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Augmented Reality for Solar System Learning

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Abstract

Along with the rapid development of smartphones and the absence of Solar System learning media in the case study of SMPN 3 RAMPI, for this reason, research, and development of Augmented Reality (AR) for Solar System Learning were made to make Android-based smartphones a media for learning the Solar System using Augmented Reality Technology and introducing Augmented Reality technology to students. The research method is the Research and Development (R&D) method with the ADDIE (analysis, Design, Development, Implementation, evaluation) development model. The results of this study are: (1) This learning application is made using Blender software, Unity, and the Vuforia database, which helps facilitate the development process; (2) This learning application can already be applied in research locations and used as learning media that are more effective, efficient, and interactive so that they can help increase students' interest in learning; (3) The results of the application feasibility test questionnaire with usability-based questions distributed to selected respondents get a score of 90%, which is converted according to the feasibility percentage table, then the application is declared very worthy.

1. INTRODUCTION

Augmented Reality is a technique that combines two-dimensional and three-dimensional virtual objects into a real three-dimensional sphere and then projects these virtual objects in real-time. With the help of tools such as smartphones or tablets with Android and iOS systems with the use of 3D world camera features designed with computer devices, it can be displayed as a popup object (Pamoedji and Maryuni, 2017).

Augmented Reality (AR) is a combination of virtual objects with natural objects. AR can be published for all senses, like hearing, touch and smell. Besides being applied in fields such as health, military, and manufacturing, augmented reality has also been applied in devices that many people use, such as smartphones, by taking advantage of the camera features available in almost all smartphones today. The primary purpose of augmented reality is to create a new environment by combining the interactivity of real and virtual environments in real time so that users feel that the environment created is natural (Susanna Dwi Yulianti Kusuma, 2018). Because of this concept, AR is considered suitable if used as one of the learning media, especially in the material of the solar system.

Learning the solar system is found in science lessons (Natural Sciences) which is a material that elementary school students must know, based on the core competencies of science subjects for SD/MI Class VI Curriculum 2013, that teachers must be able to explain the solar system and the characteristics of members Solar System (Permendikbud, 2018). Natural Science (IPA) is necessary for grade 6 elementary school students, especially in introducing the Solar System. In learning about the solar system, students are invited to get to know the planets, which indirectly invites students to imagine what the conditions are like in the Solar System or look through pictures (Sartika, Y., 2016). However, after knowing the importance of solar system material for students, it turns out that the current learning media for Solar System material is still very minimal, as well as the lack of student response because the teacher has difficulty in explaining the Solar System material (Tresnawati, 2017). In the current system, incredibly remote areas that the internet network has not reached, students only know what the solar system is from textbooks obtained from schools.

Books used in learning the solar system, of course, display pictures of objects from members of the solar system, but to get to know the solar system, it would be better to use props such as planets, the sun and other

objects as a supporting tool so that they can better absorb lessons solar system (Toufan Diansyah Tambunan, 2016).

In line with that, the Global Education Census concluded that Indonesian students are the world's most significant users of technology. Data shows that more than 67% of Indonesian students use smartphones to learn, and 81% more often do homework using smartphones (Global Education Census Report, 2018). Although the use of smartphone is very much in students' activity, the use of AR mobile applications as learning tools is not widespread among teachers (J. Mota et al., 2018).

AR technology can be applied as a learning medium for introducing the solar system to help users get information about the solar system more excitingly by using technology. As it is known that the interest in reading books in Indonesian children is shallow, only 0.01% or around 10,000 people, with the help of technology is expected to increase the number of book readers, especially children. Mobile device technology has become part of the life of modern society. Both young and old cannot be separated from their smartphones (Erlan Darmawan, 2018).

The use of AR technology in the field of education is certainly one example of the entry of the world of education in the 4.0 era where Education 4.0 is a phenomenon that responds to the needs of the fourth industrial revolution, where humans and machines are aligned to find solutions, solve problems and, of course, find innovation possibilities. Primary education to higher education, adapting the educational curriculum to the challenges and needs of the current era. A curriculum allows millennials to gain knowledge and training to become competitive and productive workers (Herman et al. l, 2016).

In the world of education, the development of information technology began to be felt to have a positive impact because the development of information technology and the world of education began to show significant changes (Ismail A at all, 2019). This is important because A good learning process must include interaction, fun, challenge, and motivation and provide space more for students to increase creativity and independence according to their talents and interests of students (Mustaqim I, 2017). But although the world of education has developed very well from time to time, this progress is not supported by the progress of Human Resources (HR) that can be aligned with each other (Fitriah D, 2019).

HR like this is also found in SMP 3 Rampi as a school located in a remote area that does not yet have an internet connection. However, even though it is a remote area, most of the community, both students and teachers, are already intense in using smartphones, so it is very appropriate if they make Augmented Reality (AR) technology a reality.

2. METHOD

2.1 Research and Development Procedur

This study uses a research and development (R&D) approach. R&D is used to produce certain products and can produce products used for needs analysis and curriculum research (Hanafi, 2017). The ADDIE (Analysis, Design, Development, Implementation, evaluation) is used as a development model. This method, in its use, has organized, orderly, and systematic stages to achieve the desired results.

The primary purpose of this development model is to design and develop an effective and efficient product (Benny A. Pribadi in WuIandari, 2018). This model consists of five steps, namely: (1) analyze, (2) design, (3) development, (4) implementation, and (5) evaluation (Widyastuti. E, 2019). Each step is explained as follows:

a. Analysis
   The first stage is, of course, the analysis stage; at this stage, what is being done is to identify what problems will be faced and what systems are suitable for solving these problems. At this stage also carried out the collection of data needed in the development of the system to be made.

b. Design
   The second stage after the analysis is the design stage, and this stage is the same as making a basic sketch. After identifying the problems that will be faced, the system design is carried out by solving problems that have been analyzed based on the data obtained. All preparations or designs must be clear and correct at the design stage.

c. Development
   After the design stage is complete and precise, the next stage is the development of the system, which has been analyzed in the analysis stage and designed in the design stage. This stage is the stage of

realizing the system sketch made at the design stage.

d. Implementation
The implementation stage can be referred to as the actual work stage. This means that the system that has been developed is applied at this stage.

e. Evaluation
The final stage in the ADDIE development model is the evaluation stage, carried out by checking or testing. This evaluation stage aims to see how the system works, and whether the system has been running well and has been as expected or not. At this evaluation stage, it assesses the system that has been made to produce revisions which will then be used as material for improvement.

2.2 Data Analysis Technique

Data analysis was carried out based on the results of questionnaires distributed to several selected respondents where each question on the questionnaire has its weight according to the provisions. The questions in the questionnaire are certainly related to the usability aspect of learning applications using Augmented Reality technology. The format used in this questionnaire also refers to the usability format, which is a quality attribute describing how easy it is to use an interface (Jacob Nielsen in Supriyatna 2018). The data from the questionnaire test with the usability format is then calculated based on the calculation formula:

$$Eligibility\ Percentage = \frac{overall\ score}{maximum\ score} x\ 100\%$$

The percentage of the calculation results using the above formula is then converted into a statement according to the following interval percentage table (Laswi A.S et all, 2022).

Table 1. *Percentage Range Interval*

No.	Percentage Interval	Criteria
1.	0% - 25%	Extreamly not worthy
2.	26% - 50%	Not worthy
3.	51% - 75%	worthy
4.	76% - 100%	Very worthy

3. RESULT AND DISCUSSION

3.1 Analisys

At this stage, a problem analysis was carried out at the research location, as well as collecting primary data through interviews with schooltt principals, teachers, and students. The results of the interviews that have been conducted include: 1) the learning process of solar system subjects at SMP 3 Rampi is only done verbally. 2) there are no learning media used in solar system subjects at the school, which means that a learning media is needed. 3)students' lack of interest in learning about solar system subjects. 3) the use of smartphones by students for the learning process has not been maximized, plus there is no cellular network or internet network. 4) Augmented Reality (AR) technology is still foreign and still unknown to almost all students and teachers at the research location.There are also secondary data in the form of learning materials by the curriculum used at the school; in this case, the material used is material on the solar system in science subjects (Natural Sciences) at the junior high school level and some material from the internet and relevant research that will be used in the development of learning applications using AR. From the results of this analysis, it was found that the solar

system material studied at the school would later be used as material for 3D solar system applications using Augmented Reality.

3.2 Design

The system description of augmented reality for learning the solar system is illustrated in the use case diagram that has been made (figure 1). The system description of this use case will be developed later. Then the sequence diagram will describe what the user can do with the menus/features available in the augmented reality application for learning the solar system; each menu is the tutorial menu (figure 2), quiz menu (figure 3), and the Scan menu or Augmented Reality markers menus (figure 4).

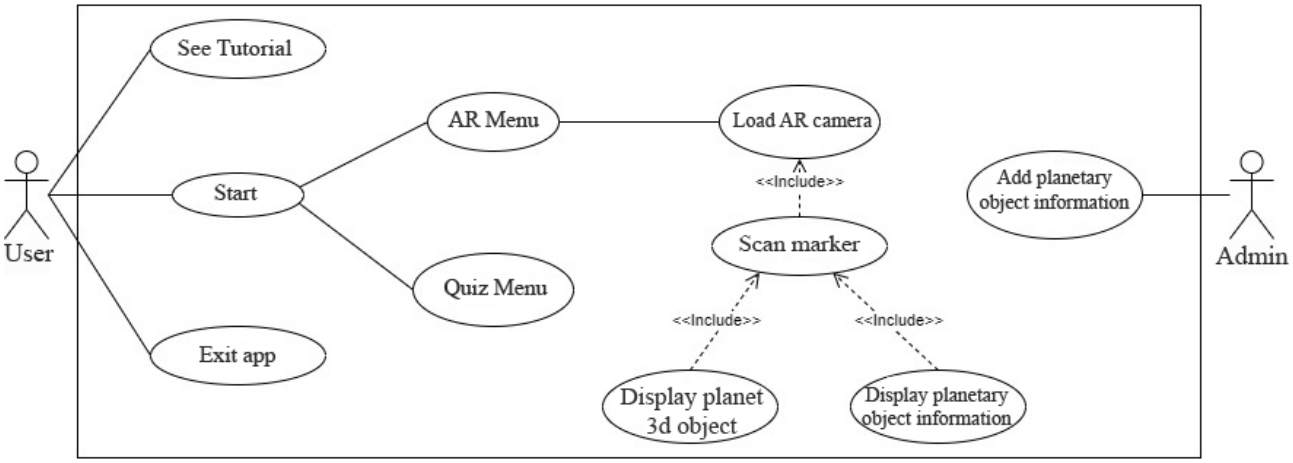


Figure 1 *Use case Diagram Augmented Reality for Solar System Learning*

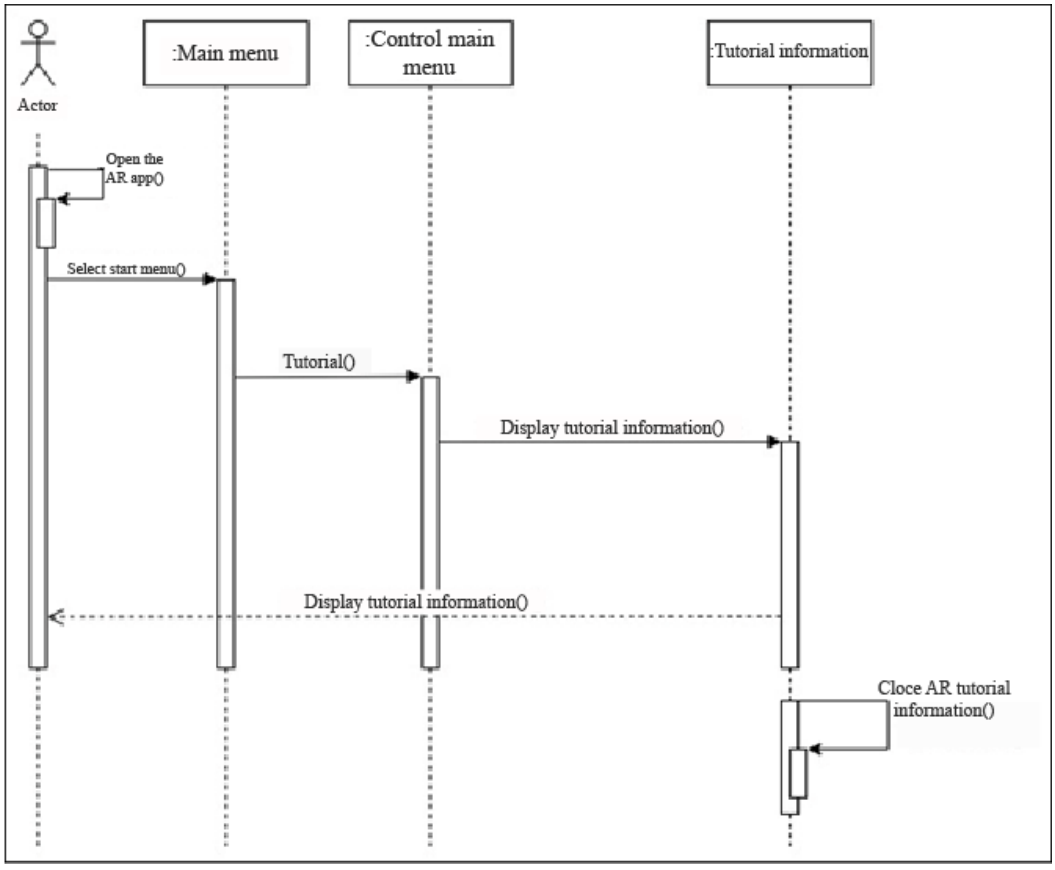


Figure 2 *Tutorial Menu Sequence Diagram*

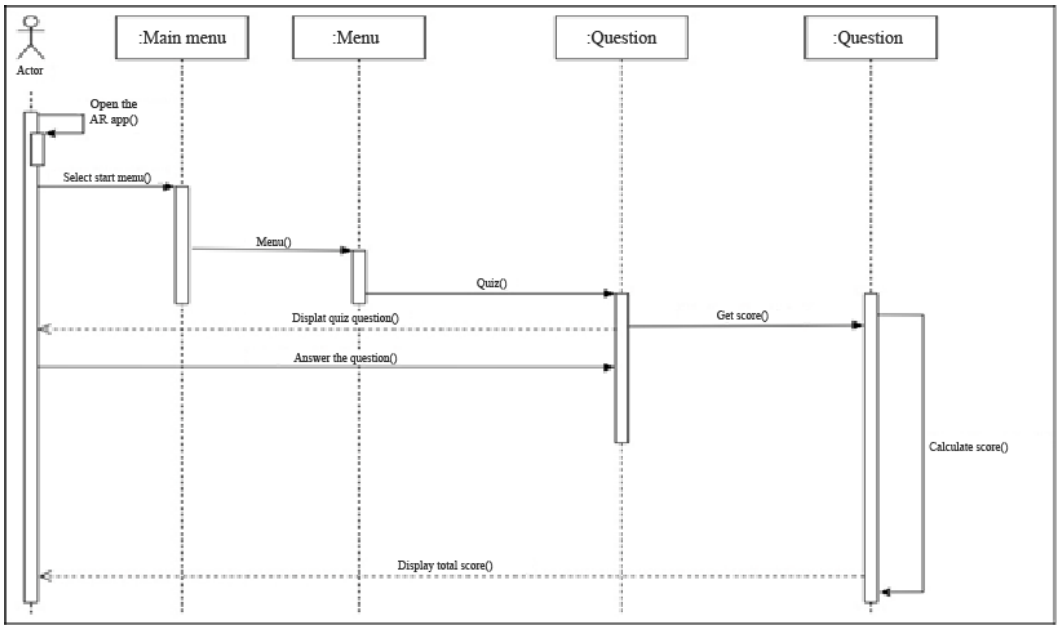


Figure 3 *Quiz Menu Sequence Diagram*

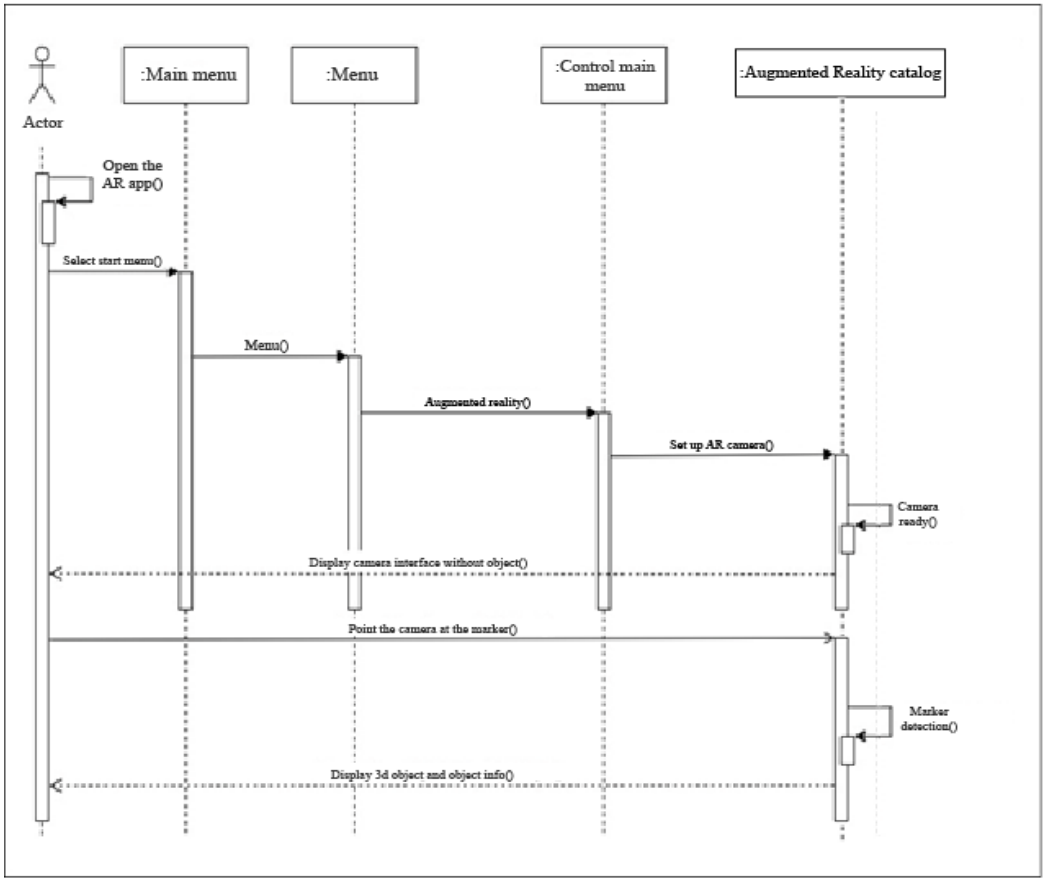


Figure 4 *Augmented Reality Menu Sequence Diagram*

After conducting interviews and direct observations, data was found in the form of several problems and solutions used to solve these problems using use cases and sequence diagrams. Then, a user interface display design was made, which can be seen in the figure below:

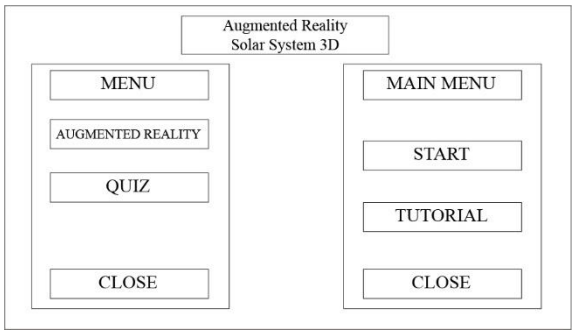


Figure 5 *Main menu*

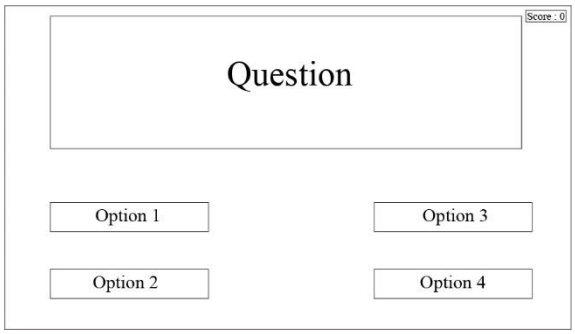


Figure 6 *Quiz menu*

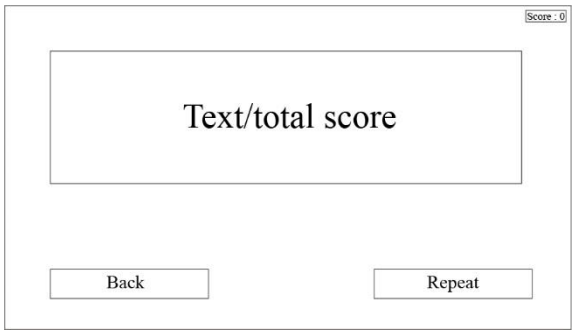


Figure 7 *Quiz menu (done)*

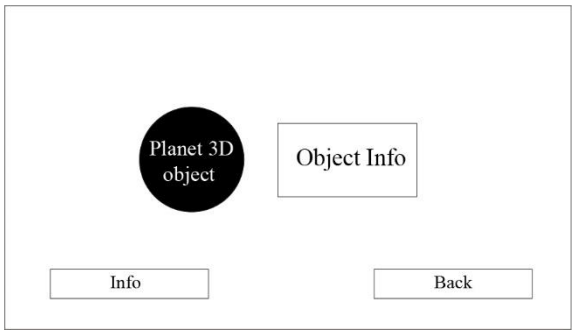


Figure 8 *Augmented Reality menu*

3.3 Development

The previously designed system is then developed using several software at this stage. For 3D models created using 3D Blender software, Blender is an open-source 3D computer software. This software creates visual effects, 3D models objects, video games, and 3D applications. Blender has features such as 3D modeling, texturing, and animation (Ardialis, 2019). Blender is a free and open-source 3D creation tool. Blender supports all 3D workflows, including modeling, rigging, animation, simulation, rendering, compositing and motion tracking, video editing, and game creation. Blender is very suitable for use by individuals as well as by small studios that are useful in 3D projects (Zebua T & Sinaga S). Blender is used to manufacture 3-dimensional planet objects apart from being free because it is straightforward and has all the tools needed to make 3-dimensional planet objects. The following is a display of a 3-dimensional planetary object created in 3D blender software:

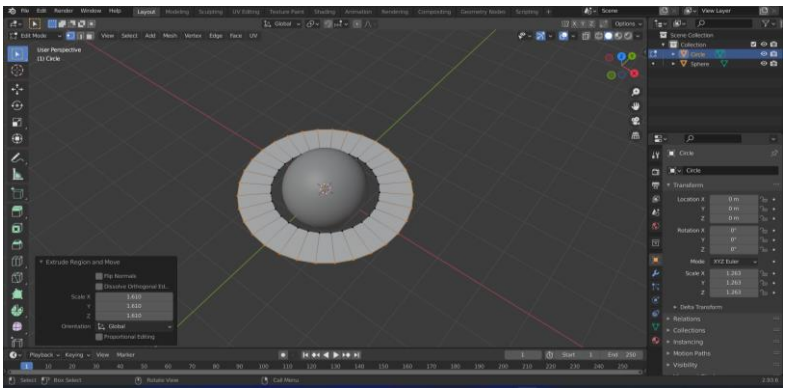


Figure 9 *3D Modeling in Blender 3D*

The user interfaces and Augmented Reality were developed using the Unity 3D software; Unity Co-founder and CEO 2013 revealed that Unity is a set of tools that can be used to build games with various technologies, including graphics, audio, physics, and interactions, and networking technologies. According to Helgason in (Irmanto 2018). Unity provides game development features on various platforms: Web, Windows, Mac, Android, iOS, Xbox, Playstation 3, and Wii. The agreement supports the creation of 2D and 3D games

but emphasizes more 3D. The programming languages used in Unity are JavaScript, C#, and BooScript programming languages (Rohmawati et all, 2019).The use of unity software in the development of AR applications for learning the solar system is based on the ability of the unity software to create user interfaces while presenting Augmented reality technology, which in its implementation is very easy to use. The following is the display of the user interface and the display when the user scans the marker to see the 3D object that has been created:

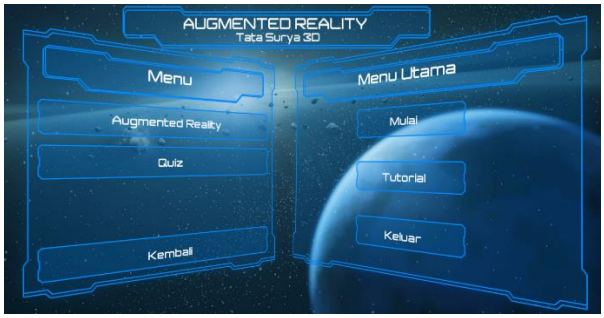


Figure 10 *Main menu*

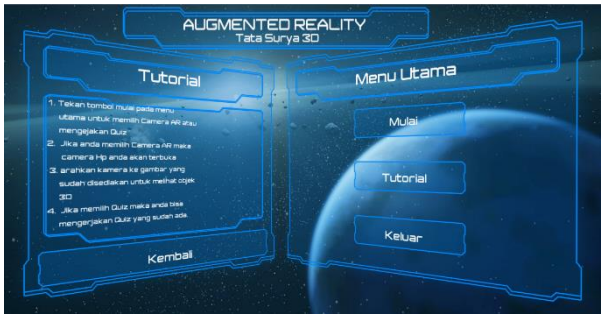


Figure 11 *Tutorial menu*



Figure 12 *Quiz menu*



Figure 13 *Augmented Reality menu*

Vuforia is an AR Software Development Kit (SDK) for mobile devices that enables the creation of AR applications. Vuforia SDK is also available to be combined with Unity, called Vuforia AR Extension for Unity. Vuforia is a Software Defelopment Kit (SDK) provided by Qualcomm to help developers create Augmented Reality (AR) applications on mobile phones (iOS, Android). The Vuforia SDK has been used in several mobile applications for both platforms (Puspitasari C et all, 2021).

Vuforia is Augmented Reality Software Development Kit (SDK) allows the creation or development of smartphone AR applications. Vuforia is an SDK provided by Qualcomm to help developers build and develop AR applications on the internet smartphones. besides that, vuforia also has many features and capabilities that can help developers realize developer thinking without limits. 3D world in real time (Ramadhan et all, 2021).

The development of AR applications for learning the solar system, the software is used as a database to store images and make these images as markers which will later be scanned using AR technology (figure 7). The software is Vuforia; this software is free and must be added to the Unity software to produce Augmented Reality applications that can run on mobile devices. Here is what the Vuforia database looks like:

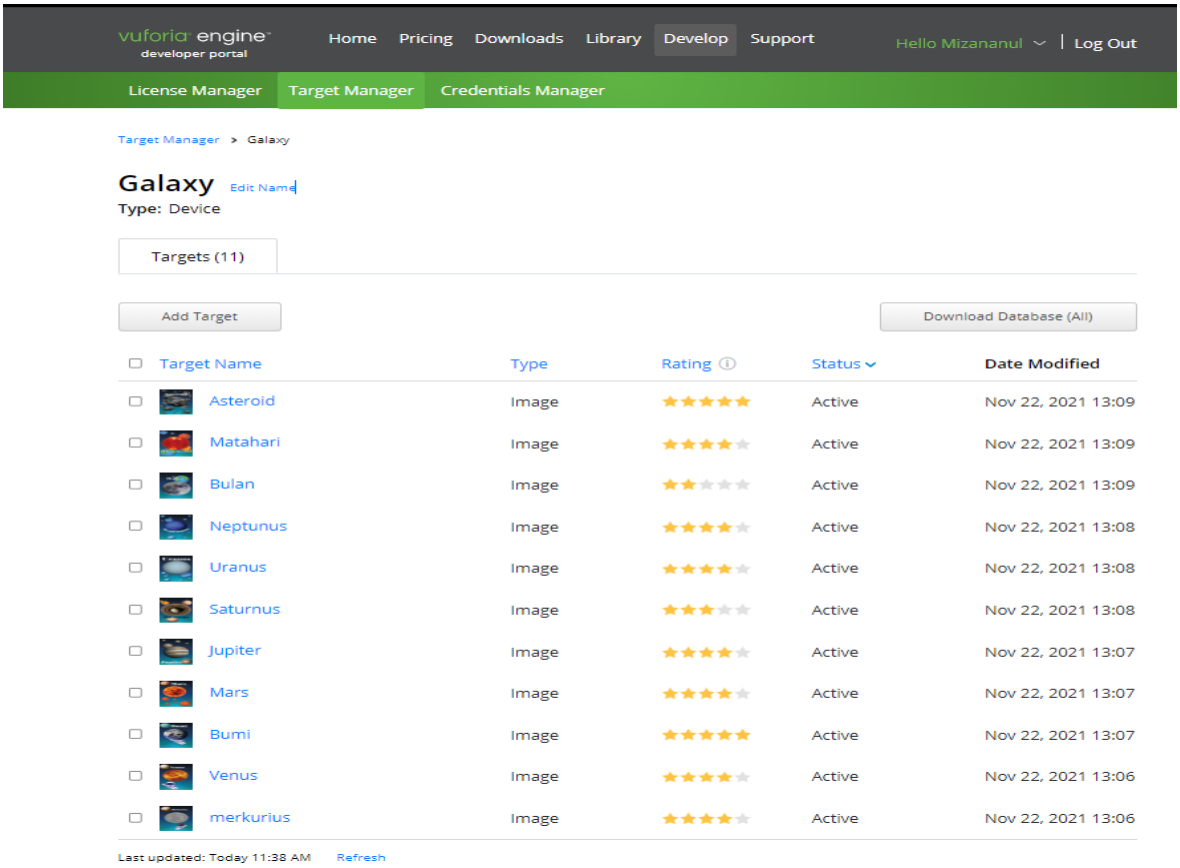


Figure 14 *Vuforia database*

3.4 Implementation

At the Implementation stage, the first thing to do is introduce what Augmented reality technology is. After the augmented reality application is installed on each student's and teacher's smartphone whit android platform, the learning process is carried out using augmented reality applications for learning the solar system. The learning process using augmented reality applications for learning the solar system between teachers and students runs smoothly; teachers and students are very enthusiastic when using the application; this is because they are experiencing and using AR technology added to the learning process of the solar system so far. Only use textbooks without other additional learning media.

3.5 Evaluation

After the implementation phase is complete, an evaluation is carried out using the previously described format. The weight of each question on the questionnaire that has been obtained and the results of the calculations are then displayed in the form of a table as follows:

Table 2. *Questionnaire calculation table*

respondent	indicator/variable																					Total Score	Max Score
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20	Q21	Q22		
1	4	4	4	4	4	3	3	3	3	4	3	3	3	3	4	3	3	4	3	3	3	3	74	88
2	3	3	3	3	3	3	3	3	4	3	4	3	3	3	3	3	3	3	3	3	4	4	70	88
3	4	3	4	4	4	3	3	4	4	4	4	4	4	3	4	4	4	3	3	4	3	3	80	88
4	3	4	3	3	3	3	4	3	3	3	2	3	4	3	4	3	3	4	3	4	4	4	73	88
5	4	3	4	4	4	4	4	4	4	4	3	4	4	4	4	4	4	4	4	4	3	4	85	88
6	4	3	4	4	4	4	4	3	4	4	3	4	4	4	4	4	4	4	4	4	4	4	85	88
7	4	4	4	4	4	4	4	4	3	3	3		4	4	4	4	4	4	4	4	4	4	81	88
8	4	3	4	3	4	4	3	4	3	3	4	3	4	3	4	4	4	3	4	4	3	4	79	88
9	3	3	4	4	4	3	4	3	4	3	3	4	4	3	4	4	4	4	4	4	3	3	79	88
10	4	4	4	4	4	4	3	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	86	88
Total																							792	880

The data calculated and displayed in the table is then calculated using the previously described formula. The calculation using this formula is as follows:

$$Eligibility\ Percentage = \frac{792}{880} x\ 100\%$$

From the calculation using this formula, a score of 90% is obtained; based on the interval table, the feasibility percentage of the results obtained is in the percentage range of 71% - 100%, with a very feasible category.

4. CONCLUSION

Based on the stages of research that have been carried out in making augmented reality applications for learning the solar system at SMPN 3 RAMPI, it can be concluded that:

1. Augmented reality applications for learning the solar system, which is in development using the software Blender, Unity, and the Vuforia plugin, have assisted the learning process to increase student interest in learning. They have been running correctly, as shown by the questionnaire results distributed to respondents with a score of 90%, which, if converted using an interval table, the proportion range is included in the very worthy category. This is an advantage of this research, considering that there were no learning media used before this research was conducted.
2. It should be noted that this Augmented Reality application for Solar System Learning can be run on smartphone devices with the Android operating system and cannot be run on devices with operating systems other than Android. This is a drawback as we know that smartphones currently circulating are not only devices with the Android operating system. Therefore, it is hoped that this application will be developed in the future so it can be run on multiplatform devices.

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