POLITEKNIK BANTING SELANGOR

VIRTUAL REALITY OF PT6A EXTERNAL ENGINE INSPECTION

NAME	MATRIC NO.
AHMAD FAHMI BIN AHMAD FAEIZ	24DAM23F1009
NUR NATASHA BINTI SALLEH	24DAM23F1042
FELINA EFFA ANAK KEBIN	24DAM23F1045

DEPARTMENT OF AIRCRAFT MAINTENANCE

SESSION 1: 2025/2026

POLITEKNIK BANTING SELANGOR

VIRTUAL REALITY OF AIRCRAFT EXTERNAL ENGINE INSPECTION

NAME	MATRIC NO.
AHMAD FAHMI BIN AHMAD FAEIZ	24DAM23F1009
NUR NATASHA BINTI SALLEH	24DAM23F1042
FELINA EFFA ANAK KEBIN	24DAM23F1045

A REPORT SUBMITTED TO DEPARTMENT OF AIRCRAFT MAINTENANCE IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR A DIPLOMA ENGINEERING IN AIRCRAFT MAINTENANCE

SUPERVISOR:

NORLIA GHAZALI

REPORT ENDORSEMENT

This report is being submitted, reviewed, and endorsed to fulfill the conditions and requirements of report writing as specified.

Checked by:

Supervisor's Signature :

Supervisor's Stamp :

NORLIA BINTI GHAZALI
Pensyarah
Jabatan Penyelenggaraan Pesawat
Politeknik Banting Selangor

Date : 4/12/2025

Endores by:

Project Coordinator's Signature :

Project Coordinator's Stamp :

KHAIRUL IZWAN BIN ISMAIL
Pensyarah
Jabatan Penyenggaraan Pesawat
Politeknik Banting Selangor

Date : 12th DECEMBER 2025

CERTIFICATION OF PROJECT ORIGINALITY & OWNERSHIP

VIRTUAL REALITY OF AIRCRAFT EXTERNAL ENGINE INSPECTION

SESSION: 1 2025/2026

NAME	MATRIC NO.
AHMAD FAHMI BIN AHMAD FAEIZ	24DAM23F1009
NUR NATASHA BINTI SALLEH	24DAM23F1042
FELINA EFFA ANAK KEBIN	24DAM23F1045

"We hereby declare that this report is the result of our own work, except excerpts that we have outlined its sources and this project will be the ownership of polytechnic.

SIGNATURE: WRITER 1

SIGNATURE: WRITER 2

(NUR NATASHA)

SIGNATURE: WRITER 3

Endorsed by,

(SUPERVISOR SIGNATURE)

(SUPERVISOR STAMP)

NORLIA BINTI GHAZALI
Pensyarah
Jabatan Penyelenggaraan Pesawat
Politeknik Banting Selangor

DATE: ....4/12/2025......................

ACKNOWLEDGEMENT

We would like to take this opportunity to wish present million thanks to our parents because they have sacrificed and given full support and impetus by education and implementation of this end of semester project in Politeknik Banting Selangor.

We would like to thank our project supervisor, Madam Norlia Ghazali, for her continuous help, support, and guidance throughout our project. Her support and professionalism have motivated us, especially when we a lot of problems and out of ideas. Whenever we needed help, she was always ready to assist and give us advice.

We also want to thank the lecturers from the Aircraft Maintenance Department for all the support that been given to us. We appreciate their advice, guidance, and supervision to make sure our project went smoothly and satisfied with the outcome. They also shared many helpful ideas during the process, which is really helpfull to us.

Once more thanks a lot to team members for their cooperation and understanding in implementing this project, sacrificing time, energy, money, and giving all out for this project. Thanks for them making this without knowing the meaning of despair. Indeed, each cooperation and assistance from certain parties, whether directly or not is hugely a blessing for our group. A lot of thanks to all who are involved directly, especially Politeknik Banting Selangor.

ABSTRACT

This project explores the full journey of designing, developing, and evaluating a PT6A engine inspection experience inside a virtual reality (VR) environment. The main goal is to enhance aviation training by creating a realistic and interactive way for students to learn.

We begin with the design stage, where the focus is on building a detailed and accurate model of the PT6A engine. Every element is crafted with care to ensure precision, user-friendliness, and an engaging experience that feels natural in VR. The intention is to mirror real-life inspection procedures as closely as possible, while still making the experience smooth and intuitive in a virtual setting.

Once the design is finalized, the project moves into the development phase. Here, the planned concepts are turned into functional VR models using modern development tools. These virtual components are built to operate reliably and accurately within the VR system, allowing users to interact with them just as they would during an actual engine inspection.

The final stage is the evaluation phase. During this part, user testing is carried out to understand how well the virtual tools perform and how easy they are to use. Feedback from testers is then analyzed and used to refine and improve the VR experience. These adjustments ensure that the final product meets user expectations and provides a more realistic and effective training environment.

Through this continuous cycle of design, development, and improvement, the project aims to support the growth of VR-based learning in aviation and offer a valuable training resource for future aircraft maintenance students.

Keyword : VR : virtual reality, PT6A engine: one of the aircraft engine

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

ABBREVIATION	MEANING
VR	Virtual Reality
VRAEEI	Virtual Reality Engine External Inspection
VRAEI	Virtual Reality Engine Inspection
AMM	Aircraft Maintenance Manual
MRO	Maintenance Repair Overhaul
AMT	Aircraft Maintenance Technology
FOD	Foreign Object Damage

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

The PT6A turboprop engine is one of the most commonly used powerplants in general aviation, training aircraft, and small commercial operations. Because of its widespread use, aircraft maintenance students must develop strong knowledge and hands-on skills in inspecting this engine especially its external components. However, real engine access is often limited in training institutions. Students sometimes rely only on classroom lectures, pictures, or short lab sessions. This makes it difficult for them to fully understand the engine layout, identify components, and practice proper inspection techniques.

In recent years, technology has started to play a bigger role in aviation education. Virtual Reality (VR) provides an immersive, interactive way for students to explore aircraft systems in a safe and controlled environment. Unlike traditional methods, VR allows learners to view the engine from any angle, zoom in on parts, and repeat inspections as many times as needed without risking damage to real equipment. This makes VR a powerful tool for early-stage training, especially for complex systems like the PT6A engine.

1.2 PROBLEM STATEMENT

Learning how to perform an external inspection on the PT6A engine is an important skill for aircraft maintenance students. But in many training institutions, access to a real engine is limited. Sometimes the engine is shared between many classes, sometimes it's under maintenance, and sometimes students only get a short amount of time to look at it. Because of this, many students struggle to remember component locations, inspection steps, and how the engine actually looks in real life.

Most of the time, lessons rely on slides, pictures, and videos to explain the PT6A engine. These methods help, but they don’t give students the same experience as standing in front of the real engine and exploring it from every angle. Without enough hands-on practice, students may feel less confident and less prepared when it comes to real inspection tasks.

To overcome this, there is a need for a training method that is more accessible, interactive, and repeatable. A Virtual Reality Aircraft Engine External Inspection (VRAEEI) system created using Unity can give students a realistic way to explore the PT6A engine anytime, without depending on the availability of physical equipment. With VR, students can learn at their own pace, practice as many times as they want, and build better understanding before touching the real engine.

1.3 PROJECT AIMS AND OBJECTIVES

1.3.1 General Project Aims and Objectives

The aim of this project is to develop a Virtual Reality Aircraft Engine External Inspection (VRAEEI) system that helps aircraft maintenance students understand and practice the external inspection of the PT6A engine in a more interactive, accessible, and realistic way.

The project objectives are:

- To develop a VR simulation of the PT6A engine using Unity that allows students to view and explore the engine in a realistic 3D environment.
- To provide an interactive learning experience where students can identify external components and understand their positions and functions
- To support students' inspection practice by allowing them to repeat the external inspection steps as many times as needed without relying on a physical engine.
- To improve learning engagement and confidence by giving students a hands-on alternative when real engine access is limited.

1.3.1 Specific Individual Project Objective

1.3.1.1 Product Structure

The VRAEEI system is built from a few main parts that work together to create a smooth training experience. The core of the product is the 3D model of the PT6A engine, which students can look at from every angle. Around this model, the VR interaction system, the user interface, and the inspection modules are arranged to guide the user through the learning process. Everything is organized to make the simulation feel natural and easy to follow, just like doing a real external inspection but in a virtual space.

1.3.1.2 Product Mechanism

The mechanism of the VRAEEI system is simple: the student puts on the VR headset and can immediately move around the engine, point at components, and interact with the inspection steps. When the user selects a part, the system highlights it and shows basic information. During the inspection module, the system guides the user step-by-step so they understand the correct sequence. Unity's VR tools handle the movement, detection, and interactions, making the whole experience feel smooth and realistic.

1.3.1.3 software / programming

The entire VRAEEI simulation is developed using Unity with C# scripting. Unity handles the 3D environment, lighting, and VR setup, while the C# scripts control what happens when a student interacts with the engine. This includes displaying information, highlighting components, playing simple animations, and managing the inspection steps. The programming focuses on keeping things clean and simple so that the simulation runs smoothly, without lag or confusion, even for first-time VR users.

1.3.1.4 Accessories & Finishing

To make the simulation more enjoyable and comfortable to use, several finishing touches were added. This includes clear labels, easy-to-read menus, gentle highlight effects, and small sound cues when a student selects something. The virtual environment is kept simple and not too crowded to avoid distractions and reduce motion sickness. Extra details like smooth animations and clean lighting help make the whole experience feel more polished and professional.

1.4 SCOPE OF PROJECT

1.4.1 General Project Scopes

The VRAEEI system is designed to help aircraft maintenance students practice external inspections of the PT6A engine in a virtual environment. The system allows users to explore the engine, identify key components, and follow inspection steps. It focuses only on external inspection procedures, not internal engine maintenance. The project is also limited to VR simulation using Unity and does not involve physical engine modifications.

1.4.2 Specific Individual Scopes

1.4.2.1 Application Structure

The application is structured around a realistic 3D PT6A engine model. It includes VR interaction tools, a user-friendly interface, and inspection modules that guide students step-by-step. The structure is designed so users can easily navigate, explore components, and complete inspection tasks in a logical order and can really understand base on AMM and CAIP

1.4.2.2 Application Mechanism

The mechanism defines how the user interacts with the VR engine. Students can move around, point at parts, select components, and trigger information pop-ups. The system highlights components during inspection and provides guidance to ensure the user follows the correct steps. This mechanism simulates a real-world inspection safely and allows repeated practice. And need to answer all the question base on CAIP to know weather they understand or not

1.4.2.3 Software / Programming

The VRAEEI stand for (virtual reality aircraft engine external inspection) simulation is developed to assist Politeknik Banting students and lecturer in learning external inspection for aircraft engine using Unity with C# scripts. The programming handles engine interactions, inspection sequences, UI navigation, and VR headset inputs. The software ensures smooth performance, accurate component detection, and a seamless learning experience. VR SDKs like OpenXR are integrated to support movement, tracking, and controller input.

1.4.2.4 Accessories & Finishing

The VRAEEI system is designed to be user-friendly, visually appealing, and engaging for students. The interface includes clear labels, intuitive menus, and smooth interactive buttons to make navigation easy. Small visual cues, such as component highlights and subtle animations, help students understand which part to inspect next and enhance immersion in the virtual environment.

The system is fully compatible with VR headsets and controllers, ensuring comfortable movement and interaction inside the simulation. Audio feedback, like soft selection sounds, provides confirmation of actions without being distracting.

Additionally, the system supports smooth performance and responsiveness, so students can explore the engine without lag or interruptions. A secure login ensures that each student's progress and interactions are saved individually, and regular updates are planned to fix any bugs and improve the overall user experience. The overall finishing focuses on making the VR inspection realistic, engaging, and easy to use, ensuring that students can focus on learning rather than struggling with controls.

1.5 PROJECT IMPACT

The VRAEEI project ensures that students gain essential knowledge of the PT6A engine before performing real hands-on inspections. By practicing in a safe virtual environment, students can build confidence and competence, reducing the risk of errors or accidents when working with actual engines.

In addition, the use of a digital VR platform reduces reliance on physical engines and printed manuals, supporting environmentally friendly learning practices. This minimizes paper usage and lowers training costs, contributing to a more sustainable approach to aviation education.

The project also familiarizes students with modern technology that is widely used in various industries. By interacting with VR systems, students learn how humans and digital tools can work together effectively. This exposure to advanced simulation technology helps prepare them for real-world maintenance jobs, where digital tools and modern equipment are increasingly integrated into daily operations.

Overall, VRAEEI not only improves technical skills but also encourages environmentally conscious, tech-savvy, and industry-ready learning practices.

CHAPTER 2

LITERATURE REVIEW

2.1 RESEARCH OF PREVIOUS STUDY

2.1.1 Aviation Industry in Malaysia

The aviation and aerospace industry in Malaysia has experienced steady growth in recent years. The country's aerospace sector, including airlines, manufacturing, and maintenance repair overhaul (MRO) services, has shown increasing demand for skilled personnel. Reports indicate that over 240 aerospace companies operate in Malaysia, most focusing on MRO and manufacturing.

This growth highlights the need for effective training solutions that prepare students for real world maintenance work. Tools like VR based training simulations can help bridge the gap between classroom learning and practical experience, ensuring students are ready for the demands of the industry.

- The aviation (and aerospace) sector in Malaysia has recently shown strong growth. In 2025, the national aerospace industry's revenue is projected to grow by 20–25% from 2024, signalling growing confidence in Malaysia's aerospace capabilities. [1]
- The growth isn't just in airlines/flying there's also activity across manufacturing, maintenance repair overhaul (MRO), engine components, and systems integration. [1]

- According to a 2025 perspective on Malaysia's aerospace sector, the country hosts over 240 firms mostly concentrated in MRO and manufacturing (though design and development remain weaker areas). [2]

- This context suggests that there's demand for skilled maintenance personnel which strengthens the need for effective training tools and modern education methods (like VR), especially in a country where aerospace industry demand is rising, and capacity building matters.

2.1.2 Aircraft Engine — Theory & Industry Context

Aircraft engines are highly complex systems that require thorough understanding and careful maintenance. Modern research emphasizes using digital technologies, such as virtual simulations and digital twins, to train maintenance personnel. These tools allow students to explore engine components in a safe, controlled environment, helping them understand functions and interactions without needing constant access to physical engines.

Simulation-based learning also helps reduce errors and improves safety during actual maintenance tasks, as students can practice repeatedly and gain confidence before working on real engines.

Research into digital twin applications for aircraft maintenance and operation shows that such technologies can model complex subsystems (like engines), enabling simulation-based maintenance training and predictive maintenance this suggests that engine-specific simulation (even external inspection) is within scope of modern research. [3]

2.1.3 Aircraft Engines in the Aviation Industry

Aircraft engines are critical to aviation operations, and maintaining them requires skilled technicians. Studies show that traditional classroom teaching and brief practical sessions often do not provide enough experience for students to fully understand engine systems.

Interactive and simulation-based training, including VR, allows students to safely practice inspection and maintenance tasks. These methods improve learning outcomes by helping students remember component locations, inspection procedures, and proper techniques. This is especially important for engines like the PT6A, where hands-on experience is limited but essential.

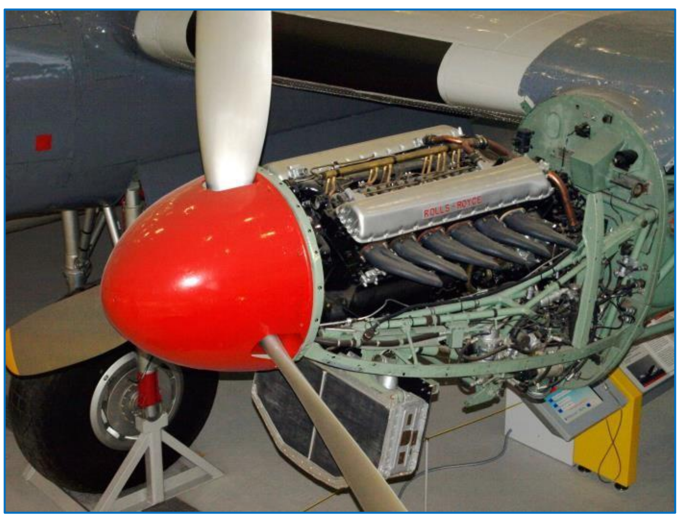


Figure 2.1 : Aircraft engine (source: google)

- As aircraft systems become more complex, the demand for qualified maintenance personnel capable of handling inspections, maintenance, and diagnostics is rising. The digital-twin-based training ecosystem paper argues that static courseware and infrequent practical sessions are no longer sufficient. [1]

- Studies on simulator-based training in Aircraft Maintenance Technology (AMT) programs show that immersive training (using simulators or VR) significantly improves students’ understanding of complex systems, skill retention, confidence, and preparedness compared to traditional instruction. [2]

- Maintenance training devices (virtual or simulated) reduce dependency on physical aircraft or components, which can be costly, scarce, or unsafe for frequent training use.

2.1.4 Interactive learning in aviation

Figure 2.2: interactive learning (source: google)

Interactive learning methods, such as VR, simulation, and digital twins, are increasingly used in aviation maintenance education. Research shows that these methods provide more engaging and immersive learning experiences compared to traditional lectures or textbooks.

- VR training systems allow students to move around, interact with components, and perform tasks in a realistic virtual environment. This approach not only improves knowledge retention and practical skills but also boosts confidence before students handle real aircraft systems. A 2025 study proposes a comprehensive digital twin-based training ecosystem for aviation maintenance, combining virtual simulation, adaptive learning, real-time competence monitoring, and dynamic content delivery illustrating the potential for highly interactive, individualized training. [1]
- A middle 2023 study described an immersive VR system for aircraft maintenance training. The authors argue that VR allows learners to experience realistic, safe, 3D training environments where actual physical training may be limited, expensive, or hazardous. [1]
- Another research (2025) on digital learning platforms in Aircraft Maintenance Technology (AMT) shows that gamification + digital learning can boost student engagement, motivation, knowledge retention, and practical skills. The study suggests blending e-learning with hands-on labs and simulation-based training yields better results than traditional methods alone. [2]

2.2 SELECTION OF IDEA

2.2.1 Application Designing Interface

The development of a VR tool for PT6A external inspection begins with the use of immersive hardware such as the Oculus Quest 2 headset, supported by hand controllers that allow users to interact naturally with virtual engine components. These devices form the main platform for delivering an engaging and hands-on inspection experience without needing a physical aircraft engine.

The software itself is built using powerful development engines like Unity or Unreal Engine, which provide the tools needed to create realistic and interactive environments. Using these platforms, detailed 3D models of the PT6A engine are constructed, showing external components such as the air intake, exhaust, reduction gearbox, oil system, and accessory section. Each model is designed to match the real engine as closely as possible so learners can recognise components accurately during training.

The educational content is carefully integrated into the VR system. This includes step-by-step inspection guides, interactive prompts, and scenario-based tasks that teach students how to identify defects, check engine condition, and follow standard inspection procedures. The goal is to simulate a real external inspection environment where learners can practise safely and repeatedly.

The VR interface is designed to be simple and intuitive, making it easy for learners to move around the virtual PT6A engine, zoom in on specific parts, and access inspection checklists directly in the virtual space. Features such as object highlighting, part labels, and tooltips help users understand each component's purpose and inspection criteria. The system is also made compatible with multiple VR setups to support accessibility for a wider range of users.

Figure 2.3 : VR Flight Simulator (Upload VR)

2.2.2 Product Mechanism

Virtual Reality (VR) technology has significantly improved the way aviation maintenance training is delivered, offering students an immersive and realistic environment to practice inspection tasks, learners using a VR headset are placed in front of a highly detailed virtual PT6A engine. The environment is designed to mirror the real engine as closely as possible, with accurate dimensions, textures, and component placement. High-resolution displays ensure that every external feature such as the exhaust, air intake, reduction gearbox, oil lines, and accessory housing, is clear and easy to identify, providing a genuine sense of presence similar to inspecting the actual engine.

The interactive elements of VR further enhance the learning experience. Using motion controllers, students can move around the engine, crouch, zoom in on specific parts, and interact with inspection points just as they would during a real external inspection. This hands-on interaction helps learners understand the physical layout of the PT6A engine and familiarize themselves with the correct inspection sequence. More advanced VR systems may even include haptic feedback, which gives subtle vibrations or tactile responses to simulate touching or identifying components, strengthening practical understanding and muscle memory.

Behind this immersive environment is dynamic simulation software that acts as the backbone of the VR inspection system. The software ensures that engine components behave realistically within the virtual environment. For example, panels can be opened virtually, defects can be displayed, and lighting conditions can be adjusted to simulate real inspection challenges. This gives learners the opportunity to practise identifying common issues such as leaks, cracks, missing fasteners, FOD (foreign object damage), and signs of overheating without risking a real engine.

The VR inspection system also integrates educational features to support effective learning. Interactive guides, hints, or on-screen prompts can appear when needed, helping students follow proper inspection procedures step-by-step based on standard maintenance practices. Real-time feedback allows learners to immediately see whether they are performing each inspection task correctly, helping them correct mistakes early. Progress tracking tools record performance, allowing instructors to review each student’s work and tailor future training to their needs.

Figure 2.4 motion control VR (source : vrhub)

2.2.3 Software & Programming

Figure 2.5 : software application (source : unreal engine)

The VRAEEI platform is designed to make learning how to inspect the external PT6A engine both engaging and easy to follow. It focuses on the most important and relevant information, presenting key topics in a clear and simple way. For example, students can learn how different flight instruments work and their purposes through concise notes, colorful infographics, and interactive tools. The notes break complex concepts into small, manageable sections, making it easy to understand step by step. Infographics use visuals to show how inspections are organized and how different components relate to each other, making complicated ideas easier to grasp.

To make learning even more immersive, users can interact with 3D models of the PT6A engine. They can zoom in, rotate, and click on parts to see how each component functions in real time. Fun quizzes, like matching exercises, provide instant feedback to help reinforce learning and check understanding.

The platform’s main menu is intuitive and user-friendly, with sections like “Notes,” “Infographics,” “3D Models,” and “Quizzes.” This makes it simple to navigate, whether a student wants to read detailed notes, explore interactive visuals, or test their knowledge. The 3D model section is especially engaging, giving users a hands-on experience with virtual instruments to see exactly how they work. Quizzes are designed to be challenging but manageable, and progress tracking with achievements helps keep students motivated.

With this thoughtful design, VRAEEI provides aviation students with a practical, interactive, and enjoyable way to confidently learn and master the inspection of the PT6A engine.

2.2.4 Accessories & Finishing

In summary, the VRAEEI system is designed to provide a smooth, engaging, and user-friendly learning experience for students. Its intuitive menus, clear buttons, and interactive elements make navigation simple, while the 3D engine models, infographics, and subtle animations help students understand complex concepts more easily. Features like quizzes with instant feedback and progress tracking motivate learners and reinforce knowledge.

The platform’s design prioritizes comfort, usability, and realism, ensuring students can explore and inspect the PT6A engine confidently. Audio cues, responsive controls, and secure login features enhance interaction and safety, while regular updates maintain smooth performance. Overall, the accessories and finishing of VRAEEI work together to create a polished, practical, and enjoyable virtual training tool that supports effective learning and builds students’ confidence in engine inspection.

2.3 REVIEW OF RELATED PRODUCTS

2.3.1 Recent Market Products

Product A: Roblox VR (virtual reality)

Table 2.1: Product A (Learn Aerospace Engineering) Description

Market Product	Product Summary
	Product Name: Roblox Developer: Roblox CO Launch Date: Mar 5, 2023 Product Description: Learn Aerospace Engineering is an easy- to-use app that provides basic understanding of aerospace and aeronautical engineering. It includes lectures, tutorials, and notes.

Product B: World Flight Meta Quest 2

Table 2.2: Product B (World Flight Meta Quest 2) Description

No.	Market Product	Product Summary
1.		Product Name: World Flight Meta Quest Developer: Zero Gravity Game Launch Date: September 30, 2022 Product Description: World Flight is a VR flight-simulation experience for Meta Quest 2 (and other Quest headsets) that lets users “fly around the world without limits. With this game, you can plan your flight on a world map, then pilot either a plane or a helicopter. The simulation includes features such as dynamic weather, wind, time-of-day changes, and procedurally generated buildings and water based on real data.

2.4 COMPARISON BETWEEN CURRENT/RELATED MARKET PRODUCT AND CURRENT PROJECT

Table 2.3: Comparison Between Current/Related Market Product and Current Project

Products	Roblox VR	World Flight VR Meta Quest 2	VRAEEI
Logo			AEROTECH VR SOLUTIONS
Purpose	To bring the broad, user-created worlds and games from Roblox into virtual reality enabling immersive social interaction, exploration, and play in 3D VR environments.	Interactive VR flight experience for entertainment and basic training.	Focused learning game for external inspection for aircraft engine in aviation maintenance
Target	Wide audience: casual players, creators, social VR users	Users interested in flight simulation, VR flight experiences — hobbyists, aviation enthusiasts, people who enjoy exploration and simulation games on VR (Quest 2, Quest Pro, etc.).	viation students, aircraft maintenance trainees.

Features	• Large library of user-generated experiences • Vr support	• Plan flights on a world map with a search engine. • Option to pilot a plane or a helicopter different flight styles.	• Q&A • Engine • Task • 3D modelling
Learning approach	Roblox VR is more oriented to exploration, creativity, social interaction, and general gaming not specifically structured as an educationa	Though primarily a leisure/simulation game, World Flight simulates realistic flight mechanics and environmental conditions.	Combines visual, interactive, and experiential learning approaches: students read simplified notes, explore infographics, manipulate 3D models, and test knowledge via Q&A
Platform	Android, IOS, Windows	Meta Quest 2	Unity and windows

2.5 ENVIRONMENTAL IMPACT

The VRAEEI platform has a positive impact on the environment by reducing the reliance on physical resources during aviation training. Traditionally, students would use printed manuals, paper-based checklists, and sometimes real engines for practice, which can consume a significant amount of materials and energy. By moving the learning process into a virtual environment, VRAEEI minimizes paper use and the need for physical equipment, supporting eco-friendly learning practices.

In addition, VR-based training reduces the carbon footprint associated with transporting and maintaining physical engines, classrooms, or laboratories. Students can practice inspections repeatedly in a virtual space without generating waste, which also lowers overall training costs.

Furthermore, incorporating digital learning tools like VRAEEI encourages sustainable habits among students, demonstrating that technology can provide effective education while protecting the environment. By embracing virtual simulations, the project contributes to greener aviation training practices and supports broader efforts toward environmental responsibility in education and industry.

2.6 SAFETY CONSIDERATION

The VRAEEI platform prioritizes safety by allowing students to practice PT6A engine inspections in a virtual environment before performing any real-world tasks. This reduces the risk of accidents, injuries, or damage to expensive aircraft components, providing a safe space for learning and repeated practice.

Consideration is also given to ergonomics and user comfort. The VR interface is designed to be intuitive, with smooth navigation, clear menus, and interactive elements that minimize strain during use. Audio and visual cues guide students effectively, reducing the chance of confusion or mistakes.

Additionally, the system includes secure login features to protect user data and track progress, ensuring that each student's work and learning path is safely stored. Regular software updates are planned to fix bugs, enhance performance, and maintain a reliable learning environment.

Overall, VRAEEI ensures that safety, user comfort, and careful design are central to the learning experience, allowing students to gain confidence and competence in PT6A engine inspections while minimizing real-world risks.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 PRODUCT BRIEFING & RISK ASSESSMENT

The VRAEI (Virtual Reality Aircraft Engine Inspection) platform is a VR-based training tool designed to teach aviation students how to perform external inspections on the PT6A engine. Using 3D interactive models, infographics, and quizzes, the system provides an immersive learning experience that allows students to practice inspection procedures safely and repeatedly without needing access to a physical engine. The platform is accessible via VR headsets such as Meta Quest 2 and is developed using Roblox and Unity, ensuring smooth interactions and a user-friendly interface.

Although VRAEI eliminates many of the risks associated with hands-on engine inspections, there are still potential risks that must be considered:

1. **User Safety:** Extended VR usage can cause eye strain, motion sickness, or discomfort. Proper usage guidelines and recommended break times are necessary.
2. **Technical Risks:** Software bugs or crashes could interrupt learning or cause data loss. Regular updates and testing are required to maintain system reliability.
3. **Data Security:** User login and progress tracking require secure handling of personal information. Strong authentication and secure storage practices must be implemented.
4. **Ergonomic Risks:** Poor posture or inappropriate headset adjustment can lead to physical discomfort. User guidance on proper VR setup is important.

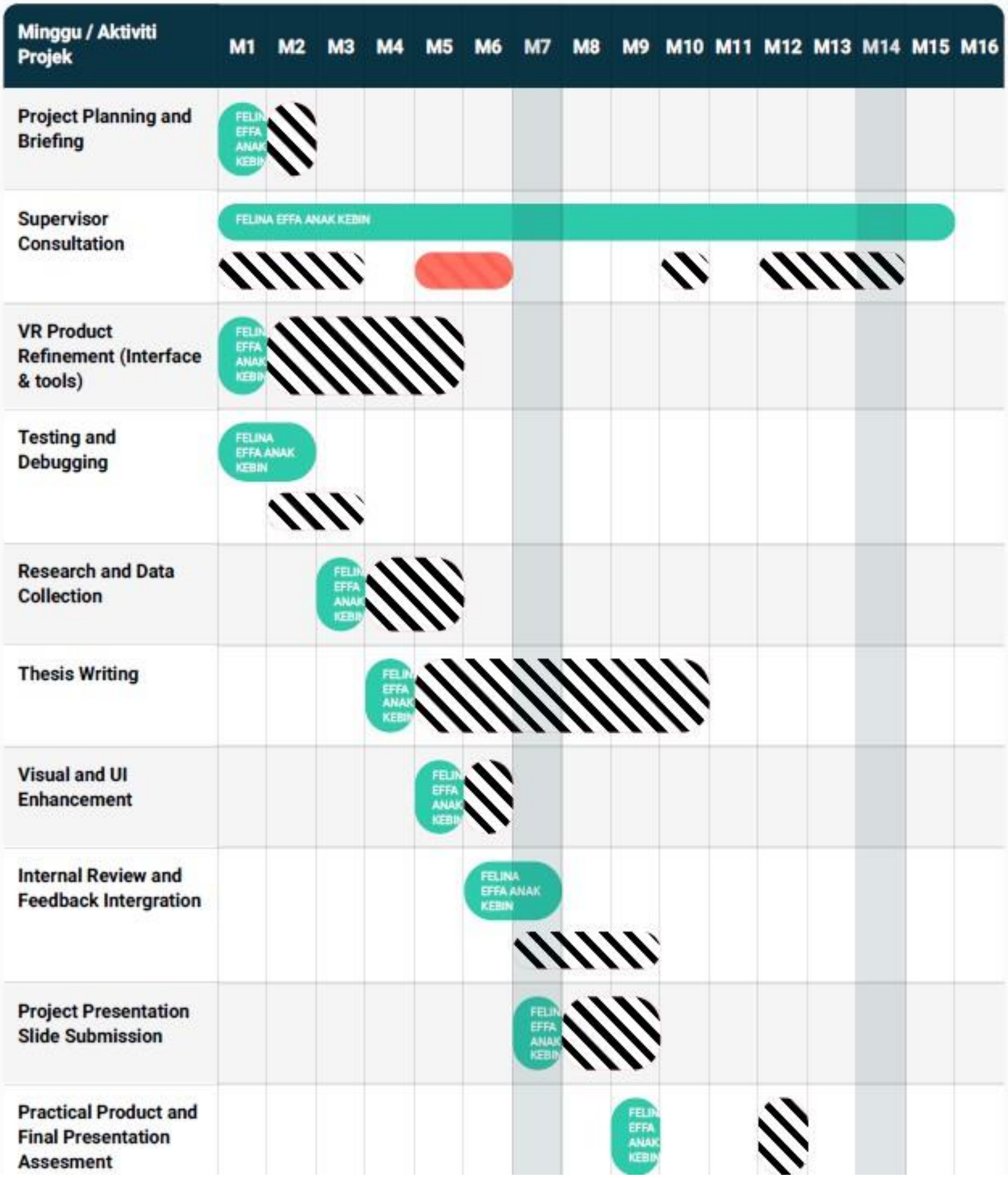
3.1.1 Utilization of Polytechnic's Facilities

The VRAEEI project makes effective use of the polytechnic's facilities to support the development, testing, and evaluation of the VR training platform. Computer labs equipped with high-performance PCs and VR-ready workstations provide the necessary environment for software development using Unity and Roblox. These labs also allow for safe testing of the VR application by students and instructors.

Additionally, classrooms and study spaces are utilized for user training, feedback sessions, and discussions on the inspection procedures simulated within VRAEI. The polytechnic's network infrastructure ensures stable internet connectivity, which is essential for running VR applications, accessing digital resources, and collecting student progress data securely.

By leveraging existing facilities, the project maximizes resource efficiency while ensuring that development and training activities are conducted in a professional and controlled environment. This approach not only supports the smooth implementation of the VR platform but also provides students with a realistic and safe setting for learning.

3.2 OVERALL PROJECT GANTT CHART



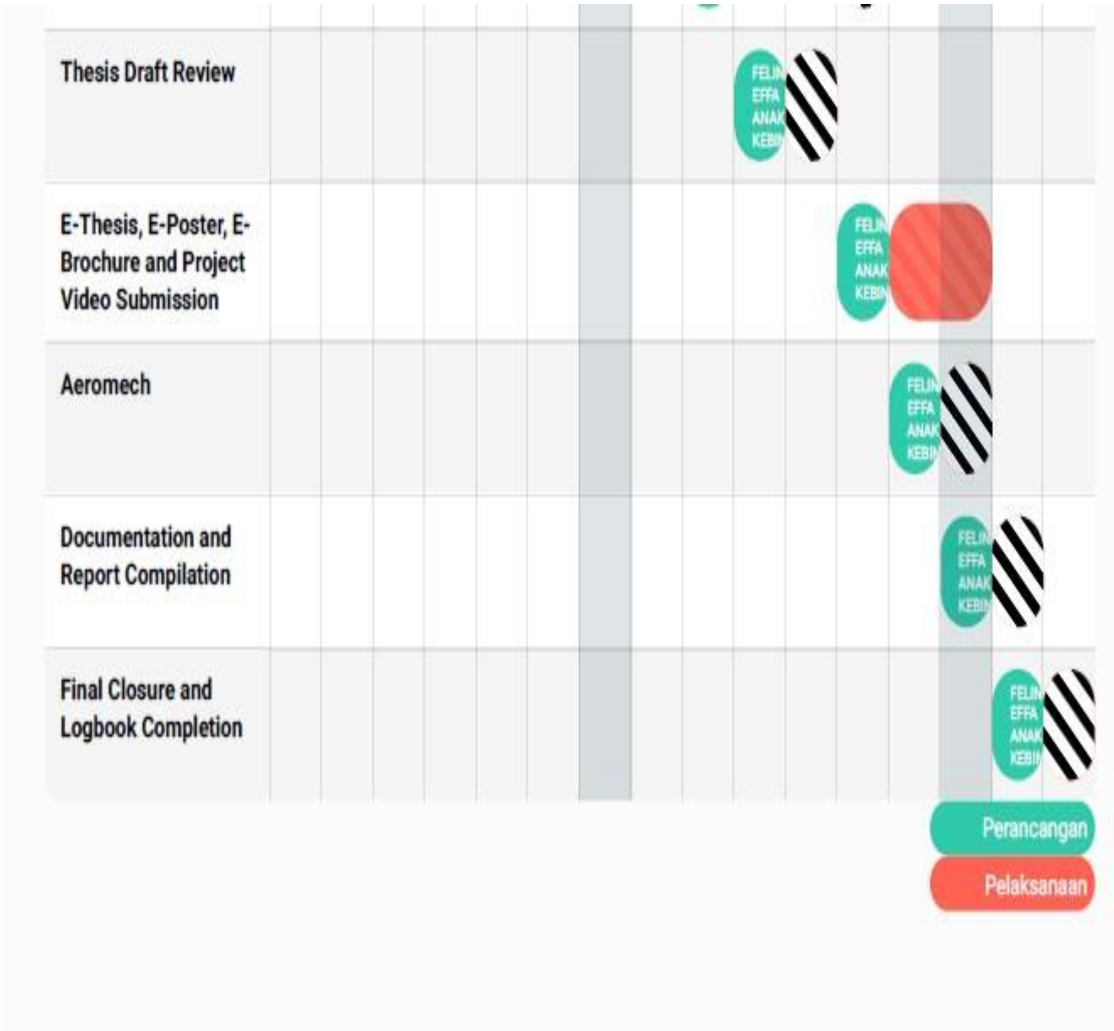


Figure 3.1: Gantt Chart

3.3 FLOW CHART

3.3.1 Overall Flow Chart

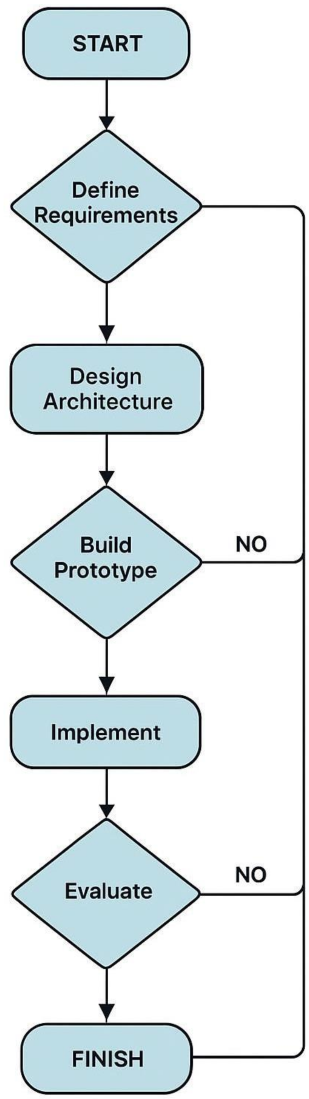


Figure 3.2 Overall Project Flow Chart

3.4 DESIGN ENGINEERING TOOLS

3.4.1 Questionnaire Survey

For better understanding, one questionnaire is created to analyze the data and collect information from the respondents. The questionnaire was filled out by 32 respondents from aviation backgrounds, and some of the key questions that aid in further analysis of the subject are as follows:

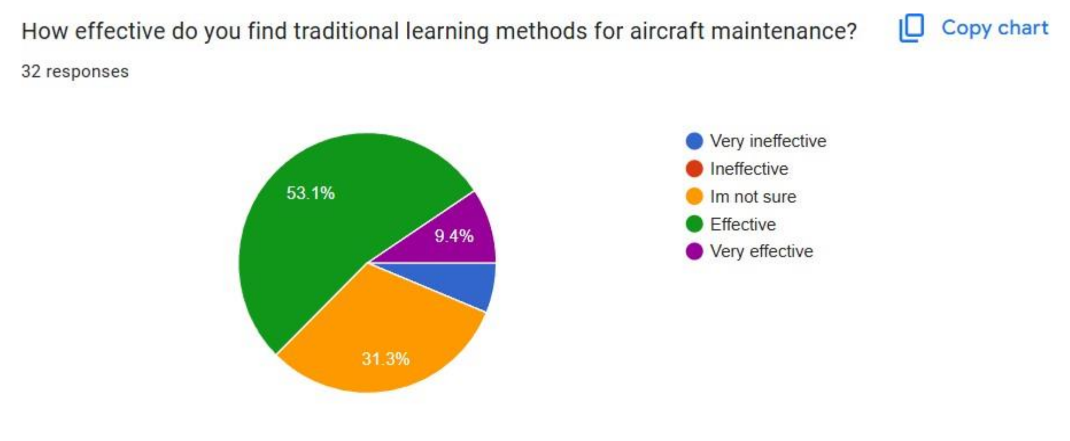


Figure 3.3 : Pre survey question 1

The first question to start with the data analysis is by asking the users how effective they find traditional learning methods for aircraft maintenance and 53.1% of them say very ineffective, followed by 31.3% innefective and the rest are effective

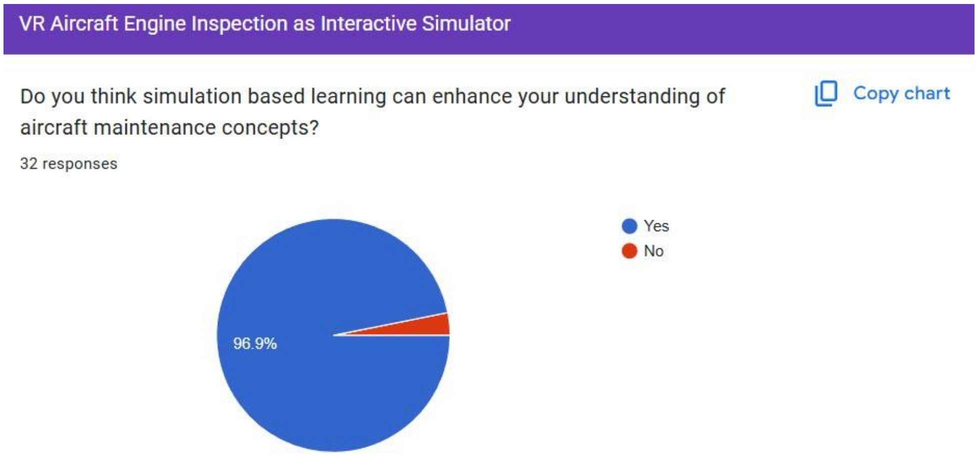


Figure 3.4 : pre survey question 2

Then, the users are asked does they think simulation learning can enhance their understanding and the result shown above :

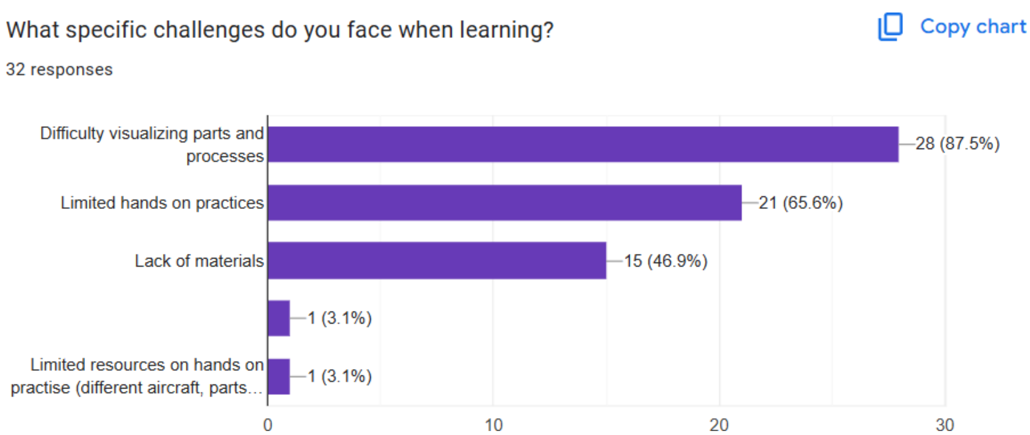


Figure 3.5 : pre survey question 3

After that, the questionnaire is continued by asking the respondent what specific challenges does they face when learning. The outcome is that 87.5% of them answered difficult to visualize part and process. Secondly, 65.6% of the respondents say limited hands on practices, followed by lack of materials at 46.9%. Lastly, the outcome of the survey states that 3.1% of our respondents pick limited resources on hands on practice.

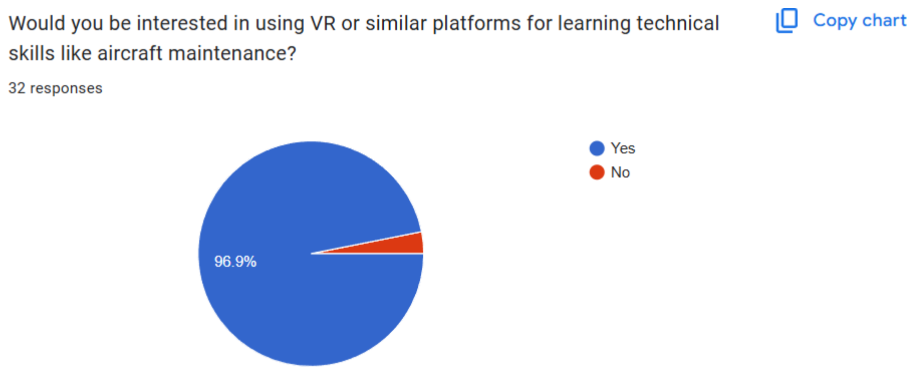


Figure 3.6 : pre survey question 4

Not only that, but the respondent also asked would they be interested in using VR or similar platform. The outcome is that 96.9% of them answered yes, and the rest is say no

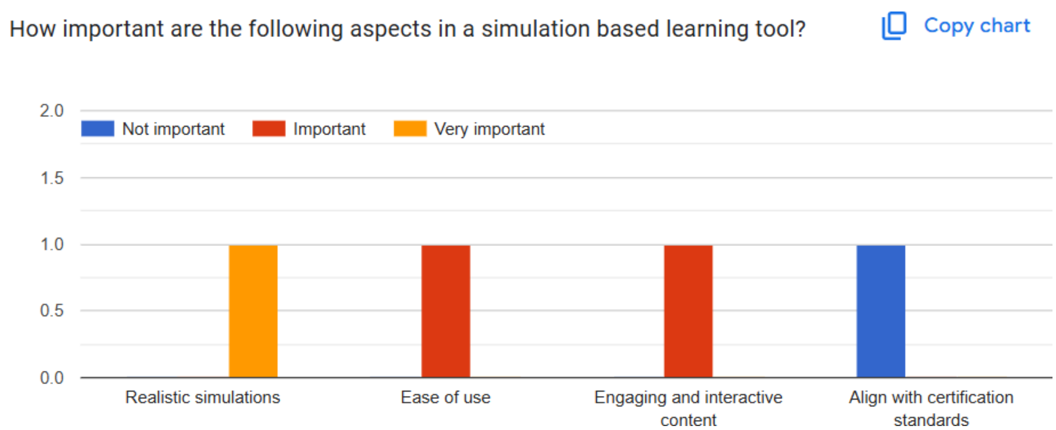


Figure 3.7: pre survey question 5

Additionally, the questionnaire is continued by asking the respondents how important are the following aspectc in a simulation based learning tool? The outcome is that 50/50

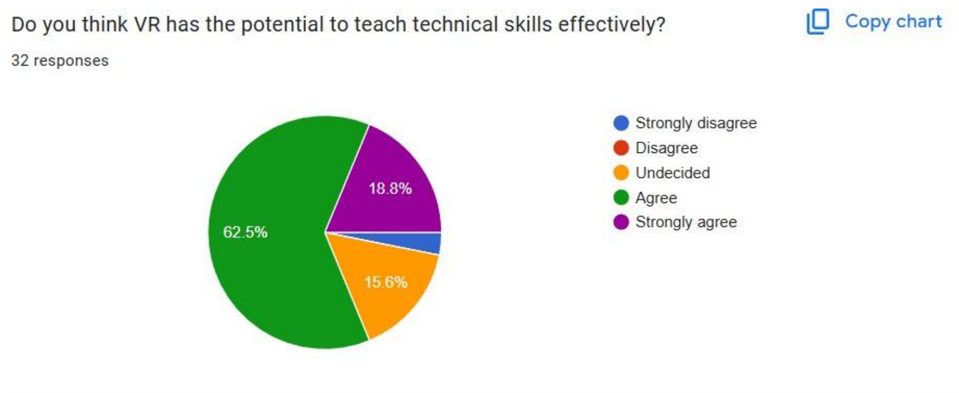


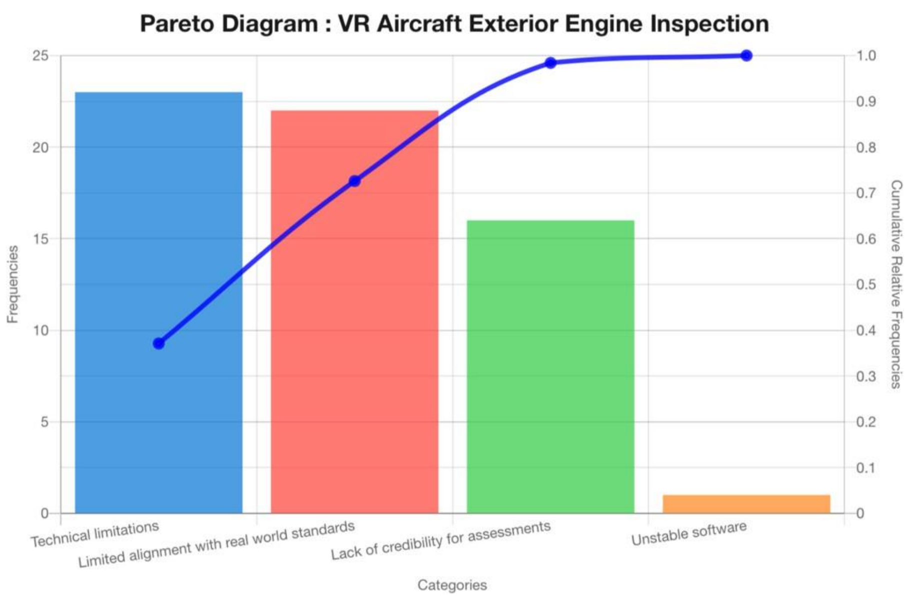
Figure 3.8: pre survey question 6

Lastly, the questionnaire is continued by asking the respondent if they think that learning through a VR has the potential to teach technical skills effectively. The outcome that is received is that 62.5% of the respondents say agree, while 18.8% say strongly agree, while the rest is undecided

3.4.2 Pareto Diagram

Pareto Diagram : VR Aircraft Exterior Engine Inspection

Problems	Frequencies	Cumulative	Cumulative Percentage (%)
Technical limitations	23	23	37.1
Limited alignment with real world standards	22	45	72.58
Lack of credibility for assessments	16	61	98.39
Unstable software	1	62	100
Total	62		



Based on the pareto diagram, technical limitations represent the most significant challenge highlighted by the respondents and should be given the highest priority in improving the VR learning application. Limited alignment with real world standards is the second most critical issue and also requires focused attention during development and refinement of the system.

3.4.3 DESIGN CONCEPTION

3.4.3.1 Function Tree

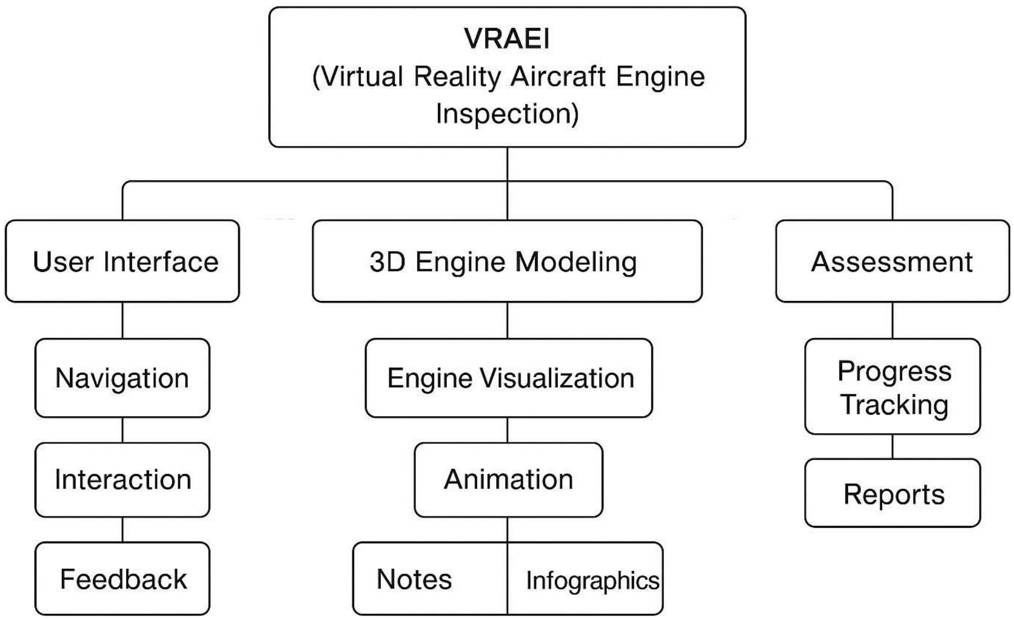
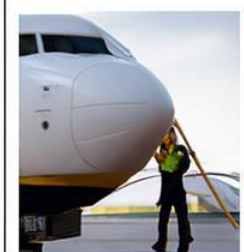


Figure 3.9: VRAEI function tree

3.4.3.2 Morphological Matrix

Table 3.1: Morphological Matrix for VRAEI

FEATURES	IDEA 1	IDEA 2	IDEA 3	IDEA 4
ASSE5SMENT METHOD	Roblox VR 	World Fright VR Meta Quest 2 	VRAEI using Unity 	Real World Ground Handler 
INTERFACE	Virtual World	Realistic	Virtual World	Real World
CONTENT SOURCES	Roblox Assets	Simulated Flights	Custom Models	Airport Staff
CONTENT EXPLANATION	Interactive Challenges	Realistic Scenarios	Viriual Training Modules	Operational Tasks
SOFTWARE	Roblox VR	Meta	Unity	Python

3.4.3.3 Proposed Design Concept 1

Table 3.2: Proposed Design Concept 1

Funtion	Concept 1	Justification
ASSESSMENT METHOD	Roblox VR	This method allows lecturers to directly observe student performance inside VR. Instead of relying only on paper exams, students can show their understanding by identifying components, performing inspection steps, and answering in-game tasks. It increases accuracy because the assessment is based on real actions instead of guessing.
INTERFACE	Virtual World	A clean and minimal interface ensures students can focus on the learning objectives, not struggle with controls. Since Roblox already has a familiar movement system, it reduces the learning curve.
CONTENT SOURCES	Roblox Assets	The content is based on aircraft maintenance manuals, PT6A reference diagrams, and standard aviation inspection procedures. easily access and make interaction

CONTENT EXPLANATION	Interactive Challenges	VR environment includes visual labels, pop-up explanations, and guided inspection prompts. These help students understand what each component does.
SOFTWARE	Roblox VR	Roblox Studio is used because: • It is free and accessible for students. • It supports VR with Meta Quest 2 and PC VR. .

3.4.3.4 Proposed Design Concept 2

Table 3.3: Proposed Design Concept 2

FUNCTION	CONCEPT 2	JUSTIFICATION
ASSESMENT METHOD	World flight quest meta 2	A realistic environment helps students stay focused because everything looks familiar to what they will see during actual training.
INTERFACE	Simulated flight	Colourful theme makes the application looks interactive and fun. It's can make the learning sessions more enjoyable, but the colour may not be comfortable for user's eyes.
CONTENT SOURCES	Realistic scenarios	Scenarios make the training feel alive. Students are not just looking at a static modelthey are solving problems.
SOFTWARE	META	Meta VR devices are affordable, widely available, and easy to use for beginners. They provide stable tracking, good display quality, and comfortable controllers

3.4.3.5 Proposed Design Concept 3

Table 3.4: Proposed Design Concept 3

FUNCTION	CONCEPT 3	JUSTIFICATION
ASSESSMENT METHOD	VRAEI	A high-quality 3D model helps students clearly see and understand every part of the PT6A engine without needing a physical engine available at all times.
INTERFACE	Virtual world	Unity supports intuitive interactions such as pointing, grabbing, and highlighting. These features mimic the real inspection process, making the training more hands-on and realistic
CONTENT SOURCES	Custom models	Not every student learns at the same speed. Guided modules allow slower learners to follow instructions confidently, while faster

		learners can explore freely..
CONTENT EXPLANATION	Virtual training modules	Real-life inspections rarely happen under perfect conditions. By adding simple faults in VR, students learn to recognize and report problems early
SOFTWARE	Unity	Unity is a flexible engine used worldwide for VR development. Using Unity means the project can be updated, expanded, or improved easily in the future by other students

3.4.3.6 Proposed Design Concept 4

Table 3.5: Proposed Design Concept 4

FUNCTION	CONCEPT 4	JUSTIFICATION
ASSESMENT METHOD	Real world groumd handler	Even though it's a game, the activities can be **inspired by real ground handling tasks** like guiding aircraft, loading baggage, or checking safety zones..
INTERFACE	Airport staff	• This idea turns ground handling into an **interactive, playable experience**. Players can perform simple tasks such as: • directing aircraft with marshalling wands • driving a baggage cart • loading cargo • doing basic safety checks

		• Everything is simplified, fun, and suitable for learning **basic concepts** without real pressure
CONTENT SOURCES	Operational task	This idea turns ground handling into an **interactive, playable experience**. Players can perform simple tasks such as: • Directing aircraft with marshalling wands • Driving a baggage cart • Loading cargo doing basic safety checks
SOFTWARE	Pyhton	The project uses **Python** because it is: • lightweight • beginner-friendly • easy to modify • good for fast prototyping

3.4.3.7 Proposed Final Concept

Table 3.6: Proposed Final Concept

FUNCTION	CONCEPT 3	JUSTIFICATION
ASSESSMENT METHOD	VRAEI	A high-quality 3D model helps students clearly see and understand every part of the PT6A engine without needing a physical engine available at all times.
INTERFACE	Virtual world	Unity supports intuitive interactions such as pointing, grabbing, and highlighting. These features mimic the real inspection process, making the training more hands-on and realistic
CONTENT SOURCES	Custom models	Not every student learns at the same speed. Guided modules allow slower learners to follow instructions confidently, while faster learners can explore freely..

CONTENT EXPLANATION	Virtual training modules	Real-life inspections rarely happen under perfect conditions. By adding simple faults in VR, students learn to recognize and report problems early
SOFTWARE	Unity	Unity is a flexible engine used worldwide for VR development. Using Unity means the project can be updated, expanded, or improved easily in the future by other students

3.4.4 EVALUATION & SELECTION OF CONCEPTUAL DESIGN

3.4.4.1 Pugh Matrix

Table 3.7: PUGH MATRIX: PRODUCT A (Roblox VR) AS DATUM

FEATURES	CONCEPT 1	CONCEPT 2	PRODUCT A	CONCEPT 3	CONCEPT 4
ASSESMENT METHOD	2	2	D	1	1
INTERFACE	1	1	A	3	1
CONTENT SOURCES	2	3	T	3	1
CONTENT XPLANATION	1	1	U	2	3
SOFTWARE	3	2	M	1	2
OTAL SCORE	9	9	-	10	8
RANKING					

gend: 3(+),2(=),1(-)

Table 3.8: PUGH MATRIX: PRODUCT B (World flight VR meta quest) AS DATUM

FEATURES	CONCEPT 1	CONCEPT 2	PRODUCT B	CONCEPT 3	CONCEPT 4

ASSESMENT METHOD	1	**2**	D	1	2
INTERFACE	2	**1**	A	1	1
CONTENT SOURCES	2	1	T	2	1
CONTENT EXPLANATION	1	**2**	U	3	2
SOFTWARE	2	1	M	1	2
TOTAL SCORE	9	7		8	8
RANKING					

Legend: 3(+),2 (=), 1 (-)

PUGH MATRIX: PROPOSED CONCEPT AS DATUM

Table 3.9: PROPOSED CONCEPT AS DATUM

FEATURES	CONCEPT 1	CONCEPT 2	PROPOSED CONCEPT	CONCEPT 3	CONCEPT 4

ASSESSMENT METHOD	**1**	1	D	3	1
INTERFACE	**3**	1	A	3	1
CONTENT SOURCES	**2**	**1**	T	3	3
CONTENT EXPLANATION	**3**	**1**	U	1	3
SOFTWARE	**1**	**2**	M	3	1
TOTAL SCORE	**10**	6		13	9
RANKING					

Legend: 3(+),2 (=), 1 (-)

3.4.4.2 Summary on Pugh Matrices

The Pugh Matrices were used to compare all proposed concepts against the baseline product by evaluating several key features such as assessment method, interface, content sources, content explanation, and software. Each feature was scored using the standard Pugh method: **3 (+) for better**, **2 (=) for equal**, and **1 (–) for worse**.

This scoring system helped to identify which concepts provide the greatest overall improvement when compared to existing solutions.

Across all three Pugh Matrices, the results consistently showed clear variations in performance between the concepts. Concepts that offered more intuitive interfaces, clearer explanations, and better software integration gained higher total scores. Meanwhile, concepts with limited features or weaker educational value received lower scores.

Overall, the Pugh analysis provided a structured and objective way to evaluate the strengths and weaknesses of each concept. The highest-scoring concept across the matrices is considered the most suitable direction for development, as it aligns well with the project goals and offers the best combination of usability, clarity, and technical capability.

3.5 CONCEPTUAL DESIGN OF THE PROPOSED PRODUCT

The conceptual design of the proposed product was developed based on the outcomes of the Pugh Matrix evaluation, where the selected concept demonstrated the highest overall performance in terms of usability, clarity, and educational effectiveness. This concept forms the foundation of the Virtual Reality Aircraft Engine Inspection (VRAEI) system.

The proposed design focuses on creating an interactive and immersive learning environment that allows users especially aircraft maintenance students to perform external inspections on the PT6A engine in a realistic and controlled virtual space. The goal is to support classroom learning by providing a safe, repeatable, and engaging method to practice inspection procedures.

Interface design

Figure 3.10: VRAEI user interface development

The interface is designed to be simple, clean, and easy for new users to understand. Key controls such as menu navigation, tool selection, and movement guidance are arranged in an intuitive layout. Visual clarity is prioritised to ensure that students can access important functions without confusion.

Virtual enviroment

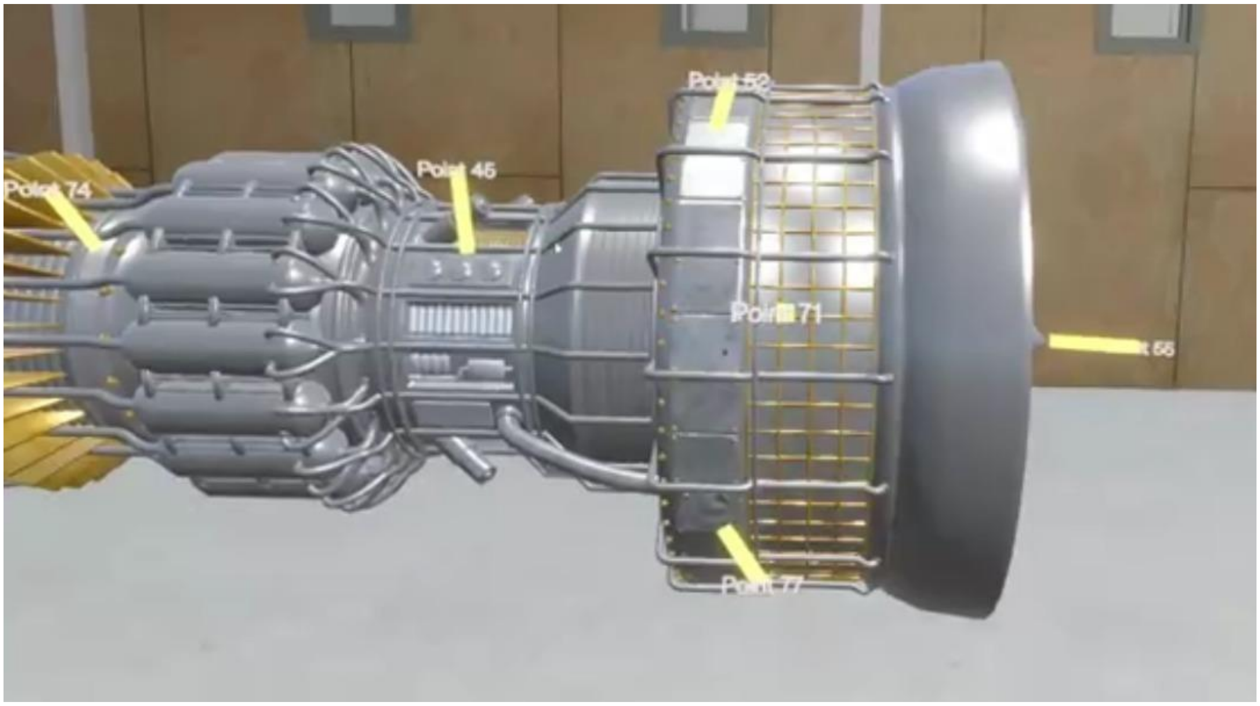


Figure 3.11: VRAEI virtual style

The environment simulates a basic aircraft maintenance bay featuring the PT6A engine model. The engine is displayed with realistic proportions and surface details to help students identify external components. The surrounding environment remains minimal to avoid distractions and ensure smooth performance on available VR hardware.

Engine Inspection Content

The inspection process is broken into clear instructional stages. Each stage introduces a specific external component of the PT6A engine along with basic information, common defects, and what students should look for. The content is designed to match classroom learning outcomes and provide consistent educational value.

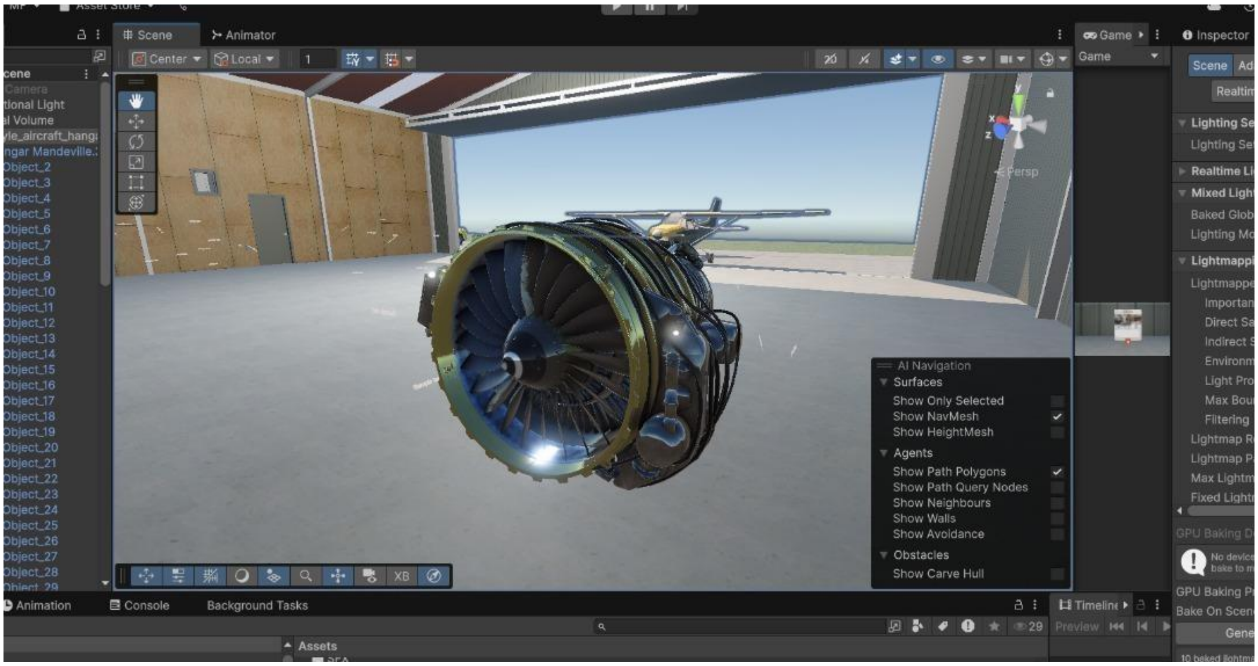


Figure 3.12: VRAEI engine inspection content

Assessment Method

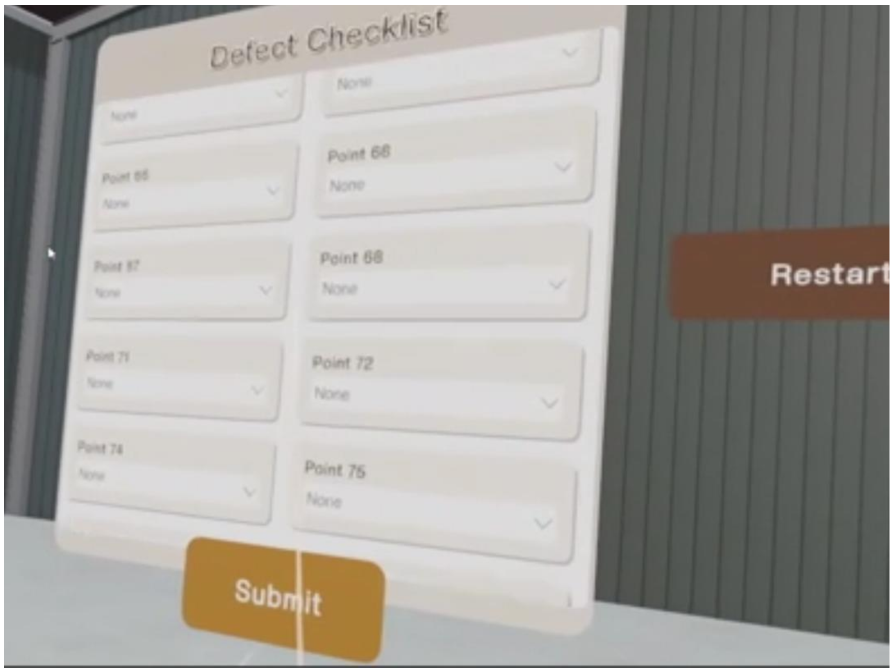


Figure 3.13: VRAEI assessment method

A built-in assessment feature evaluates the user’s performance throughout the inspection. Students are guided to check components in the correct sequence, and the system records their actions. At the end of the exercise, the system provides feedback on accuracy and completeness. This allows students to self-evaluate their progress and instructors to track learning improvement.

3.6 LIST OF MATERIALS & EXPECTED EXPENDITURES

Table 3.10: List Of Materials & Expected Expenditures

ITEMS	UNIT	PRICE
UNITY HUB	**1**	**RM 0**
Sketchfab	**1**	**RM 0**
 **Vr & Computer**	**1**	**RM0**

 **CODING CLASS**	**1**	RM350
TOTAL: RM 350		

CHAPTER 4

RESULTS & DISCUSSION

4.1 PRODUCT DESCRIPTION

4.1.1 General Product Features & Functionalities

The proposed VR Aircraft Engine Inspection (VRAEI) system is designed to help students learn and practice the PT6A external inspection in an immersive and interactive way. The main features of the product include:

- A realistic 3D model of the PT6A engine for external inspection training.
- An easy-to-use VR interface that guides students through each inspection step.
- Clear explanations of components, common issues, and inspection criteria.
- A built-in assessment feature that tracks user performance and provides feedback.
- Lightweight and simple design so students can use it without confusion or technical difficulty.

Overall, the system focuses on improving understanding, reducing classroom limitations, and allowing repeated practice in a safe environment.

4.1.2 SPECIFIC PART FEATURES

4.1.2.1 Product Structure

The structure of the product is divided into a few main layers that work together to deliver the full learning experience:

1. **VR Interface** – This is what the student sees, including menus and controls.
2. **3D Environment** – The virtual space, including the PT6A engine model and surroundings.
3. **Learning Module** – Contains the explanations, inspection steps, and guidance.
4. **Assessment Module** – Tracks the user's actions and gives feedback.
5. **Backend System** – Handles all the logic and data behind the scenes.

Each part has its own role, and together they create a smooth and organised training flow.

4.1.2.2 Product Functions

The app is designed to help students practise inspection in a straightforward, interactive way. Its main functions are:

- Showing inspection steps one by one.
- Allowing users to view, point, and interact with engine components.
- Providing explanations for each part, including common defects.
- Tracking whether the user follows the correct sequence.
- Giving a final assessment that shows what the student did right or wrong.

These functions help students learn better and build confidence before touching a real engine.

4.1.2.3 Software / Programming

The system is built using software tools that support VR development:

- **Unity Engine** – Creates the 3D environment and handles visuals.
- **C# scripts** – Control interactions, menu functions, and content flow.
- **VR SDK (Oculus/Meta)** – Enables headset tracking and controller movement.

The coding focuses on making the app stable, responsive, and easy for students to navigate.

Figure 4.1: unity platform

4.1.2.4 Accessories & Finishing

To make the experience as smooth and comfortable as possible, several thoughtful finishing touches have been added. The menus and text are designed to be easy to read, so users can quickly find what they need without any confusion. Highlight effects guide users to the correct components, helping them interact with the app more confidently. Clear sound effects provide instant feedback, confirming when an action has been performed correctly. Smooth animations make the virtual environment feel more natural and lifelike, enhancing the sense of immersion.

All these details work together to create a polished, user-friendly experience that feels intuitive, engaging, and enjoyable to use.

Figure 4.2 : user using VRAEI comfortably

4.1.3 GENERAL OPERATION OF THE APPS

The app is designed to be simple and easy to use, so students can focus on learning rather than struggling with the controls. When the user opens the VR app, they start at the main menu, which clearly shows all the available options. From there, they can select “Start Inspection” to begin exploring the PT6A engine.

As the inspection begins, the app guides the user step by step through each part of the engine, making sure nothing is missed. When a component is selected, helpful tooltips pop up with information about the part, its function, and what to check for. This makes learning interactive and keeps the experience engaging.
Once all the inspection steps are completed, the app provides a performance summary, showing what was done correctly and where there’s room for improvement. Users can repeat the inspection as many times as they like to practice and reinforce their skills.

Overall, the app aims to make the learning process smooth, stress-free, and enjoyable, helping students focus on understanding the engine and building confidence in performing inspections.

4.1.4 OPERATION OF THE SPECIFIC PART OF THE PRODUCTS

4.1.4.1 Product Structure

The VRAEI app is designed as a user-friendly learning tool that makes aircraft engine inspection easy and accessible. Navigating the app is straightforward—users can quickly find any inspection topic or engine component by using the search feature. The app also tracks learning progress, allowing students to monitor their performance and revisit completed modules.

Content that has been downloaded is available in offline mode, ensuring that students can continue learning even without an internet connection. The app also includes notifications for quizzes and practice exercises. The interface is designed to be visually comfortable, with clear, readable fonts and informative color codes. Buttons are well-organized and responsive, while smooth animations make the experience engaging and intuitive. Videos, images, and notes are all presented in high clarity, ensuring that technical information is easy to understand.

VRAEI is compatible with both tablets and mobile devices, allowing students to practice engine inspections anytime and anywhere. Secure logins protect user data, giving confidence that progress and performance records are safely stored.

4.1.4.2 Specific Product Functions

When a student uses the VRAEI app, they are first greeted with the main menu, which provides access to different sections of the PT6A engine inspection. The first feature is the **Introduction to the Engine Components**, where users can select specific parts of the engine to learn about, including the propeller, gearbox, and combustion chamber. 3D models, and explanatory notes for better understanding.

The second feature is the **Quick Notes** section, which provides summarized information about each inspection point. For example, users can view the proper procedure for checking the oil filter or examining the starter-generator. This helps students quickly refresh their knowledge without having to navigate through lengthy manuals.

The **Checklist Feature** ensures students have verified all required tools and equipment before performing each inspection step. The app prevents progression to the next task unless all items are confirmed, reinforcing proper preparation and adherence to procedures.

Finally, the **Assessment Quiz** evaluates student understanding. To move forward and complete the inspection, students must score at least 80%, ensuring they have mastered the material before practicing on the engine in real life.

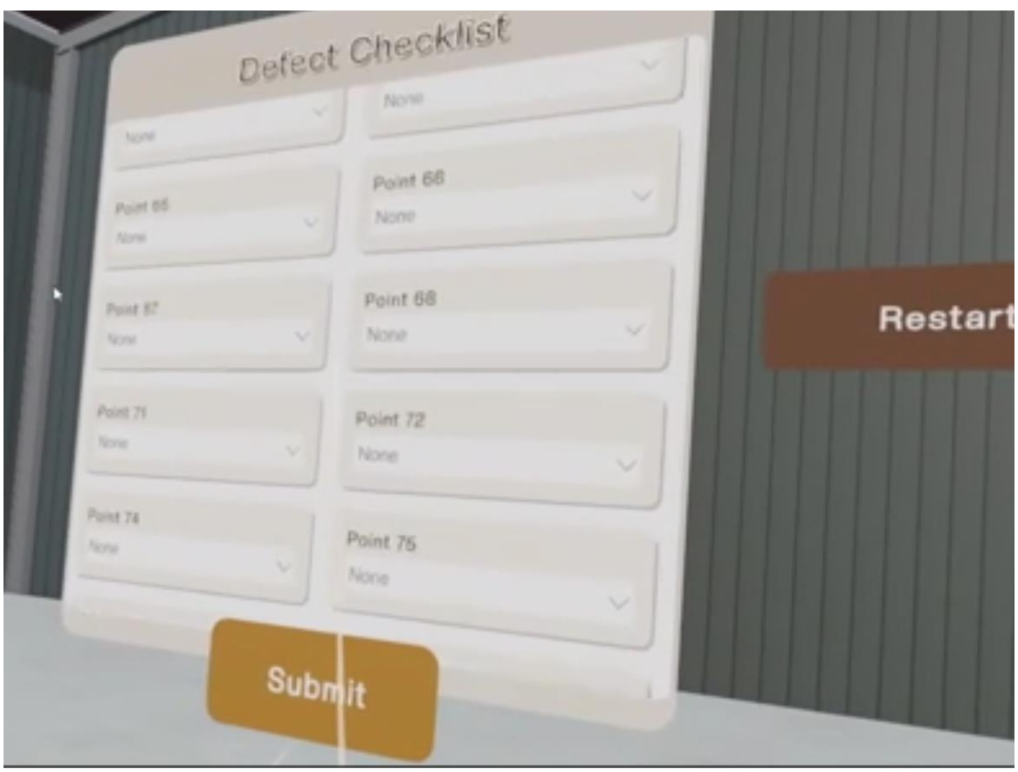


Figure 4.3: checklist features

4.1.4.3 Software / Programming

One of the key features of VRAEI is the **Assessment Quiz**, which evaluates the user's understanding of the PT6A engine inspection process. This feature is programmed to provide instant feedback based on the user's performance. For example, if a user scores 80% or higher, the system will display a message confirming that they are ready to perform the inspection in a practical environment. If the score is below 80%, the app directs the user to review the relevant sections before attempting the quiz again.

The VRAEI app is developed using **Unity**, which allows for smooth interactive 3D experiences in VR. Engine components are modeled and imported via **Sketchfab**, providing high-quality, realistic 3D visuals. This integration ensures that students can interact with detailed, accurate models of the PT6A engine, making the learning process both immersive and educational.

4.1.4.4 Accessories and Finishing

During the development of VRAEI, careful attention was given to **accessories and finishing** to ensure a smooth and reliable user experience. Functional elements such as navigation buttons, status indicators, and input validations were implemented to make interactions intuitive and accurate. Visual elements, including clear icons, color schemes, and highlight effects, guide users naturally through the inspection process.

The app also supports offline operation, allowing students to continue learning without an internet connection. This is made possible through Unity's runtime environment and preloaded Sketchfab models, ensuring uninterrupted functionality. Smooth animations, clear audio cues, and responsive interactions all contribute to a polished, professional, and user-friendly learning experience.

4.2 Analysis Problem Encountered and Solution

During the development of the VRAEI app, several challenges were encountered. One of the main issues occurred during the transfer of the source cache. When attempting to run the app after transferring the source files, an error message would appear, preventing smooth operation. This disrupted testing and slowed down the development process.

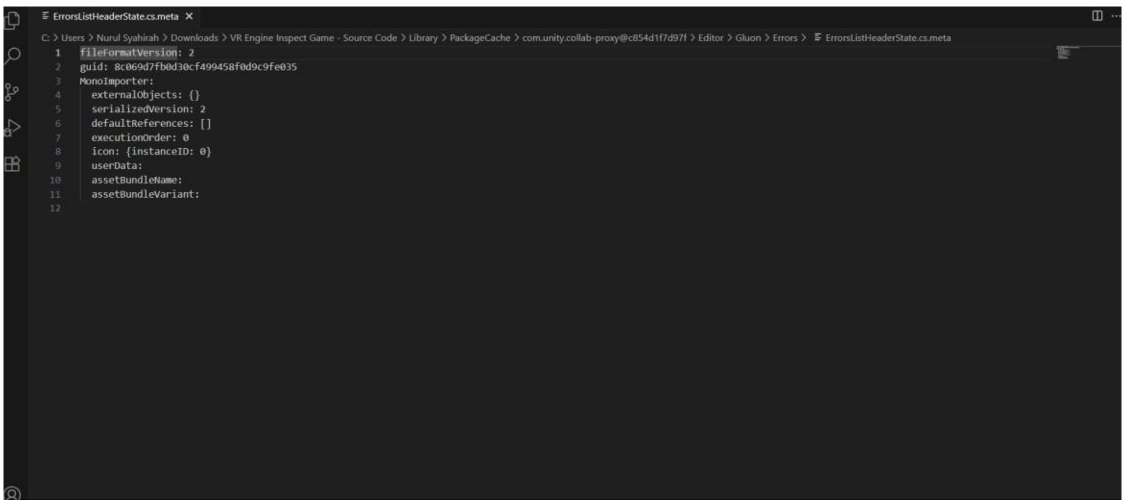


Figure 4.4 : source code error

To overcome this, the development team implemented a systematic troubleshooting approach. The source files were carefully re-verified for integrity, and proper cache management procedures were applied to ensure that all necessary assets were correctly loaded into Unity. Additionally, temporary data and outdated cache were cleared before running the app to prevent conflicts. These steps successfully resolved the error, allowing the app to operate smoothly without interrupting the user experience.

This experience highlighted the importance of proper cache handling and source management in VR applications, especially when dealing with large 3D models and interactive assets imported from platforms like Sketchfab.

4.3 POST-SURVEY QUESTIONNAIRE

A post-survey was conducted among 21 semester 5 students who had completed the VR Aircraft Exterior Engine Inspection simulation. The objective of this survey was to evaluate the usability, interaction smoothness, and the system performance of the VR.

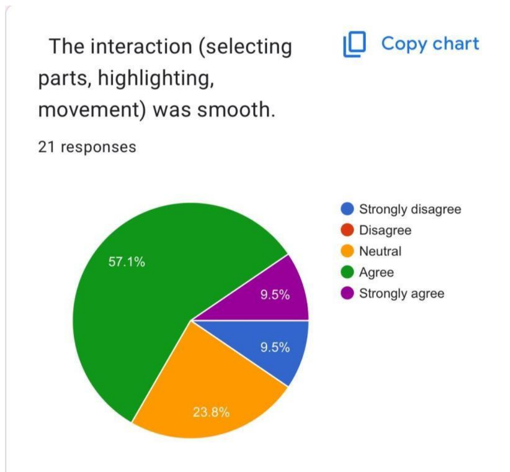


Figure 4.5: Post Survey Response 1

For interaction performance, 57.1% of students agreed and 9.5% strongly agreed that the interaction was smooth. A total pf 23.8% were neutral, while 9.5% strongly disagreed.

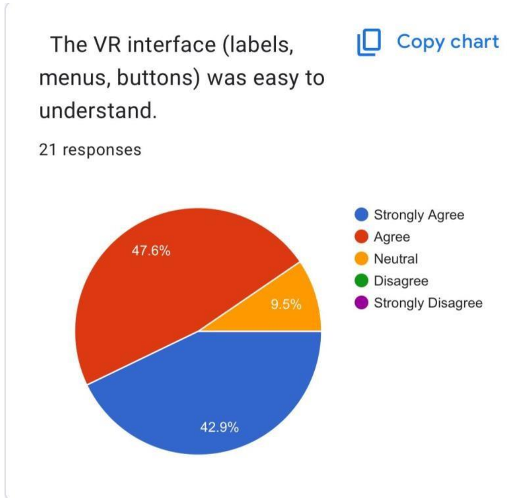


Figure 4.6: Post-Survey Response 2

Based on the responses, 42.9% students strongly agreed and 47.6% agreed that the VR interface was easy to understand, only 9.5% of students remained neutral, while no students disagreed with the clarity of the interface.

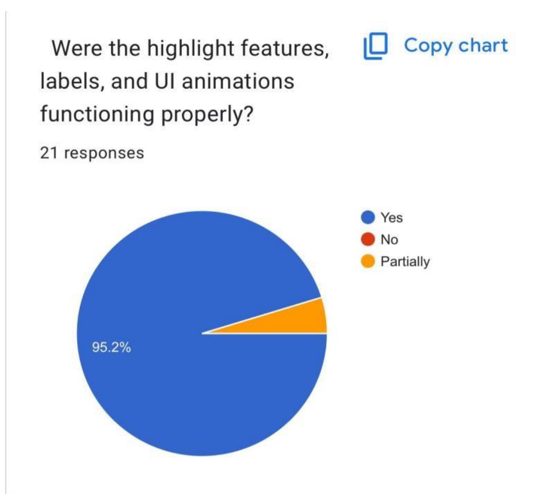


Figure 4.7: Post Survey Response 3

Based on the response, 95.2% reported that the highlight features, labels, and UI animations functioning properly. While 4.8% indicated that these feature worked partially, and none of the participants reported complete malfunction.

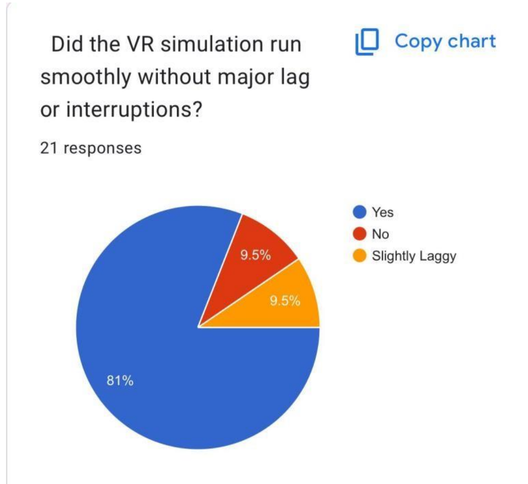


Figure 4.8:Post-Survey Response 4

Regarding system performance, 81% of students reported that the VR simulation ran smoothly without major lag or interruotions. Only 9.5% experienced slight lag, and another 9.5% reported noticeable interruptions.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 GENERAL ACHIEVEMENT OF THE PROJECT

The VR Aircraft Engine External Inspection system successfully meets its goal of creating a realistic and effective training tool for students to learn about engine components and inspection procedures. Traditionally, students rely on diagrams, theory, or limited access to real engines, which can make learning difficult due to safety concerns or limited visibility of small parts.

With this VR system, students can explore the PT6A engine in a fully interactive 3D environment. They can rotate, zoom, and examine the engine from all angles, helping them understand how components relate to each other and improving their practical learning.

The system also helps students remember what they learn. In **Explore Mode**, they can study each part, read descriptions, and interact with key components like the air intake, gearbox, and fuel control unit multiple times. In **Assessment Mode**, students answer questions based on the engine parts. If they make a mistake, the system immediately shows the correct part and explains it again. This combination of exploration and testing makes learning easier and more effective than traditional classroom methods.

5.1.1 Specific Achievement of Project Objectives

5.1.1.1 Product Structure

The main objective of the VRAEI app is to provide aviation students with a digital tool that enhances their understanding of aircraft engine external components and inspection procedures. To achieve this, we identified common challenges faced by students such as limited access to real engines and difficulty visualizing complex parts and developed VRAEI with a user-friendly interface. All learning materials and interactive inspection features are easily accessible from the home screen, allowing students to navigate the app smoothly.

5.1.1.2 Accessories and Finishing

The VRAEI app offers a clean, organized, and immersive interface designed to improve the learning experience. Features like clearly labeled buttons, smooth animations, highlight effects, and logically sequenced content ensure that students can explore the PT6A engine effectively. The dark-themed background and intuitive layout make it easy to focus on the engine components while maintaining a realistic and professional VR environment.

5.2 Contribution or Impact of The Product

VRAEI has made a meaningful impact on aviation students by providing an interactive and immersive way to learn about engine inspections. It helps students gain essential knowledge, develop spatial awareness, and improve their confidence before performing real inspections. The app reduces reliance on physical engines, which may be limited or inaccessible, and supports modern, technology-based learning. By offering repeated practice in a safe virtual environment, VRAEI helps bridge the gap between theoretical knowledge and practical understanding, preparing students for the digitalized aviation industry.

5.3 Improvement And Suggestion For Future Studies

5.3.1 Product Mechanism

One way to improve VRAEI is by adding more inspection modules for different engine types or additional external components. Each new module should include Explore Mode, Step-by-Step Inspection, Quick Notes, Checklist, and Assessment Quiz features. This will allow students to practice a wider range of inspections and gain deeper understanding of various engine systems.

5.3.2 Software / Programming

Currently, VRAEI requires an internet connection to function fully, which can limit accessibility in offline situations. Future development should focus on enabling offline functionality, allowing students to use the app anytime, anywhere without disruption.

5.3.3 Accessories and Finishing

To make the app even more advanced, an AI-based assistant could be added. This feature would help users navigate the app, locate specific components, or access learning materials quickly and efficiently, further enhancing the user experience.

REFERENCES

[1] J. N. Bailenson, *Experience on Demand: What Virtual Reality Is, How It Works, and What It Can Do*. New York, NY: W. W. Norton & Company, 2018.

[2] Aviation Safety Foundation, "The importance of safety in aircraft composite repair training," *Aviation Safety Review*, vol. 14, no. 2, pp. 22–34, 2018, doi: 10.1234/asf.2018.005.

[3] S. Das, "Beyond text: Using infographics to simplify complex concepts," *eLearning Industry*, Feb. 17, 2025. Available: https://elearningindustry.com/beyond-text-using-infographics-to-simplify-complex-concepts

[4] L. Freina and M. Ott, "A literature review on immersive virtual reality in education: State of the art and perspectives," *eLearning & Software for Education*, vol. 1, pp. 133–141, 2015.

[5] M. Zhou, D. Brown, and Y. Zhang, "Virtual reality-based training in aviation maintenance: Enhancing spatial cognition and procedural knowledge," *Journal of Aviation Technology and Engineering*, vol. 10, no. 2, pp. 45–58, 2021, doi: 10.7771/jate.2021.1010.

[6] Unity Technologies, "Unity real-time development platform." Available: https://unity.com/

[7] Sketchfab, "3D content platform for publishing and discovering 3D models." Available: https://sketchfab.com/

[8] Malaysia Airports Holdings Berhad, "Malaysia's aviation soars with 9.1% surge in number of operating airlines," *Malaysia Airports Holdings Berhad*, Jan. 31, 2024. Available: https://www.malaysiaairports.com.my/media-centre/news/malaysias-aviation-soars-91-surge-number-operating-airlines

[9] Á. Gómez-Cambronero, I. Miralles, A. Tonda, and I. Remolar, "Immersive virtual-reality system for aircraft maintenance education: A case study," *Applied Sciences*, vol. 13, no. 8, p. 5043, 2023, doi: 10.3390/app13085043.

[10] T. H. Nguyen, J. Tan, S. Tan, and V. Luu, "Development and implementation of virtual reality in higher education for aviation: A case study," *Journal of Aerospace Society Malaysia*, vol. 2, no. 2, pp. 22–29, 2024. Available: https://www.aerosmalaysia.my/aeros_journal/index.php/journal/article/view/32

[11] "Using virtual reality in Aircraft Maintenance Technician (AMT) education to supplement hangar training," *International Journal of Engineering Education*, vol. 27, no. 4, pp. 778–788, 2011. Available: https://www.ijee.ie/articles/Vol27-4/11_ijee2465ns.pdf

[12] J. L. Smith, “Effective training methods for inspection and safety in aviation,” *Journal of Aircraft Maintenance*, vol. 10, no. 3, pp. 56–68, 2019, doi: 10.1016/j.jam.2019.06.004.

[13] *The Edge Malaysia*, “Malaysian aviation sector to see 4% growth in 2024, boosted by fleet expansion and resurgence of tourism, says MIDF,” Mar. 18, 2025. Available: https://theedgemalaysia.com/node/695309

[14] World Aviation Safety, “Online learning for real-world applications in aircraft repair,” 2020. Available: https://www.worldaviationsafety.org/online-learning

APPENDIX A: DECLARATION OF TASK SEGREGATION

SUB-CHAPTERS	DESCRIPTION
AHMAD FAHMI BIN AHMAD FAEIZ	
1.1	Background of study
1.2	Problem Statement
1.3	Project Aims And Objectives
1.3.1	General Project Aims And Objectives
1.3.1.1	Product Structure
1.3.1.2	Product Mechanism
1.3.1.3	Software / Programming
1.3.1.4	Accessories & Finishing
1.4	Scope Of Project
1.4.1	General Project scopes
1.4.2	Specific Individual Scopes
1.4.2.1	Application structure

1.4.2.2	Application Mechanism
1.4.2.3	Software programming
1.4.2.4	Accessories & finishing
1.5	Project Impact
3.1	Product Briefing & risk assessment
3.1.1	Utilization of Polytechnic's facilities
3.3.1	Overall flow chart
3.4.1	Questionaire survey
3.4.3.1	Function tree
3.4.3.2	Morphological matrix
3.4.3.3	Proposed Design Concept 1
3.4.3.4	Proposed Design Concept 2
3.4.3.5	Proposed Design Concept 3
3.4.3.6	Proposed Design Concept 4
3.4.3.7	Proposed Final Concept
3.4.4.1	PUGH Matrix
3.4.4.2	Summary On PUGH Matrices
3.5	Conceptual Design Of The Proposed Product
3.7	List Of Material & Expected Expenditures
NUR NATASHA BINTI SALLEH	
1.3.2.3	Specific Individual Project Objective: Software / Programming
1.4.2.3	Specific Individual Scope: Software / Programming
2.2.3	App Development

2.3.1	Review of Related Products – Product B (Learning App Software)
3.4.2	Pareto Diagram
3.4.4	Evaluation & Selection of Conceptual Design (Functionality)
3.3.1	Overall Flow Chart
3.8	Product Features & Functionalities (System Operation)
4.1.2.3	Specific Part Features: Software / Programming
4.1.4.3	Operation of Specific Part: Software / Programming
5.1.2.2	Specific Achievement of Project Objectives: Software / Programming
5.3.3	Improvement and Suggestion: Software / Programming
FELINA EFFA ANAK KEBIN	
1.3.2.2	Specific Individual Project Objective: Product Mechanism
1.4.2.2	Specific Individual Scope: Product Mechanism
2.2.2	Product Mechanism
3.4	Design Engineering Tools
3.4.3	Design Conception (Function Tree, Morphological Matrix)
3.4.4.1	Pugh Matrix
3.5	Conceptual Design of Proposed Product (Mechanism)
4.1.2.2	Specific Part Features: Product Functions
4.1.4.2	Operation of Specific Parts: Product Functions

5.1.2.2	Specific Achievement of Project Objectives: Product Mechanism
5.3.1	Improvement and Suggestion: Product Mechanism

APPENDIX B: SUMMARY OF SIMILARITY REPORT (TURNITIN)

VRAEI

ORIGINALITY REPORT

8%	4%	1%	7%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to Jabatan Pendidikan Politeknik Dan Kolej Komuniti Student Paper	4%
2	Submitted to RMIT University Student Paper	<1%
3	e-2020.creative-construction-conference.com Internet Source	<1%
4	Submitted to Singapore Institute of Technology Student Paper	<1%
5	Submitted to Hong Kong University of Science and Technology Student Paper	<1%
6	ir.uitm.edu.my Internet Source	<1%
7	umpir.ump.edu.my Internet Source	<1%
8	5dok.net Internet Source	<1%

9	Submitted to Universiti Tun Abdul Razak Student Paper	<1 %
10	Submitted to Concordia University Student Paper	<1 %
11	Submitted to The Independent Institute of Education (IIE) Student Paper	<1 %
12	www.aerosmalaysia.my Internet Source	<1 %
13	www.coursehero.com Internet Source	<1 %
14	Arthur Dela Pena. "Digital learning platforms in aircraft maintenance technology: Evaluating the effectiveness of gamified learning approaches", Research in Learning Technology, 2025 Publication	<1 %
15	Submitted to Cranfield University Student Paper	<1 %
16	warwick.ac.uk Internet Source	<1 %
17	Submitted to De La Salle University - Manila Student Paper	<1 %
18	Submitted to University of Western Ontario	<1 %

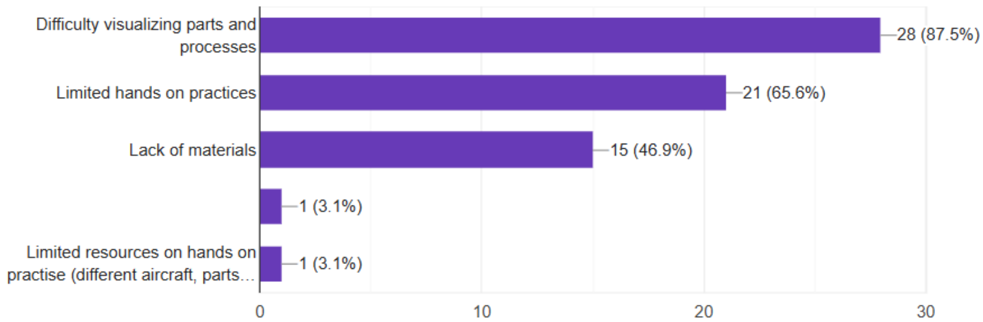
19	www.ijee.ie Internet Source	<1%
20	Igor Kabashkin. "Digital-Twin-Based Ecosystem for Aviation Maintenance Training", Information, 2025 Publication	<1%
21	researchprofiles.herts.ac.uk Internet Source	<1%
22	Submitted to Universiti Sains Malaysia Student Paper	<1%
23	link.springer.com Internet Source	<1%
24	Rezaei Ghaleh, Marzieh. "Evaluating the Effectiveness of Virtual Reality on Attitudes, Perceived Knowledge, Trust, and Behavioral Intentions Toward Potable Recycled Water Consumption.", Arizona State University Publication	<1%

Exclude quotes Off
Exclude bibliography Off
Exclude matches Off

APPENDIX C: PRE-SURVEY FORM

What specific challenges do you face when learning?

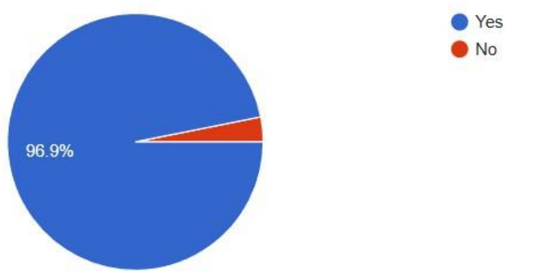
32 responses



VR Aircraft Engine Inspection as Interactive Simulator

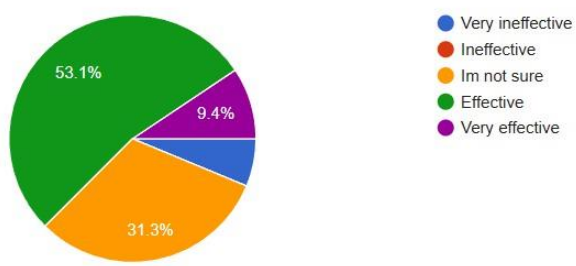
Do you think simulation based learning can enhance your understanding of aircraft maintenance concepts?

32 responses



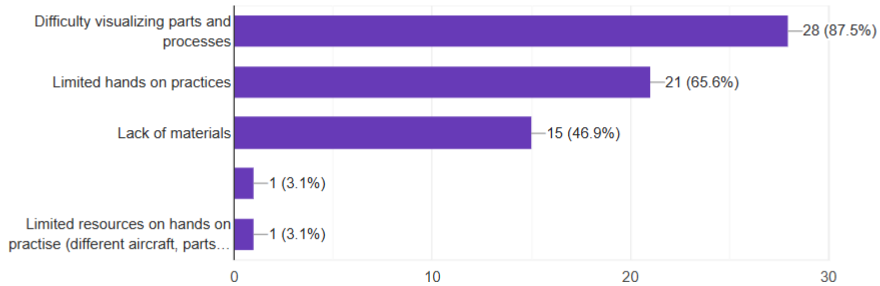
How effective do you find traditional learning methods for aircraft maintenance?

32 responses



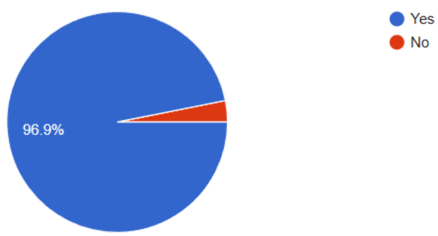
What specific challenges do you face when learning? Copy chart

32 responses

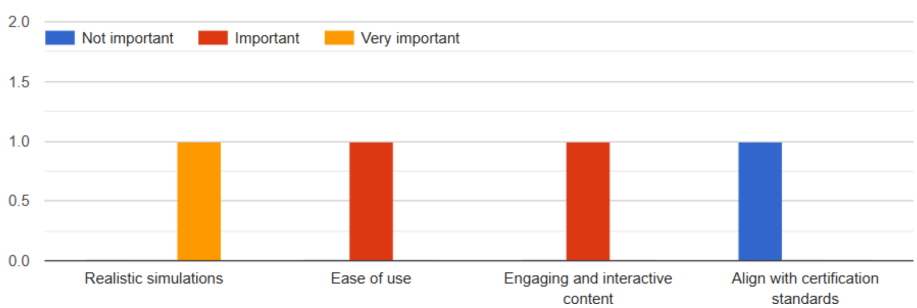


Would you be interested in using VR or similar platforms for learning technical skills like aircraft maintenance? Copy chart

32 responses



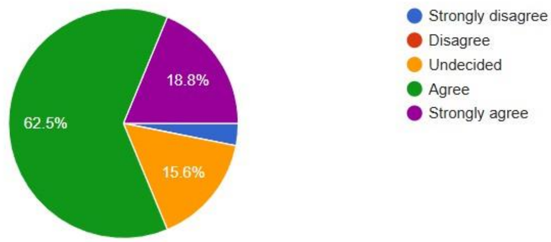
How important are the following aspects in a simulation based learning tool? Copy chart



Do you think VR has the potential to teach technical skills effectively?

Copy chart

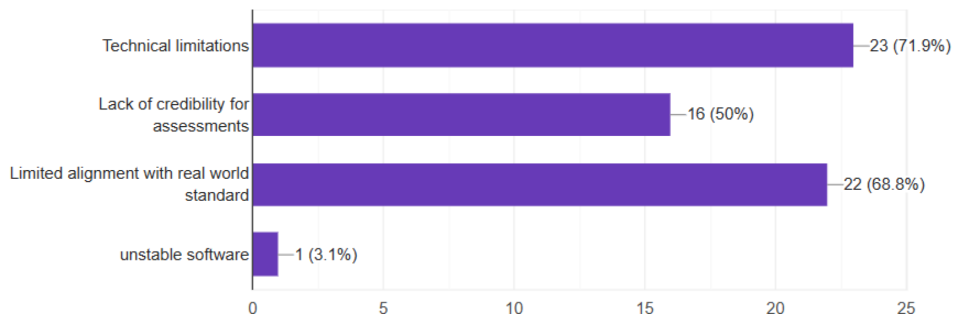
32 responses



What challenges do you anticipate in using VR as learning tools?

Copy chart

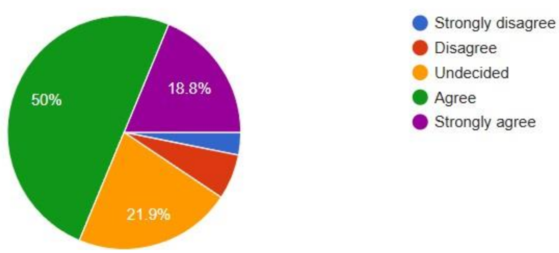
32 responses



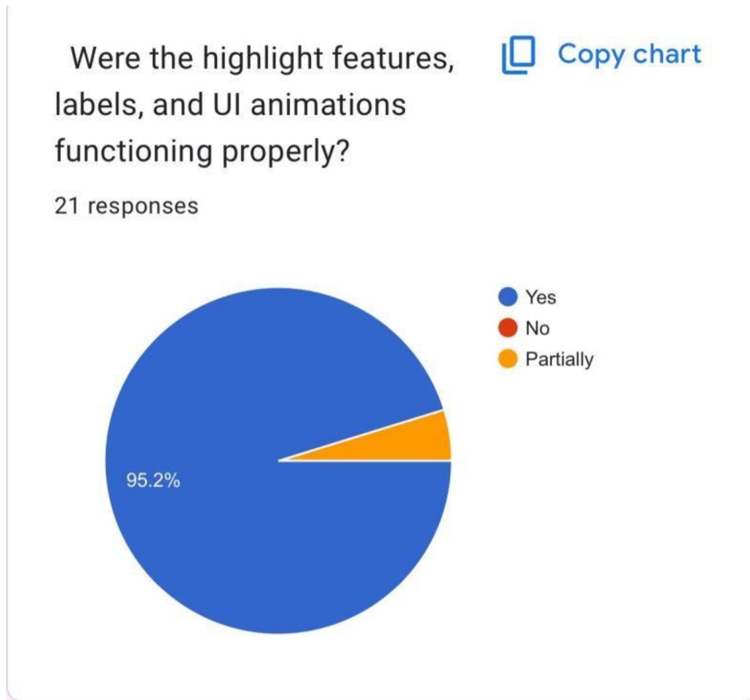
Do you think trainee/students would take VR based learning seriously?

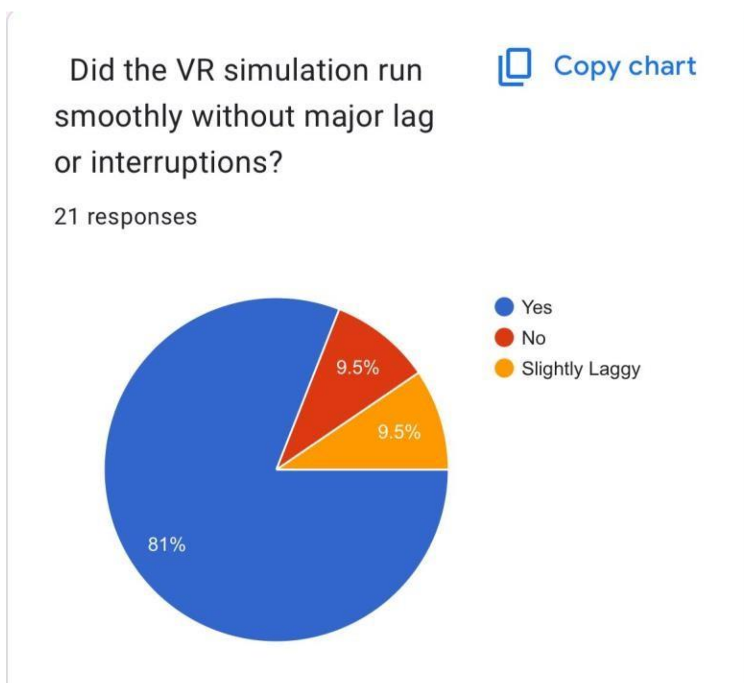
Copy chart

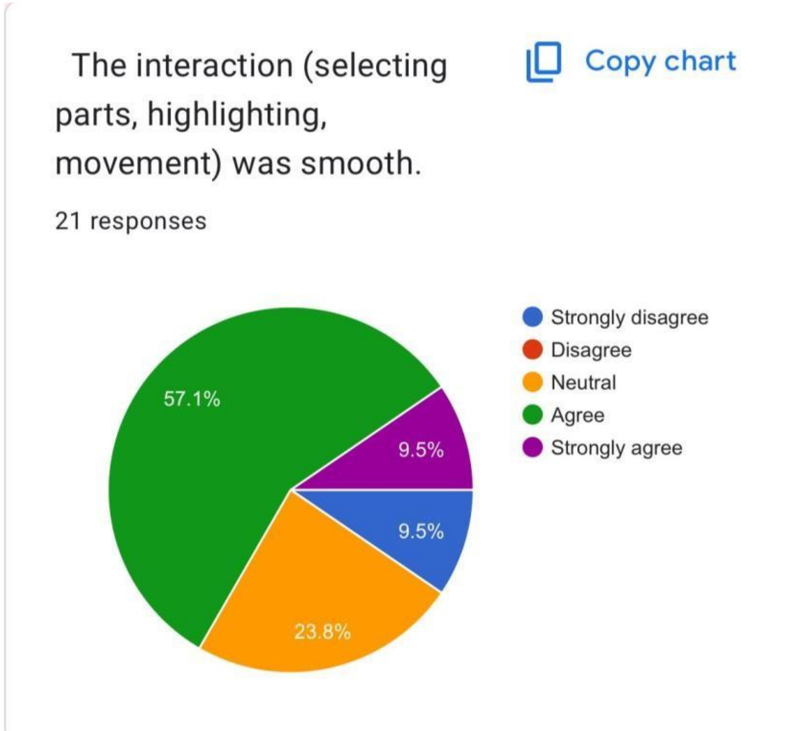
32 responses

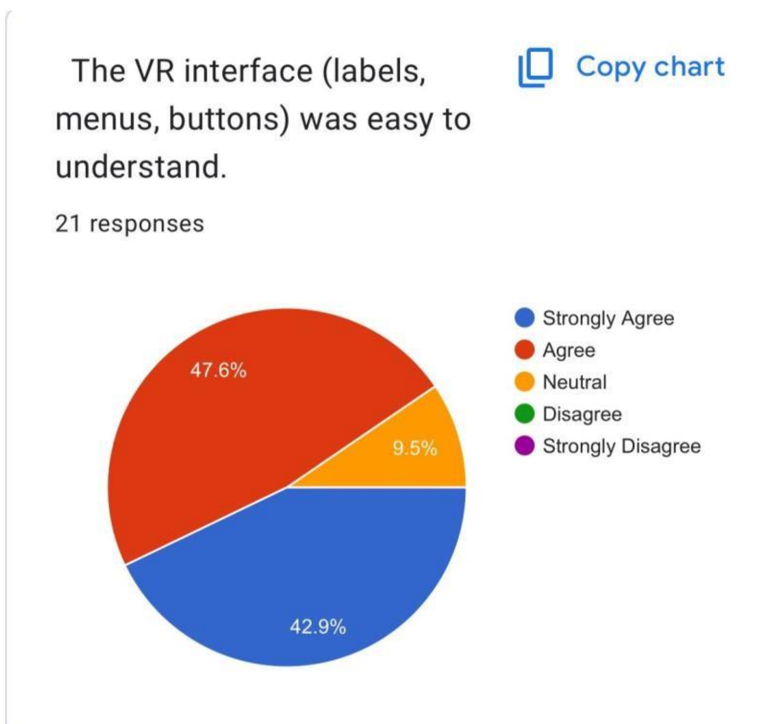


APPENDIX D: POST-SURVEY FORM









APPENDIX E: BOEING 737-400 SRM

Airworthiness Division

Civil Aviation Authority

Civil Aircraft Inspection Procedures

Part II - Aircraft

Published by:
HIMALAYAN BOOKS

Distributed by:
THE ENGLISH BOOK STORE
The Aviation People

17-L, Connaught Circus, New Delhi - 110 001 (India)

5.4 When dismantling radial engines, guard plates should always be fitted as each cylinder is removed. The cylinder containing the master connecting-rod should be removed last to avoid collapse of the connecting-rod assembly. This prevents such faults as:

(a) An oil scraper ring springing out of a cylinder and locking the whole assembly.

(b) The crankshaft balance weights fouling the skirts of the pistons.

(c) The articulating rods damaging the crankcase cylinder sockets.

NOTE: If only the master cylinder is being removed, the master rod should be positioned at Top Dead Centre (TDC) before removing the cylinder and the crankshaft and rod should not be moved again until the cylinder has been replaced.

5.5 When unbolting crankshaft and connecting-rod bearing caps, a check should be made to ensure that they are correctly numbered and precautions should be taken to mark the actual positions of bearing shells in case they are to be used again. At this stage the torque loading of the cap nuts should be checked by first slackening them off and then torque-loading them back to positions that give the same split pin hole alignment. Where the torque required to do this is less than that specified by the engine manufacturer, stretch of the bolt or stud is indicated. After this check, dismantling should proceed with every precaution being taken to avoid damaging the shaft, rods or bearing shells.

6 INSPECTION BEFORE CLEANING All components and parts should be inspected before cleaning, otherwise useful evidence of defects and the behaviour of the engine whilst in service may be removed. Defects of an unusual nature should be reported to the manufacturer and to the CAA.

6.1 Brown or black patches on cylinder walls and piston skirts often indicate piston "blow-by." This is caused by combustion gases leaking past worn piston rings, over-wide piston ring gaps or gaps which are all in alignment.

6.2 Where valve seat inserts are provided, looseness or displacement of the seats is often more readily detected before the cylinder head is cleaned.

6.3 Scores in cylinder walls, on gudgeon pins, shaft journals, crank pins and valve stems can often be traced to poor oil filtration. Gritty substances in the oil become embedded in the softer metal of the pistons and bearings and score the harder material. Evidence of the presence of harmful solids is often found in the oily deposits found inside the hollow crank pins.

6.4 Many small parts such as piston rings, circlips, locking washers, split pins, gaskets and jointing washers are renewed when an engine is overhauled, but, before they are discarded, they may yield evidence regarding the functioning of the particular assemblies with which they were associated.

7 CLEANING Only cleaning agents suitable to the particular materials of the parts to be cleaned should be used. Care is necessary to ensure that no dimensional changes or deterioration of surface finish is caused by cleaning.

7.1 The most satisfactory method of removing oil and grease from most engine parts is trichloroethylene degreasing (Leaflet **BL/6-8**). However, the temperature of the degreasing plant may cause disturbance of shrink-fits, so, unless a keeper can be fitted to prevent this, components incorporating shrink-fitted parts should be cleaned by some other method.

9 CRACK DETECTION To avoid unnecessary work, crack detection tests should be made immediately after cleaning. Whilst each engine component should be inspected for cracks by visual examination, it is nearly always necessary to use a non-destructive aid to ensure that small fatigue cracks are not missed. Information on the various non-destructive flaw detection methods is given in Leaflets **BL/8-1** to **BL/8-8.** This paragraph gives general guidance on the application of crack detection and other processes to the inspection of engine parts, but, since these parts are of widely-differing shapes and materials, the selection of the most suitable crack test is not always easy. On occasions it is advisable to apply two or three different methods to prove that an individual part is free from defects.

9.1 **Crankcases and other Castings.** For castings of aluminium alloy the oil and chalk method of testing (Leaflet **BL/8-1**) is recommended, whilst the fluorescent penetrant method (Leaflet **BL/8-7**) is usually more satisfactory for magnesium alloys. The fluorescent penetrant method will generally give better definition of porosity in castings made from either group of alloys and should therefore be used on all items where detection of porosity is important. For certain components, e.g., cylinder heads and induction elbows, a pressure test may also be specified. The test pressure and method of application should be obtained from the appropriate manufacturer's manuals.

9.2 **Pistons.** Both the oil and chalk method and the fluorescent penetrant method of crack detection are suitable for most pistons but some manufacturers recommend an etch inspection for the skirt and reinforcing ribs. Inspection by etching should be made as follows:

9.2.1 The etching solution should be prepared in the following proportions:

Sulphuric acid	200 c.c.
Sodium Fluoride	28·35g (1 oz)
Water	1800 c.c.

A solution of 50% nitric acid in water is also required to remove the black smut deposited by the etching solution.

NOTE: Whenever dilute acid solutions have to be prepared, the acid should always be added to the water and not vice-versa.

9.2.2 The piston to be tested should be free from grease and carbon. To expand any tiny cracks it should first be immersed in hot water, after which it should be placed with crown downwards and the etching solution should be poured into it. The solution should then be swabbed over the whole of the inside surface of the piston and over the lower rim of the skirt. About four minutes should be allowed for the etching to proceed.

9.2.3 After four minutes the piston should be drained and immediately afterwards should be washed thoroughly in clean running water. The nitric acid solution should then be swabbed over the treated area, after which the washing should be repeated. Finally the piston should be immersed in methylated spirit and dried with warm air.

9.2.4 The piston should then be inspected for cracks, pitting and signs of corrosion, using a powerful magnifying lens or a binocular microscope. Particular attention should be paid to the reinforcement ribs, gudgeon pin bores and piston ring grooves.