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PC Guide: Development of Learning Application for Building a Computer in Virtual Reality

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Abstract: Virtual Reality (VR) technology has recently been used in several industries to simulate any imaginable 3D object. VR technology is also commonly used to visualize and explore real-world environments. VR technology is also useful in a variety of application in university for certain course area, especially for the student who needs a practical approach to operating an appliance in a physical lab and have trouble to take a chance. Hence, the learning application for building a computer in VR, namely PC Guide is developed on the additional device such as a VR Oculus headset as the platform to visualize the part of the computer components. The target user for the proposed application is the student who takes the Computer Architecture course (BIC10503). The PC Guide application is composed of three distinct modules which are PC Parts, PC Peripherals, and PC Simulation. TRES-D is used as the methodology for developing the PC Guide application. The information about computer components is obtained from research on Computer Architecture subject. The result of the user acceptance test gives an average score of 80.0, which falls in the "Good" range. Therefore, it can be concluded that the PC Guide application can be used as a guide for the target user.

Keywords: Learning Application, Computer Architecture, Virtual Reality, TRES-D

1. Introduction

The use of virtual reality (VR) technology has gained significant attention in the field of education, offering immersive and interactive experiences to enhance learning. This project aims to explore the implementation of VR in education, specifically in the context of computer architecture. The proposed application, PC Guide, is designed to assist students taking the Computer Architecture course (BIC10503) in building a computer through a virtual reality environment. By utilizing VR, the proposed application provides a fully immersive experience that allows students to interact with computer parts and peripherals in a realistic virtual setting.

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The objective of the PC Guide application is to provide a comprehensive and engaging learning experience for students. The application's main goals are to design a learning tool that aligns with the specific needs of the computer architecture course and to develop a guidance application using the Unity 3D platform. By employing the TRES-D methodology, which encompasses initial requirements, understanding user needs, concept design, iterative design, building and implementation, and deployment and maintenance, a systematic and structured approach is followed throughout the development process.

The PC Guide application serves as a virtual guide for students, enabling them to gain hands-on experience in building a computer. The immersive nature of VR allows students to visualize and interact with computer components in a way that traditional methods cannot replicate. By providing step-by-step instructions, detailed descriptions, and realistic simulations, the application aims to bridge the gap between theoretical knowledge and practical application in computer architecture.

This project report aims to evaluate the effectiveness and usability of the PC Guide application in achieving its objectives. Through user testing and feedback, the functionality and usability of the application will be assessed. The report will also discuss the background of the application, including the rationale behind utilizing VR and interactive elements in education. Overall, the PC Guide application seeks to enhance student's learning experience in the Computer Architecture course by providing a visually immersive, interactive, and practical learning tool.

This proceeding discussed the related work which consists of the background of the study, and the comparative analysis. After that, the methodology was discussed based on the TRES-D methodology. In addition, the result and discussion were discussed about the functional testing and user acceptance result. Lastly, the conclusion part explained the overall study of this project.

2. Related Work

In this section, the background of the study, the technology used, and the result of the comparative analysis are discussed.

2.1 Virtual Reality Facilitating Knowledge of Computer Architecture.

Virtual reality (VR) has the potential to revolutionize the way we learn and understand complex subjects such as computer architecture [11]. With the ability to fully immerse oneself in a simulated environment, VR provides a unique and interactive learning experience that can facilitate a deeper understanding of complex concepts. One of the primary benefits of VR in teaching computer architecture is the ability to visualize and manipulate computer components in a three-dimensional space.

Traditional methods of teaching computer architecture often rely on abstract concepts and diagrams, which can be difficult for some students to fully grasp. With VR, students can see and interact with computer components in a way that is both engaging and intuitive. For example, students can use VR to build their own computers from scratch, starting with the motherboard and adding in various parts such as processors, memory, and storage devices. This hands-on approach allows students to see firsthand how each component fits together and how it contributes to the overall functioning of the computer.

In addition to visualization, VR can also provide a more immersive and interactive learning experience. Instead of simply reading about or watching a demonstration of a computer component, students can use VR to actively explore and experiment with it. This can include tasks such as troubleshooting problems, testing different configurations, and even simulating real-world scenarios. Overall, the use of VR in teaching computer architecture has the potential to greatly enhance the learning experience for students. By providing a more interactive and immersive way to understand

complex concepts, VR can help students better retain and apply their knowledge. As VR technology continues to advance, it is likely that we will see more and more educational institutions incorporating it into their curricula, further facilitating the learning and understanding of computer architecture [3]. Next, the methodology used in this project will be discussed in depth.

2.2 Technology Used

The PC Guide application employs several essential technologies to deliver an immersive and interactive learning experience in a virtual reality (VR) environment. The primary technology utilized is the Oculus Quest 2 platform, a standalone VR headset known for its high-quality performance and untethered experience [7]. With precise motion tracking, high-resolution displays, and intuitive controllers, the Oculus Quest 2 allows users to seamlessly interact with the virtual environment, enhancing the learning process.

The development of the PC Guide application is based on the Unity 3D platform, a versatile game engine that supports VR applications [9]. Unity provides a comprehensive set of tools and features, such as 3D modeling, physics simulations, and scripting capabilities, making it suitable for creating realistic VR experiences. It ensures compatibility with various VR devices and facilitates the integration of interactive elements within the virtual environment, enhancing the overall user experience.

For the creation of 3D models and assets utilized in the PC Guide application, Blender, a popular open-source 3D modeling software, is employed [8]. Blender offers an array of tools for designing detailed and realistic 3D objects, including computer components, peripherals, and the virtual environment itself. Its precise modeling, texturing, and animation capabilities enable developers to design visually captivating and accurate representations of computer architecture elements. Blender's seamless compatibility with Unity ensures a smooth workflow for importing and integrating the 3D assets into the application.

By leveraging these technologies, the PC Guide application aims to provide students with a comprehensive and engaging learning experience in computer architecture through VR. Through the combination of Oculus Quest 2, Unity 3D, and Blender, the application creates a visually captivating, user-friendly, and realistic VR environment, empowering students to gain practical skills and a deeper understanding of computer assembly and architecture.

2.3 Comparative Analysis

In this section, a comparison has been made between existing applications, such as PC Building Simulator – NZXT Workshop [4], PC Building Simulator [5], and PC Virtual Lab [6]. PC Building Simulator – NZXT Workshop is a popular simulation application that allows users to experience the process of building and managing their own PC workshop. PC Building Simulator is another virtual reality application that focuses on teaching users the ins and outs of building a computer. PC Virtual Lab is an educational platform that offers a virtual environment for learning and practicing computer assembly. Figure 1 (a), (b), and (c) shows the main interface of the three existing applications. Meanwhile, 8 features have been discussed, as shown in Table 1. It includes the platform, language, play area, input, modules, technical aspects, strengths, and limitations.

Based on Table 1, several strengths and limitations of the proposed application can be concluded. First, the proposed application provides a fully immersive learning experience through virtual reality, allowing users to interact with computer components and simulate the building process in a realistic 3D environment. While the other applications only allow the user to be played using a mouse and keyboard. Besides, the proposed application offers visual and interactive guidelines that guide users' step by step through the computer-building process. This helps users understand the sequence of tasks and the proper techniques for handling components.

Figure 1(a): PC Building Simulator - NZXT Workshop [4]

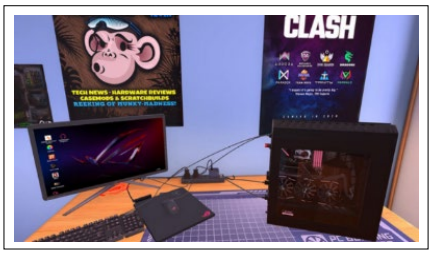


Figure 1(b): PC Building Simulator [5]

Figure 1(c): PC Virtual Lab [6]

Table 1: Comparison between existing application and proposed application

Features	PC Building Simulator - NZXT Workshop	PC Building Simulator	PC Virtual Lab	PC Guide
Platform	Steam	Steam	Steam	Oculus
Language	Using the English language			
Play Area	Standing, Room-scale	Standing, Room-scale	Room-scale	Standing, Room-scale
Input	Tracked Motion Controllers			
Modules	• Allow users to interact with virtual versions	• Simulate various hardware components • Allows players to experience the process of building and repairing PC	• Simulate different parts and peripherals • Provides diagnostic tools	• PC simulation in a virtual reality environment
Technical aspect	• The expansion adds new virtual components and an NZXT-themed workshop environment for an enhanced building experience.	• Provides a realistic virtual environment for players to navigate the workshop, select components, and perform actions required for PC building and customization	• Can only be played using a mouse and keyboard. • Provides a realistic virtual environment	• Provide fully immersive interactive elements using virtual reality technology approach.

Features	PC Building Simulator - NZXT Workshop	PC Building Simulator	PC Virtual Lab	PC Guide
Strengths	• Provides interactive tutorials • Users can customize their virtual PC builds	• Users can engage in a career mode where they take on PC-building tasks	• Free to download • Provide realistic graphics and physics	• Free to download • Provide an objective panel that indicates the progression
Limitations	• Lack of physical hands-on experience • Limited platform support which only on	• Lack of real-time updates • Restrict users from exploring and learning about less common or specialized parts.	• Limited physical feedback	• Does not cover all of the complex tasks due to limited module

3. Methodology

TRES-D methodology has been chosen in the process of development for the PC Guide application. The TRES-D model was selected for its comprehensive coverage of the development process, from requirements gathering to deployment and maintenance. This methodology encompasses six essential components such as initial requirements, understanding requirements, concept design, iterative design, building and implementation, and deploy and maintenance which are shown in Figure 2. Next, each phase of the TRES-D model is discussed in the following subsections.

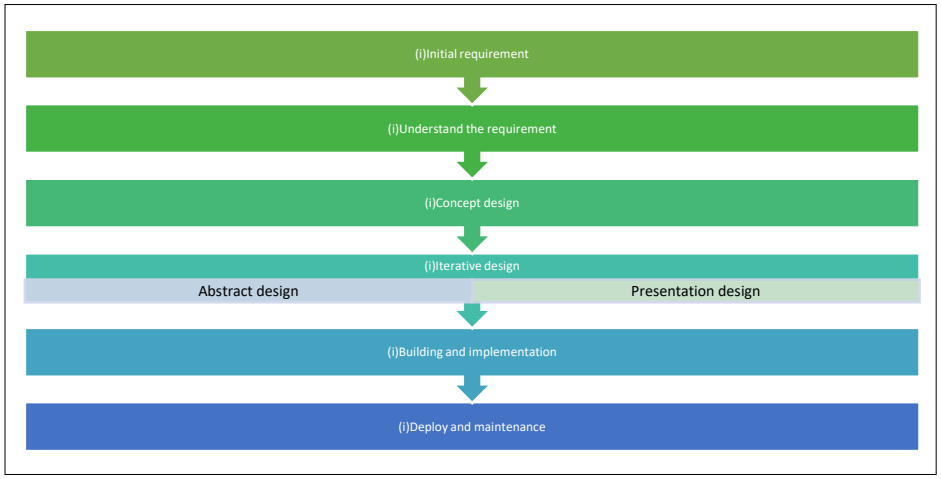


Figure 2: TRES-D Methodology [2]

3.1 Initial Requirement

The initial requirement is the first phase of the TRES-D methodology. This phase involved conducting market research and analysis to identify the target audience and their needs. Requirements are collected through user surveys, interviews, and consultations with Subject Matter Expertise (SME), Dr Firkhan

Ali Bin Hamid Ali. The goals and objectives of the project were defined, and a project plan was created, including timelines and resource allocation. It also included defining the goals and objectives of the PC Guide application and conducting a feasibility study to assess technical and resource requirements. In addition, a set of questionnaires is prepared and distributed to the target user via Google Forms. A total of 30 responses from a student who takes Computer Architecture courses (BIC10503) at University Tun Hussien Onn Malaysia have been collected as in Figure 3 and Figure 4 below. To summarize, the majority (100%) of the respondents prefer to operate computer components interactively with the application of virtual reality in the application. The results of the user analysis are tabulated in Table 2.

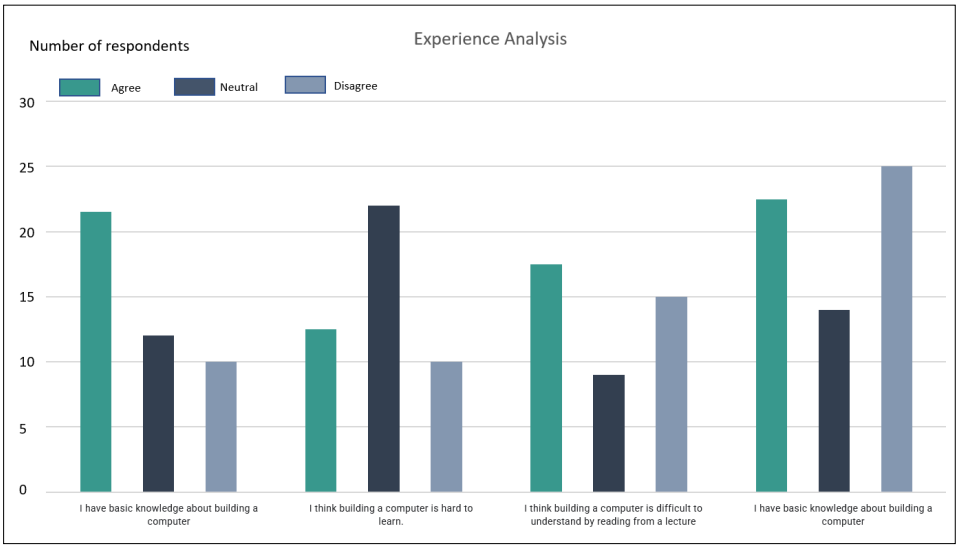


Figure 3: User Experience Analysis

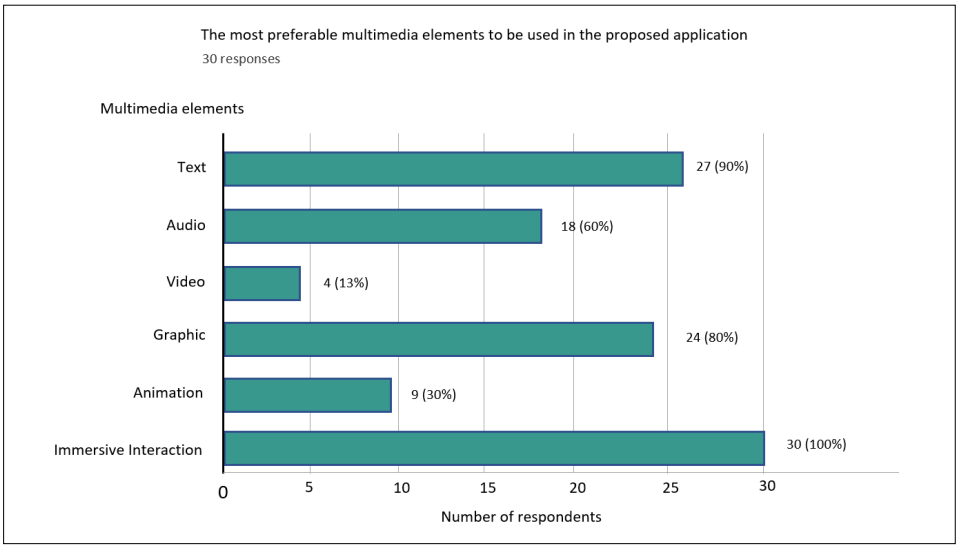


Figure 4: Preferable Multimedia Elements

Table 2: User Analysis

Stakeholder Category	Role in Product	Design Implication	Action Needed
	Senior lecturer, Department of	Based on the interview,	• Use icon-based buttons instead of text buttons.

Stakeholder Category	Role in Product	Design Implication	Action Needed
Subject Matter Expertise (SME), Dr. Firkhan Ali Bin Hamid Ali	Information Security and Web Technology from the Faculty of Computer Science and Information Technology, UTHM	a simple user interface design	• Avoid using the unnecessary button to reduce confusion. • Apply a big button for important purposes.
		Reliable content, use simple words and short sentences	• Include all the components in each module of learning. • Avoid complicated words and long sentences of description. • Apply a suitable font size and type in the content.
		Easy to navigate	• Use the previous, next, and home buttons to navigate to relative pages.
		Multimedia content	• Use audio to attract users' interest.
Target User (student who takes Computer Architecture course (BIC10503))	End-user of the proposed application	Based on the questionnaire, the user preferences	• The application should be developed on an Oculus device. • The application should be developed in the English language. • The application should be implemented more on interaction.

3.2 Understand the requirement

In this stage, the collected requirements are analyzed and further refined to gain a deeper understanding of the project scope. The requirements were reviewed and clarified to ensure that they are specific, measurable, achievable, and relevant. The requirements for the PC Guide were studied in order to develop the user experience (UX) and user interface (UI) designs. Figure 5 shows the content structure. A storyboard of the PC Guide application was created as shown in Figure 6. Other than that, it was important to ensure that the PC Guide was intuitive and useful while designing user interfaces and user experience. PC Guide must not require users to spend a lot of time learning how to use it. The design was also based on the functional and non-functional requirements of the proposed application as shown in Table 3, and Table 4.

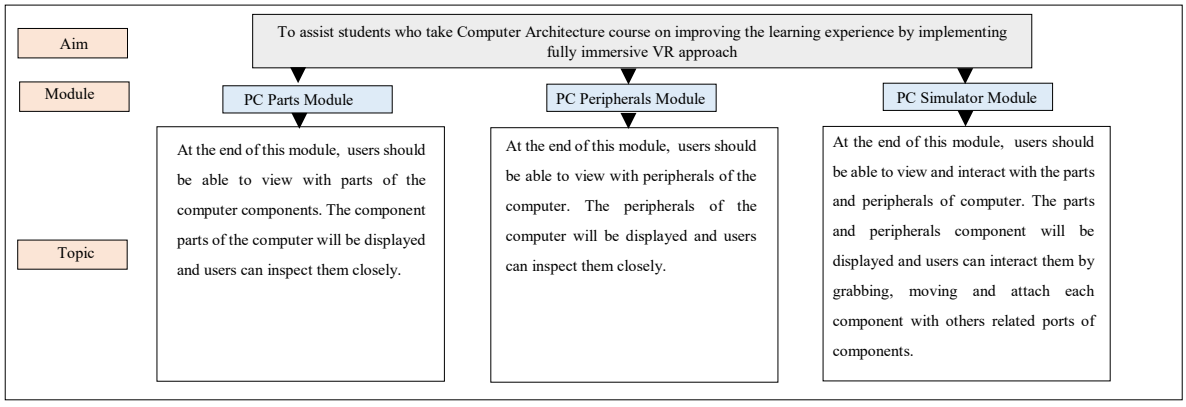


Figure 5: Content Structure

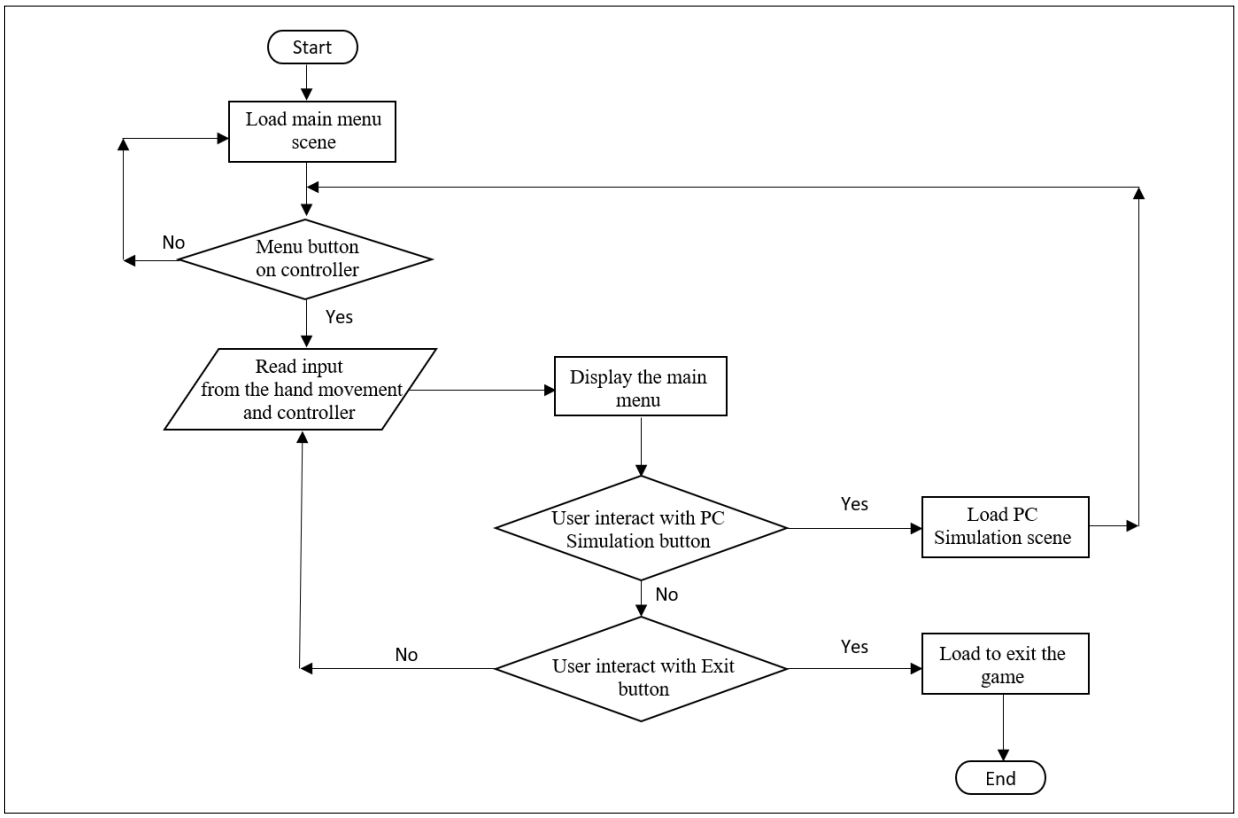


Figure 6: System flowchart

Table 3: Functional requirements

Functional requirements	Description
Autonomous system activities	• The PC Guide application should play when the users enter the application. • The PC Guide application should allow users to explore this application in a VR environment. • The application should allow the users to interact with the object such as grabbing, moving, and attaching. • The PC Guide application should allow users to explore this application in a VR environment.
Provide learning content	• The application should allow users to learn basic knowledge about the components of the computer. • The PC Guide application should allow users to walk around each of the modules.
User interaction support	• The PC Guide application should allow users to use the VR Oculus headset as the input device to interact with this application. • The PC Guide application should allow users to pick and drop the object on the simulation module. • The PC Guide application should allow users to interact with each button.

Table 4: Non-functional requirements

Non-Functional Requirements	Description
Operational Requirement	• The PC Guide application should be able to access with an Oculus device. • The PC Guide application should be accessible at any time. • The PC Guide application should be in a virtual reality interface.
Usability Requirement	• The PC Guide application should be designed in the English Language. • The font type of the PC Guide application should be San Serif. • The button of the PC Guide application should be designed in consistent and user familiar.
Performance Requirement	• The PC Guide application should react within 1 second after the user is navigated.

3.3 Concept design

One of the primary objectives of the concept design stage is to define the tasks that users will be able to perform within the PC Guide application. This includes identifying the specific actions or operations that users need to carry out to achieve their objectives while using the application. These tasks are typically derived from the initial requirements gathered from user surveys, interviews, and consultations with subject matter experts. During the concept design phase, several tasks related to user interactions are identified and incorporated into the application. Table 5 shows the button design. Next, Table 6 shows the controller button. These tasks are designed to enable users to effectively engage with the virtual environment and interact with the computer components. The specific tasks can vary depending on the objectives and requirements of the PC Guide application, but some common examples include:

3.3.1 Component Selection

Users can select different computer components, such as the motherboard, CPU, GPU, RAM, and storage devices, by interacting with them. This can involve using hand gestures or controller inputs in the virtual reality environment to hover over and select the desired components.

3.3.2 Object Manipulation

Users can manipulate the selected components to examine them closely or position them within the computer assembly. This can involve grabbing and moving objects, rotating them for a better view, and adjusting their placement within the virtual environment.

3.3.3 Assembly Instructions

The application can provide step-by-step assembly instructions to guide users through the process of building a computer. Users can interact with instructional prompts and visual cues to understand each step and perform the required actions, such as attaching parts of the computer components.

3.3.4 Troubleshooting Assistance

In case users encounter issues or errors during the assembly process, the application can provide interactive troubleshooting assistance. Users can interact with a troubleshooting feature that provides guidance on identifying and resolving common problems, such as incompatible components, or incorrect placements.

Table 5 : Button design

Button	Functionality Description
	• This PC simulation button is displayed on the Main Menu interface. • User will navigate to the PC simulation scene where the user can interact with all of the computer parts and peripherals such as grabbing, moving, or attaching the components.
	• This exit button is displayed on the Main Menu interface. • This exit button will navigate users to exit the application by pressing this button.

Table 6: Controller button

Controller Button	Controller Description
	Right controller
Trigger button	• Use to point at the UI interface and make a selection. • Use as the ray direction to point at any object in order to grab the object.
Grip button	• Use to grab, move, and throw the objects.
Menu button	• Use to direct exit the application.
Joystick	• Use to make a rotation in order to reduce motion sickness.
	Left controller
Trigger button	• Use to point at UI interface and make a selection. • Use as the ray direction to point at any object in order to grab the object.
Grip button	• Use to grab, move and throw the objects.
Menu button	• Use to pop up the menu interface.
Joystick	• Use to make movements such as forward, backward, right and left in order to reduce motion sickness.

3.4 Iterative design

In this stage, an iterative design approach is adopted to refine the application's design and functionality. The development of prototypes and usability testing was conducted with representative users to gather feedback and make iterative improvements. At each cycle, interaction designers carry out the specification of each of the components of the application using tools of increasing detail, as the ones we describe in [2]. This iterative process helps identify and address usability issues, ensuring that the final application meets user expectations.

3.4.1 Abstract Design

Abstract design refers to the overall structure and functionality of the application. It involves defining the underlying architecture, data flow, and system components. The abstract design stage includes tasks such as:

- Designing the application's navigation system: This includes defining the hierarchy of screens, menus, and interactive elements that allow users to navigate through the application's features and functionalities.

- Defining the data model: This involves determining the data structures and relationships required to support the application's functionalities, such as storing information about computer components, and assembly steps.

- Specifying the interaction flow. This includes mapping out the sequence of user interactions, such as selecting components, manipulating objects, and accessing instructional prompts. It ensures a logical and intuitive flow of actions within the application.

3.4.2 Presentation Design

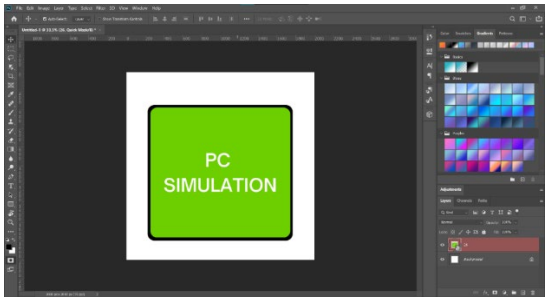
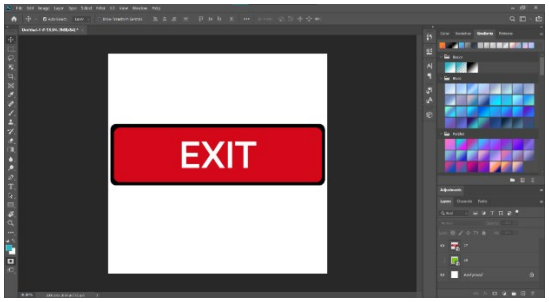
Presentation design involves the visual and interactive aspects of the application [12]. It focuses on creating an appealing user interface, incorporating suitable graphics, colors, typography, and interactive elements. Table 7 shows the application assets development while Table 8 contains 3D modeling of the parts and peripherals for the project. The presentation design stage includes tasks such as:

- Creating visual assets: This includes designing icons, buttons, and other graphical elements that enhance the visual appeal of the application.

- Defining the layout and typography: This involves determining the arrangement of elements on the screen, selecting appropriate fonts, and ensuring readability and consistency throughout the application.

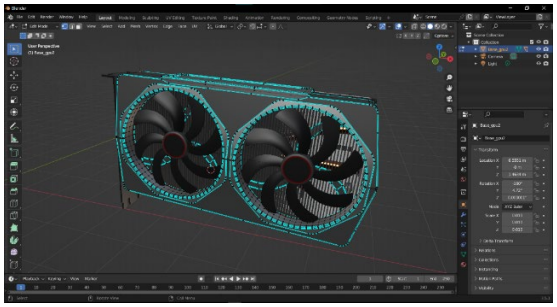
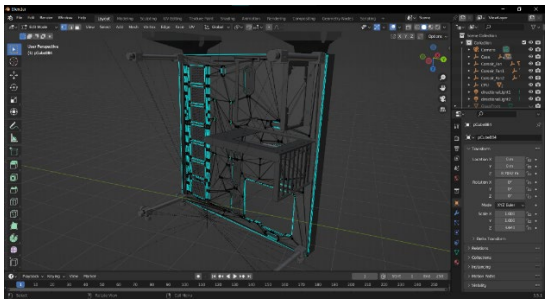
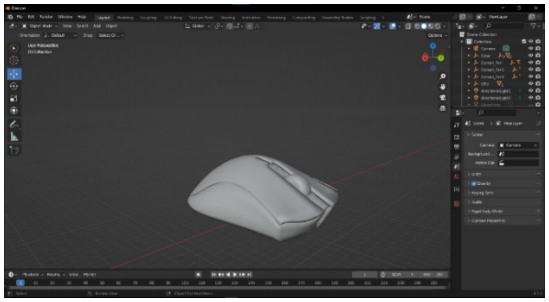
- Incorporating interactive elements: This includes adding animations, transitions, and other interactive features to make the user interface engaging and responsive.

Table 7: Application assets development

Asset	Development	Description
PC Simulation button		The PC Simulation button is in the main menu interface. It is a button that allows the user to interact and press to go to the next scene. The user will navigate to the next scene which is the pc simulation scene. In that scene, users are able to interact with the computer parts and peripherals.
Exit button		The Exit button is also in the main menu interface in order to navigate the user to exit the application. The user is able to point to the button in order to select the button and exit the application.

Asset	Development	Description
Audio		Most of the audio applied in PC Guide are obtained from an online website that offers free audio resources, which is Pixalbay.

Table 8: 3D modeling of the parts and peripherals

Model	Development	Description
Graphic card		The development process of the 3D modeling of the part which is the graphic card. The modeling process began with the creation of a basic shape using polygonal modeling techniques in the software which is Blender.
PC case		The development process of the 3D modeling of the part which is the PC case. The process started with gathering reference materials such as technical specifications, images, and physical samples of the actual parts.
Mouse		The development process of the 3D modeling of the peripheral which is the mouse. The model was refined by adjusting proportions, smoothing edges, and adding realistic textures to enhance its visual appeal.

3.5 Building and Implementation

This section focuses on the actual building and implementation of the PC Guide application. The development team utilizes the chosen platforms and tools, such as Unity 3D, Blender, and Visual Studio Code, to code and integrate the various components. The application's functionalities and features are implemented based on the defined requirements and design specifications.

3.5.1 Coding and Development

Using Unity 3D as the development platform and Visual Studio Code as the code editor, I began writing scripts and code to bring the PC Guide Application to life. The primary programming language used was C#. Throughout the development process, the best practices were followed in order to code conventions to ensure maintainable and clean code. To integrate the necessary assets, the Blender was utilized as the modeling software to create 3D models of computer components, such as the motherboard, CPU, and GPU. These assets were then imported into Unity 3D and appropriately positioned within the virtual environment. Table 9 shows the Visual Studio framework with C# while Table 10 shows the interface of the development application for the project.

Table 9: Visual Studio Framework with C#

Functions	C# Script	Description

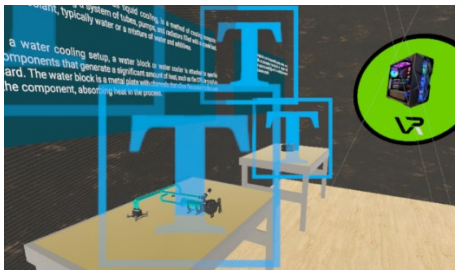
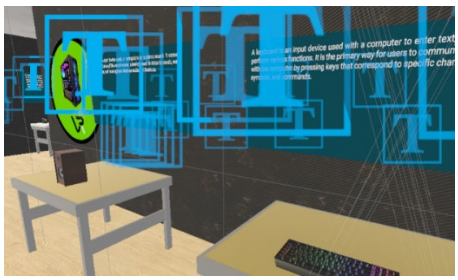
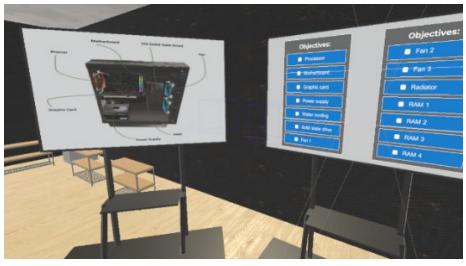
Interaction for movement (Action Based Controller)	public InputActionProperty rotateAnchorAction
	{
	get => m_RotateAnchorAction;
	set => SetInputActionProperty(ref m_RotateAnchorAction, value);
	}
	public InputActionProperty activateActionValue
	{
	get => m_ActivateActionValue;
	set => SetInputActionProperty(ref m_ActivateActionValue, value);
	}
		The code snippet for the Action Based Controller script enables the users to physically engage in movement by utilizing the triggers, button, and joystick to make a movement.

Interaction for grabable (XR Grab Interactable)	public partial class XRGrabInteractable : XRBaseInteractable
	{
	const float k_DefaultTighteningAmount = 0.5f;
	const float k_DefaultSmoothingAmount = 5f;
	const float k_VelocityDamping = 1f;
	const float k_VelocityScale = 1f;
	const float k_AngularVelocityDamping = 1f;
	const float k_AngularVelocityScale = 1f;
	const int k_ThrowSmoothingFrameCount = 20;
	const float k_DefaultAttachEaseInTime = 0.15f;
	const float k_DefaultThrowSmoothingDuration = 0.25f;
	const float k_DefaultThrowVelocityScale = 1.5f;
	const float k_DefaultThrowAngularVelocityScale= 1f;
	const float k_DeltaTimeThreshold = 0.001f;
		The code snippet for the XR Grab Interactable script enables players to physically interact with objects within the virtual environment. It allows them to reach out and grab objects using their VR controllers, providing a more immersive and intuitive experience. Players can pick up, manipulate, and inspect objects as if they were interacting with them in the real world.

Functions	C# Script	Description

Interaction for attachment (XR Socket Interactor)	[DisallowMultipleComponent]
	[AddComponentMenu("XR/XR Socket Interactor", 11)]
	[HelpURL(XRHelpURLConstants.k_XRSocketInteractor)]
	public partial class XRSocketInteractor : XRBaseInteractor
	{
	[SerializeField]
	bool m_ShowInteractableHoverMeshes = true;
	public bool showInteractableHoverMeshes
	{
	get => m_ShowInteractableHoverMeshes;
	set => m_ShowInteractableHoverMeshes = value;
	}
		The code snippet for the XR Socket Interactor script facilitates the attachment of objects to specific attachment points or ports within the virtual reality environment. It provides a mechanism for the player to physically interact with objects and accurately place them onto designated sockets or attachment areas.

Table 10: Interface of the Development Application

Module	Interfaces	Description
PC Parts		The PC Parts interface provides users with a comprehensive and organized view of various computer parts. The interface typically includes visual representations and descriptions of each component, along with relevant specifications and compatibility information.
PC Peripherals		The PC Peripherals interface focuses on the additional devices and accessories that enhance the functionality and usability of a computer. The interface provides users with detailed information about each peripheral, including features, specifications, and compatibility with different PC configurations.
PC Simulation		The PC Simulation interface offers a virtual environment where users can simulate the process of building or assembling a computer. The interface may also include interactive tooltips, visual cues, and feedback mechanisms to assist users during the simulation process and ensure a seamless learning experience.

3.5.2 Integration and System Testing

Integration was a crucial step in ensuring that all the components of the PC Guide application worked seamlessly together. The user interface elements, such as buttons, menus, and instructional prompts was

connected to their corresponding scripts and functionalities. This integration allowed users to interact with the application's features in a cohesive manner. To validate the functionality and performance of the application, system testing was conducted thoroughly. This involved running comprehensive test scenarios to identify any bugs or errors. Various interactions were tested systematically, such as component selection, object manipulation, and following assembly instructions, to ensure they functioned as intended. Additionally, compatibility testing was performed across different VR headsets and hardware configurations to ensure a consistent user experience across platforms.

3.5.3 Refinement and Optimization

Feedback from users played a vital role in refining the PC Guide application. Any issues or bugs were identified during testing through code debugging and error fixing. This ensured that the application was stable and free from major flaws. Performance optimization was another aspect that was focused on during the implementation stage. The application's performance was optimized to achieve smooth frame rates, responsive interactions, and efficient resource usage. Techniques such as code optimization, asset optimization, and memory management were employed to enhance the overall performance of the application. Furthermore, usability improvements were made based on user feedback. The user interface was refined, improved instructional prompts, and fine-tuned the application's navigation and interaction design to enhance the overall user experience.

3.6 Deploy and maintenance

This final section focuses on the deployment and maintenance of the PC Guide application. The application is packaged and deployed to the target platform, such as virtual reality headsets, for users to access and experience. Ongoing maintenance and support processes are established to address any issues, provide updates, and ensure the application's smooth operation.

3.6.1 Deploy

To deploy the application to the Oculus Quest 2, the necessary steps outlined by the Oculus developer documentation were followed. The Oculus Quest 2 is a popular standalone virtual reality (VR) headset developed by Oculus, a subsidiary of Facebook [7]. This involved building and packaging the application in a format compatible with the Oculus Quest 2, such as an APK (Android Package) file. Once the application was built, it was sideloaded onto the Oculus Quest 2 device using the Oculus Developer Hub or other suitable methods. This allowed users to install and access the PC Guide Application directly on their Oculus Quest 2 headset.

3.6.2 Maintenance

The maintenance process for the PC Guide Application on the Oculus Quest 2 focused primarily on bug fixing and ensuring the smooth operation of the application.

- Bug Fixes:
  User feedback and reports were actively monitored to identify any bugs or issues encountered during the usage of the PC Guide application. Reported bugs were promptly investigated and addressed, and subsequent updates were released to provide bug fixes. This approach ensured that users could have an optimized and bug-free experience while utilizing the application.

- Compatibility Updates:
  Regular checks were conducted to ensure compatibility between the PC Guide application and the Oculus Quest 2 platform. As Oculus released updates for the Quest 2 firmware and software, necessary adjustments were made to maintain compatibility. This proactive approach guaranteed that the application remained compatible with the latest versions of the Oculus Quest 2, providing a seamless experience for users.

4. Result and Discussion

To ensure that the learning application for building a computer in virtual reality meets all the requirements, functional testing was conducted as shown in Table 11 and Table 12.

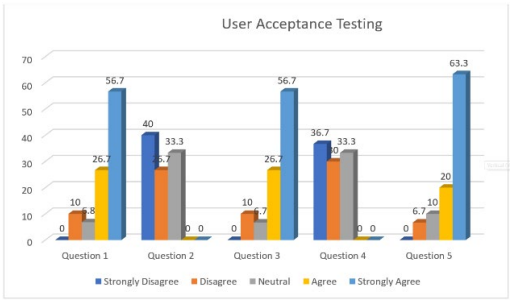
Table 11: Functional testing results (buttons)

Buttons	Expected Result	Actual Result	Corrective Action
PC simulation button	Entering the PC simulation scene	Works well as expected	Not needed
Exit button	Display Exit Warning interface	Works well as expected	Not needed

Table 12: Functional testing results (interactions)

Interaction	Expected Result	Actual Result	Corrective Action
Computer Assembly			
Assemble the parts of the computer	Assemble all parts of the computer	Works well as expected	Not needed
Dissamble parts of the computer	Dissemble all parts of the computer	Works well as expected	Update on panel objective
Interaction and Manipulation			
Grab the object	Can grab the object	Works well as expected	Not needed
Move the object	Can move the object	Works well as expected	Not needed
Rotate the object	Can rotate the object	Works well as expected	Not needed
Instructional Guidance			
Panel objective	Can display the objective achievement	Works well as expected	Update on panel objective
Instructional prompt	Can display the panel instruction	Works well as expected	Update on panel instruction
Error Handling			
Incorrect connection part	Cannot attach to the placement object	Works well as expected	Update on the wrong indicator

Other than that, to ensure that the learning application for building a computer in virtual reality meets user expectations and provides an enjoyable experience, user acceptance testing was conducted and the result is shown in Figures 7(a), and (b). Other than that, the respondent score for the user acceptance test can be shown in Table 13.



Question 1: I think that I would like to use this system frequently.

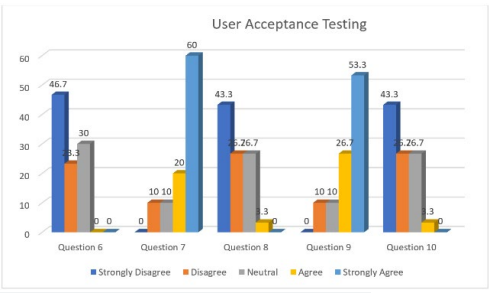
Question 2: I found the system unnecessarily complex.

Question 3: I thought the system was easy to use.

Question 4: I think that I would need the support of a technical person to be able to use this system.

Question 5: I found the various functions in this system were well integrated.

Figure 7(a): Analysis of User Acceptance Testing



Question 6: I thought there was too much inconsistency in this system.

Question 7: I would imagine that most people would learn to use this system very quickly.

Question 8: I found the system very cumbersome to use.

Question 9: I felt very confident using the system.

Question 10: I needed to learn a lot of things before I could get going with this system.

Figure 7(b): Analysis of User Acceptance Testing

Table 13: Respondent's Score (User Acceptance Test)

Respondent	Score Item										Total Score
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	
R01	5	1	5	1	5	1	5	1	5	1	100
R02	5	1	5	1	5	1	5	1	5	1	100
R03	5	1	5	1	5	1	5	1	5	1	100
R04	5	1	5	1	5	1	5	1	5	1	100
R05	5	1	5	1	5	1	5	1	5	1	100
R06	5	1	5	1	5	1	5	1	5	1	100
R07	5	1	5	1	5	1	5	1	5	1	100
R08	5	1	5	1	5	1	5	1	5	1	100
R09	5	1	5	1	5	1	5	1	5	1	100
R10	5	1	5	1	5	1	5	1	5	1	100

Respondent	Score Item										Total Score
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	
R11	4	2	4	2	4	2	4	2	4	2	75
R12	4	2	4	2	4	2	4	2	4	2	75
R13	4	2	4	2	4	2	4	2	4	2	75
R14	4	2	4	2	4	2	4	2	4	2	75
R15	4	2	4	2	4	2	4	2	4	2	75
R16	3	2	3	3	4	3	3	4	3	4	50
R17	3	3	2	3	3	2	3	3	2	3	47.5
R18	2	3	2	3	2	3	2	3	2	3	37.5
R19	2	3	2	3	2	3	2	3	2	3	37.5
R20	2	3	3	2	3	3	2	2	3	2	52.5
R21	4	2	5	2	5	1	5	2	4	2	85
R22	4	1	4	3	5	2	5	1	3	1	82.5
R23	5	1	5	1	5	1	5	1	5	1	100
R24	4	3	4	2	3	1	4	2	4	2	72.5
R25	5	2	4	2	5	1	3	1	4	1	85
R26	5	3	5	3	5	3	5	3	5	3	75
R27	5	3	5	3	5	3	5	3	5	3	75
R28	5	3	5	3	5	3	5	3	5	3	75
R29	5	3	5	3	5	3	5	3	5	3	75
R30	5	3	5	3	5	3	5	3	5	3	75
Average Score											80.0

Table 13 shows the total score of the usability value of the PC Guide application. The System Usability Scale (SUS) is used for usability tests to calculate the average score of user acceptance. The System Usability Scale (SUS) provides a “quick and dirty”, reliable tool for measuring the usability [13]. The formula used to obtain usability results based on the SUS are:

Total score = (odd items + even items) x 2.5

$$\text{Average score} = \frac{\text{Total score}}{\text{Total respondent}}$$

Where :

Odd items (Q1, Q3, Q5, Q7, Q9) = contribution - 5

Even items (Q2, Q4, Q6, Q8, Q10) = 25 – contribution

Therefore, the Average score

$$= \frac{100 + 100 + 100 + 100 + 100 + 100 + 100 + 100 + 100 + 100 + 75 + 75 + 75 + 75 + 75 + 50 + 47.5 + 37.5 + 37.5 + 52.5}{30}$$

Table 14: Grading SUS key

Grading SUS Key		
SUS Score	Grade	Adjectival Rating
>80.3	A	Excellent
68-80.3	B	Good
68	C	Okay
51-68	D	Awful
<51	E	Poor

Based on the grading SUS key depicted in Table 14, the average score of the usability value is 80.0 which falls in the "Good" range. Overall, the PC Guide application can be classified as successfully meet the needs of the target users.

5. Conclusion

In conclusion, the PC Guide application was successfully developed with three main modules, namely PC Parts, Pc Peripherals, and PC Simulation. The System Usability Scale (SUS) is a widely used questionnaire for assessing the usability of a system or product [10]. Besides, the usability testing obtained the SUS score of 80.0 which is the acceptable range based on the System Usability Scale (SUS).

All three objectives set from the beginning of the project have been achieved. The three objectives of this project were fully accomplished by designing the PC Guide application based on the TRES-D model. Second, the proposed application was successfully developed in a VR platform which is an Oculus Quest 2 headset that provides an immersive virtual reality environment, intuitive interaction mechanics, clear instructional guidance, and the ability to simulate realistic computer assembly. Lastly, performing the functional and user acceptance testing after the development phase was completed.

The PC Guide application has several advantages, such as the content has been verified by the senior lecturer, Department of Information Security and Web Technology from the Faculty of Computer Science and Information Technology, University Tun Hussien Onn Malaysia as the Subject Matter Expert (SME). Therefore, the application has the ability to simulate realistic computer assembly. Besides, the able to provide the same knowledge as the computer architecture needs because of the outlines and strengths of the application has referred from the Computer Architecture Course (BIC 10503) which is one of the subjects that exists in the faculty program.

The advantages of the PC Guide application include its ability to simulate realistic computer assembly and also provided an instructional panel in order to assist the user and give the support technical to be able the user to use this system. Apart from its advantages, the PC Guide application has a number of flaws that were discovered during user testing. Hence, for future work, it is suggested that a number of interactive elements such as a troubleshooting simulation that can enhance user engagement and promote a deeper understanding of computer assembly concepts need to increase.

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