Jurnal Pendidikan Multimedia
(EDSENCE)

Journal homepage: https://ejournal.upi.edu/index.php/Edsence

Implementation of Augmented Reality as a Marker-Based Learning Media for the Human Respiratory System

Ratu Verlaili Erlindriyani[1], Ahmad Ramadhani[1], Nauval Franata[1], Muchtar Ali Setyo Yudono[1], Danu Adi Prasetyo[2], Muhammad Naufal Alhafizh[2], Muhammad Rafif Naufal[2], Rizki Alfa Reza[2]

[1]Universitas Sultan Ageng Tirtayasa, Cilegon, Indonesia
[2]Politeknik Negeri Media kreatif, Jakarta, Indonesia
Correspondence: E-mail: ratu.verlalili@untirta.ac.id

ABSTRACT

Learning biology, particularly the topic of the human respiratory system, still faces challenges in terms of effectiveness especially when delivered using conventional media such as 2D textbooks. Static images and limited interactivity make it difficult for students to understand the anatomical structures and dynamic physiological processes. This situation highlights the urgency for more representative and interactive learning media. This study offers a solution through the development of an Augmented Reality (AR)-based learning medium that enables the visualization of human respiratory organs in three dimensions, accompanied by animated breathing processes and educational narration. The development was carried out using an iterative approach based on the Software Development Life Cycle (SDLC) method and implemented through the Unity 3D platform. Evaluation was conducted through limited trials with students of SMAN 1 Tirtayasa to assess engagement, learning motivation, and material comprehension. The evaluation results indicate that the use of AR technology enhances learning appeal, strengthens conceptual understanding, and provides a more immersive learning experience. Therefore, the application of AR holds potential as an innovative tool to support more effective and enjoyable biology learning.

ARTICLE INFO

Article History:
Submitted/Received 28 Mei 2025
First Revised 21 Jun 2025
Accepted 23 Jun 2025
First Available online 27 Jun 2025
Publication Date 27 Jun 2025

Keyword:
Augmented Reality (AR),
Biology Learning,
Respiratory System,
3D Visualization,
Educational Technology.

1. INTRODUCTION

According to the Ministry of Education and Culture of the Republic of Indonesia (2013), learning about the human respiratory system is one of the basic aspects of biology and health sciences at the Senior High School (SMA) level. However, conventional learning approaches often leave students feeling bored and less engaged (Evanjeli et al., 2024). To overcome this challenge, Augmented Reality (AR) technology can be an innovative solution. Previous research has shown that AR can increase the learning motivation of students who are the digital native generation (Carolina, 2022). This application is designed to help students understand the human respiratory system in an interactive and in-depth way. This application will provide descriptive information about the respiratory organs as well as interactive features that can enrich the learning experience. The development process of this application uses the SDLC method with an iterative model to achieve optimal results and open up opportunities for AR integration in the education system. With this application, it is hoped that students can experience a more interactive, effective, and enjoyable learning process. The development of this application is also expected to be an innovative solution in supporting technology-based education and improving the quality of learning.

The human respiratory system plays a vital role in supporting life by enabling gas exchange within the body. This physiological process involves the intake of oxygen (O_2) from the external environment and the release of carbon dioxide (CO_2) as a metabolic byproduct (Siregar et al., 2022; Aulia et al., 2023). Air enters the body through the nasal cavity, travels down the respiratory tract, and reaches the lungs, where gas exchange occurs in the alveoli. Oxygen is absorbed into the bloodstream while CO_2 is expelled during exhalation (Rohmah, 2022). Understanding this system is essential, particularly in educational contexts where interactive and engaging media can enhance learning.

In recent years, Augmented Reality (AR) has emerged as a promising technology for enhancing learning experiences by integrating virtual content into the real world in real time. AR allows users to interact with digital elements—such as text, images, or 3D models—through devices like smartphones or AR glasses, thereby creating immersive and interactive environments (Alfitriani, 2021). This capability is particularly beneficial in educational settings, where abstract or complex subjects, such as human anatomy and physiology, can be visualized more effectively.

AR implementation typically utilizes two main tracking methods: Marker-Based and Markerless Tracking. Marker-Based Tracking uses specific patterns or images that are recognized by the camera to render virtual objects, while Markerless Tracking relies on environmental features, such as flat surfaces, to anchor digital elements (Warmanto et al., 2021). Marker-Based Tracking offers high accuracy and ease of deployment, making it a popular choice for educational AR applications. This method detects the position and orientation of markers across three coordinate axes (X, Y, and Z), allowing virtual objects to be correctly aligned with the real-world perspective (Boonbrahma, Boonbrahma, & Kaewrat, 2020).

One of the most widely used platforms for developing AR applications is Unity 3D. Unity is a cross-platform development environment that supports the creation of 2D, 3D, Virtual Reality (VR), and AR content. With its powerful visual editor, support for C# programming, and integration with AR development kits, Unity enables developers to build interactive simulations efficiently. Its flexibility and broad compatibility with various operating systems

DOI: https://doi.org/10.17509/edsence.v7i1.83885
p-ISSN:2685-2489 | e-ISSN:2685-2535

and devices have led to its adoption across multiple fields, including education, healthcare, and industrial training (Suparmi, 2024).

Based on these technological advancements, the integration of AR into educational media such as learning materials for the human respiratory system—has the potential to improve conceptual understanding, engagement, and retention (Evanjeli et al., 2024; Rahayu & Wulandari, 2024).

The purpose of developing this Augmented Reality (AR) application is to create interactive learning media that can visualize the human respiratory system in a more concrete and interesting way for high school students. By utilizing marker-based tracking technology integrated into the Unity 3D platform, this application is designed to help students understand the structure and physiological processes of the respiratory system in three dimensions. This visual and interactive approach is expected to improve students' understanding of the material, strengthen memory, and increase engagement in the learning process. In addition, this application is also intended as an innovative solution to the limitations of conventional media, with the hope of supporting more effective, modern, and contextual science learning according to the needs of today's digital generation.

2. METHODS

This study employs the Iterative Software Development Life Cycle (SDLC) model to develop an Augmented Reality (AR)-based learning application focused on the human respiratory system. The iterative model is chosen due to its flexibility in accommodating continuous evaluation and improvement throughout the development process. The methodology consists of four primary stages: analysis, design, implementation, and evaluation (Diansyah et al., 2023).

In the analysis phase, a needs assessment is conducted to identify the key functionalities required in the application. This includes determining user expectations, content requirements, and the technical specifications for AR implementation. The design phase involves the creation of interface prototypes and interaction flow diagrams. At this stage, Marker-Based Tracking is selected as the AR method, and Unity 3D is designated as the development platform due to its support for AR SDKs and compatibility across devices. The implementation phase focuses on translating the design into a functional application. The development process includes programming the interaction logic, integrating AR markers, rendering 3D models of the respiratory system, and embedding textual and audio information to support learning objectives.

In the evaluation phase, usability testing is conducted with a sample of target users to assess the application's functionality, ease of use, accuracy of information, and level of interactivity. Feedback obtained from this phase is used to refine the application in subsequent iterations. This cyclical process continues until the application meets the predefined criteria for quality and usability in **Figure 1**.

DOI: https://doi.org/10.17509/edsence.v7i1.83885
p-ISSN:2685-2489 | e-ISSN:2685-2535

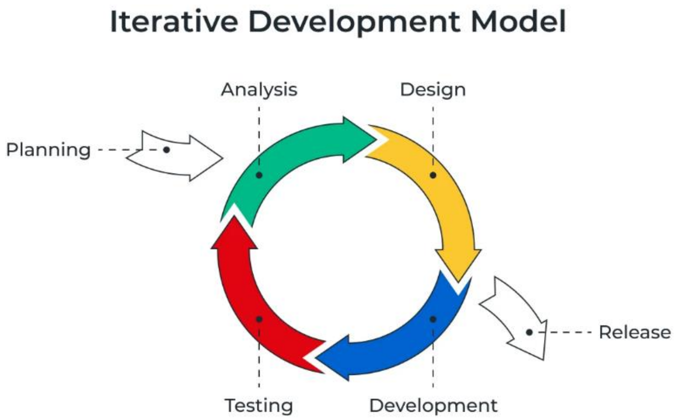


Figure 1. Iterative development model

2.1. Analysis

The analysis stage aims to identify and gather the necessary data and information for developing a marker-based Augmented Reality (AR) application as a learning medium for the human respiratory system. This analysis begins by identifying the needs of the target users, specifically Senior high school students. According to the official science textbook from the Kurikulum Merdeka (Independent Curriculum), published by the Ministry of Education, Culture, Research, and Technology of Indonesia (Munawir, 2020), the topic of the human respiratory system is thoroughly covered in Grade VIII, particularly in Chapter 8. The content includes:

1. The structure and function of human respiratory organs.
2. The respiratory process (inhalation and exhalation).
3. Disorders and diseases affecting the respiratory system.
4. Efforts to maintain respiratory health.

To support application development, the data and information collected include:

a) Human respiratory organs, such as the nose, trachea, bronchi, lungs, alveoli, and diaphragm.
b) The respiratory process, including the mechanism of air entering and exiting the lungs.
c) Types of respiratory disorders and diseases, such as asthma, bronchitis, emphysema, and others.
d) Preventive and educational measures to maintain respiratory health.

These data were obtained through a literature review of textbooks, scientific references, and official sources from Kemendikbud Ristek, ensuring that the information presented in the application is aligned with the current curriculum and supports an interactive and educational learning process.

2.2. Design

Following the data analysis, the next step involves the design of a marker-based Augmented Reality (AR) system, which includes several key components. First, markers were designed in the form of images representing respiratory organs that can be recognized by a camera. These markers serve as triggers to display three-dimensional (3D) models of the respiratory organs upon scanning.

DOI: https://doi.org/10.17509/edsence.v7i1.83885
p-ISSN:2685-2489 | e-ISSN:2685-2535

Next, the user interface (UI/UX) was designed, encompassing the main page, organ selection menu, information buttons, and other navigation elements. The interface is created to be interactive and responsive when a marker is detected by the system. In addition, 3D models of each respiratory organ were developed using software such as Blender or by utilizing assets from an asset store.

Finally, a system design diagram was created, including flowcharts and the navigational structure of the application. These diagrams illustrate the overall workflow and the interrelationships between various components in the application.

2.3. Development

The development phase involves the implementation of the previously designed AR system, with the main goal of realizing an interactive marker-based AR learning application on the human respiratory system. This process utilized Unity 3D as the primary game engine and Vuforia SDK for image recognition to support marker-based AR technology.

The process begins with the integration of markers static images previously designed as image targets linked to corresponding 3D models of respiratory organs such as the nose, trachea, bronchi, lungs, alveoli, and diaphragm. Each 3D model is positioned accurately on its marker so that when scanned by a device camera, the models appear proportionally and realistically and can be observed from various perspectives.

To enhance the learning experience, various interactive features were added. These include virtual buttons that allow users to access detailed information about each organ. This information is presented in the form of interactive descriptive text, explaining the function, role, and location of each organ in the respiratory process. To support auditory learning styles, voice-over narration is integrated and can be played automatically or manually by the user.

Additionally, simple animations such as the expansion and contraction of the lungs during inhalation and exhalation or the visualization of airflow from the nose to the alveoli—are incorporated to improve the understanding of dynamic concepts that are difficult to grasp through static visuals alone.

On the technical side, performance optimization is carried out to ensure smooth operation on various devices, particularly Android devices with limited specifications. This includes adjusting file sizes and the resolution of 3D textures to maintain visual quality while keeping the application lightweight. Camera sensitivity to marker detection is also calibrated in Vuforia, enabling stable and accurate recognition even under poor lighting or at non-optimal viewing angles. The outcome of this development phase is a functional prototype of the AR application, ready for limited use and further evaluation in the next stage, namely Testing.

2.4. Testing

The testing phase is a critical component in the development process, particularly in the waterfall methodology, where it occurs after development and before application release. The primary objective is to ensure that the application functions according to predefined specifications, is free of errors or bugs, and delivers an optimal learning experience.

In this phase, the black-box testing method is employed focusing on the application's functionality without examining its internal code structure. Testers evaluate whether the application produces the correct output for given inputs.

DOI: https://doi.org/10.17509/edsence.v7i1.83885
p-ISSN:2685-2489 | e-ISSN:2685-2535

Several testing scenarios are conducted to ensure proper functioning across different aspects:

- Marker response: verifying if the application can quickly recognize the marker upon scanning, whether the 3D model appears accurately aligned with the marker, and whether environmental factors such as lighting and camera angle affect recognition.
- 3D model rendering: checking that respiratory organ models are displayed correctly without visual defects like transparency, disappearance, or floating, and ensuring that animations run smoothly.
- Interactive buttons: ensuring all interactive elements (e.g., information buttons) respond correctly when pressed, and that educational content such as organ descriptions or voice narration appears as expected.

If issues or bugs are discovered during testing, a debugging process follows. This involves identifying the root cause and applying the appropriate solution. For instance:

- If markers are not recognized well, the marker may be redesigned for higher contrast or used with improved lighting.
- If 3D models fail to render properly, optimization might include reducing polygon counts or correcting anchor positions in Unity.
- For unresponsive buttons, the event handler script and touch area must be reviewed.
- In cases of application lag or crashes, Unity's profiling tools are used to identify bottlenecks and optimize memory usage.

Through this comprehensive testing and refinement, the application is expected to operate stably and efficiently, providing users with an effective and engaging learning experience.

The testing activity was carried out by 35 students of SMAN 1 Tirtayasa. Based on the questionnaire given regarding application performance and learning effectiveness using AR, 85% of students were able to improve their understanding of the material, strengthen their memory, and increase their involvement in the learning process, while 15% experienced technical or adaptation problems when using the application, such as difficulty running the application, device limitations, or not understanding how to interact. In terms of technology, the Augmented Reality (AR) application in Biology learning provides significant convenience for students because it can be accessed through commonly owned devices, such as Android or iOS smartphones or tablets. Application installation is relatively easy without requiring additional hardware such as high computer specifications or laboratory equipment. The intuitively designed interface allows students to explore three-dimensional biological objects, such as human organs, simply by pointing the camera at the provided markers. With the support of marker-based tracking technology, the system automatically recognizes images and displays interactive visuals in real time, without the need for a constant internet connection. In addition, integration with development platforms such as Unity 3D allows for efficient content updates and development, making the application flexible and easily adaptable to various Biology subjects at the high school level.

3. RESULTS AND DISCUSSION

3.1. Analysis of the Existing System

The current learning system for the human respiratory system in most schools primarily relies on traditional methods, such as textbook-based explanations, two-dimensional diagrams, and verbal explanations from teachers. While this approach delivers fundamental

DOI: https://doi.org/10.17509/edsence.v7i1.83885
p-ISSN:2685-2489 | e-ISSN:2685-2535

concepts effectively, it presents several limitations in delivering complex three-dimensional structures such as alveoli, bronchioles, and diaphragm movement.

Moreover, student engagement and interactivity tend to be low due to the passive nature of traditional instruction. Students often struggle to visualize how air flows through the respiratory tract, how gas exchange occurs in the alveoli, or how the diaphragm contributes to breathing. This gap becomes more evident in assessments where conceptual understanding is required rather than rote memorization.

Some schools have attempted to improve understanding using video animations or PowerPoint presentations, but these tools are still non-interactive, linear, and lack real-time user control. As a result, they do not fully support self-paced learning or inquiry-based exploration.

There is no integration of Augmented Reality (AR) in the existing system, especially marker-based AR, which allows users to scan an image or object (marker) and trigger a 3D respiratory model on screen. Students are not yet exposed to immersive experiences where they can interact directly with virtual anatomical models—something that has been proven to increase retention, motivation, and spatial understanding.

Thus, the current system needs an innovative approach that enhances visualization, interactivity, and learner engagement. Marker-based AR offers an opportunity to bridge this gap by allowing students to explore detailed 3D respiratory models through their mobile devices, making learning more tangible and experiential (see **Table 1**).

Table 1. Summary of the Current System Problems

Aspect	**Current Condition**	**Main Limitations**
Method	Books, 2D illustrations, lectures	Not interactive, limited visualization
Digital media	Videos, PowerPoint presentations	Not real-time, no student control
Conceptual understanding	Low on 3D structure and physiological processes	Difficult to imagine respiratory dynamics
Interactive technology	Not yet implemented	No application of Augmented Reality (AR)

3.2. System Design

The system workflow implemented in the AR application is illustrated in the flowchart shown in **Figure 2**.

DOI: https://doi.org/10.17509/edsence.v7i1.83885
p-ISSN:2685-2489 | e-ISSN:2685-2535

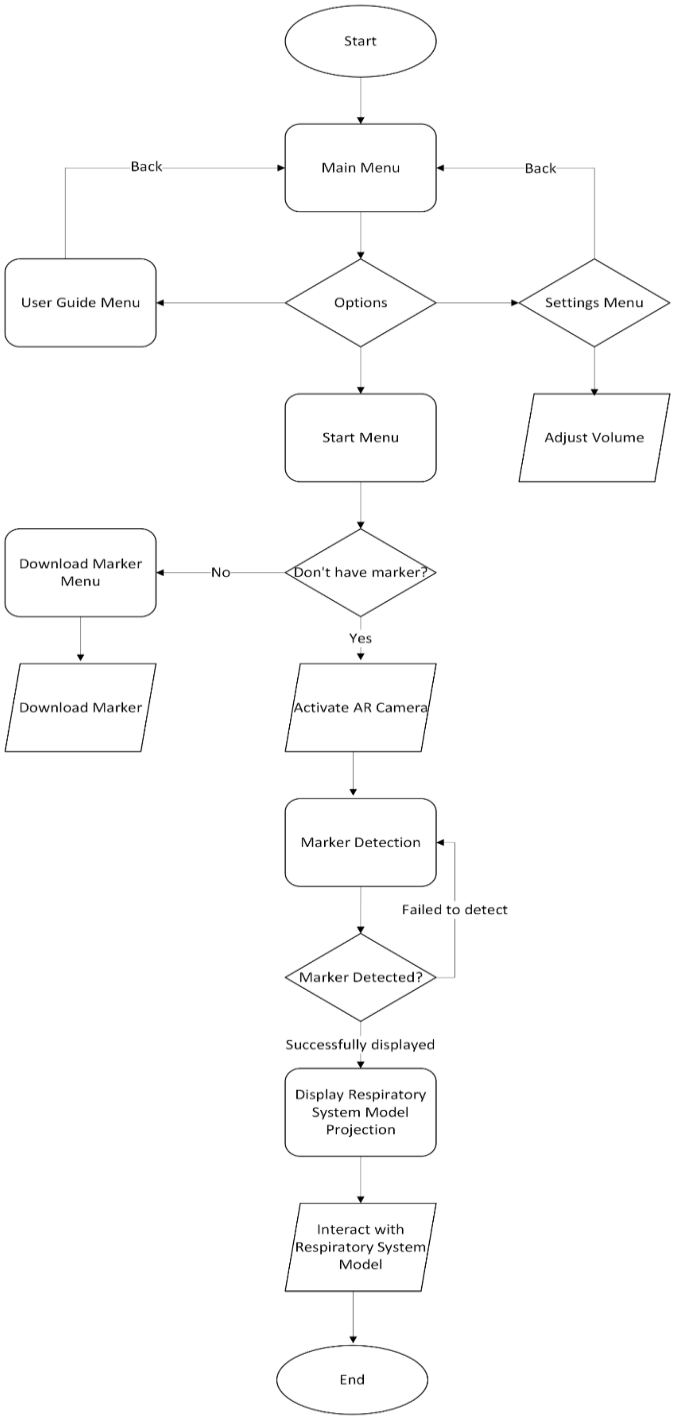
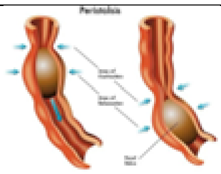
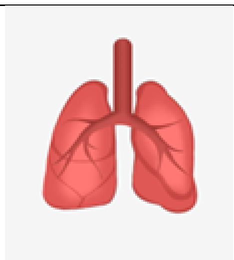


Figure 2. *Flowchart*

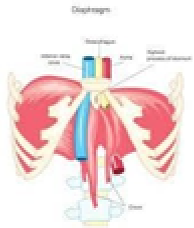
The following is a list of tables used as objects that can be scanned using markers within the human respiratory system application shown in **Table 2.**

DOI: https://doi.org/10.17509/edsence.v7i1.83885
p-ISSN:2685-2489 | e-ISSN:2685-2535

Table 2. Description of respiratory organs

Organ Names and Descriptions:	Marker	3D Object
Nasal Cavity		
The nasal cavity plays a vital role in both the sense of smell and respiratory protection. Key components include cilia that filter the air, olfactory nerve fibers that detect scents, and mucous membranes that produce mucus to protect against dirt and bacteria. Mucus also serves as an indicator of health conditions (Marieb & Hoehn, 2019).		
Throat		
The throat consists of three main parts: the pharynx, larynx, and trachea. The pharynx serves as a connecting passage between the mouth/nose and throat, facilitating swallowing and breathing. The larynx produces sound and protects the respiratory tract. The trachea is a long tube that connects the pharynx/larynx to the lungs, serving as the main airway during breathing and is lined with protective tissue (Albahout & Lopez, 2023).		
Lungs		
The lungs are composed of three main parts: the bronchi, bronchioles, and alveoli. The bronchi are the primary airways leading into the lungs. The bronchioles channel air to the innermost parts of the lungs. The alveoli, which are small air sacs, function as the site of gas exchange, where oxygen is absorbed and carbon dioxide is expelled (Marieb & Hoehn, 2019).		
Diaphragm		

DOI: https://doi.org/10.17509/edsence.v7i1.83885
p-ISSN:2685-2489 | e-ISSN:2685-2535

The diaphragm is a large muscle located beneath the lungs that separates the chest cavity from the abdominal cavity. Breathing involves the diaphragm moving up and down. When inhaling, the diaphragm moves downward, increasing the volume of the chest cavity, allowing the lungs to expand and air to enter. Conversely, when exhaling, the diaphragm moves upward, reducing the chest cavity volume and pushing air out of the lungs (Marieb & Hoehn, 2019).		

3.3. User Interface Design

3.3.1. Main Menu

Displays the game logo and buttons such as *Start*, *Guide*, *Settings*, *About Us*, and *Exit*, each with its respective function in **Figure 3**.

Figure 3. Main menu

3.3.2. Settings Menu

Displays a slider that allows users to increase or decrease the background volume in **Figure 4**.

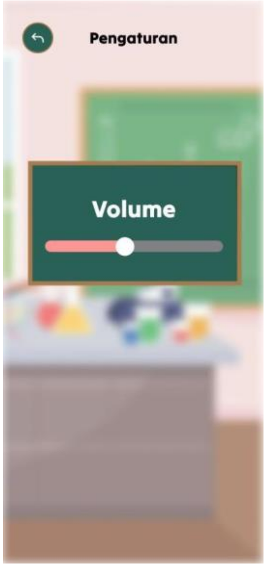


Figure 4. Setting

3.3.3. Guide Menu

Contains instructions on how to use the application, starting from downloading the marker to scanning the marker in **Figure 5**.

Figure 5. Guide menu

3.3.5. Camera Selection and Marker Download Menu

A menu that appears before accessing the AR camera, also includes an option to download the marker for scanning in **Figure 6**.

DOI: https://doi.org/10.17509/edsence.v7i1.83885
p-ISSN:2685-2489 | e-ISSN:2685-2535

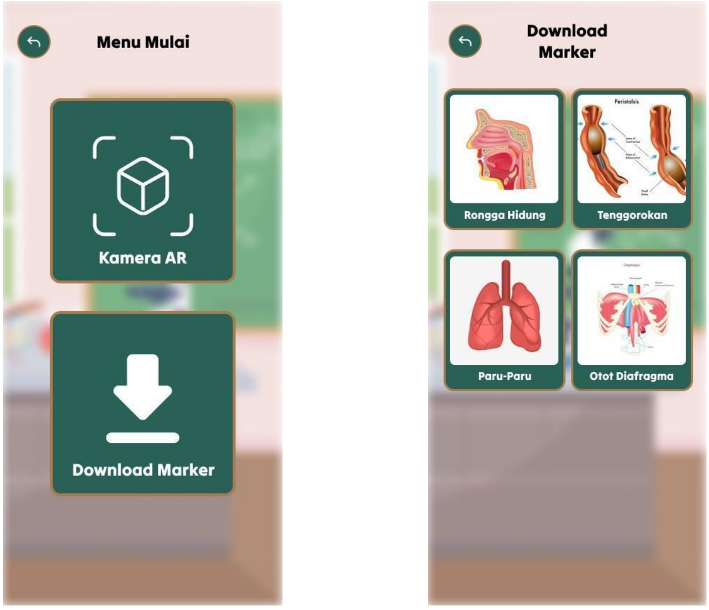


Figure 6. Start menu and Download marker

3.4. Implementation

3.4.1. 3D Object Modeling in Blender

The process begins by creating a model of one of the human respiratory organs in Blender. This starts with forming the basic shape of the object using primitives such as cubes or planes, and manipulating them using tools like *extrude*, *scale*, and *sculpting*. Once the object's shape is formed, textures are applied by adding materials through the *Shader Editor* and performing *UV unwrap* on the textures. The completed object is then arranged into several parts by parenting multiple objects together and duplicating sections as needed. The results are shown in the **Figure 7** below.

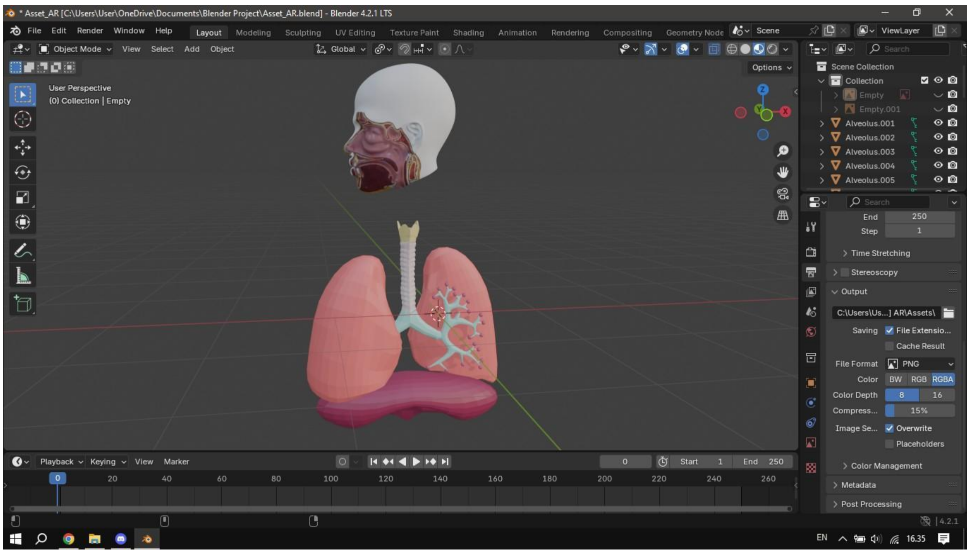


Figure 7. 3D Model Respitory Organs

DOI: https://doi.org/10.17509/edsence.v7i1.83885
p-ISSN:2685-2489 | e-ISSN:2685-2535

3.4.2. UI Canvas Development in Unity

The creation of the UI canvas in Unity begins by adding a *Canvas* component to the scene, which serves as a container for all user interface (UI) elements. The first step is to open Unity and select GameObject > UI > Canvas. Unity will then automatically add a Canvas object to the scene, along with components such as *Canvas Renderer* and *Event System* to handle user interactions. This canvas hosts various UI elements to be added, such as buttons, text, images, and panels. These UI components can be added by navigating to GameObject > UI and selecting the desired component. For example, to add a button, select *Button* from the UI menu in **Figure 8**.

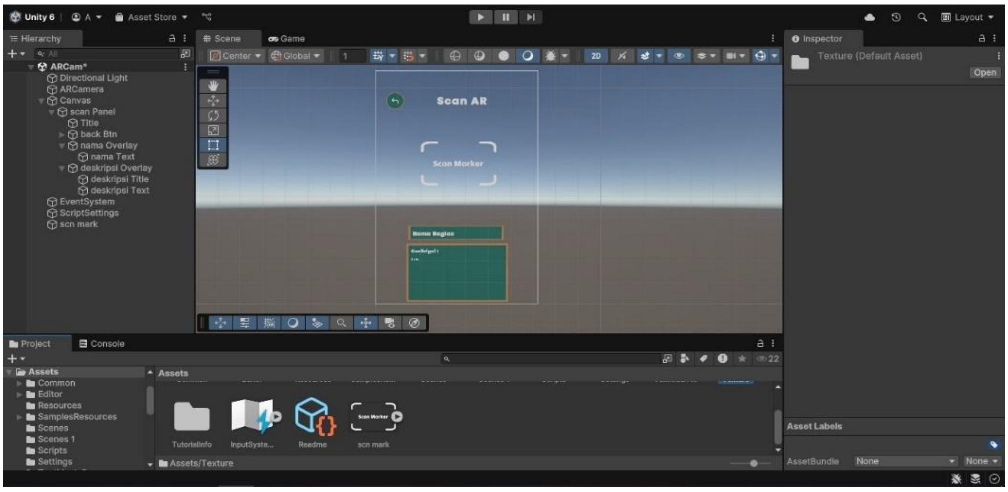


Figure 8. Canvas Placement in Unity

3.4.3. Application Gameplay

The gameplay of the respiratory anatomy application follows a simple and intuitive flow. Users only need to download the provided marker and can immediately begin using the features of each marker. The gameplay flow is as follows:

- **Download the Application**
  Users can download and install the application on their smartphones via a link provided by the developer.
- **Display the Main Menu**
  After launching the application, users can access the main functionality by selecting the *Start* button, which leads to the marker scanning menu in **Figure 9**.

DOI: https://doi.org/10.17509/edsence.v7i1.83885
p-ISSN:2685-2489 | e-ISSN:2685-2535

Figure 9. Main menu display

- **Marker Scan Menu**
  Users can select the AR camera to start using the application and scan the pre-downloaded marker image in **Figure 10**.

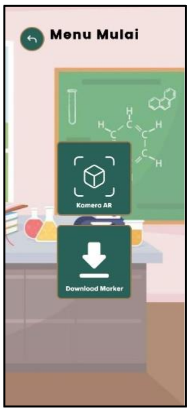


Figure 10. Scan AR menu

- **Download Marker**
  Users download the markers provided, which represent four different parts of the respiratory system in **Figure 11**.

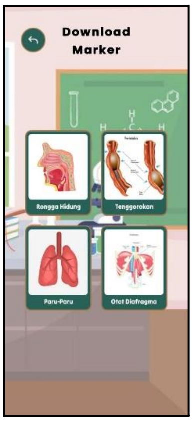


Figure 11. Download marker menu

DOI: https://doi.org/10.17509/edsence.v7i1.83885
p-ISSN:2685-2489 | e-ISSN:2685-2535

- **Scan Marker**
  Users scan the markers to view 3D objects along with descriptive information about the respiratory anatomy in **Figure 12**.

Figure 12. Scan marker menu

4. CONCLUSION

Based on the results of the development of the respiratory system anatomy learning application based on Augmented Reality (AR) technology, a direct trial has been conducted on 35 students at SMAN 1 Tirtayasa. In this activity, students were asked to download and install the application independently on their respective mobile devices, then test the available features. After the trial process, the students filled out a questionnaire designed to convey the application's performance and the effectiveness of learning with the help of AR technology.

The results of filling out the questionnaire showed that 85% of students experienced an increase in understanding of the material, strengthening memory, and more active involvement in the learning process. On the other hand, around 15% of students faced technical obstacles or adaptation obstacles, such as difficulty running the application, limited device specifications, or not understanding how to interact with the interface system.

These findings indicate that the use of marker-based Augmented Reality technology can create a more interactive, visual, and interesting learning experience. Through three-dimensional visualizations that approach real representations, this technology is able to convey learning materials more concretely and comprehensively. With great potential in improving the quality of learning, this application is very appropriate to be widely applied in educational environments as an innovative media that supports effective, enjoyable, and meaningful learning processes.

AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

DOI: https://doi.org/10.17509/edsence.v7i1.83885
p-ISSN:2685-2489 | e-ISSN:2685-2535

REFERENCES

Albahout, K. S., & Lopez, R. A. (2023). *Anatomy, Head and Neck, Pharynx*. In StatPearls. StatPearls Publishing.

Alfitriani, N., Maula, W. A., & Hadiapurwa, A. (n.d.). Penggunaan media augmented reality dalam pembelajaran mengenal bentuk rupa bumi. Jurnal Penelitian Pendidikan. Universitas Pendidikan Indonesia.

Aulia, H., Ramdani, A., & Sedijani, P. (2023). Pengaruh pembelajaran sistem pernapasan pada manusia berbasis praktikum terhadap keterampilan proses sains peserta didik. *Journal of Classroom Action Research*, *5*(3), 55–60.

Boonbrahma, S., Boonbrahma, P., & Kaewrat, C. (2020). The use of marker-based augmented reality in space measurement. *Procedia Manufacturing, 42*, 337–343.

Carolina, Y. D. (2022). Augmented Reality sebagai Media Pembelajaran Interaktif 3D untuk Meningkatkan Motivasi Belajar Siswa Digital Native. *Ideguru: Jurnal Karya Ilmiah Guru, 8*(1), 10-16.

Diansyah, A. F., Rahman, M. R., Handayani, R., Cahyo, D. D. N., & Utami, E. (2023). Comparative Analysis of Software Development Lifecycle Methods in Software Development: A Systematic Literature Review. *International Journal of Advances in Data and Information Systems, 4*(2), 97-106.

Evanjeli, A., Pratama, D., & Wulandari, S. (2024). Augmented Reality-Based 3D Technology Learning Media for Human Respiratory Organs. *Jurnal Informatika dan Edukasi, 15*(1), 45–52.

Kementerian Pendidikan dan Kebudayaan Republik Indonesia. (2013). *Peraturan Menteri Pendidikan dan Kebudayaan Republik Indonesia Nomor 69 Tahun 2013 tentang Kerangka Dasar dan Struktur Kurikulum Sekolah Menengah Atas/Madrasah Aliyah*. Jakarta: Kementerian Pendidikan dan Kebudayaan.

Marieb, E. N., & Hoehn, K. (2019). *Human anatomy & physiology* (11th ed.). Pearson Education.

Munawir. (2020). *Modul pembelajaran Biologi SMA kelas XI: Sistem pernapasan*. Kementerian Pendidikan dan Kebudayaan Republik Indonesia.

Rahayu, H. P., & Wulandari, D. (2024). Development of Augmented Reality Learning Media on IPAS Subject Matter of the Respiratory System. *Jurnal Penelitian Pendidikan IPA, 10*(10), 7562–7571.

Rohmah, Nailir (2022). *Pengembangan E-Modul Pembelajaran Biologi Berbasis Problem Based Learning dan Integrasi Nilai Keislaman Pada Materi Sistem Pernapasan Manusia.* Undergraduate thesis, IAIN KUDUS.

Siregar, M. M., Fikri, F., Sinaga, H. A., & Hayati, Z. (2022). Implementasi efektivitas pembelajaran biologi tentang sistem pernapasan pada manusia dengan model pembelajaran problem solving berbantuan aplikasi *Respiratory System Anatomy* untuk

DOI: https://doi.org/10.17509/edsence.v7i1.83885
p-ISSN:2685-2489 | e-ISSN:2685-2535

meningkatkan kualitas belajar siswa kelas XII MAS YPRA Batang Kuis. *Jurnal Pendidikan Tambusai*, 6(1), 3286–3292.

Suparmi, N. W., Dinatha, N. M., & Kua, M. Y. (2024). Pengaruh media pembelajaran berbasis Unity 3D pada materi tata surya. *Didaktika: Jurnal Kependidikan, 13*(3), 3193.

Warmanto, I. E., Lahinta, A., & Tuloli, M. S. (2021). Penerapan Teknologi Augmented Reality dengan Metode Marker Based Tracking pada Pengenalan Gedung Fakultas Teknik. *Jurnal Nama. 1*(2), 13.

DOI: https://doi.org/10.17509/edsence.v7i1.83885
p-ISSN:2685-2489 | e-ISSN:2685-2535

DOI: https://doi.org/10.17509/edsence.v7i1.83885
p-ISSN:2685-2489 | e-ISSN:2685-2535