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Utilization of AR as Learning Media for Photosynthesis to Improve Understanding of Science Concepts

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ABSTRACT

The use of technology is currently increasingly widespread, one of which is the use of AR in creating learning media. Expanding information from printed advertising materials to promotional media in videos can be done using augmented reality (AR) technology. This study aims to determine how using augmented reality (AR) as a learning medium for photosynthesis can improve understanding of scientific ideas. This study uses a research and development (R&D) method with a qualitative and quantitative approach. The sample in this study was Class VIII F of SMP Negeri 2 Tuban. The data collection technique used pretest and posttest photosynthesis material. The data analysis technique, the average percentage value of the pretest and posttest, was then analyzed using the N-Gain test score equation. The results of using AR in science learning have a lot of influence on learning activities in the classroom. Students feel more involved and motivated, while teachers find it easier to explain science concepts. Therefore, applying augmented reality technology learning to SMP Negeri 2 Tuban students can be used as a new, fun teaching material.

Keywords: Media; Augmented Reality; Learning; Science

Introduction

Augmented reality is a technology that combines real-world elements with virtual elements, creating a rich and immersive experience for users (Indahsari & Sumirat, 2023; Sari et al., 2022). *Augmented reality* (AR) can present additional information in real time on top of physical objects using hardware such as cameras, sensors, and graphic displays. This technology allows users to see and interact with the real world, enhanced by virtual elements. Extending information from printed advertising materials to promotional media in videos may be designed with augmented reality technology (Ayuna et al., 2022; Kuswinardi et al., 2023; Makhasin, 2023). The built system can recognize markers and display videos loaded via URL. In research conducted by Yusup et al. (2023), Blender was used to create the animation, and Qualcomm Augmented Reality (QCAR) produced the augmented reality process. The application, seen on an Android smartphone, can show clean and unclean settings. These findings may offer a different multimedia learning option.

Augmented Reality (AR) is a technology that combines computer-generated virtual elements with the real world, thus creating a composite display that enriches the user's perception of Reality (Elsayed et al., 2024). The application of Augmented Reality (AR) in education is expanding to provide immersive and interactive learning experiences. Augmented Reality plays a role in contextualizing information and offering authentic experiences that can increase student understanding and engagement (Zhang & Pérez-Paredes, 2021). Since augmented Reality (AR) has entertainment components that can boost students' interest in learning, playing, and projecting it realistically, and involving all five senses of students, using AR technology in conjunction with learning media is very helpful in enhancing the learning process and students' interest in learning (Robianto et al., 2022). Augmented Reality is growing rapidly, allowing applications in various fields (Robianto et al., 2022; Sari et al., 2022). Augmented Reality can be used in education, one of which is in science learning.

Science learning at SMP Negeri 2 Tuban is still dominated by printed media and the lecture method, which results in a lack of interactivity and variety in the teaching-learning process. In particular, photosynthesis material in science subjects is still delivered through conventional media, and props are used as practical materials. In the current learning process, the teachers still write and explain, and students will record the material written by the teacher. Thus, these items may become 3D objects if Augmented Reality can transfer the virtual world into the actual world. This will make learning more engaging and inspire students to study more, like the process of photosynthesis.

Interactive learning in science education can significantly improve student outcomes and engagement. However, the effectiveness of various interactive tools varies, and their successful implementation requires careful consideration of technological and pedagogical factors. Addressing these challenges can create a more interactive and practical science learning environment. Based on the background above, the author raises the title "Utilization of Augmented Reality Technology as Photosynthesis Learning Media to Improve the Concept of Science Understanding." The author chose this title to develop the author's ability to utilize AR technology. The author also hopes that with this AR technology, teachers and students at school will find it easier to undergo the teaching and learning process.

Methods

This research uses the research and development (R&D) method. Research and Development (R&D) is a comprehensive research method encompassing a variety of approaches and techniques that aim to solve scientific problems and advance knowledge (Wingate, 2025). The R&D research was conducted using qualitative and quantitative approaches. The R&D method was chosen because this research aims to develop and evaluate Augmented Reality (AR) based learning media. The qualitative approach was conducted to determine student responses to learning media. The quantitative approach is used to measure the effectiveness

of the media in improving the understanding of science concepts, as measured through pretest and post-test activities of understanding photosynthesis material in the form of data analysis of the average value of the Pretest and post-test. The author looks for references related to the application of tapes in books and journals that are already available from various sources.

The research subjects were 30 students of class VIII F of SMP Negeri 2 TUBAN. Observations were made to observe and collect data on what learning media students of class VIII SMP Negeri 2 Tuban used. The author also collects data with the help of textbooks that teachers commonly use to carry out the learning process in class. This development research uses the Multimedia Development Life Cycle (MDLC) approach. Multimedia Development Life Cycle (MDLC) is a systematic methodology for developing multimedia applications and systems (Kumala et al., 2021). This learning media design is made using Unity 3D software, an application used to develop cross-platform games that are easy to use. Augmented Reality implementation is done using Unity 3D software. The implementation is done by inserting the marker into the software development kit called Vuforia to get the library that will be used in Unity 3D. Then, the 3D model of the environment, image information, and platform design will be displayed.

The data analysis technique was carried out by calculating the mean percentage value of the pretest and posttest. The results of the mean percentage value of the pretest and posttest were then analyzed using the following equation and then interpreted in Table 1.

$$\mathrm{N-Gain\ (g)} = \frac{\bar{X}\mathrm{posttest} - \bar{X}\mathrm{pretest}}{\bar{X}\mathrm{max} - \bar{X}\mathrm{pretest}}$$

Table 1. The significance category of the increase in the N-Gain test score (g)

N-Gain (g)	Category
$g \geq 0{,}7$	High
$0{,}3 \leq g \leq 0{,}7$	Moderate
$g < 0{,}3$	Low

Source: Ma'Firah et al. (2023)

Results and Discussion

The results of this research require several stages to achieve reasonable and appropriate design results. Some of these stages will be explained below.

System requirements analysis

System requirements analysis describes the activities implemented in an application and explains the requirements needed for the application to run correctly. Software used in a system is commands given to hardware to interact between the two. The software needed to create Augmented Reality-based learning media applications is as follows:

1. Windows 11 Operating System
2. Unity 3D 2017
3. 3Ds Max
4. Using Visual Studio Code
5. Image editing tools such as Illustrator

Flowchart System Plan

A system has steps and sequences. The following is a flowchart of the system design that will be made.

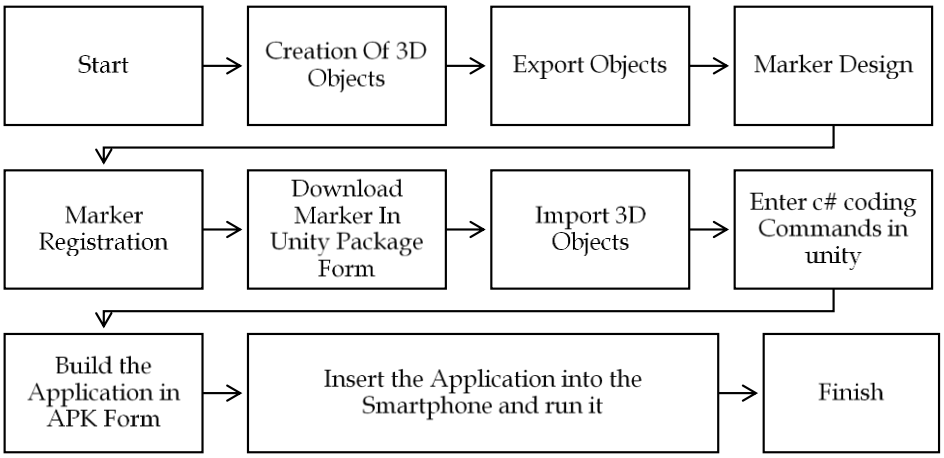

Figure 1. System design flowchart

Based on the flowchart above, the program flow can be explained as follows:

1. We started by creating a water plant object in 3D.
2. After creating a 3D object in 3D Max software, the object is exported into .obj form.
3. After creating and exporting the object, the next step is to design a marker to display the 3D object on the camera.
4. Then, the marker is registered to the Vuforia *SDK* website.
5. After registration, the marker can be downloaded as a Unity package.
6. Then, the 3D object created earlier must be imported into the Unity 3D application.
7. After all assets are collected, the application creation process can be completed by entering several C # coding commands.
8. After the application is complete, build it into an app form for use on a smartphone.
9. Then, insert the application into the smartphone and run it. Open it on your smartphone and run it.

Flowchart Application

A flowchart is a picture of the flow of a product to be developed. The main flowchart of the learning media can be created in the image below.

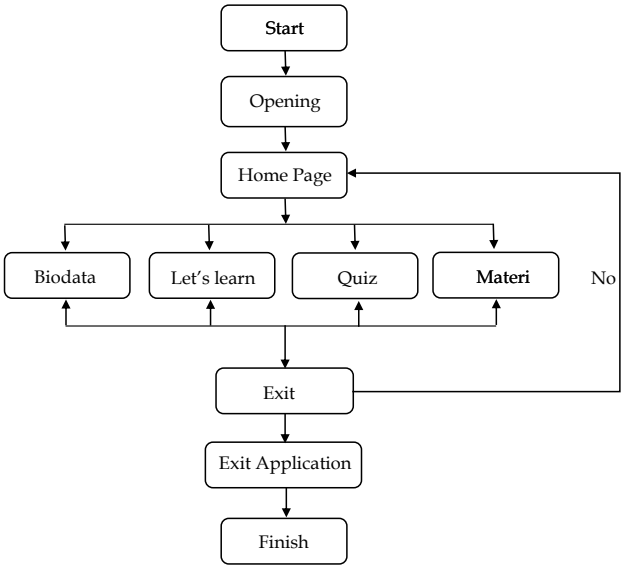

Figure 2. Application flowchart

Based on the flowchart above, the application flow can be explained as follows:

1. The application's opening display will be the initial display when the application is opened.
2. After the opening display, the menu page will appear. On the menu page, there are several menus: biodata, let us learn, quizzes, and essential materials.
3. There are also other menus on each main menu.
4. If the user has finished using the application and wants to exit, it will close, but if they still want to use it, they will return to the menu page.

Implementation

1. Initial Menu Display

   The display on the menu above can be explained as the initial menu page will display the name of the learning media and other submenus in the application.

Figure 3. Shows the initial menu display. Biodata Page View

2. The biodata page

   The biodata page displays the creator's biodata and the supervisor's name. In the upper right corner, there is a next button to go to the home menu page. The page view can be seen in the image below.

Figure 4. Shows the biodata page display

3. Material Page Display

   The material page will display several explanations about photosynthesis that will help users answer the quiz. The image below shows the material page display.

Figure 5. Shows the material page view

4. Page Appearance
   On the Ayo Belajar page, several types of environments can be viewed in 3D using the markers provided by downloading them and the download marker button. The appearance can be seen in the image below.

Figure 6. Displays the Let's Learn page

5. Scan Marker Page View
   Users can directly scan the downloaded marker on the scan page by pointing the camera at the image. This page also has a play button with a sound explanation about the plant, an info button with a short description, and a button to return to the Let's Learn menu. The appearance of the page can be seen in the image below.

Figure 7. Shows the scan marker page display

6. Quiz Page View
   The quiz page will display several questions related to the previous material. The quiz page view can be seen in the image below.

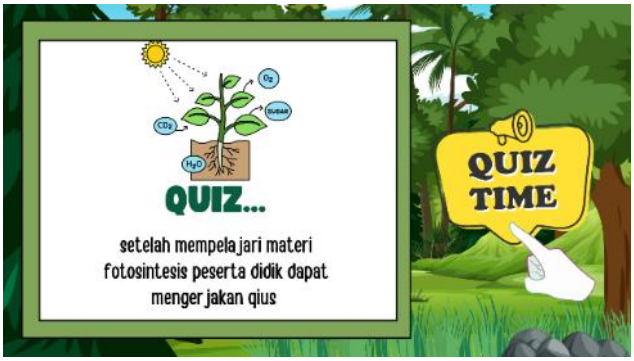

Figure 8. Shows the quiz page view

7. Quiz Finish Pop-Up Display
   A pop-up will appear when the user has finished the quiz, as shown in the image below.

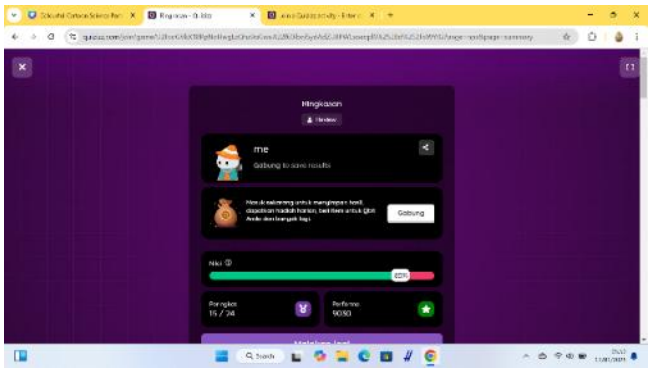

Figure 9. Pop-up completed quiz

8. Exit View
   If the user wants to exit the application, a pop-up will appear, as in the image below.

Figure 10. Pop-up displays exit

Questionnaire Results

Observations were conducted while implementing Augmented Reality (AR)-based learning media at SMP N 2 TUBAN. Data showed that students showed high engagement when using AR media. They were active in discussions, answering questions, and interacting with AR elements. Observations also noted that students were more focused on the subject and appeared more enthusiastic than in conventional learning methods. The results of interviews with students and teachers provided additional insights into the effectiveness of AR media. Students reported that this media made science learning more enjoyable and easier to understand. They considered three-dimensional visualization of science concepts an innovation that helped them better understand the material. Teachers also expressed that AR media made it easier to explain complex concepts and increased student participation in learning activities. Comprehension tests were conducted before and after the use of AR media. Data showed a significant increase in student comprehension scores. The average score before using AR media was 65, while after using AR media, it increased to 85. The following table shows changes in the average student comprehension scores:

Table 2. Changes in Average Student Understanding Scores Before and After Using AR Media

Treatment	score	N-gain	category
Pretest	65	0.57	Moderate
posttest	85		

Table 2 shows that using Augmented Reality as a learning medium can improve students' grades. This is proven through the N-Gain test, which scored 0.57 in a moderate category. Thus, Augmented Reality can be used as a learning medium for photosynthesis to improve students' understanding of science concepts in the mild category. This table shows the average increase in students' understanding scores before and after using AR-based learning media. The N-Gain test showed a significant difference in scores before and after using AR media. The following graph shows a comparison of students' average understanding scores:

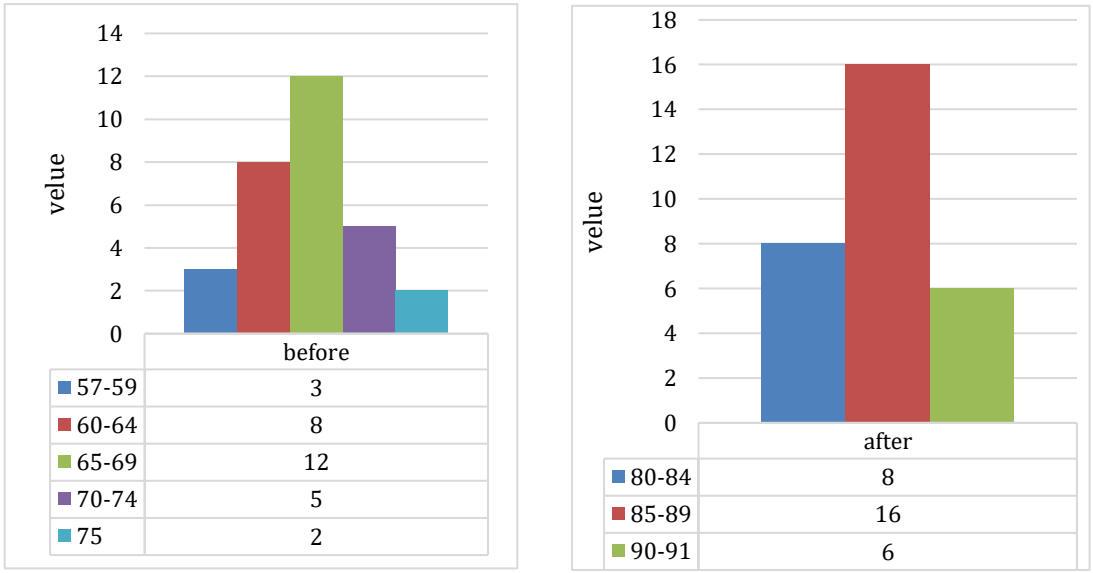

Figure 11. Comparison of average student understanding before and after using AR media

This graph shows the increase in the average score of students' understanding after using AR-based learning media. Qualitative analysis of interviews and questionnaires revealed that AR media was considered an effective tool in the learning process. Students felt more involved and motivated, while teachers found it easier to explain science concepts. These findings align with previous studies showing that interactive technologies such as AR can improve student engagement and learning outcomes (Hapsari & Wulandari, 2020; Wiliyanti et al., 2024; Yusup A. et al., 2023). Observations and questionnaires showed that AR media increased students' motivation to learn science. Students were more active in discussing and exploring science concepts and showed greater interest. This is supported by studies showing that interactive technology can increase student motivation and engagement (Carolina, 2022; Prabowo & Wakhudin, 2024). The results of the N-gain score that have been analyzed are presented in Table 1.

Conclusion

Based on the research titled Utilization of Augmented Reality Technology as a Media for Learning Photosynthesis in Science Lessons for Grade VIII F Students of SMP Negeri 2 Tuban, it can be concluded. Learning applications using Augmented Reality technology for SMP Negeri 2 Tuban students can be used as new and fun teaching materials. The design of Augmented Reality-based photosynthesis learning media with the MDLC method is based on six stages in its implementation to produce more realistic and interactive learning media through Augmented Reality technology and used in learning activities by students of SMP Negeri 2 Tuban.

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