

Design of Augmented Reality-Based Learning Media in Computer Assembly Courses: A Preliminary Study

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Abstract. This study aims to design and develop augmented reality-based learning media for the topic of computer assembly in the Informatics and Computer Technology Education program. The background arises from the need for visual learning tools among students and the limitations of conventional teaching methods that do not adequately support spatial understanding or hands-on practice. The research uses a Research and Development approach with the Multimedia Development Life Cycle model. This preliminary stage is limited to early development without expert validation or effectiveness testing. The product is an Android-based application that scans markers and displays 3D computer components. Black box testing showed all features functioned well and stably. The prototype is technically feasible and provides a basis for further development and classroom use.

Keywords: Augmented Reality, Learning Media, Computer Assembly, MDLC, R&D

1 Introduction

Computer assembly is one of the important topics in the information technology and computer education curriculum, especially in the Information Technology and Computer Education Study Program (PTIK). Mastering this skill not only involves theoretical understanding of the functions and structure of hardware, but also requires practical experience in assembling and identifying computer components. For PTIK students preparing to become educators in the field of technology, a comprehensive understanding of computer assembly concepts is a fundamental requirement[1].

Computer assembly learning, however, often faces various obstacles when implemented. Conventional learning methods, such as limited presentations, the use of static images, and lectures, are still the main choices. These methods are one-way and tend to be less interactive, thus limiting students' learning experiences in studying computer hardware spatially and functionally[2]. In addition, students' opportunities to be directly involved in the practical

process of assembling computers are increasingly limited due to constraints in facilities and infrastructure, such as the number of physical devices available in the laboratory.

The world of education has begun to implement various creative methods to overcome this problem in line with advances in information technology. One of these is the use of Augmented Reality (AR) in learning[1]. AR enables mobile devices such as smartphones to integrate three-dimensional virtual objects into the real environment in real time[3]. This technology enables interactive visualization of computer components without the need for physical hardware in computer assembly learning[4]. Learning becomes more engaging, flexible, and safe as students can view the shape, name, and function of each component through AR markers scanned by a camera[5].

Previous studies have shown that the application of AR in education can increase student engagement, conceptual understanding, and motivation[6][7]. However, the development of AR-based media specifically designed for computer assembly topics is still limited, especially in the context of higher education in teacher training programs such as PTIK.

This research was conducted as a preliminary study aimed at designing and developing an AR-based learning media prototype for the topic of computer assembly. The focus of the research was on the design and development stages of the media using the Multimedia Development Life Cycle (MDLC) approach. The testing process was limited to internal functional testing using the black box method without involving expert validation or testing by students.

This study is not intended to measure the effectiveness of media on learning outcomes, but rather focuses on the initial development and technical feasibility of the prototype as a basis for further research and development.

Based on the results of the initial needs assessment, it was found that students in the PTIK study program require learning media that can provide direct visual guidance on the process and components of computer assembly. In addition, lecturers teaching the course stated the need for interactive media to explain the material to students who have visual and kinesthetic learning styles. From a technical standpoint, users also want a simple, intuitive, and easy-to-use application interface that does not require special skills. These identification results form the basis for the design process of the learning media developed in this study.

2 Literature Review

2.1 Interactive Learning Media

Learning media is anything that can be used to convey messages from the sender to the recipient in order to stimulate the thoughts, feelings, attention, and interest of learners and improve the effectiveness of learning[8]. Learning media in the digital age is no longer limited to conventional visual aids such as images and videos, but also includes technology-based interactive media such as augmented reality and multimedia[9]. Interactive media has the potential to make learning more engaging, personalized, and student-centered[10]. Interactive media enables real-time feedback and active user involvement in the learning process, which can enhance retention and deeper understanding of concepts—key features of interactive media[11].

2.2 Augmented Reality Technology in Learning

Augmented Reality (AR) is a technology that combines virtual elements (text, images, 3D objects) into the real world through digital devices such as smartphones or tablets, and displays them in real time[12]. AR is a system that has three main characteristics: combining the real and virtual worlds, real-time interactivity, and displaying objects in three dimensions[4].

In the context of education, AR has been proven to increase student engagement and understanding by presenting material in a dynamic and explorable visual form[13]. Several previous studies have shown that the use of AR in learning can improve student learning outcomes, motivation, and overall learning experience[14].

2.3 Computer Assembly as Learning Material

Computer assembly is the process of assembling and integrating hardware components such as processors, memory, motherboards, and power supplies into a fully functional system[15]. In the context of information technology education, this skill not only covers technical aspects, but also involves a conceptual understanding of computer architecture, the functions of each component, and the interrelationships between parts within the system[16].

According to constructivist theory, learning will be more meaningful if students actively build understanding through direct experience and visualization[17]. However, limitations in facilities, practice time, and the scarcity of visual representation media pose challenges that hinder this process. Therefore, the use of simulation-based learning media and immersive technology, such as Augmented Reality (AR), becomes relevant to support the mastery of concepts and computer assembly skills without relying solely on physical hardware[15].

2.4 Preliminary Development Research in R&D

In research and development (R&D), preliminary studies or initial development studies are an important stage in producing initial prototypes that can be tested from a technical and design perspective. According to Gall et al. (2003), this stage aims to identify the potential usefulness of a product before further validation is carried out[18].

Early development studies do not focus on the effectiveness of the media on learning outcomes, but rather on the success of the design and basic functionality of the media. Therefore, testing at this stage is technical in nature (e.g., black box testing), which is used to ensure that the media runs according to specifications before entering the expert validation and field testing stages[19].

3 Methods

3.1 Types and Approaches to Research

This research is part of a Research and Development (R&D) approach with a focus on the preliminary development stage. The aim is to design and build a prototype of Augmented Reality (AR)-based learning media for the topic of computer assembly. This research does not include validation by subject matter or media experts, nor does it involve testing with end users.

3.2 Development Model

The development model used is the Multimedia Development Life Cycle (MDLC) proposed by Luther[20]. MDLC was chosen because it is suitable for the development of interactive multimedia systems, including AR-based media. This model consists of six stages, namely: Concept, Design, Material Collecting, Assembly, Testing, and Distribution[20]. In this study, the stages carried out only reached stage 5 (Testing), while the Distribution stage was not carried out because the research was still in the early stages of development.

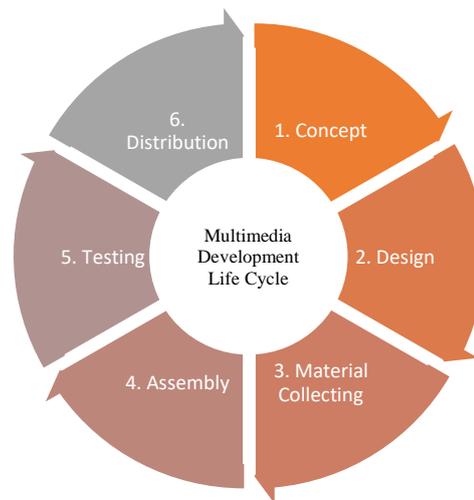


Fig 1. Multimedia Development Life Cycle

3.2 Development Procedure

Concept

This stage aims to identify the learning needs of PTIK students related to the topic of computer assembly. Information is gathered based on curriculum analysis, learning objectives, and the characteristics of appropriate materials and media.

Design

At this stage, the application navigation, user interface, AR marker system, and media storyboard were designed. The main menu designed includes: Simulation, Instructions, Evaluation, and Scan. Markers for each computer component were prepared so that they could be recognized by the system.

Material Collecting

Researchers collected and compiled the necessary multimedia resources, including: 3D models of components, functional descriptions of each component, marker images, and 3D models.

Assembly

At this stage, all media elements are integrated using Unity 3D software and Vuforia SDK to build an AR-based Android application. The system will display a 3D model when the user scans the corresponding marker through the smartphone camera.

Testing

Testing was conducted internally by the research team using the Black Box Testing method. The aim was to ensure that every feature in the application functioned as intended, including: navigation between menus, marker recognition, 3D object display, button response, and screen transitions.

4 Result and Discussion

This chapter presents the results of the development process of Augmented Reality (AR)-based learning media for the topic of computer assembly, in accordance with the stages in the Multimedia Development Life Cycle (MDLC) model used in this study, as well as a discussion of the results of functional testing of the media prototype that has been built.

4.1 Media Development Results Based on MDLC Stages

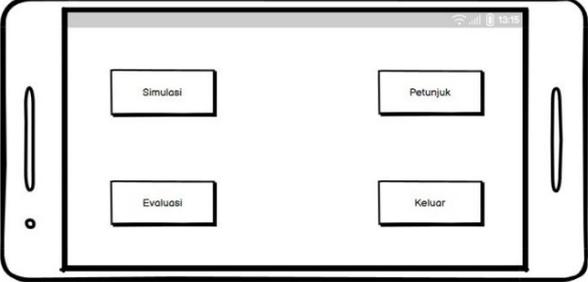
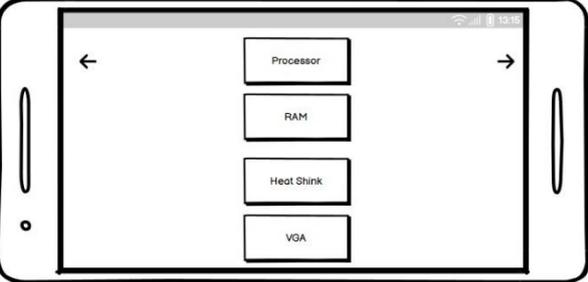
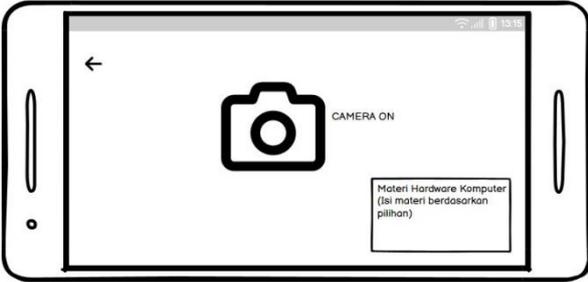
Concept

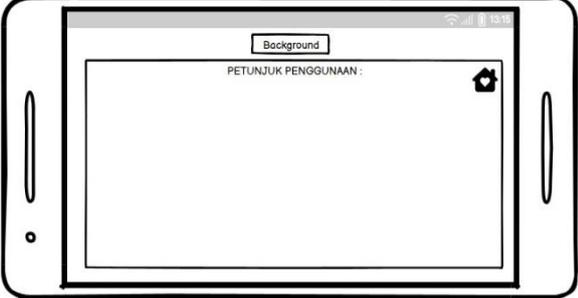
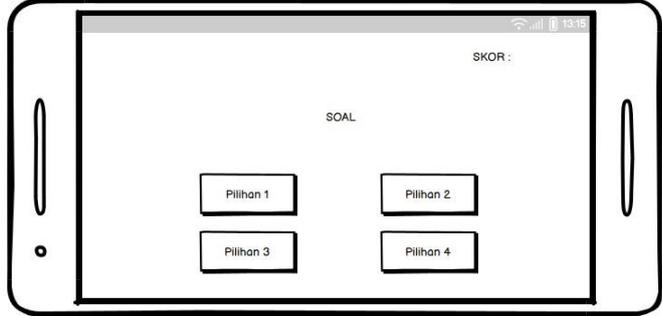
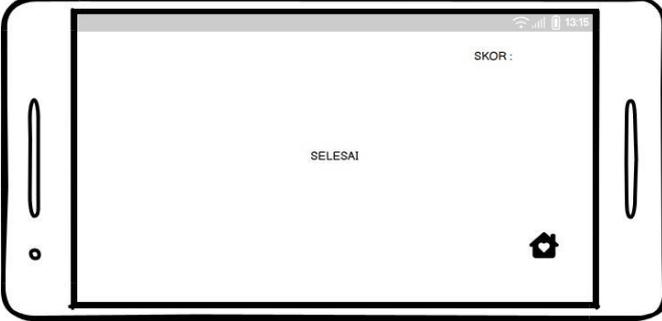
User needs were identified to formulate the basis for media development. The analysis results showed that PTIK students needed learning media that could provide visual guidance on the computer assembly process, especially in recognizing the shapes and functions of each component. Lecturers, as learning facilitators, also needed media that could explain the material more clearly to students with visual learning styles. In addition, students wanted media that was simple and easy to use without requiring in-depth technical expertise. These identification results serve as a reference in determining the main features, menu structure, and interaction design of the developed media.

Design

During the design phase, user interaction flows are mapped out using storyboards and application interface designs.

Table 1. Storyboard Application

| No. | Interface Design | Description |
|-----|---|--|
| 1. |  | <p>The home page, where users are given menu options such as Simulation to directly use the computer assembly simulation, Instructions for instructions on how to use the application, Evaluation in the form of questions related to computer assembly, and finally Exit to exit the application.</p> |
| 2. |  | <p>Simulation Page, where users will be given several hardware options to simulate.</p> |
| 3. |  | <p>AR Simulation Page, where users will be shown a simulation of the computer assembly process for one of the hardware devices selected by the user.</p> |

| | | |
|----|--|--|
| 4. |  | <p>The User Guide page displays instructions for using the application when the user selects the Guide menu.</p> |
| 5. |  | <p>The Evaluation page contains questions related to computer assembly to test users' knowledge after using this application, and this page is located in the Evaluation menu.</p> |
| 6. |  | <p>Final Score Page, showing the final score of the user after completing the evaluation questions</p> |

Each marker is designed to bring up 3D objects of corresponding computer components, such as the processor, RAM, heatsink, and VGA. The design is kept as simple as possible to support ease of use.

Material Collecting

At this stage, supporting media elements are collected and developed, including: 3D models of computer components, functional descriptions of each component, printed marker images used for AR scanning. Icons and UI elements are designed to support the readability and aesthetics of the application.

Assembly

This stage involves the technical implementation of all elements into an Android-based application. Development is carried out using Unity 3D and the Vuforia SDK plugin. Markers are linked to 3D objects so that when scanned, the objects appear in real time on the screen. The application generates an .apk file that can be run on an Android smartphone. When the user points the camera at a specific marker, the 3D object appears with a description of its associated function.

Testing (Functional Testing Results)

Testing was conducted on the main functionality of the application using the black box method. The purpose of the testing was to ensure that all features worked according to the design without any technical errors.

Table 2. Blackbox Testing

| No. | Testing | Expected Results | Testing | |
|-----|--|---|---------|-----------|
| | | | Valid | Not Valid |
| 1. | Opening the Application | The application can be opened without any problems and displays the main menu. | √ | |
| 2. | Simulation | The Simulation button works well, displaying several simulation options, namely processor simulation, RAM, Heat Shink, VGA, PC Casing, Hard Disk, and Power Supply. | √ | |
| 3. | Simulation – select one of the simulations | The processor, RAM, Heat Shink, VGA, PC casing, hard disk, and power supply simulation buttons work well; when pressed, they open the camera, and when the camera is pointed at the target image, they display the AR simulation. | √ | |
| 4. | Instructions | The Help button works well, displaying the application's help page. | √ | |
| 5. | Evaluation | The Evaluation button works well, displaying questions to determine whether students | √ | |

understand the simulations in the application.

Based on the test results, all features were found to function properly and the application prototype ran stably on Android devices. 3D objects appeared accurately when markers were recognized, and users could view functional descriptions in real time.

4.3 Discussion

The results of the development show that the AR-based learning media prototype for computer assembly material can be developed and operated well technically. The main features have been successfully implemented in accordance with the identified user needs, such as a simple display, intuitive navigation, and marker-based interaction that provides a visual experience of the hardware components.

From a functionality perspective, internal black-box testing results indicate that all components within the application function as intended. Although expert validation or effectiveness testing of student learning outcomes has not yet been conducted, the developed prototype demonstrates readiness for further evaluation.

The use of AR in computer assembly learning has great potential to overcome the limitations of hands-on practice that requires physical devices. Through 3D visual simulations, students can still fully understand the form and function of components. This aligns with previous study findings indicating that AR media can enhance engagement and conceptual understanding of visually and spatially based content.

5 Conclusion

This study has successfully designed and developed a prototype of an Augmented Reality (AR)-based learning media for the topic of computer assembly within the scope of courses in the Information Technology and Computer Education Study Program (PTIK). The development process was carried out using the Multimedia Development Life Cycle (MDLC) model, which includes five stages: Concept, Design, Material Collecting, Assembly, and Testing. The media was successfully developed to meet user needs, specifically those of PTIK students and faculty who sought interactive visual guidance, user-friendly media, and support for visual-kinesthetic learning styles. The application's key features functioned effectively, from menu navigation and marker scanning to the display of 3D objects and descriptions of computer component functions. Black box testing showed that the application runs stably on Android devices and all functions operate as designed. This media has the potential to be used as an innovative learning tool for understanding the structure and functions of computer hardware in a visual and contextual manner.

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