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Virtual Reality Development for Computer Assembly Practical Simulation Learning Media

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ABSTRACTS

Computers function as a central instrument in today's learning processes; consequently, students are often expected to possess baseline competencies in assembling them. This study develops a Virtual Reality (VR)–based computer-assembly practicum simulation using Unity and Oculus Quest 2 to help students at Amikom University Yogyakarta grasp assembly procedures in an interactive, realistic way. The application follows the Multimedia Development Life Cycle (MDLC), which comprises concept, design, material collection, assembly, testing, and distribution. Core functionality includes a sequenced simulation of assembly steps—installing the motherboard, processor, RAM—and a concluding functionality test. Evaluation employed Blackbox Testing to verify system behavior and the System Usability Scale (SUS) to assess usability. Blackbox Testing showed that all features worked properly. The mean SUS score was 74.63, categorized as Grade B, indicating good usability and ease of use. Overall, the findings underscore VR's promise as an effective and innovative medium for computer-assembly practicums.

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1. INTRODUCTION

Innovation remains a priority across the education sector, particularly for courses requiring hands-on practice to optimize knowledge acquisition. Among essential subjects in computer engineering—especially for students taking the Introduction to Information Technology course at Amikom University Yogyakarta—the computer-assembly practical holds a vital role. Students must understand component requirements and specifications, as well as the correct steps for assembling a computer [1].

Traditional computer-assembly practicums, however, frequently encounter barriers. Constraints include limited information and communication technology (ICT) facilities and uneven availability of tools across institutions [2]. Rising hardware costs, concerns over component safety during assembly, and restricted time or access to physical equipment can curtail opportunities for repeated, in-depth practice [3]. Such conditions widen the gap between the need for authentic practical experience and the resources available, potentially hampering comprehensive understanding of assembly concepts.

With the momentum of the Industrial Revolution 4.0, technologies such as Virtual Reality (VR) present a compelling alternative. VR produces a simulated environment that users can experience as though physically present, despite its computer-generated nature. In educational contexts, principal advantages include immersive engagement, cost-efficient simulation, and rich interactivity [4]. By utilizing Unity as the development engine and Oculus Quest 2 as the deployment device, VR can provide a safe, repeatable, and realistic setting that enables practice without risking hardware damage or incurring high costs. This approach not only supports novice learners in computer assembly but also reduces the expense of procuring physical equipment.

Virtual Reality (VR) thus enables a computer-generated three-dimensional environment with which users can interact [5]. Salient components include sense of presence (a feeling of being in the virtual world), immersion (perceived physical presence in a non-physical space), sensory feedback (simulated visual, auditory, and haptic cues), and interactivity (system responsiveness to user actions). Devices such as VR headsets (e.g., Oculus Quest 2) facilitate these interactions, yielding immersive, participatory experiences.

Evidence from prior studies highlights VR's applicability in learning and simulation across multiple domains [6], [7], [8]. In computer assembly specifically, one study implemented a practicum simulation with Unreal Engine [1]. The results indicated that users gained novel experiences and that novice learners found assembly more accessible, while costs were reduced. The application was judged feasible and easy to use. Complementary work on VR for computer-network practicums suggested that practicum activities can be supported at any time [9].

Beyond computing, VR has been applied in other areas. For example, VR learning media for corrosion testing materials improved students' science-process skills and mitigated constraints such as long observation times and the limited availability of equipment or chemicals [10]. Likewise, VR media for the solar system aimed to help students analyze planetary structure while boosting learning interest [11].

Although VR-based computer-assembly simulations have been explored, many studies have not focused specifically on Unity and Oculus Quest 2 as the principal development and implementation platforms. Moreover, there remains a need for more comprehensive and in-depth usability testing of VR computer-assembly applications, particularly for university-level cohorts. This gap motivates an application that not only visualizes procedural steps but also supports active interaction at each stage, enhancing usability and broadening user testing on specific platforms [12], [13].

Developing VR applications for computer assembly requires a robust methodological approach. Immersive, technology-based practical learning has been shown to strengthen technical and creative thinking skills [14]. Experiences from serious-game development in manufacturing simulations [15] and Virtual 3D applications for complex procedures [16] show that VR can provide realistic, interactive learning. The Multimedia Development Life Cycle (MDLC) has been effectively employed in educational VR projects—from solar-system learning [17] to religious education [18], [19]—demonstrating its suitability for systematic VR development and its relevance to computer assembly, which demands procedural precision and deep conceptual understanding.

Responding to limitations of conventional practicums—facility constraints, high costs, and limited access—and to gaps in prior work that did not foreground Unity and Oculus Quest 2, this study proposes an innovative learning-media solution. The VR-based practicum simulation is designed to help Amikom University Yogyakarta students understand assembly procedures in an interactive, realistic manner. By creating a virtual environment, the application addresses geographical and temporal constraints, enabling sustained practice without risking physical components.

The application is expected to improve learning effectiveness via immersive, realistic experiences and to foster motivation through engaging media. It encompasses all assembly stages, from basic components to final testing. Beyond problem-solving, the study also intends to contribute to the literature on VR in engineering education, especially in procedural simulation and human–computer interaction.

Accordingly, the research questions are: (1) How can a Virtual Reality application be developed to facilitate interactive and realistic computer-assembly practicum simulations using Unity? (2) What is the usability level of the Virtual Reality application for computer-assembly practicum simulations based on user evaluation? In parallel, the objectives are: (1) To develop an interactive and realistic Virtual Reality–based computer-assembly practicum simulation using Unity that supports students' understanding of assembly procedures. (2) To evaluate the application's usability through the System Usability Scale (SUS) to ensure a good level of usability

2. RESEARCH METHODOLOGY

A software development approach was employed, adopting the Multimedia Development Life Cycle (MDLC) as the methodological framework. The MDLC method was selected due to its systematic structure and established effectiveness in the development of interactive multimedia applications, including those based on Virtual Reality. The model consisted of six stages: Concept, Design, Material Collecting, Assembly, Testing, and Distribution [20]. Through these stages, development was conducted in a structured sequence, beginning with the formulation of ideas and concluding with the evaluation and distribution of the final product. Figure 1 illustrates the overall workflow of the MDLC method.

The Concept stage was carried out by formulating the initial framework of the VR-based computer assembly practicum simulation application. The essential features to be implemented were identified, such as sequential assembly of components including the motherboard, processor, heatsink, RAM, power supply, SSD, hard disk, VGA, case cover, screws, drill usage, HDMI cable installation, and final power testing.

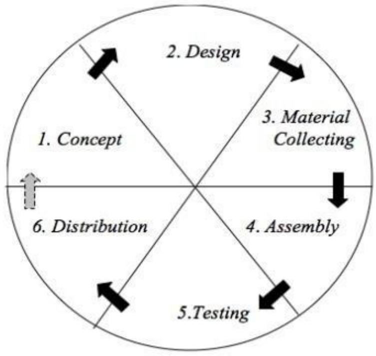

FIG 1. MDLC Method

In the Design stage, the user interface (UI) and user experience (UX) were designed. The UI was created in Figma, while interaction flow was represented through a use-case diagram. These activities ensured that the visualization of system interactions within the virtual environment was coherent and aligned with the required features.

The Material Collecting stage was then conducted to gather the resources necessary for development. Theoretical references, 3D models of PC components, furniture, and other supporting digital assets were collected. All materials were stored in a structured repository to facilitate easy access and systematic use during subsequent stages.

During the Assembly stage, the application development process was executed using Unity as the main game engine, while Blender was used to create 3D assets. This stage involved the integration of assets into Unity, accompanied by programming logic to regulate the sequence of computer assembly procedures.

The Testing stage was designed to evaluate both system functionality and usability. Two primary testing methods were applied: Blackbox Testing and Usability Testing using the System Usability Scale (SUS). Blackbox Testing was performed to confirm that each application function worked as intended from the user perspective, without reference to the internal structure of the code [21]. Each testing scenario was executed to determine whether the expected results—such as correct component installation or monitor activation—were achieved. Outcomes were documented as either “Pass” or “Fail.” Usability Testing was then conducted with students at Amikom University Yogyakarta as respondents. The SUS method was applied, consisting of a standardized 10-item questionnaire with a five-point Likert scale ranging from “Strongly Disagree” to “Strongly Agree” [22]. This instrument was utilized to capture perceptions of usability in terms of effectiveness, efficiency, and user satisfaction [23].

Finally, the Distribution stage was conducted by saving the VR application in .apk or other compatible formats, enabling installation on Oculus Quest devices. The files were prepared for distribution through portable media such as flash drives or cloud storage (e.g., Google Drive). In cases where errors occurred during installation, the .apk version was rebuilt and redistributed to ensure functionality

3. RESULTS AND DISCUSSION

The results of the development process for the Virtual Reality–based computer assembly practicum simulation application are presented according to the stages of the Multimedia Development Life Cycle (MDLC). Each stage is described sequentially, supported by figures and tables that document the outputs.

1. *Concept*

At the concept stage, the planning of the application framework was completed. The Virtual Reality computer assembly simulation was specified to support interactive learning for students at Amikom University Yogyakarta. The simulation included the entire computer assembly process, in which each component had to be placed in the correct order and position. A magnet feature was integrated to facilitate placement. In addition, a room-decoration feature was added, allowing users to purchase items from a virtual store and arrange them freely. All features were made accessible through an interactive menu displayed on a large TV within the simulation.

2. *Design*

In the design stage, both user interface (UI) and user experience (UX) elements were developed. A high-fidelity UI was produced in Figma, providing detailed and interactive design layouts. An example of the interface design is displayed in Figure 2.

A use-case diagram was also created to represent the possible user interactions with the system. This diagram outlined available functionalities, such as starting the simulation, navigating menus, conducting assembly, and accessing settings. The use-case diagram is shown in Figure 3, with detailed descriptions summarized in Table 1.

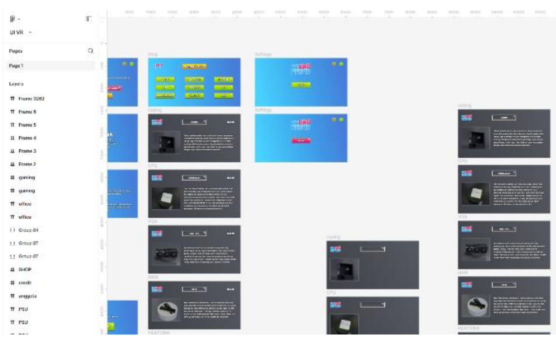

FIG 2. VR PC Assembly UI Design

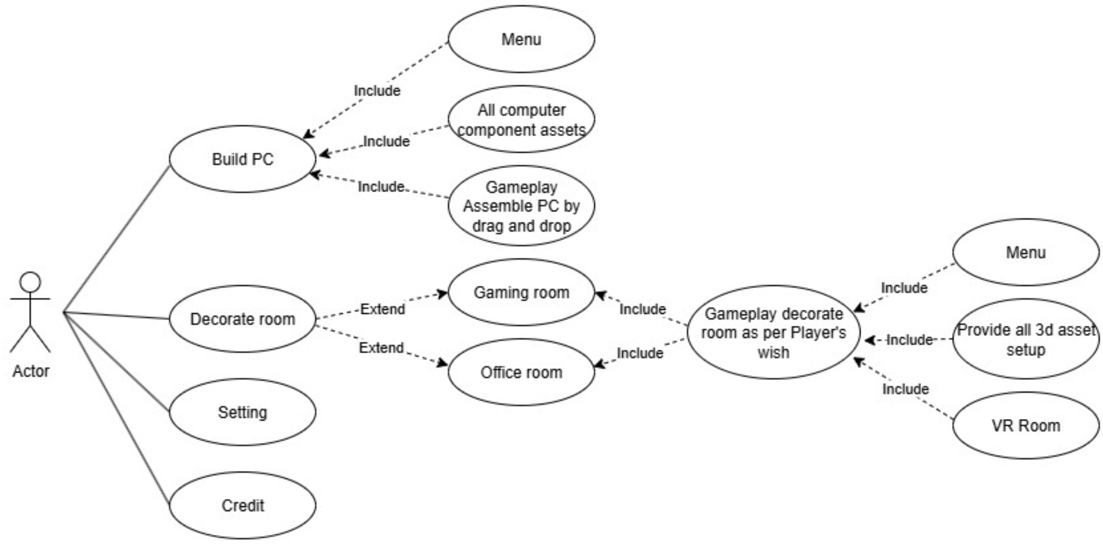

FIG 3. VR PC Assembly Use Case

3. *Material Collecting*

At this stage, all resources required for development were compiled. The materials included theoretical references and digital assets, such as three-dimensional models of computer components (motherboards, CPUs, GPUs, and RAM), as well as furniture and decorative items. Assets were organized systematically in a repository to ensure accessibility and to support efficient development in later stages.

TABLE 1. VR PC Assembly Use Case Description

No	Use Case	Description
1.	Build PC	The user clicks the "Build PC" button to go directly to the first scene of computer assembly.
2.	Menu	Users open the main menu to select various options, including access to assets and gameplay.
3.	All Computer Component Assets	Users select from a list of available computer components to use in assembly.
4.	Gameplay Assemble PC by drag and drop	Users drag and drop components into the PC case, connect cables, and complete the assembly process according to the instructions.
5.	Decorate Room	Users click the "Decorate Room" button to select the type of room to decorate.
6.	Gaming Room	Users select the "Gaming Room" option to decorate a room with gaming-specific themes and assets.
7.	Office Room	Users select the "Office Room" option to decorate the room with office-themed assets and decorations.
8.	Gameplay Decorate Room as per Player’s wish	Users move, rotate, and place 3D objects within the room to create the desired layout.
9.	Provide All 3D Asset Setup	Users open the asset catalog to view and select available 3D objects and VR room options.
10.	Setting	Users click the "Settings" button to adjust settings such as sound volume, graphics quality, and control schemes.
11.	Credit	Users click the "Credit" button to view a list of the development team and other contributors.

FIG 4. 3D asset of a complete computer device

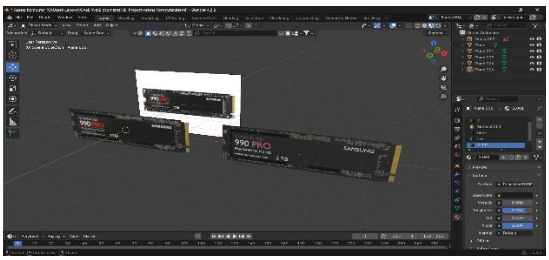

FIG 5. 3D asset of computer RAM

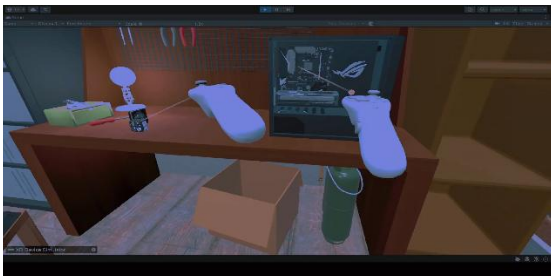

FIG 6. Computer Assembly Display

4. Assembly

The assembly stage involved the creation of assets and their integration into Unity. Blender software was used to model three-dimensional assets for computer components and the laboratory environment. Examples of the design outputs are displayed in Figures 4 and 5.

Once assets were finalized, they were imported into Unity. Programming logic was applied to enforce correct assembly procedures, requiring users to follow the appropriate sequence. Feedback was provided at each stage of the assembly. When the assembly process was performed correctly, the system powered on the computer and displayed a monitor signal. If the sequence was not followed, the system prevented activation. Figure 6 illustrates the installation of components, Figure 7 shows the powered-on computer, and Figure 8 presents the room-decoration feature.

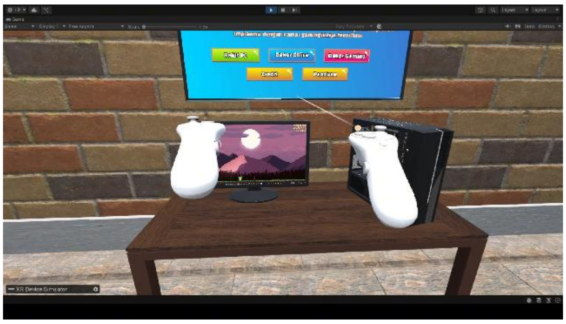

FIG 7. Display When the Computer Successfully Turns On

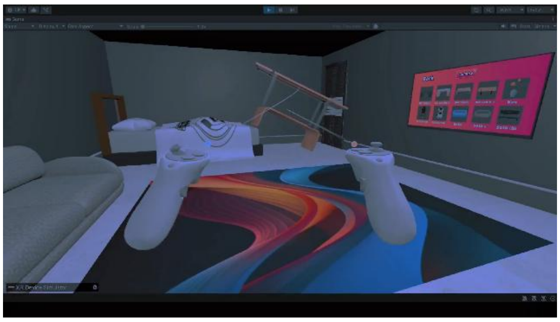

FIG 8. Room Decoration Display

5. Testing

Testing was conducted using two methods: Blackbox Testing and Usability Testing.

A. Blackbox Testing

Blackbox Testing verified system functionality by evaluating each scenario. The outcomes are shown in Table 2.

TABLE 2. Blackbox testing

No	Test Scenario	Testing Test	Results
1	Run Application	Display the main menu screen	Success
2	PC Assembly Menu	Enter the assembly simulation	Success
3	Click Decorate Room	Enter the room decoration simulation	Success
4	Click Settings	Displaying the settings page	Success
5	Click Credit	Display the application developer page	Success
6	Motherboard Installation	The motherboard is installed on the provided holo	Success
7	Processor installation	Processor installed on the provided holo	Success
8	RAM Installation	RAM installed on the provided holo	Success
9	Power Supply Installation	Power supply installed on the provided holo	Success
10	SSD Installation	SSD installed on the provided holo	Success
11	Hard Disk Installation	Hard disk installed on the provided holo	Success
12	VGA Installation	VGA is installed on the provided holo	Success
13	Casing Installation	The casing cover is installed on the provided holo	Success
14	Shop Features	Can purchase items for room decoration	Success
15	Grab Item	Can grab all items	Success

The results indicated that all tested functions produced successful outcomes.

B. Usability Testing (System Usability Scale - SUS)

Usability Testing was performed with 20 students from Amikom University Yogyakarta as respondents. Each respondent completed the System Usability Scale (SUS), which consisted of 10 items rated on a five-point Likert scale. The results are displayed in Figure 9 and summarized in Table 3.

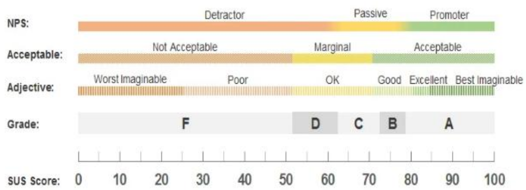

FIG 9. Interpretation of the SUS Scores

TABLE 3. SUS Usability Testing

Responden	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Total	Nilai Total*2.5
1	2	4	3	3	3	2	3	2	3	1	26	65
2	2	2	4	3	3	3	2	3	3	1	26	65
3	3	3	4	4	4	4	4	3	3	3	35	87.5
4	2	4	4	3	4	3	3	4	4	3	34	85
5	3	2	2	2	3	1	3	2	3	2	23	57.5
6	2	4	4	0	4	4	4	4	4	3	33	82.5
7	3	4	4	2	3	3	3	2	3	4	31	77.5
8	4	2	4	3	4	3	3	3	3	3	32	80
9	3	2	3	1	3	2	3	2	3	1	23	57.5
10	3	4	4	2	4	3	4	3	4	3	34	85
11	1	4	4	2	2	2	1	2	2	3	23	57.5
12	4	4	4	2	4	4	4	4	4	4	38	95
13	4	1	3	0	4	3	3	3	2	3	26	65
14	4	3	4	3	3	3	3	3	3	3	32	80
15	2	4	4	2	4	2	4	2	3	2	29	72.5
16	3	3	3	2	3	3	3	3	2	2	27	67.5
17	4	4	4	1	4	4	4	4	4	3	36	90
18	4	2	3	4	2	2	4	3	2	4	30	75
19	3	3	3	2	3	4	3	3	4	2	30	75
20	3	3	3	2	3	3	3	3	3	3	29	72.5
Average SUS score												74.63

As shown in Table 3, the average SUS score reached 74.63, placing the application in Grade B and indicating good usability. These results suggest that the VR computer-assembly practicum simulation is easy to use and well received by students.

To complement the quantitative results, a qualitative review of respondent answers was also considered. Several students who provided lower scores (e.g., respondents 5, 9, and 11 with total scores of 23 or 57.5 after conversion) expressed difficulties in navigating certain menus and noted that the sequence of assembly steps sometimes felt less intuitive. In addition, a few comments mentioned that the visual feedback during incorrect placement of components could be improved to make errors clearer. Conversely, students who gave higher scores (such as respondents 12 and 17, with converted scores of 95 and 90, respectively) highlighted the ease of interaction and immersive features of the application as strong points. These qualitative insights help explain why variation occurred in SUS responses and indicate specific aspects—such as interface clarity and error feedback—that may be refined in future versions.

Taken together, usability was assessed objectively through Blackbox Testing and subjectively through the SUS. Blackbox outcomes validated core functionality, while the mean SUS score of 74.63 (Grade B) reflected good overall usability, implying that students can learn and operate the application readily. Even so, several individual responses in the SUS table indicate opportunities to refine specific aspects of usability to reach an optimal user experience for students in future implementations of the application

4. CONCLUSIONS

The research successfully developed a Virtual Reality–based computer-assembly practicum simulation using Unity and Oculus Quest 2. Delivering an immersive, interactive environment, the application addresses limitations of conventional practicums, such as hardware costs and facility availability. Blackbox Testing confirmed that all principal features and functionalities operated as expected. The system facilitates sequential assembly—from core component installation through functionality testing—and includes a complementary room-decoration feature. Usability evaluation via the System Usability Scale (SUS) produced an average score of 74.63, corresponding to "Grade B," which indicates a good level of usability. Consequently, the application offers an innovative pathway for introducing computer components and assembly processes to beginners while enabling realistic practicum experiences without risk of physical damage.

For future work, several directions are recommended:

1. Improved Interactive Features: Incorporate richer interactivity, such as voice guidance, more realistic component-motion animations, or integrated quizzes at each stage to directly assess user understanding.
2. Expansion of Content and Realism: Update simulations with the latest components and more complex scenarios, and incorporate more detailed cable-installation procedures to heighten realism.

3. More Diverse User Testing: Extend usability evaluations to broader populations—not only university students but also vocational students, instructors, and individuals with varied backgrounds and skill levels

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