



## Augmented Reality Markerless Implementation Method in Benign Education Application for Prostatic Mobile-Based Hyperplasia (BPH)

Muhammad Fari Abiyyudhiya\*, Neny Rosmawarni, Hamonangan Kinantan Prabu  
Universitas Pembangunan Nasional "Veteran" Jakarta, Indonesia

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### Abstract

Technological developments in recent years have brought significant changes in education, particularly through the integration of Information and Communication Technology (ICT). ICT enables broader and more flexible access to learning resources through distance learning, educational applications, and digital platforms. One notable innovation is Augmented Reality (AR), which integrates two-dimensional (2D) and three-dimensional (3D) virtual objects into real-world environments in real time, providing more interactive and concrete learning experiences. This study aims to develop a mobile-based educational application using markerless Augmented Reality to improve the general population's understanding of Benign Prostatic Hyperplasia (BPH). This common health condition remains poorly understood. The research methodology adopts the Multimedia Development Life Cycle (MDLC), which consists of concept, design, material collection, assembly, testing, and distribution stages. The application was developed using Unity and Vuforia SDK and implemented on mobile devices. The findings show that the developed application functions properly, as demonstrated by black-box testing and markerless distance testing. Questionnaire and knowledge test results indicate that users' understanding of BPH improved after using the application. Users also provided positive feedback regarding usability, visual quality, and the effectiveness of AR-based learning. In conclusion, the proposed markerless AR educational application is an effective interactive learning medium for increasing public awareness, supporting early understanding, and encouraging timely treatment of Benign Prostatic Hyperplasia.

**Keywords:** *ICT, Augmented Reality, Education, BPH, Application, Mobile-Based*

### INTRODUCTION

Technological developments in recent years have significantly changed education. Information and Communication Technology (ICT) has opened up more expansive, flexible access to educational resources. The positive impacts are clearly felt, changing the approach to learning and creating innovative opportunities across various disciplines. Innovations such as distance learning, educational apps, online platforms, and interactive learning resources have changed the way students and educators interact with subject matter.

Technology has opened the door to continuous learning and constant renewal in education. Thus, technology's influence has made learning more accessible, interactive, and relevant to the demands of the times. This positive shift continues to grow in education, preparing individuals for an increasingly connected and technology-based future.

One form of innovative educational technology is Augmented Reality (AR) technology. Augmented Reality (AR) is a technology that integrates two-dimensional (2D) or three-dimensional (3D) virtual objects into the real environment in real time (Agil & Sitio, 2022). AR technology in education has several advantages that make it innovative and valuable. When combined with AR hardware and software, AR applications offer new opportunities for greater student interaction, attract more attention to education, provide educational benefits, and increase the effectiveness of the learning process (Djibril & Çakır, 2021).

In addition, AR allows for better visualization of complex or abstract concepts. Users can see

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virtual objects integrated with the real environment to explain complex concepts more concretely. The use of AR also has the potential to stimulate students' mindsets to think critically about specific problems.

AR is used in healthcare training to provide realistic experiences in education and care. This technology is more cost-effective and consistent than conventional methods and enriches learning in various fields. Implementing the markerless method allows interaction with 3D content without physical markers, providing a more flexible learning experience. For example, in prostate disease education, AR facilitates the understanding of anatomy and increases user information retention.

When we talk about health issues like prostate disease, it is essential to understand that lack of education about the prostate gland can be a source of concern, as the prostate is an integral part of the male reproductive system, which also includes the penis and testicles. The prostate is the most prominent accessory gland in men, located just below the bladder and on the anterior side of the rectum, about the size of a walnut, and surrounds the prostatic urethra.

The most common abnormality found in the prostate gland is benign prostatic enlargement or benign prostatic hyperplasia (BPH). BPH is a benign tumor that occurs in men, and its incidence is related to increasing age. About 70% of men over 60 experience this disease, rising to 90% in those over 80 (Muwafiq et al., 2022).

In Indonesia, Benign Prostatic Hyperplasia (BPH) is the second most common condition after urinary tract stones. It is estimated to be found in 50% of men over 50 years old, with an average life expectancy in Indonesia of 65 years (Diana & Prasetyo, 2020). Therefore, it is essential to realize that education about this disease is crucial in early understanding efforts. BPH disease education is needed because a lack of understanding can hinder timely medical care.

BPH education is necessary because a lack of understanding can hinder the timely seeking of medical care. Education about BPH is essential to increase public awareness about this condition and its treatment options. However, conventional educational methods, such as brochures, may only reach some people effectively. AR technology offers an engaging, interactive way to deliver content in BPH education.

Several researchers have developed health-related educational applications using AR technology, for example, Mustagfirin and Riyanto (2021) and Amirullah (2021) each developed educational applications regarding Drug Dangers, Counseling Media, Health Protocols, and Information on the Spread of COVID-19 in Indonesia. Research conducted by Mustagfirin and Riyanto (2021) developed an Android-based application to educate users about the dangers of drugs. In contrast, the research by Amirullah (2021) developed an Android-based application to provide health protocol education and information about the spread of COVID-19 in Indonesia. However, based on prior research, no educational applications for BPH have been developed in Indonesia.

BPH is a significant health problem, but the general understanding of the disease is still limited. This is where AR BPH education becomes an innovative step. By integrating AR into education about BPH, the author conducted a study titled "Implementation of Augmented Reality Markerless Method in Mobile-Based Benign Prostatic Hyperplasia (BPH) Education Application," which is expected to improve public understanding of this disease.

Despite the rapid development of educational technology, several challenges remain in health education, particularly in delivering medical information to the general public. Health-related topics often involve complex anatomical structures and disease mechanisms that are difficult to explain using conventional educational media such as text, brochures, or static images. These limitations can reduce public engagement and understanding, which may lead to delayed diagnosis and inadequate treatment-seeking behavior, especially for diseases that require early awareness, such as Benign Prostatic Hyperplasia (BPH).

The importance of this study lies in addressing the gap between medical knowledge and public understanding of BPH through an interactive and visually based learning approach. Considering the high prevalence of BPH among aging men and the limited availability of engaging educational media in Indonesia, there is a strong need for an educational tool that can effectively communicate prostate anatomy, disease characteristics, and potential health impacts. By integrating markerless Augmented Reality (AR) into a mobile-based application, this study provides an innovative educational solution that allows users to visualize prostate conditions more concretely and intuitively, thereby enhancing comprehension and learning retention.

Based on this background, the objective of this research is to develop and implement a mobile-based educational application that uses markerless Augmented Reality technology for education on Benign Prostatic Hyperplasia (BPH). Specifically, this study aims to:

1. Design and develop a markerless AR-based mobile application as an educational medium for BPH.
2. Evaluate the functionality and usability of the developed application.
3. Assess the effectiveness of the application in improving users' understanding of BPH.

Accordingly, the research questions addressed in this study are as follows:

1. How can a markerless Augmented Reality-based mobile application be developed to support education on Benign Prostatic Hyperplasia?
2. How does the developed application perform in terms of functionality and usability?
3. To what extent does the use of a markerless AR-based educational application improve users' understanding of Benign Prostatic Hyperplasia?

## **LITERATURE REVIEW**

### **Benign Prostatic Hyperplasia (BPH)**

Benign Prostatic Hyperplasia (BPH) or Benign Prostate Enlargement (BPH) is a histological disorder characterized by the proliferation of prostate cells. BPH is a prostate condition that is commonly experienced by older men, where the prostate gland experiences non-cancerous enlargement that can cause symptoms such as difficulty urinating, frequent urination, and a feeling of incomplete urination. Although BPH itself is not malignant, prostate enlargement can obstruct the flow of urine from the bladder, disrupt the quality of life of sufferers, and, if left untreated, can cause serious complications such as urinary tract infections or bladder damage. Treatment for BPH ranges from the use of drugs that help reduce symptoms and laser therapy to surgical procedures such as prostatectomy, which are chosen based on the severity of symptoms and individual needs.

### **Augmented Reality (AR)**

Augmented Reality (AR) is a technology that enables the integration of two-dimensional (2D) or three-dimensional (3D) virtual objects into the real environment in real time. One of the advantages of AR technology is the ability to display virtual objects in three dimensions in the real world using a camera. With AR, users can experience enriched interactions with their environment, in which virtual objects and additional information are embedded in real views.

AR has presented a variety of applications, from video games that involve physical movement in the surrounding environment to tourist guides that directly present historical or geographical information. In addition, AR has been applied in education, healthcare, product design, and various other industries, opening new opportunities for how we interact with the world around us. The working principle of Augmented Reality is tracking and reconstruction. The tracking process can be done with or without markers.

**Application**

An application uses a computer, and instructions or statements are arranged so that the computer can process input into output. Applications cover various purposes, from communication, productivity, and entertainment to education, and have changed how we interact with technology. Applications provide easy access to information, services, and entertainment, facilitating everyday life in previously impossible ways. Moreover, developers continue to create innovative applications that expand the possibilities of our electronic devices, opening the door to more prosperous, more connected experiences in many aspects of modern life.

**Education**

Education, also called education, is all efforts planned to influence others, individuals, groups, and communities to do what the education practitioners expect. Education prepares individuals to face increasingly complex challenges in a changing world through various education systems, from formal schools to lifelong learning. In addition, education is not only about teaching academic concepts but also about developing critical thinking skills.

In the context of health education, effective educational media are essential for conveying complex medical information to the general public. Conventional educational methods, such as text-based explanations or brochures, often have limitations in clearly explaining anatomical structures and disease mechanisms. Therefore, the integration of interactive technology, such as Augmented Reality (AR), into educational applications is considered a promising approach to enhance learning effectiveness, engagement, and understanding, particularly for health-related topics such as Benign Prostatic Hyperplasia (BPH).

**Vuforia**

Vuforia is a plugin and database used to create AR. Qualcomm developed it using highly consistent computer vision sources, with a focus on image recognition. Using Vuforia, users can see and interact with virtual objects, additional information, or 3D views overlaid on the real world through smartphones, tablets, or smart glasses. This platform is known for its ability to track and recognize real objects, allowing developers to create more immersive AR experiences. Vuforia has been applied across various fields, including games, education, healthcare, and manufacturing, opening up endless opportunities for AR innovation ([Endra & Saputra, 2022](#)).

**Unity**

Unity is a professional-quality game engine for creating video games targeting multiple platforms. Unity enables developers to create interactive 2D and 3D applications and games, supporting various platforms, including PCs, game consoles, mobile phones, tablets, and VR/AR devices. Unity offers powerful, flexible development tools and an intuitive visual environment for designing, testing, and optimizing projects. Unity's strengths include extensive community support, a wide range of educational resources, and a robust asset store, allowing developers to accelerate the development cycle and create more engaging experiences for end users. With its ever-growing popularity, Unity has become one of the leading platforms in the game development industry, providing powerful tools to bring creative ideas to life through engaging applications and games.

This study examines the relationship among Augmented Reality (AR), education, and Benign Prostatic Hyperplasia (BPH). AR technology is used as an educational medium to deliver interactive, visual learning experiences that can improve users' understanding of health-related information. By integrating markerless AR into a mobile-based educational application, complex information regarding prostate anatomy and BPH conditions can be delivered more effectively. Improved

educational delivery is expected to enhance public understanding, awareness, and early detection of BPH.

### **Multimedia Development Life Cycle (MDLC)**

The methodology used is the Multimedia Development Life Cycle (MDLC), a research methodology with several stages. Several stages of the Multimedia Development Life Cycle (MDLC) include concept, design, material collection, creation, testing, and distribution.

MDLC is a widely used development method for multimedia applications, particularly those integrating text, images, animation, audio, and interactive elements. The MDLC method was first introduced by Luther and further developed by Vaughan, who described MDLC as a systematic approach to designing and developing multimedia systems through iterative stages.

### **Mobile Application**

Mobile applications, also known as Mobile Apps, run on mobile devices such as iPads, Tablets, Smartphones, and others, and can be standalone or run on operating systems that support the software. Mobile applications can come from pre-installed apps on mobile devices or be downloaded from distribution channels. Mobile applications generally allow users to access internet services that are usually only available on a PC or notebook. Thus, mobile applications can help users access internet services more efficiently on their mobile devices ([Satria et al., 2023](#)).

In this study, the mobile application serves as an educational medium that delivers information about Benign Prostatic Hyperplasia (BPH) using markerless Augmented Reality (AR). The application is designed to run on Android, enabling users to access educational content anytime, anywhere on a smartphone.

### **Input Data of the Application (BPH Educational Content)**

The input data used in this application are derived from validated medical and educational sources related to Benign Prostatic Hyperplasia (BPH). The inputs include textual information, anatomical illustrations, and three-dimensional (3D) prostate models representing normal and BPH conditions.

These data are used as educational inputs rather than diagnostic data. The 3D prostate models are developed from general anatomical references and medical literature to visually illustrate prostate enlargement and its impact on the urinary system. No personal patient data is used in this application. The input data are processed and visualized through the AR system to provide interactive educational experiences for users.

### **Unified Modeling Language (UML)**

Unified Modeling Language (UML) is used for object-oriented analysis and design. In its implementation, UML includes various graphical notation methods to create a visual model of a software system. Through graphical diagrams, UML helps developers and customers understand the system. UML provides various Types of diagrams that can be used in system development, namely: Use Case Diagram, Activity Diagram, Class Diagram, Sequence Diagram, Collaboration Diagram (UML Communication Diagram), State Machine Diagram, Component Diagram, and Deployment Diagram. In this research, UML diagrams are used to model system functionality, user interaction, and application workflow, ensuring that the AR-based educational system meets the defined requirements.

### **Flow chart**

A flowchart is a diagram that explains the process flow of a program. This is very important

when building a program because it helps explain the process, making it easier to understand. Each step is depicted as a diagram and connected with a line or an arrow indicating direction, making it easier to understand and more concise while reducing the possibility of misinterpretation. Flowcharts are a great way to connect non-technical and technical needs in the programming world (Setiawan, 2021).

**Interactive Multimedia**

Multimedia comprises various media types that convey messages or information to users, each with its own purpose and function. Several multimedia components are digitally arranged to engage and motivate users to learn. These components are text, images, audio, video, and animation. One more component can be added: interactivity (user control and feedback), so multimedia can be called Interactive Multimedia. In this application, interactive multimedia elements are integrated with Augmented Reality to enhance user engagement and learning effectiveness, particularly in understanding prostate anatomy and BPH.

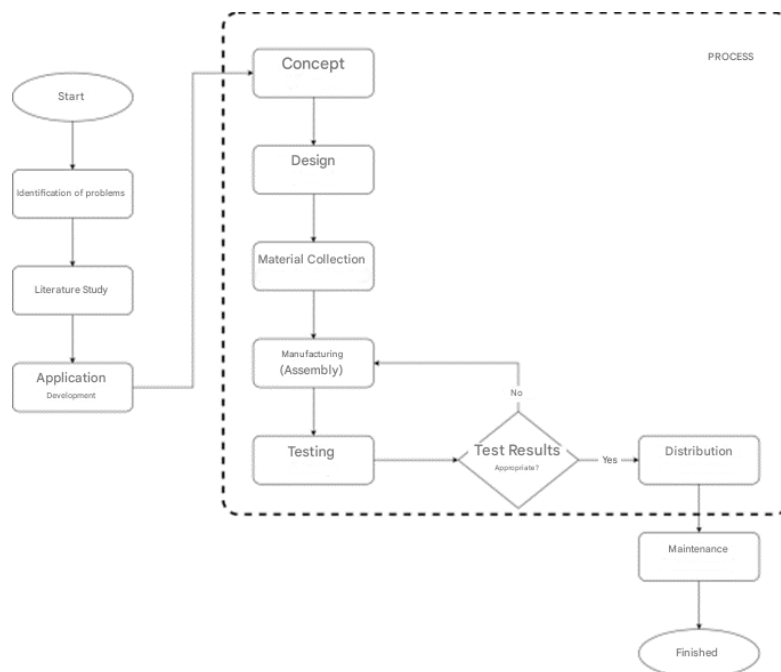
**Testing Scenario of the Application**

The testing phase is conducted to ensure that the application functions correctly and meets educational objectives. Testing scenarios include functional testing of AR features, usability testing, and content validation. Users are asked to interact with the application by accessing AR objects, reading educational materials, and navigating menus. The testing process is repeated until the application reaches a saturated result, where no significant errors are found, and user interactions run smoothly across multiple testing sessions and devices.

**RESEARCH METHOD**

**Research Stages**

To achieve the research objectives, the author will compile the stages of the research conducted based on various previous related studies. An overview of the research stages is shown in Figure 1 below.



**Figure 1** Stages Study

### Identification of problems

This study identified a lack of educational resources that leverage AR technology to improve understanding of BPH. Based on these problems, this study aims to address them by integrating AR technology into educational applications that provide more in-depth information and enable more effective, interactive learning about BPH.

### Literature Study

At this stage, the author explores various aspects, including AR technology in education, understanding of BPH, health education through mobile applications, the use of AR in health education applications, and user needs and expectations for such applications, drawing on relevant references and literature.

### Application Development

This study uses the MDLC (Multimedia Development Life Cycle) method to develop the application. The following are the stages in the MDLC methodology:

#### *Concept*

The objectives have been determined at this stage, and the application is being developed for whom? One will describe the concept of the educational application to be developed:

**Table 1.** Application Concept

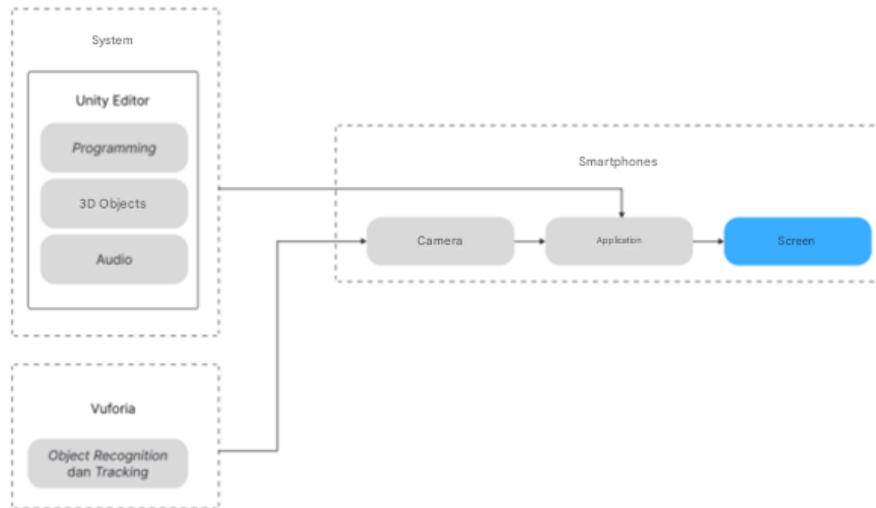
<b>Concept Category</b>	<b>Concept Description</b>
Application Title	Benign Prostatic Hyperplasia Education App
Multimedia Types	The text contains general information, images, and audio about Benign Prostatic Hyperplasia, as well as Augmented Reality visualizations of the affected areas.
Objective	The general public aged 18 years and over (especially men) receive education about Benign Prostatic Hyperplasia in a descriptive and interactive manner.
Target Users	The general public aged 18 years and over (especially men) who are still unaware of Benign Prostatic Hyperplasia.
Minimum Hardware Specifications	The minimum hardware and operating system specifications required to run this application are Android 8.0 Oreo and iOS 15.0.
Audio	Backsound dubbing, with audio format (*.wav, and *.mp3).
3D Assets	Three-dimensional assets of a male body model and the shape of the male reproductive organs and their parts.

#### *Design*

At the design stage, specifications regarding the program architecture, style, appearance, and material or ingredient requirements were made.

##### a. Block Diagram System

A block diagram illustrates the system's principles and performance in tool design. The block diagram in Figure 2 below illustrates how the tool to be produced works.



**Figure 2**Block Diagram

b. Storyboard

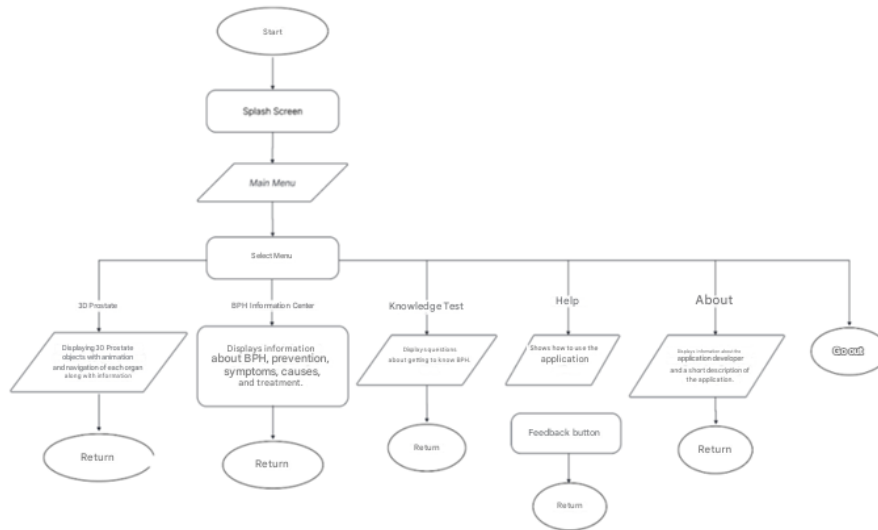
A storyboard has been created to determine the flow of activities for each page in the application, as shown in Table 2 below.

**Table 2.** Storyboard

Scene	Menu	Information
1	Main course	There are menu options connected via navigation buttons, including the AR camera menu button, information center menu, BPH knowledge test menu, help, about, and exit.
2	3D Prostate Menu	This page contains AR of the male body and male reproductive organs with explanations of the organs affected by BPH.
3	Information Center Menu	There is information about BPH, symptoms, causes, and treatment.
4	Knowledge Test Menu	This page has a number of questions that users can answer to test their knowledge of BPH.
5	Help Menu	On this page, there is a description of how to use the application, along with a feedback button to request new material and input for further development.
6	Menu About	This page includes information about the application developer and a brief description of the application.
7	Exit menu	This button can be used to exit the application.

c. Application Workflow

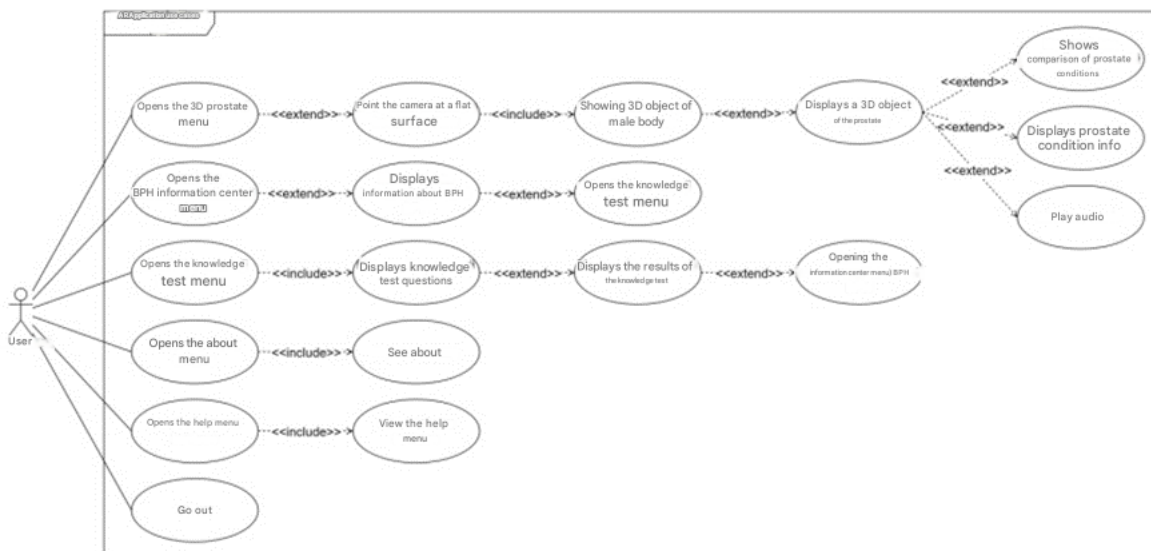
The workflow of the BPH disease education application is shown in Figure 3 below.



**Figure 3** Application Workflow

d. Use Case Diagram

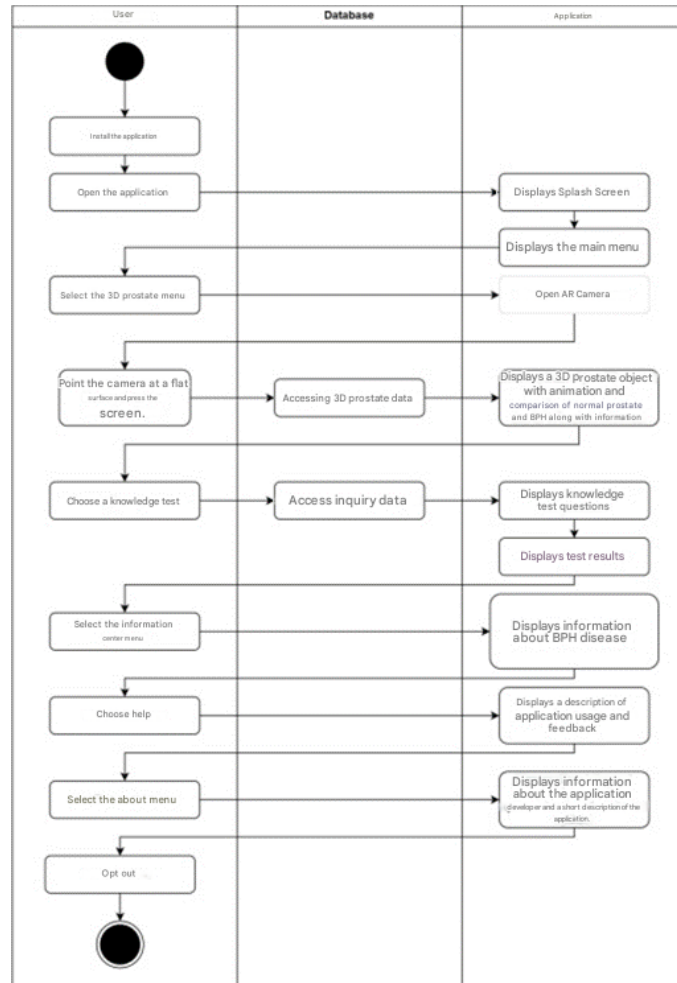
A use case diagram is a textual depiction of interaction scenarios. Each scenario describes the sequence of actions an actor performs when interacting with the system. In this application, users can select menus such as 3D prostate, information center, knowledge test, help, and exit. The Use Case Diagram for this study is shown in Figure 4 below.



**Figure 4** Use Case Diagram

e. Activity Diagram

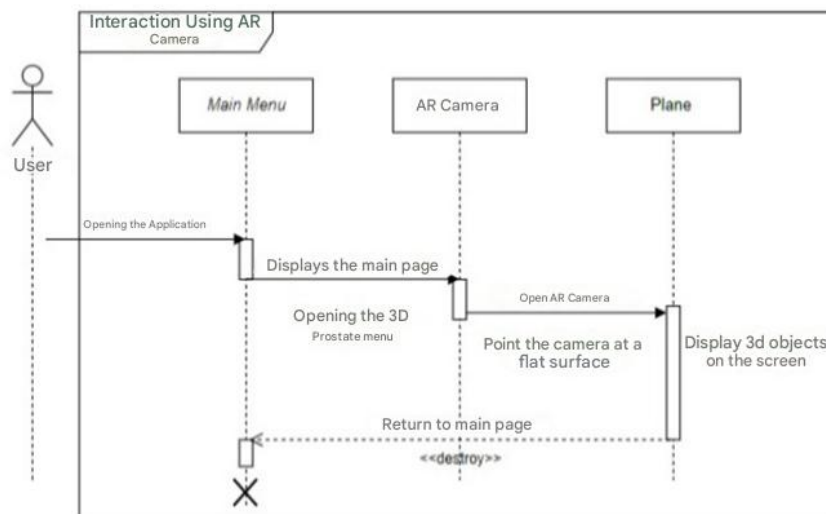
An Activity Diagram is a system that provides a workflow for designing an activity that will be run. It can also define or group the display flow in a system, with components of a particular form connected by arrows. The Activity Diagram is shown in Figure 5 below.



**Figure 5** Activity Diagram

f. Sequence Diagram

Use a Sequence Diagram to determine the sequence of events that can produce the desired output. The Sequence Diagram, displayed using an AR Camera, is shown in Figure 6 below.



**Figure 6.** Sequence Diagram Using AR Camera

g. User Interface Design

The user interface sketch design is carried out in Figma at this stage, in accordance with the application workflow and activity diagram above. The interface design will then be imported into Unity to be displayed as an easy-to-use application that helps achieve user satisfaction. The following is a design for the benign prostatic hyperplasia education application interface, with the application's features shown in Figure 7 below.

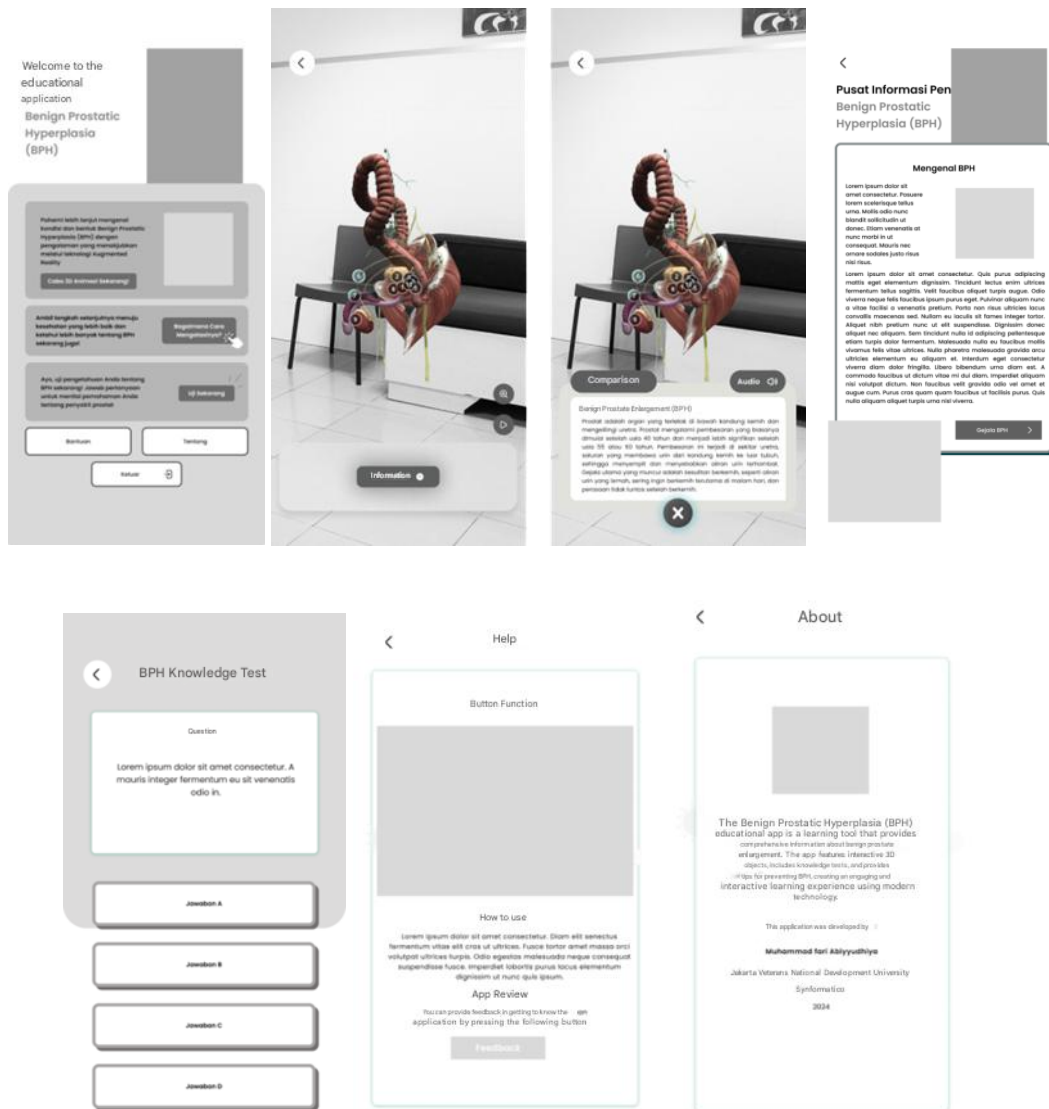


Figure 6 Application Interface Design Plan

Material Collection

Teaching materials will be presented in learning media at the material collection stage (material collection). These materials will include BPH learning materials, images, animations, and audio to support the educational application being created.

Assembly

All objects or multimedia materials obtained are developed at the assembly stage (creation).

Application creation is based on the design stage, such as system block diagrams, storyboards, application workflows, use case diagrams, activity diagrams, and sequence diagrams. This stage usually uses software such as Unity or others as a tool for making it.

#### *Testing*

Testing is performed after completing the creation stage by running the application and checking for any errors in the created learning media. At this stage, Black-Box Testing will be conducted to determine whether the creation process aligns with the plan.

#### *Distribution*

At the distribution stage, the application or product will be stored on a storage medium such as a USB drive, a CD, or online storage. This stage can also be considered an evaluation and reporting stage for developing finished products, providing better information about deficiencies or errors in the application.

#### **Maintenance**

During the maintenance phase, many essential steps are taken to ensure that the application functions properly and is relevant to users. These efforts include bug fixes, feature updates, adaptation to technological changes in the environment, performance optimization, and ongoing monitoring to identify and resolve issues.

The maintenance user feedback evaluation results also include end-user training and support; updating technical documentation and user guides; managing security systems and protecting user data; and configuration management to ensure changes are tracked and implemented correctly. These actions ensure that the application remains operational and secure and can adapt to needs and technological advances.

#### **Research Tools**

- a. Hardware
- b. Following are the details of the hardware used in the research:
- c. Model: Dell Inspiron 15 7567
- d. Processor: Intel(R) Core (TM) i7-7700HQ
- e. GPU: NVIDIA GeForce GTX 1050 Ti
- f. RAM: 16 GB DDR4
- g. Storage: 1 TB HDD TOSHIBA MQ01ABD100
- h. Software
- i. Operating System: Windows 10 Home Single Language
- j. IDE: Visual Studio Code
- k. Programming Language: C#
- l. Application: Unity Editor 2022.3.20f
- m. Plugins: Vuforia SDK 10.24

#### **FINDINGS AND DISCUSSION**

##### **Concept Stage Results**

The learning objectives, material concepts, and media content concepts have been determined. At this stage, the objectives for whom the application is developed have also been determined. The findings of this study are consistent with previous research by [Mustagfirin and Riyanto \(2021\)](#) and [Amirullah \(2021\)](#), which reported that AR-based educational applications improve user engagement and understanding of health-related topics.

However, unlike previous studies that focused on general health education, this research specifically addresses Benign Prostatic Hyperplasia, a condition that requires anatomical understanding and early awareness. Therefore, this application provides a more targeted educational contribution in the context of BPH education. These results indicate that AR-based learning media have significant implications for BPH education, particularly in increasing public awareness and supporting early detection efforts through improved understanding.

### Design Phase Results

At the design stage, specifications regarding the program architecture, style, appearance, and material or ingredient requirements were made. This phase focuses on translating the application's conceptual ideas into detailed design components that serve as guidelines for the development process.

The program architecture was designed to define the interaction between system components, including user interfaces, AR modules, educational content, and data processing functions. The user interface was designed to ensure ease of navigation and user-friendly interaction, allowing users to access educational materials, AR visualizations, and evaluation features efficiently. The application's visual style and appearance were designed to be simple, clear, and informative, emphasizing readability and visual clarity to support learning objectives.

In addition, the material and ingredient requirements were identified during this phase, including educational content on Benign Prostatic Hyperplasia (BPH), three-dimensional prostate models, image assets, and interactive multimedia elements. These materials were designed and prepared to align with educational goals and to ensure consistency with the markerless Augmented Reality implementation. As a result, the design phase produces comprehensive specifications that guide the application's development and implementation.

### *Splash Screen View*

The splash page implementation *screen* of a previously created design:



**Figure 8.** Splash Screen Page

*Main Menu View*

The following is the result of implementing the main menu page from a previously created design:



**Figure 9.** Main Menu Page

*3D Prostate Menu View*

The following is the result of implementing the 3D Prostate page from a previously created design:



**Figure 10.** 3D Prostate Menu Page

*Knowledge Test Menu View*

The following are the results of implementing a knowledge test page from a previously created design:



**Figure 7** Knowledge Test Page

*Help Menu View*

The following is the result of implementing a help page from a previously created design :



**Figure 12.** Help Menu Page

*About Menu View*

The following is the result of implementing a help page from a previously created design:



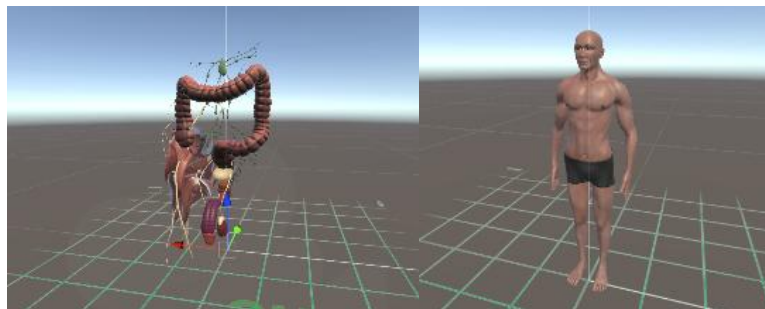
**Figure 13.** About Menu Page

### Material Collecting Stage Results

At the material collection stage, teaching materials to be presented in the learning media have been collected. These materials include BPH learning resources, images, animations, and audio to support educational applications.

#### *Assets of the Male Body and Male Reproductive Organs*

3D object assets in the form of a male body and male reproductive organs imported from Sketchfab.com. The male reproductive organ assets have details on each organ, including the prostate, and this 3D object is saved in Unity, as shown in Figure 14 below.



**Figure 14.** 3D Assets of Male Body and Male Reproductive Organs

#### *Asset Male Body Texture and Male Reproductive Organs*

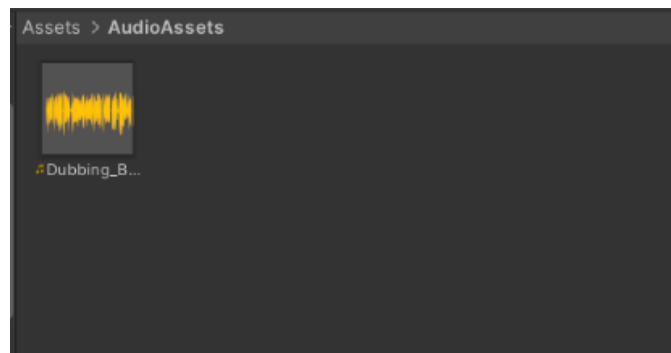
Imported male body and male reproductive organ texture assets from Sketchfab.com. This asset includes male body textures and details of each organ in the male reproductive system; each texture will be attached to the corresponding 3D object. The texture assets are shown in Figure 15 below.



**Figure 15.** Male Body Texture Assets and Male Reproductive Organs

#### *Asset Audio*

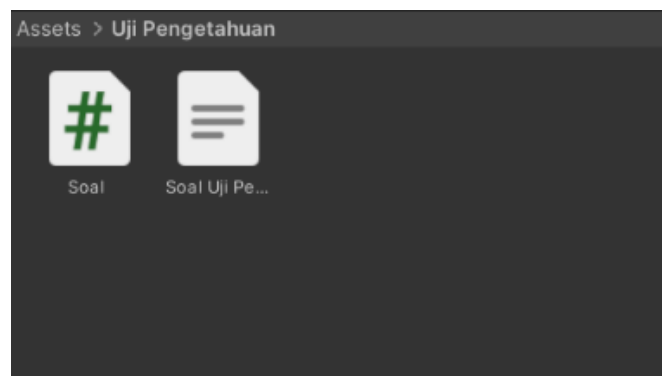
Sound materials are collected and created to make the application more engaging and interactive. Audio in voice dubbing created using Artificial Intelligence contains explanatory sounds of prostate disease. The file format used is .mp3, as seen in Figure 16 below.



**Figure 16.** Audio Assets

#### *Asset Knowledge Test Questions*

The collection and writing of questions are used to assess students' understanding of BPH through the application. The quiz questions consist of 10 multiple-choice questions with options a to d. The file format used is .txt, as seen in Figure 17 below.



**Figure 8** Knowledge Test Question Assets

#### *Assembly Phase Results*

At this stage, the implementation of the previous stage is carried out, namely, the collection of materials based on the design at the design stage. At this stage of manufacturing, materials are

assembled using Unity 2022.3.20f1 game development software and the Vuforia SDK 10.24 platform for augmented reality. The assembly process is handled differently in each scene. In the Prostate 3D Scene, the Benign Prostatic Hyperplasia application displays 3D objects with a markerless technique, using Plane Finder to map flat surfaces.

To import Plane Finder into Unity, install the latest Unity and Vuforia SDK, add the Vuforia package Engine via Package Manager, and enter AR Camera and Plane Finder into the scene. Make sure the 3D model is in a compatible format, such as .fbx or .obj, and use the Ground Plane Stage to display 3D objects on detected flat surfaces. The display of 3D objects can be seen in the following figure 18:



**Figure 18.** Male Body 3D Object

The `Rotate()` function automatically rotates objects. When this method is called, the button to stop rotation is enabled, the button to start rotation is disabled, and the `is rotating` variable is set to `true`. The object is rotated around the vertical and counterclockwise axes at the specified speed. The `Zoom()` function manages the object's zoom and transition functions, enables the zoom button, and sets the `is zooming` and `currentIndex` variables. The `SetTarget (int index)` method manages the object's target position, rotation, and scale. The `Rotate()`, `Zoom()`, and `SetTarget()` functions can be seen in Figure 19 below:

```

2 references
public void Rotate()
{
    btnStopRotate.SetActive(true);
    btnRotate.SetActive(false);
    isRotating = true;
    model.transform.Rotate(Vector3.up * speedY);
    modelBody.transform.Rotate(Vector3.back * speedZ);
}

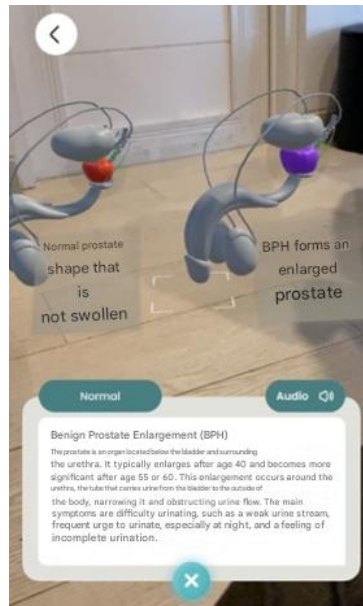
1 reference
public void Zoom()
{
    btnZoomIn.SetActive(false);
    btnZoomOut.SetActive(true);
    isZooming = true;
    currentIndex = 1;
    SetTarget(currentIndex);
}

4 references
public void SetTarget(int index)
{
    targetPosition = targetPositions[index];
    targetRotation = targetRotations[index];
    targetScale = targetScales[index];
    isTransitioning = true;
}

```

**Figure 9'**Rotate( )', 'Zoom()', and 'SetTarget()' functions

The information button controls the appearance and interaction of buttons within the application. This method reduces unnecessary UI elements and enables the corresponding information UI elements. A highlight effect is applied to highlight essential elements. The `Zoom()` function initiates the object's transition to information mode, and the `isInfo` variable is set to `true`. The `StopRotate()` function stops the object from rotating when it enters information mode. The compare button sets the comparison mode, enables model comparison, and turns off unnecessary objects. The comparison view can be seen in Figure 20 below:



**Figure 20.** 3D View of Prostate Comparison

The application provides information about BPH in the Information Center Scene with the following buttons: Back. The next button directs the user to the information page and the knowledge test scene on the last page. The Knowledge Test scene contains the logic of testing questions in the Soal.cs script, with methods to process and display questions, check answers, calculate grades, and display results. The Help scene provides an interface for using the application, a back button, and a feedback button. The About scene provides information about the application and its developer with a simple interface.

### Testing Phase Results

The benign prostatic hyperplasia education application is tested in the following stages. Each element in each scene is tested to ensure each button functions as expected.

#### *Black Box Testing*

*Black box* testing on the iPhone 11 device involves testing scenarios in the Main Menu and various scenes of the BPH educational application. The results show that all functions work as expected, including buttons and features on the Main menus, 3D Prostate, Knowledge Test, Information Center, About, and Help. For example, opening the app displays the Main Menu, and each button, such as 3D Prostate, Information Center, and Knowledge Test, displays the appropriate scene or pop-up. All testing actions, such as button clicks and pop-up displays, are thriving as expected without any technical issues, so it can be concluded that the black box testing indicates the application is operating correctly and stably.

#### *Distance Testing*

Markerless method distance testing involves area detection tracking from 100cm to 300cm between the camera and the patterned floor surface. The results show that 3D objects appear correctly at 100cm to 300cm, but at 300cm, rendering takes longer. From this test, it can be concluded that the best distance for displaying markerless objects is between 100cm and 250cm, where the objects can appear quickly and clearly. In comparison, although the object still appears at a distance of 300cm, it takes longer to detect and appear.

### Questionnaire Testing

Questionnaire testing involved the general public in assessing the use of the application. The results showed that the application was easy to use with helpful features, good display quality, and easy-to-use AR features. Respondents also stated that the app content was accurate and informative, and that the knowledge test feature effectively measured understanding of BPH. Suggestions from respondents include publishing the app on the Google Play Store or App Store. In conclusion, this application received positive user feedback on ease of use, display quality, and content accuracy.

### Knowledge Test Test

Knowledge test results showed increased user understanding after using the application, with pre- and post-education scores indicating higher scores. For example, users who initially rated "Fair" increased their rating to "Good" or "Very Good" after using the application. In conclusion, the application effectively increases users' understanding of BPH, as evidenced by higher knowledge test scores after receiving education through the application, indicating that it is successful in its educational purpose. The table of value weights from the assessment category intervals used can be seen in Table 3 below:

**Table 3.** Assessment Category Interval

Percentage	Information
80% - 100%	Very good
60% - 79.9%	Good
40% - 59.9%	Enough
20% - 39.9%	Not enough
0 % - 19.9 %	Very less

### Distribution Stage Results

At this stage, the created application is distributed to end users. In addition to distributing the application, the research report results are also written at this stage. Application distribution requires media to reach users; the media the author uses for this distribution is internet-based, using Google Drive for Android devices and a third-party for iOS. At this stage, the developed application is implemented in the research environment. This process involves installation, configuration, and adaptation so that the product functions appropriately for the specified purpose.

### Maintenance

After the application is implemented and evaluated, the research team continues to maintain the completed application, improving it based on information about deficiencies or errors that may occur. Several important activities are carried out to ensure that the application continues to function optimally and is relevant to users. Maintenance will be carried out periodically whenever there is a change in the elementary school curriculum, following its development; developers will carry out maintenance on the application. These activities include bug fixes, feature updates, adaptation to changes in the technological environment, performance optimization, and continuous monitoring to detect and fix problems.

### CONCLUSIONS

This study has successfully implemented a markerless Augmented Reality (AR) approach in a mobile-based educational application for Benign Prostatic Hyperplasia (BPH) using the Multimedia Development Life Cycle (MDLC) method. The developed application integrates

interactive multimedia elements and three-dimensional visualization to present prostate anatomy and BPH-related information in a more engaging and understandable way. Based on the testing and evaluation results, including functional testing, usability assessment, and knowledge tests, the application demonstrates stable performance and positive user responses, indicating its effectiveness as an educational medium.

The findings of this study indicate that markerless AR can enhance users' understanding of BPH by transforming abstract, complex medical information into concrete visual representations. This approach helps increase user engagement and supports better comprehension compared to conventional text-based educational media. From a theoretical perspective, this research contributes to the development of AR-based health education by providing empirical evidence of the effectiveness of interactive visualization in improving learning outcomes.

From a practical perspective, the application serves as an accessible educational tool for the general public to raise awareness of BPH, support early understanding of prostate health, and encourage timely medical consultation. Therefore, the proposed application has the potential to serve as an innovative alternative for health education, particularly in the context of Benign Prostatic Hyperplasia.

### **LIMITATION & FURTHER RESEARCH**

This study has several limitations that should be considered. First, the evaluation of the application involved a limited number of users and was conducted in a controlled environment, which may not fully represent real-world usage conditions. Second, the developed application is intended solely for educational purposes and does not provide diagnostic or clinical decision-making features. In addition, the effectiveness of the augmented reality visualization is influenced by device specifications, camera quality, and environmental lighting conditions, which may affect overall user experience and application performance, particularly on less capable devices.

Despite these limitations, this study opens opportunities for further development and future research. After deployment, the application can be continuously improved by adding new features and regularly updating content to ensure the educational information remains relevant and up to date in the health domain. Future research is recommended to involve a larger and more diverse group of users to obtain more comprehensive and representative evaluation results.

Further enhancements may include optimizing application performance for a wider range of devices, integrating interactive simulations, expanding educational content, supporting multilingual features, and incorporating adaptive or personalized learning systems. Moreover, future studies could explore integrating artificial intelligence to enhance user engagement and improve the effectiveness of augmented reality-based health education applications. The application may also be distributed more widely through official platforms such as the Google Play Store or App Store to increase accessibility and public impact.

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