmetic skills, basic knowledge, and skills. The subjects given at the SD level consist of Citizenship Education, Indonesian Language, Mathematics, Cultural Arts, Sports and Health Physical Education (PJOK), Social Sciences (IPS), and Natural Sciences (IPA).

Natural Sciences (IPA) is a subject that provides information about phenomena that occur in nature. Natural science learning in elementary schools should open up opportunities to nurture students' curiosity scientifically. This method will help them

develop the ability to ask questions and seek answers to natural phenomena. Science is a subject that is difficult to understand. One of the causes of science subjects experiencing difficulty for students is the lack of learning media that can provide illustrative images of real phenomena so that students seem to have difficulty understanding the material without media availability (Awal, 2015).

Science subject material for grade 3 SD, second semester, discuss the motion of objects and energy, the application of energy, the shape of the earth's surface, weather and natural resources, and the environment, which requires media and examples to be understood by students. Science lessons are challenging, requiring students to do imagination which is sometimes right and wrong. Therefore, visual aids or animation are needed to help students understand it.

Based on these problems, the authors in this study developed an e-learning based learning aid in science subjects for grade 3, second-semester at elementary school. E-learning-based learning does specializer in science subject matter about the motion of objects and energy and the shape of the earth's surface, animated by VR and AR technology. The results of this study can examine the impact of using this technology on the learning process.

METHODS

A Science related to e-learning-based learning involves a scientific study of how a person or group of people will learn in an environment that utilizes electronic learning technology. Three main elements proposed by Mayer (2003), where the three elements needed to support e-learning based learning are:

a) evidence: learning based on a finding that does virtually replicated from a research study that is difficult to illustrate and conforms to reality;

b) theory: research-based concepts and theories about learning methods in the electronic learning environment, which can produce testable predictions; and

c) application: theory-based principles concerning the application of designing learning in electronic learning environments, which by themselves can do tester in research studies.

E-learning focuses on the use of technology in education and learning. E-learning refers to advanced information communication technology in the learning process, where advanced technology consists of electronic media. E-learning has not yet become a large-scale teacher training method in education (Agarwal, 2013; Dhir et al., 2017). Compared to traditional teacher training methods, e-learning has the benefit of cutting costs in the learning process because e-learning does not use paper or pencil and reduces costs in teacher training. E-learning can do done anywhere and anytime. E-learning does not require a teacher or an organization to select the material, but students can choose and get their own knowledge needs.

Virtual Reality (VR) is a technology that allows users to immerse themselves in an artificial world that can either be a completely imaginary universe or simply a reproduction of the real world. The research by Elmqaddem (2019), VR is an interactive computer-based multimedia environment that places users in a virtual environment generated by a computer. VR uses a computer device in its use. Some of the devices used in VR include Headset and joystick. The VR headset will simulate a 3D environment using two screens (1 screen for each eye). Two autofocus lenses generally place between the screen and the eye, which adjusts based on the individual's movement and positioning. Visual on the screen is displayed using either a mobile device or an HDMI cable connected to a PC. In the VR application, three sensors do use on the device, namely accelerometers,

magnetometers, and gyroscopes. VR can do applied in various fields such as training with simulators, simulation of surgical procedures, architecture, archeology with site reconstruction, virtual museum visits, treatment of phobias, and various other types of learning.

Augmented Reality (AR) is a technology that refers to a virtual interface that enhances or adds information to the real world. The research by Elmqaddem (2019), AR shows the physical environment of the real world and the visualization of computer-generated digital images that change the perception of reality. The reality displayed can be in images, 3D objects, videos, text, and sound. AR can place in various fields such as entertainment, tourism, architecture, medicine, education, and industry. In the field of education and training, AR allows technicians to learn new procedures in real conditions. AR is a bridge between the physical and virtual worlds and removes barriers between them. AR allows students to interact with virtual objects and real objects. Each new interaction can cause a different response, namely, as a source of new information and knowledge based on the actions performed with virtual objects.

The waterfall software development method or the so-called classic life cycle represents a systematic, sequential software development approach. The waterfall model begins with a specification of requirements and then goes through the modeling, construction, and deployment process.
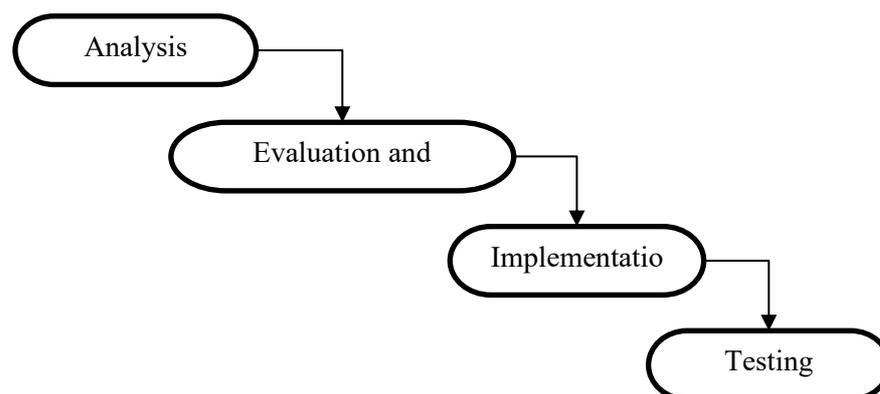

Figure 1. Waterfall Development Method

Figure 1 shows the waterfall method used in the study. At the analysis stage, a needs analysis is carried out for the program to be made, including knowing the scope of information, the functions required, the performance capabilities to do producer, and the tools needed. The application display design and related assets do carrier out in the software at the evaluation and design stage. It does determine whether the application is running correctly and there are no errors at the evaluation stage. If there are errors or bugs, configuration changes will be made according to the errors or bugs found in the design. At the implementation stage, application-based e-learning using software development through the Unity game engine. This application was only running on the Android platform. The tests stage the application's use get the sample in a small group of 5 students in class 3 and a teacher at an elementary school (SDN Balimester 01 Pagi) in Jakarta on March 30, 2020. The test sample data do conduct from population data on five students with an average value of 77.86 from 32 students in one class. The test does carry out three types of testing is:

1. Learning e-learning method
2. Conventional Learning Methods (Without e-learning)

3. Combination Learning Methods (Conventional method and e-learning method)
The test results on a group of data obtained in a testing (each group of pre-test and post-test scores) require an average value.
The average value is data, a group that is the sum of all the existing data values, then divided by the amount of data shown in equation 1.

$$Average\ value = \frac{Total\ value}{number\ of\ data} \times 100\% \tag{1}$$

Based on each testing trial's average (mean) value on the pre-test and post-test, the difference between the values of increase or decrease in the trials does show in equation 2.

$$Testing_{result} = Mean\ of\ post_{test} - Mean\ of\ pre_{test} \tag{2}$$

RESULTS & DISCUSSION

Results

In this section, the author will explain the results of the research by conducting testing. The purpose of testing whether the benefits of learning can help students understand science subjects. As mentioned earlier, these tests do carry out three types of testing.

1. Learning e-learning method
Learning at this stage applies the e-learning method with available applications, while the science subject teacher does not explain the material do study it by students. Testing was carried out by 5 participants using e-learning-based applications, while the teacher only monitors the students working on the questions without explaining.
Testing this stage is no good because learning only uses e-learning-based methods in science subjects for grade 3 students in elementary schools. Based on the test results, the participants did a pre-test without doing any previous learning. After conducting the pre-test, students learn using an e-learning based application and then do a post-test to work on the application's questions. The test stages do show in Figure 2.
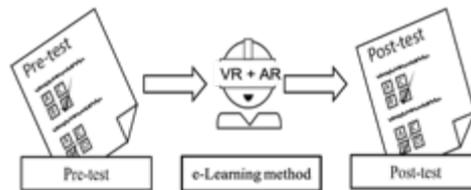

Figure 2. Learning e-learning method

The test results in Table 1 show the results of the pre-test and post-test conducted by the five participants in learning testing with e-learning-based applications.

Table 1. Results of learning e-learning method

Participants	Score	
	Pre-test	Post-test
F	40	40
FR	80	80
SA	40	40
MF	60	80
SH	60	80

Average	52%	60%

Learning using e-learning based applications, but without the role of a teacher who can explain material on science subjects, will negatively impact students. The results obtained in testing using the learning method without explanation from the teacher did not significantly increase the five participants, with the following calculations. Increased understanding of the five students by 8%

$$Testing_{result(1)} = Mean\ of\ post_{test} - Mean\ of\ pre_{test}$$

$$Testing_{result(1)} = 60\% - 52\%$$

$$Testing_{result(1)} = 8\%$$

2. Conventional Learning Methods (Without e-learning)

In the conventional learning model (without e-learning-based applications) in science subjects, a teacher provides an explanation, and students pay attention and note what the teacher explains. However, sometimes the teacher cannot illustrate a particular subject (for example, movement style).

The learning method results are based on the teacher and 5 participants' testing without using the application. The test results do show in Figure 3.
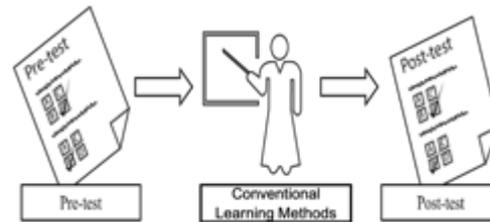

Figure 3. Conventional Learning Methods

In the initial stage of testing, participants did a pre-test. After conducting the pre-test, the teacher explains the related material. After the teacher explains the material, the participants do a post-test. Table 2 shows the pre-test and post-test results conducted by the five participants on the test without application.

Table 2. Results of Conventional Learning Methods

Participants	Score	
	Pre-test	Post-test
F	60	60
FR	60	80
SA	40	60
MF	80	100
SH	100	100
Average	68%	80%

In the test results shown in Table 2, the results of the five participants' improvement do obtain. The following calculations are made. Based on the calculations made, it was found that the understanding of the five students increased by 12%.

$$Testing_{result(2)} = Mean\ of\ post_{test} - Mean\ of\ pre_{test}$$

$$Testing_{result(2)} = 80\% - 68\%$$

$$Testing_{result(2)} = 12\%$$

3. Hybrid Learning Methods (Conventional method and e-learning method)

Learning uses the teaching method by the teacher and the e-learning method. Pre-test does carry out before learning from teachers and using application-based e-learning on science subjects and 5 participants from grade 3 in elementary schools. Learning is carried out by the teacher's explanation first, then learning methods using e-learning-based applications.

The implementation of learning at the initial stage is the same, where the participants conduct an early-stage test on the participants doing a pre-test. After conducting the pre-test, a science subject teacher explains a particular material, and also participants used e-learning-based learning methods. After learning science subjects, the participants were tried again as a post-test to work on the e-learning-based application questions. The test results of stages do show in Figure 4.
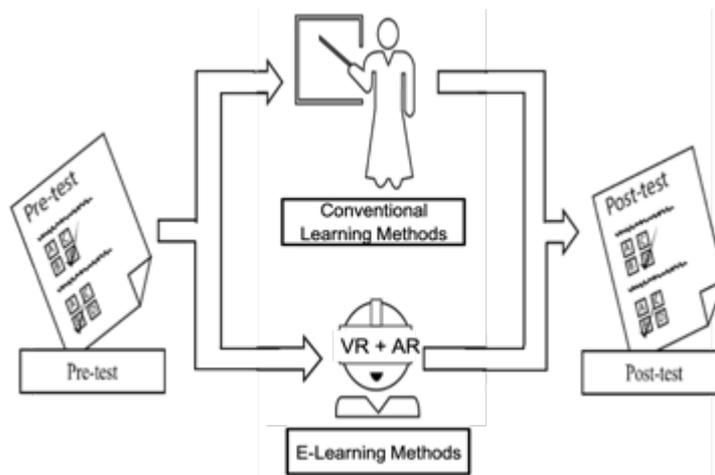

Figure 4. Hybrid Learning Methods

Table 3 shows the pre-test and post-test results of the five participants in the learning test with the application and teacher's explanation.

Table 3. Results of Hybrid Learning Methods

Participants	Score	
	Pre-test	Post-test
F	40	100
FR	60	80
SA	80	100
MF	80	100
SH	60	60
Average	64%	88%

The learning simulation test, as in Table 3, has increased in the five participants. The calculation does carry out as follows. Based on the calculations carried out, an increase in understanding of the five students do obtain by 24%.

$$Testing_{result(3)} = Mean\ of\ post_{test} - Mean\ of\ pre_{test}$$

$$Testing_{result(3)} = 88\% - 64\%$$

$$Testing_{result(3)} = 24\%$$

Discussion

This study aims to determine the interrelated factors between interest in learning and learning motivation in students with science subjects in grade III elementary school. Based on Karina et al. (2017) and Awe & Benge (2017) research, students' interest in learning science is an internal factor. Besides, educators' difficulties in the teaching process and the level of understanding of students on the material described by the teacher do trigger by learning interest. Explanation of material without the existence of media or teaching aids so that the material's delivery becomes a factor that influences student learning interest which results in poor student learning outcomes. So it takes an external factor in the form of learning media that can provide learning motivation to students for science subjects. Januarisman & Ghufron (2016) stated that learning media is a web-based learning application for science subjects using CMS (Content Management System) software. The result of the analysis by Setyawan et al. (2019) and Oktaviani et al. (2019) researched the influence of learning motivation using Augmented Reality as a learning medium on student interest in science subjects.

This study proposes and utilizes VR and AR technology to use as a learning medium propose increase students' interest and motivation in learning and a visual aid as a teaching medium by educators.

The author carried out the design stage of an e-learning based learning application that operates on the Android platform. The design uses a navigation structure that can connect different work processes. The e-learning based learning application builds using unity software, and the flow does determine as a navigation structure applied in the application. The navigation structure of the e-learning based learning application is in the form of a hierarchy.

Figure 5 shows the appearance of the main menu page, which displays menus at level 1 based on the navigation structure of the e-learning based learning application. The Start button (see Figure 5.a) do use to enter the e-learning-based learning menu page. The Help button does use to enter the help menu page. Figure 5.b looks like it shows how the Help page of the learning application. The help button contains help and how to use this application, and there is a button that does use to return to the main menu page. The About button do use to enter the about menu page. For information about e-learning based learning applications in Figure 5.c shows the About page display of the learning application, in the about menu appearance, which contains a simple description of the learning application and a button used to return to the main menu page.

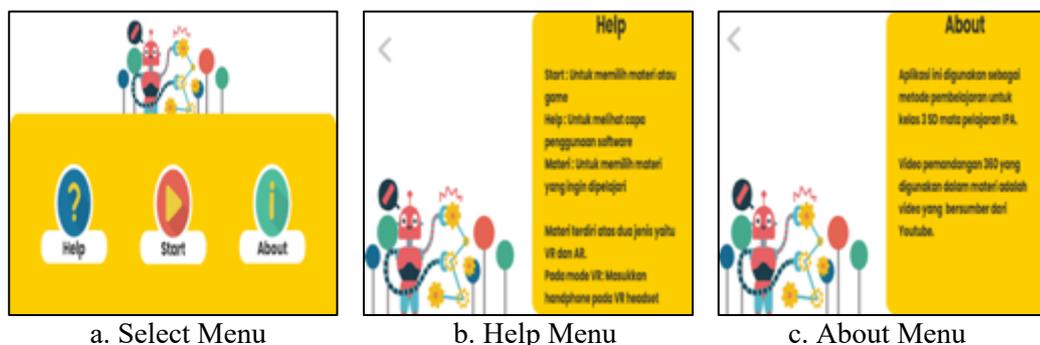| a. Select Menu | b. Help Menu | c. About Menu |

Figure 5. The screen displays the Main Menu

When selecting and pressing the Start button, a new layer will appear (a. Choice of Material and Game Menu b. Choice of material to be studied

Figure 6.a) where the Material button enters the e-learning-based subject matter menu page. Simultaneously, the Game button uses puzzles and guessing pictures to enter the game menu page. The game is related to science subjects in grade 3 elementary school.
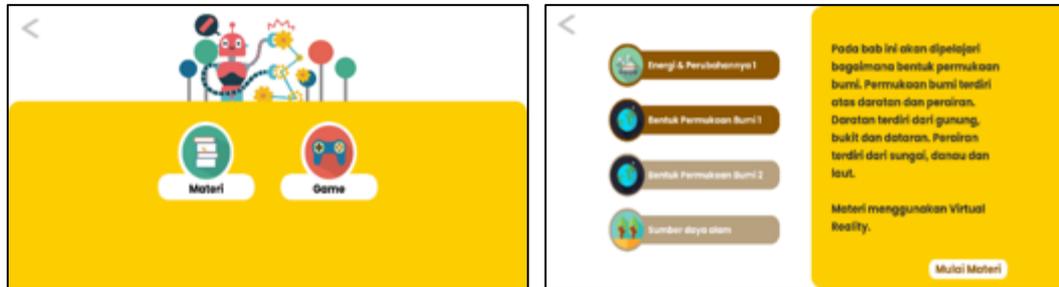
a. Choice of Material and Game Menu   b. Choice of material to be studied

Figure 6. Screenshots of the Start Menu and e-learning Materials

There are four buttons used to select the material and a button used to enter the selected material. A panel uses to provide a simple description of the material to be studied. E-learning-based learning for science subjects can be of interest to students; one of the materials about moving objects is demonstrated by utilizing Virtual Reality technology and equipped with a voice as a narrative for each selected learning material. Material selection can take by selecting the subject matter shown in Figure 6.b. The topic of learning about moving objects based on events when falling, hovering, bouncing, and others can see in VR shown in Figure 7.a. Meanwhile, e-learning-based learning about the material on the introduction of lakes, mountains, evidence, sea, and others shown in Figure 7.b. shows the appearance of the Material menu page of the learning application. It takes a VR Glass or VR Box tool to see the Virtual Reality results and install them, as shown in Figure 7.c.

a. Learn about moving objects   b. Learn about Nature

c. Illustration using VR Glass

Figure 7. Display of e-learning utilizing Virtual Reality technology

E-learning-based learning with Augmented Reality (AR) technology is a learning method that can increase students' interest and motivation to learn. AR technology requires a camera device that can capture cover images of science subject books (see Figure 8.a). The image is used to trigger an AR result by detecting points or lines from the camera's get a marker image. Figure 8.a is the cover image in the science textbook for grade 3. The image will function as a marker detection; the earth's surface object as AR will appear right above the marker/image (see illustration Figure 8.b). When an object that appears does touch on the smartphone screen, each part of the earth's surface will produce an image of the selected object, such as lakes, hills, mountains, Etc. In AR, there is also an explanation of the part of the earth's surface touched on the screen. For example (Figure 8.c), the user presses the lake part of the object; then, the AR will speaking a sound explaining the lake's description and definition accompanied by an example of a lake image.
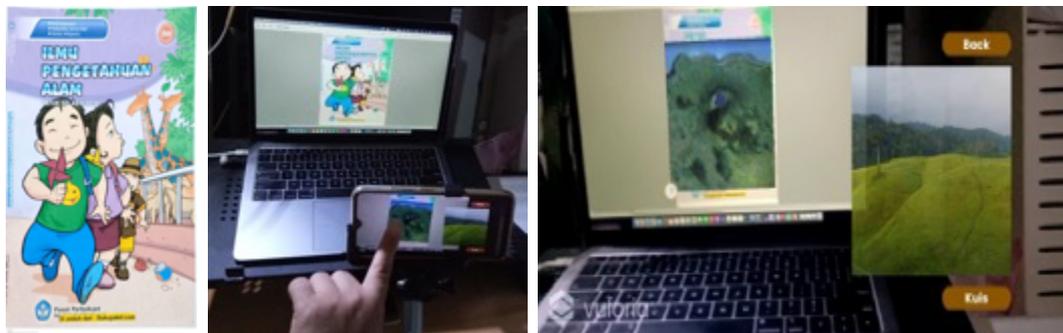
a. Marker   b. AR demo illustration   c. E-learning with AR
Figure 8. Display of e-learning utilizing Augmented Reality technology

The examination process on the application does carry out after studying a science subject. Each material will work on the exam totaling ten questions. The emergence of the questions will do carried out randomly, so the questions would not appear simultaneously as the test takers. The time limit for answering each question is enforced for 30 seconds per exam question, shown in the upper right corner in Figure 9.a. There are four buttons and a panel for the answer options for each question. Whereas Figure 9.b shows the test results based on the score of the quiz or exam that was done.
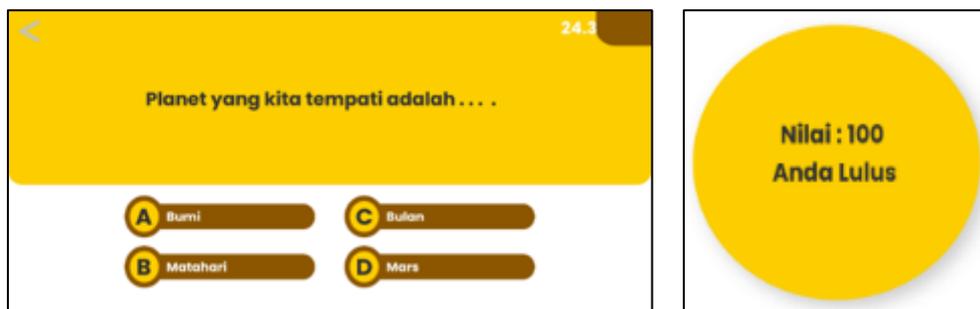
a. Questions for the examination of each topic   b. test scores
Figure 9. Displays the questions and the results of the scores obtained

In addition to learning material in science subjects utilizing VR and AR technology, Figure 10.a shows the learning application's Game menu page display. There are two buttons. The Puzzle button is used to enter an image cut into pieces arranged to find a particular image object (Figure 10.b). There is also a 2nd button, namely, a button to

guess a correct image based on the question. Figure 10.c shows another Game menu page display, where there are four images as an image to be selected, the one with the correct answer.

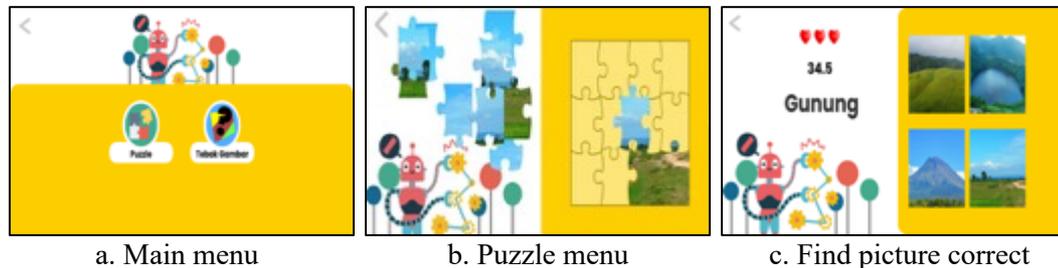| a. Main menu | b. Puzzle menu | c. Find picture correct |

Figure 10. Display on Game Menu

CONCLUSION

Using learning during the Covid-19 pandemic by utilizing Virtual Reality (VR) technology and Augmented Reality (AR) on science subjects in grade 3 in elementary schools has a direct impact on learning. The use of e-learning-based learning applications in the learning process accompanied by teacher explanations in the learning process showed an increase in understanding by 24%. The main factor connected between learning interest and learning motivation will be learning new concepts using the e-learning method.

It is necessary to do experiments and improvements in learning content on other materials and subjects and increase interest in learning and be easily understood by students.

CONFLICT OF INTEREST

There is no conflict between the author, manager of the journal, and the place of research during the registration process, review, until publication.

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