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Developing an Augmented Reality Application as Instruction Media to Help in Learning the Solar System

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ABSTRACT

The purpose of this study was to develop an application to help in learning the solar system by using Augmented Reality (AR) technology. In the era where technology is very developed, the learning about the solar system can be made more interactive by providing 3D illustrations to the students. One of the technologies that can be applied to support the development of educational applications to help in learning the solar system is AR technology. It can create 3D illustrations. The study is the Research and Development (R&D). The research produced an AR-based solar system introduction application. This application can be used as a learning media for students. The developed AR application was tested using alpha and beta testing. The alpha testing was the marker accuracy testing and black-box testing, while the beta testing was done by distributing questionnaires to 30 respondents and then doing validity and reliability test. This study produced an AR application to help in learning the solar system. The black-box testing showed that the AR application in general was functioning well. The marker accuracy testing showed that the AR camera succeeded in scanning markers up to 25% of the marker area. The data obtained from distributing questionnaires was processed to know the validity in terms of the attractiveness and the effectiveness, and the results showed the data was valid. Moreover, the reliability testing was carried out with Cronbach's alpha, and the result was 0.771 for the attractiveness aspect and 0.742 for the effectiveness aspect. These values mean that most of the beta testers agree that the AR application was an attractive and effective.

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1. INTRODUCTION

The solar system is one of the instructional materials in the elementary school in science classes. The solar system is a system consisting of the sun and the celestial bodies that revolve around it. Generally, when delivering instructional materials of the solar system, teachers use pictures. The process of delivering instructional materials in science classes, especially on the topic of the solar system, really needs instructional media to help in providing real experience to students because if teachers deliver the instructional materials in the form of stories, it will certainly make students only memorize the materials and cannot understand the real solar system. The solar system is one of the instructional materials in science classes in elementary and junior high schools [1], [2].

In an era where technology is very developed, the method of delivering instructional materials of the solar system is not only in the form of images, but technology enables instructional materials to be more attractive so that students are expected to have better understanding of the solar system. With technology, especially augmented reality technology, the instructional materials of the solar system such as the images of planets and the process of orbital revolution can be displayed in 3D.

AR technology is a technology that combines 2D or 3D computer-generated objects with the real-world environment. With AR technology, users can generate new perceptions that allow them to interact with virtual objects in the real-world environment [3], [4]. The use of AR in learning has been developed such as to help in learning instructional materials about fish [5], biology [6] and chemistry [7].

There are many studies conducted on the use of AR in education and industrial world. For example, the study conducted by Tresnawati produced an application to help in learning the solar system. By using AR technology, the developed application enabled the users to see images on cards in 3D. To see the 3D images, the users pointed their phones to a card to capture a planet marker, and then the users saw a 3D image on their smartphone screen in real-time [8].

The study conducted by Paramita analysed several articles on the use of AR technology in nutrition education. The study showed that AR technology received a very good rating from the respondents because it was very useful and made the users more quickly understand and remember the material in nutritional learning [9]. Another study that uses AR technology to help in learning is the study conducted by Borisaova [10]. The study concluded that an AR application was useful to help in learning fashion study. Miundy [11] conducted a study on the use of AR technology to help in learning mathematics. Osman [12] developed an AR application to help in learning computer assembly. Daineko [13] developed an AR application to help in learning physics. Other studies are [14], [15], and [16].

The use of AR technology is not only used to help in learning instructional materials for students but is also used in the fields other than education. The study conducted by Haryani [17] investigated the use of AR technology to help museum visitors in exploring the collections of the Indonesian Cryptology Museum in the city of Yogyakarta. With this application, the visitors can see the collections in 3D in real time and interact with the collections interactively in the real-world environment.

The study conducted by Fahmi developed an AR application that can be used to assist consumers in viewing car products at an auto show. This application can be install on a smartphone and it can display a car product with a variety of different features in real-time. The AR application development was used the software of Vuforia and 3D Unity [18].

The study conducted by Chiu [19] developed an AR application to help tour guides in understanding knowledge about the culture of Dalongdong, Taipei, Taiwan. Another study on the used of AR technology in the tourism sector was conducted by Meily [20]. She developed an AR application to support the tourism in the Taman Ayun Temple, Bali. Other studies on AR application development in tourism sector were conducted by Bhatt [21] and Tahyudin [22].

Along with the development of AR technology, an AR application can display information visually in 3D of instructional materials or any information. The researchers found that there were disadvantages in learning the solar system by only using textbooks. The disadvantages were that students only memorized the solar system instructional materials and had difficulty visualizing the orbital revolution. This study produced an AR application to help in learning the solar system, so it is necessary to have an application that can describe the solar system in animation or 3D.. The AR application developed can be an alternative for elementary school students in learning. With this AR application, it is expected that it can help students understand the instructional materials of the solar system. Students can see how the planets revolve around the sun, so students are interested and do not get bored quickly in learning, and students can understand the instructional material of the solar system better.

2. RESEARCH METHOD

This study is Research and Development (R&D). The study aimed to develop an AR application to help in learning the solar system. The researchers developed this application as instructional media to support teaching and learning process about the solar system, and this application is expected to make the students get better understanding on the solar system. The researchers carried out some stages that were Analysis, Design, Development, Implementation, and Evaluation (ADDIE). The figure 1 presents the stages in conducting this research.

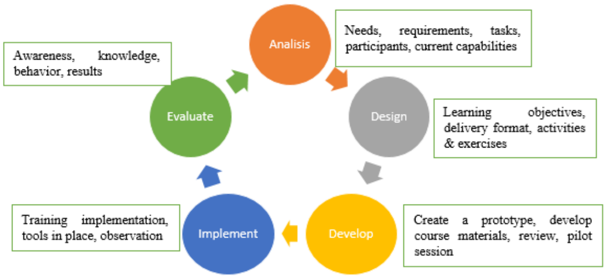

Figure 1. The research stages

3. RESULTS AND DISCUSSION

3.1. Marker Based Tracking

In AR technology, one of the ways to bring up virtual objects is by using a marker. The method is commonly known as marker based tracking. A marker is a 2D object that has a pattern that can be read by a computer through a webcam or a camera connected to a computer, and it is usually a black and white image with a thick black border and white background [23]. A marker is an image that has to be scanned by a camera to display 3d virtual objects. The figure 2 is a collection of markers on a brochure.

Figure 2. A collection of markers on a brochure to bring up virtual objects of the solar system

To bring up the virtual objects, the users have to scan one of the markers through a camera, and the AR application will detect it. If the scanning process is correct, the AR application will bring up the 3d virtual objects. The figure 3 presents the process of bringing up the 3D virtual objects by using an AR application.

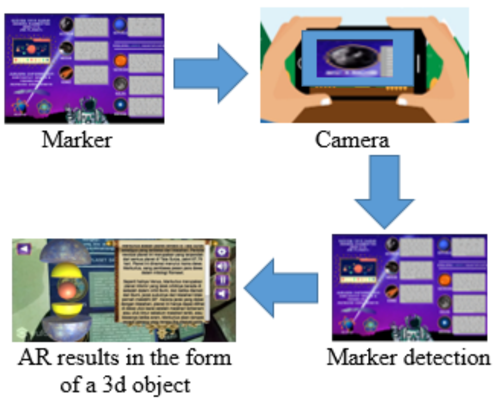

Figure 3. The process of bringing up 3D virtual objects by using an AR application

3.2. Database Design

The database design used in the development of the AR application was used to store images of the markers. The table structure was implemented in Vuforia. The figure 4 was the table contents in the database designed in Vuforia.

Target Name	Type	Rating	Status	Date Modified
cover	Single Image	★★★★★	Active	May 02, 2021 11:50
meteor	Single Image	★★★★	Active	May 02, 2021 11:49
bulan	Single Image	★★★	Active	May 02, 2021 11:48
asteroid	Single Image	★★★★	Active	May 02, 2021 11:47
komet	Single Image	★★★	Active	May 02, 2021 11:46
jupiter	Single Image	★★★	Active	May 02, 2021 11:44
neptunus	Single Image	★★★★	Active	May 02, 2021 11:40

Figure 4. Database in Vuforia.

3.3. Menu Page Display

On the main menu page, the users can select the menu they want to access. The users can access the AR Camera menu by pressing the AR Camera menu to start scanning markers. The users can press the Video menu to see the types of planets. The figure 5 is the main menu page display of the AR application.

Figure 5. The Main Menu Page Display.

3.4. AR Camera Menu Page Display

On the ARCamera menu page, there is an automatic rotation feature. This feature allows the users to see virtual objects rotating that appear when the users scan the markers on the brochure. The users can scan the a marker on the brochure to see the 3D virtual objects. The users will see a 3D object and an information button. If the users click the information button, the application will provide more detailed information on 3D objects in the form of animation, audio and text. The 3D virtual objects and information in forms of audio and text will appear if the ARCamera successfully scans the markers on the brochure that match the markers in the database. An example of the ARCamera menu page display is presented in the figure 6.

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Figure 6. the display of the 3D objects that appear if the users choose the ARCamera menu and then scan a marker on the brochure

3.5. Application Testing

3.5.1. Marker Accuracy Test

The marker accuracy test is a test conducted by scanning the markers in several sizes of marker area. To scan the marker, the users use the ARCamera feature. The table 1 presents the results of scanning the markers with different distances between the camera and the markers, and the table 2 presents the results of scanning the markers with different sizes from 100% to 5%.

Table 1. The results of scanning the markers with different distances between the camera and the markers

No	Distance from the Camera to Markers (cm)	Results
1	1-10	Can display the objects
2	11-20	Can display the objects
3	21-30	Can display the objects
4	16-40	Can display the objects
5	41-50	Can display the objects
6	51-60	Can display the objects
7	61-70	Can display the objects
8	71-80	Can display the objects
9	81-90	Can display the objects
10	91-100	Can display the objects

Table 2. The results of scanning the markers with different sizes

No	Marker sizes (%)	Results
1	76- 100	Can display the objects
2	51-75	Can display the objects
3	26 50	Can display the objects
4	11- 25	Can display the objects
5	5-10	Cannot display the object

3.5.2. Black-box testing

The alpha testing on the AR application was also carried out by applying the black-box method. The black-box method is testing the functionality or usability of an application. The table 3 presents the results of the black-box testing.

Table 3 The results of the black-box testing.

Test Case	Expected results	Test results
Pointing the ARCamera at the Sun marker	The first 3D object and information button appears	According to plan
	A second 3D object appears along with information in the form of audio and text	According to plan
Pointing the ARCamera at the Mercury marker	The first 3D object and information button appears	According to plan
	A second 3D object appears along with information in the form of audio and text	According to plan
Pointing the ARCamera at the Venus marker	The first 3D object and information button appears	According to plan

	A second 3D object appears along with information in the form of audio and text	According to plan
Pointing the ARCamera at the Earth marker	The first 3D object and information button appears	According to plan
	A second 3D object appears along with information in the form of audio and text	According to plan
Pointing the ARCamera at the Mars marker	The first 3D object and information button appears	According to plan
	A second 3D object appears along with information in the form of audio and text	According to plan
Pointing the ARCamera at the Jupiter marker	The first 3D object and information button appears	According to plan
	A second 3D object appears along with information in the form of audio and text	According to plan
Pointing the ARCamera at the Saturn marker	The first 3D object and information button appears	According to plan
	A second 3D object appears along with information in the form of audio and text	According to plan
Pointing the ARCamera at the Neptune marker	The first 3D object and information button appears	According to plan
	A second 3D object appears along with information in the form of audio and text	According to plan
Pointing the ARCamera at the Uranus marker	The first 3D object and information button appears	According to plan
	A second 3D object appears along with information in the form of audio and text	According to plan
Pointing the ARCamera at the Moon marker	The first 3D object and information button appears	According to plan
	A second 3D object appears along with information in the form of audio and text	According to plan
Pointing the ARCamera at the Star marker	The first 3D object and information button appears	According to plan
	A second 3D object appears along with information in the form of audio and text	According to plan

3.5.3. Beta Testing

Questionnaires were distributed to 30 respondents to assess the attractiveness and the effectiveness of the AR application. Both aspects were measured using a Likert scale. The results were tested for validity and reliability. The results of respondents' answers to the question of whether the Solar System AR application design is attractive, 15 (50%) respondents answered strongly agree, 13 (43%) respondents answered agree and 2 (7%) respondents answered disagree. The question of whether the delivery of information on the solar system AR application is interesting, as many as 21 respondents (70%) answered strongly agree, 9 respondents (30%) answered agree. The question of whether the 3D display on the AR Planet application is interesting, as many as 22 respondents (73%)

answered strongly agree, 8 respondents (27%) answered agree and the question whether the solar system AR application made more interested in obtaining more detailed information was 17 respondents (57%)) answered strongly agree, 13 respondents (43%) answered agree.. The figure 7 presents a graph of the results of the questionnaire on the attractiveness of the application.

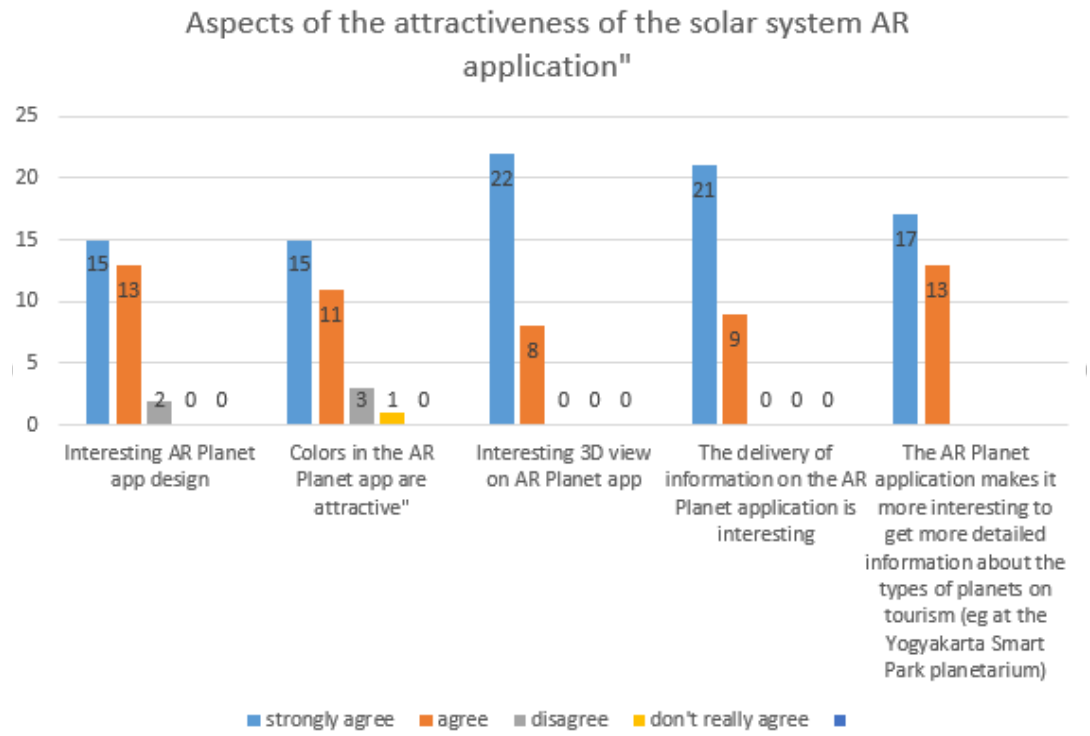

Figure 7. The graph of the results of the questionnaire on the attractiveness of the application

The results of the graph above were tested for validity and reliability with SPSS, and the results of these tests are shown in the table 4.

Table 4 The Validity of the Application Attractiveness data

Correlations								
		Item_1	Item_2	Item_3	Item_4	Item_5	Skor_Total
Item_1	Pearson Correlation	1	.316	.548**	-.099	.394*	.555**
	Sig. (2-tailed)		.089	.002	.604	.031	.001
	N	30	30	30	30	30	30
Item_2	Pearson Correlation	.316	1	.485**	.468**	.683**	.861**
	Sig. (2-tailed)	.089		.007	.009	.000	.000
	N	30	30	30	30	30	30
Item_3	Pearson Correlation	.548**	.485**	1	.428*	.554**	.768**
	Sig. (2-tailed)	.002	.007		.018	.001	.000
	N	30	30	30	30	30	30
Item_4	Pearson Correlation	-.099	.468**	.428*	1	.494**	.616**
	Sig. (2-tailed)	.604	.009	.018		.006	.000
	N	30	30	30	30	30	30
Item_5	Pearson Correlation	.394*	.683**	.554**	.494**	1	.839**
	Sig. (2-tailed)	.031	.000	.001	.006		.000
	N	30	30	30	30	30	30
Skor_Total	Pearson Correlation	.555**	.861**	.768**	.616**	.839**	1
	Sig. (2-tailed)	.001	.000	.000	.000	.000	
	N	30	30	30	30	30	30

4. CONCLUSION

The AR application can be one of the instructional media to help in learning the solar system. With the AR application, students study the instructional materials in the forms of 3D images. To use the AR application, students do not need internet connection. To use the AR application, students must have a brochure that contains some markers. The brochure also contains information of each planet, and when students scan the markers with a camera, on their smartphone appears an image of a planet in 3D.

The developed AR application was tested using alpha and beta testing. The alpha testing was the marker accuracy testing and black-box testing, while the beta testing was done by distributing questionnaires to 30 respondents and then doing validity and reliability test. This study produced an AR application to help in learning the solar system. The black-box testing showed that the AR application in general was functioning well. The marker accuracy testing showed that the AR camera succeeded in scanning markers up to 25% of the marker area. The data obtained from distributing questionnaires was processed to know the validity in terms of the attractiveness and the effectiveness, and the results showed the data was valid. Moreover, the reliability testing was carried out with Alpha (Cronbach) calculations, and the result was 0.771 for the attractiveness aspect and 0.742 for the effectiveness aspect. These values mean that most of the beta testers agree that the AR application was an attractive and effective application.

The development of research results can focus more on 3D that is more realistic so that it can describe like real reality and be equipped with 3D from other solar systems.

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