

# Developing and Evaluating the ARSy: Augmented Reality Solar System for Students Elementary School Learning

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**Abstract.** The existence of smartphones has facilitated society in this era. Many schools are beginning to leave the outdated approach and adopt the new one. Individuals are forced to interact remotely and maintain their distance in crowded spaces due to the present pandemic, which makes it difficult for people to carry out activities and interact. Many educational materials are not delivered to pupils because teachers find it difficult to perform online learning. In the modern era, smartphones are outfitted with augmented reality technologies. Just by aiming the camera at the marker, users may see the learning material of 3D objects. Educational augmented reality (AR) technologies are an excellent approach to presenting and engaging students with any subject in the classroom. Textbooks and traditional teaching methods cannot compete with the advantages of this technology. We developed an augmented reality solar system application for elementary school thematic lessons and evaluated the application for elementary students. The application was tested using a user experience questionnaire, and the results showed a number above 2.00, indicating that it functioned very well and received positive feedback from respondents.

**Keywords.** Augmented Reality, Learning, Interactive learning media, User experience questionnaire

## 1 Introduction

Learning is a process in which a person acquires the necessary skills and knowledge. Furthermore, learning can also be regarded as a process of elaboration as the primary goal of the learning process is to develop professional skills or competencies. Effective learning should pay attention to engaging teaching methods, i.e., learning that may attract students' interest and keep them engaged throughout the lesson. Technology integration in the classroom to assist learning is challenging for educators [1]. Learning that place in a pleasant and attractive environment will be effective and joyful. An enjoyable and memorable learning environment will draw students to participate actively to maximize learning objectives. Because of the learner will gain knowledge through hearing and seeing the material, visualizing it, imagining it, acting it out, or memorizing it. In addition, how students currently learn has significantly changed; they now favor enjoyable learning over procedural learning.

Augmented reality (AR) has several uses in higher and elementary education. With the help of this technology, educators and students can overlay data, images, and other content onto the real world to create fresh contexts and make strong connections that will improve learning and comprehension. The learning experiences may improve, make it easier to deliver new knowledge, stimulate students' minds, and grab their

interest in discovering new academic topics by utilizing the interaction and experimentation the AR technology.

Several studies have recently been published using augmented reality technology for various educational areas [2]–[7]. We may take from this that by implementing AR technology, we will be able to overcome the drawbacks of print-based learning materials. Many academic institutions now use augmented reality technology as an educational tool. This is because by utilizing AR with virtual simulation teaching materials, students may study actively and visually, resulting in more effective learning. Diverse learning technology in desktop-based 3D virtual astronomy learning that uses 3D representation and comparison with 2D illustration delivers higher learning outcomes than simply utilizing 2D images [8]. Our study utilized AR with 3D object assets to enhance the learning experience.

The multiple marker approach offers benefits of AR technology. The advantage of multi markers is that we may use more than two separate markers to highlight various items. New 3D objects can be displayed on the user's screen by using the multi-marker approach. This study developed AR technology to virtually teach elementary school students about the solar system. The objective was to provide students with more experiences while bringing a more exciting learning environment, especially for science subjects.

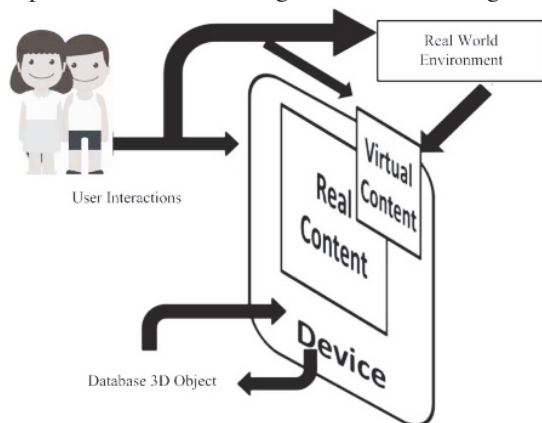
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The rest manuscripts were organized as follows: a literature review provides the background information for the problem discussed in the paper's first section. Experimental results from the system design are then presented, and the last section includes more discussion, a system evaluation, and study conclusions.

## 2 Literature Review

### 2.1 Augmented Reality

Computer-generated images and real-world live video are merged with AR technology [9]. AR generates visualizations that give the impression that the real and virtual worlds are interconnected and may enable user interaction with virtual objects. Learning with AR offers a greater comprehension of the specifics of spatial structures than traditional learning media, such as textbooks, videos, or even pc programs. Radu [10] studied how users could learn about spatial structures and functions through an AR-based application. AR can improve a learner's perceptual skills, such as general spatial abilities related to their capacity to scan their visual system, comprehend the form of objects and their positions, create mental representations of those positions and shapes, and manipulate those representations. This is significant for learning about 3D



**Fig. 1.** An illustration of the fundamental of AR

objects since a mental 3D model of the object must be maintained in memory to recall information from a different perspective.

The image that a specific marker uses determines how AR works. The system will examine whether the marker matches the database after the camera has detected the given marker and marked its pattern. The process will continue if the information on the marker matches the database to continue rendering and displaying the previously created 3D object or animation.

### 2.2 Augmented Reality Marker

The marker, known by another name, a fiducial image, is a marker made up of some reference points that make it easier to figure out the variables required for image processing. The marker is an image the camera uses as a point marker when searching the tracking point for

markers pointed in its direction. Markers can be words, points, lines, forms, or future-forming objects. If the computer can determine the position and orientation of the marker, virtual objects in the form of 3D objects are formed at the positions (0, 0, 0) and three axes (X, Y, Z).

### 2.3 User Experience Questionnaire

User Experience Questionnaire (UEQ), a simple and effective tool or questionnaire for measuring User Experience (UX), is at <https://www.ueq-online.org>. With the help of this UEQ, measuring UX in application design is made simple. There are six rating scales in UEQ, including:

- •How appealing is the product? Do users like it or not?
- •Perspicacity: Can the user easily learn about the product? Is it simple to utilize the product after you get it?
- •Efficiency: Are activities easy for people to perform with little effort?
- •Dependability: Is the user given a sense of control over the interaction?
- •Stimulation: Is using the product engaging and appealing?
- •Novelty: Is the product original and imaginative? Is the product attracting users' attention?

The UEQ contains seven possible answers and 26 question items. UEQ was created in English initially, but it is now accessible at [www.ueq-online.org](http://www.ueq-online.org) in 17 different languages. There is a limitation of 1000 respondents that can be calculated using the UEQ. Results from each assessment scale will be drawn from the computed data in the Data Analysis Tools. Each score received has a ranking. Bad, Below Average, Above Average, Good, and Excellent are listed in ascending order.

### 2.4 T-Test Parametric Method

The t-test was used to identify relevant claims that each independent variable partially impacts the dependent variable. This t-test, also known as the Student's test, is used to determine whether there is a significant difference between the means of two populations. The t-test is separated into two processes based on the number of samples: the one-sample t-test and the two-sample t-test. The average of one variable is tested against a predetermined constant value in a one-sample t-test, a test method for a single sample [11]. The standard deviation (s) of data x is calculated from each data group's total data (n) to perform the T-test.

$$s = \sqrt{\frac{\sum x^2}{N}} \quad (1)$$

$$t = \frac{x1 - x2}{\sqrt{\frac{s1^2}{n1} + \frac{s2^2}{n2} - 2r\left(\frac{s1}{\sqrt{n1}}\right)\left(\frac{s2}{\sqrt{n2}}\right)}} \quad (2)$$

### 3 System Design

The system's overall architecture is created to make it easier for application developers to follow directions in application structures and other markers. The application flowchart starts with creating an application design and ends with conclusions on the application's performance.

The Unity3D application is employed in this study as the platform for efficient implementation. It uses the Gimp program to create various necessary User Interface designs. While utilizing the 3D Blender application was required for creating 3D objects. The final product will be an Android application that can read markers and operates the camera API. In the detailed design, Usecase and Activity diagrams give a more detailed description of the system being designed, as seen in Figure 2.

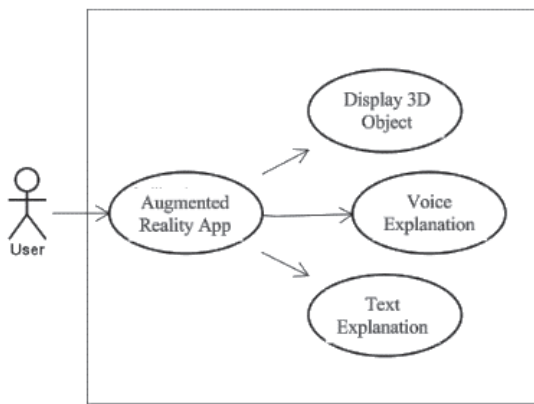


Fig. 2. Usecase Diagram The ARSy

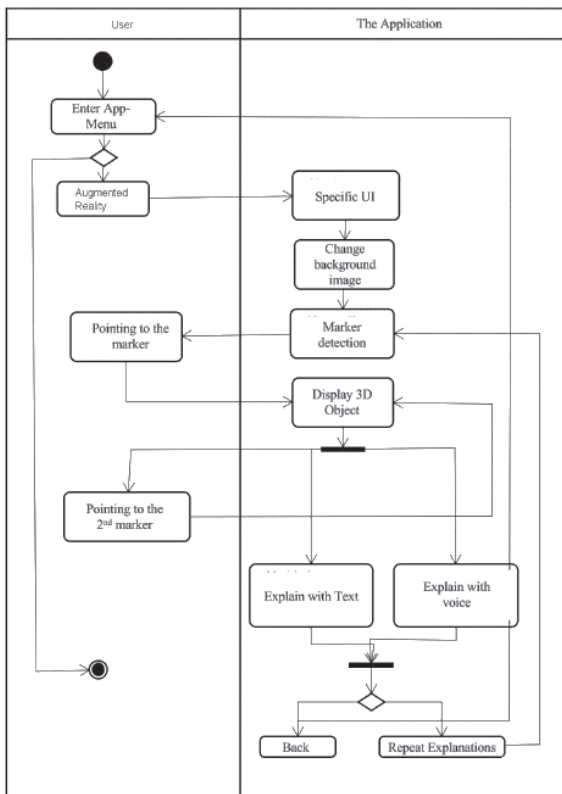


Fig. 3. Activity Diagram of the ARSy

Figure 3 confirms the multi-marker will activate and generate a new object if two markers are joined. When all virtual world objects are visible and every planet has been investigated. The user can either choose to go back to the application's main menu or select the repeat explanation button at that point.

In the asset development, we used image editing software to produce the materials, although some parts also included free-to-use fonts and images from the internet. The free assets used are published by someone who the general public can indeed use. The 3D blender application is used to create 3D objects shown in the ARSy application. Every single object is made by hand, one at a time. However, the creator used the original shape of the chosen planet from <https://www.solarsystemscope.com/textures/> for the material images. This is because the object will match the surface when the material is applied to it.








Fig. 4. Menu dan button design of the ARSy






### 4 Evaluation of The Experimental Results

#### 4.1 Functionality Testing

Functionality testing is done by using the Black Box testing method. This test is carried out to test the function of the buttons on the application. The results of the test can be seen in Table 1.

Table 1. Interface testing

Action	Interface	Expected result	Conclusion
Button play		User login on the next screen	Success
Button		User login on view	Success
Instructi ons		Instructions	Success
Button		The user enters the settings menu	Success
Arrange ment		User returns to	Success

Button		Previous menu	Success
Return		User goes to the next menu	Success
Next button		User returns to view	Success
Home Button		Start menu	Success
Button Exit Game		User can log out	Success

#### 4.2 Marker Accuracy Test

When evaluating the accuracy of the marker, overall markers can be recognized when the camera distance is at the closest distance of 10 cm and the farthest average is at a distance of 50 cm. The marker and camera should be effectively set at an angle of greater than 10° but less than 80°.

The results of the multi-marker test are shown in Figure 4. But unfortunately, rather than appearing between the two marks, the object will appear above one of them. The object appears smaller since it is in one marker and not between two marks, but it may still be rotated like one marker.

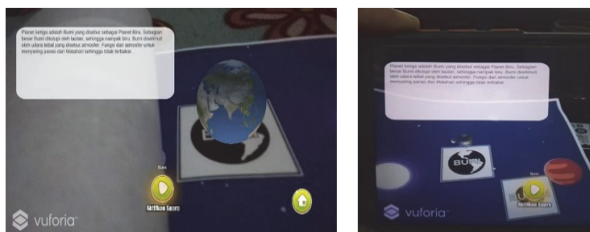


Fig. 5. Single and multi-marker accuracy testing

#### 4.3 User Experience Questionnaire Results

Using the ARSy application, a questionnaire with 26 items taken from UEQ-Online was distributed to 100 students. After the data was collected, it was analyzed to reveal that all respondents gave the application positive ratings. All respondents gave the application positive ratings when the data were analyzed, with the results indicating that the application has a maximum score of 2,525 points for attractiveness, 2,427 points for clarity, 2,194 points for efficiency, 2,160 points for accuracy, 2,496 points for stimulation, and 2,238 points for novelty. Three is the highest point. The study of the data yielded the conclusion that the respondents' overall rating was excellent and had the optimal results since the overall value should be higher than 2.00.

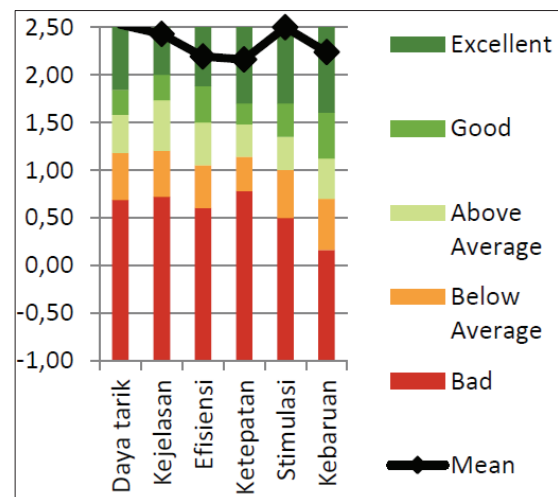


Fig. 6. Evaluation results using UEQ – questionnaire

#### 4.4 Evaluation Results Using T. Test

Ten questions that were the same for users of ebooks and augmented reality were distributed to 100 students as part of a test, with class A for ebooks and class B for augmented reality. The data shows a disparity between class 6A and class 6B students, with class B students using augmented reality scoring higher on average (77.3), while class A students using ebooks receive a score of 67.4.

The standard deviation of the two groups is significantly different, according to the findings of the T-test computations. The deviation calculation yielded a T test result of -2.45856, indicating that there isn't much difference between groups A and B.

### 5 Conclusions

The multi-maker approach is a great way to enhance learning for young elementary school students. The results of a study utilizing the UEQ Experience Questionnaire, which reveals the overall score is over 2.00 from -1.00 to 2.00 and also received positive replies from respondents, provide support.

The evaluation's results compare augmented reality by 10 points for ten questions that were examined on 50 students of class A ebook users, who averaged 67,41935, and 50 students of class B AR users, who averaged 77,41935. The T table parametric method was used to evaluate and analyze these data to conclude that employing augmented reality has a more significant impact than using ebooks. The totalling results of T-tests mean they are significantly different and provide substantial outcomes. The result obtained was -2.39012, while 1% of T-reference is -2.45846.

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