POLITEKNIK BANTING SELANGOR

VIRTUAL TURBINE ENGINE: IMMERSIVE EXPLORATION OF ENGINE PART

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DEPARTMENT OF AIRCRAFT MAINTENANCE

SESSION I 2024/2025

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

SUPERVISOR

MR MOHAMMAD SUFFIAN BIN ABDUL LATIB

REPORT ENDORSEMENT

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CERTIFICATION OF PROJECT ORIGINALITY & OWNERSHIP

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"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.

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ABSTRACT

In the present day, where learners are best able to learn through meaningful and entertaining activities, it is not surprising to note that in reality, the incorporation of advanced technologies in the classroom has become an integral part of the innovative ways of teaching. This is most noticeable in the creation of more interactive educational products such as Virtual Turbine Engine: Immersive Exploration of Engine Part, which uses the Unity platform to deliver engaging learning experiences combined with state-of-the-art VR. Such tools provide a great opportunity to further facilitate students' comprehension of complex topics such as gas turbine engines by integrating basic principles with hands-on virtual applications.

Although much research has been done on the use technology in enhancing the learning process, the role of VR in the teaching and learning of aviation and engineering concepts is still limited. Reviews of earlier studies conducted on educational technology often focus on the benefits of the interactive devices used in the studies but fail to examine in detail the effect of VR interaction on both conventional and digital modes of education. This study aims at bridging such a knowledge gap by exploring the impacts of VR integration on the teaching and learning of gas turbine engines.

The Virtual Turbine Engine: Immersive Exploration of Engine Part represents the engagement opportunities for students to explore the complicated parts of the gas turbine engines in a virtual environment. We present herein a quantitative evaluation of the effectiveness of the tool regarding its usability, the influence of the approach on students' knowledge about the engine systems, and satisfaction of users. Findings reveal that there is huge potential for educational aids using VR in aviation and engineering studies. The Virtual Turbine Engine: Immersive Exploration of Engine Part, by enabling an immersive and self-directed learning experience, can bridge the gap between theory and practice, making technical education more accessible and engaging and thus more effective.

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GTE	Gas Turbine Engine
VR	Virtual Reality
VTE	Virtual Turbine Engine: Immersive Exploration of Engine Part

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Figure 1.1: VR of Gas Turbine Engine Assembly

Gas turbine engine refer to any internal combustion engine that uses gas as a working fluid to turn a turbine. The term is also traditionally used to describe a complete internal combustion engine consisting of at least a compressor, a combustion chamber, and a turbine. It can use a generator, pump or propeller, or in the case of a clean jet then develop thrust by accelerating the turbine exhaust flow through a nozzle. A large amount of power can be produced by an engine that is much smaller and lighter than a piston combustion engine for the same power. Reciprocating engines rely on the up-down motion of the piston, which must then be reversed by the crankshaft into a rotary motion, while the gas turbine supplies power directly to the rotary shaft.

Most gas turbines operate with an open cycle, where air is taken from the atmosphere, compressed in a centrifugal or axial flow compressor and then brought into the combustion chamber. Here, fuel is added and burned at essentially constant pressure with little air. The additional compressed air, which is passed around the combustion chamber and then mixed with the very hot combustion gases, is necessary to keep the burner inlet temperature low enough to keep the turbine running continuously. When the device has to produce shaft power, the products of combustion expand to atmospheric pressure in the turbine. Most of the power of the turbine is used to move the compressor but only the rest is available to power the shaft operation of a generator, pump or other device. In a jet engine, the turbine is designed to produce just enough power to drive the compressor and auxiliaries. The gas stream then leaves the turbine at intermediate pressure and is directed through a nozzle to generate thrust.

In order to ensure reliability and performance of GTE, regular inspection and maintenance must be taken correctly by certified staff. However, for the persons who currently participate in maintenance training will overcome difficulty to identify the structure of these engines as they consist of numerous interconnected parts and various components such as compressors, turbines, combustion chambers, rotors, stators and fuel systems.

The concept of virtual reality (VR) has a long and storied history, gradually shifting from an experimental and unique concept to a practical and versatile tool with numerous applications in the present-day society across diverse fields such as education, entertainment, medicine, and engineering. Of those applications, aerospace and mechanical engineering especially in uses of VR in design and maintenance of turbine engines have the most possible results. This paper aims at establishing the role of VR in the analysis and utilization of the turbine engines with special attention to the advantages that goes alone with the recent progress and future enhancements.

Back to the issue mentioned in Paragraph 3 earlier, nowadays there already have VR technology application in the aviation sector and gas turbine engine training. The purpose of creating this virtual system was to improve the level of interaction with advanced machines and the acquisition of new skills. This immersive technology works in real time and places the learner in a simulated virtual world of an expert with accurate hand tracking and excellent detail. These elements help increase the efficiency and speed of training more than traditional learning techniques can provide.

1.2 PROBLEM STATEMENT

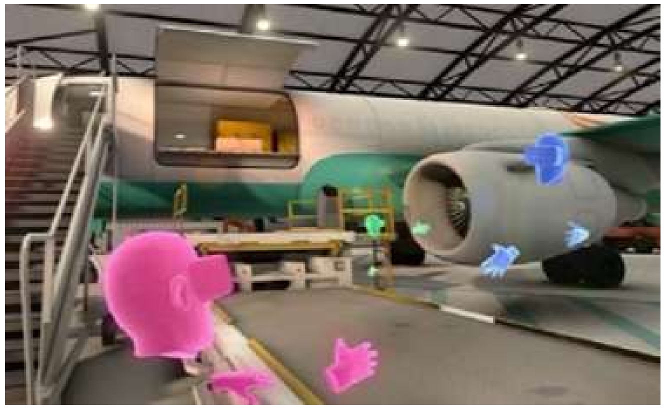


Figure 1.2: VR in Hangar and Aircraft Surroundings

Polytechnic Banting Selangor as Part 147 maintenance training organisation also requires this VR technology as their additional learning methods. The current approach to teaching and learning of gas turbine engines at Polytechnic Banting Selangor has some main challenges that include as mentioned, the teaching and learning tools include scarce resources such as a few actual engines to work on, meaning long hours to complete the modules. Furthermore, there are no adequately safe areas with appropriate facilities for students to rehearse or work that is important for confidence-building. This is mainly attributed to shortage of manpower which affects teaching and classroom learning processes, as well as the inadequate use of VR technologies among the students, thus reducing their exposure to advanced forms of learning that can improve their skills and knowledge through innovative methods such as VR technologies.

1.3 PROJECT OBJECTIVE

1.3.1 General Project Objective

The project objective of the "Virtual Turbine Engine: Immersive Exploration of Engine Part" is to develop virtual reality for engine maintenance. After that, facilitate the design and verification of assembly operations for aircraft turbine engines through the use of Virtual Reality (VR) models. This project aims to provide realistic practice in a safe and regulated environment. Also, it is designed to give early exposure of training in a fraction of the time, and with no travel needed.

1.3.2 Specific Individual Project Objective

1.3.2.1 Product Structure

- Design and build an enhanced generation of virtual reality (VR) software for use in a 3D experience of the product architecture of a gas turbine engine.
- Provide a detailed and modern view of the engine components' configuration and their mutual interaction, which will be useful for both student and working engineer.
- It is aimed at developing a useful and comprehensive VR learning tool that improves visualization, while imitating reality, consolidating practical knowledge, and performing the role of a transition between theoretical knowledge and actual practice.
- The project will expand on current gaps that exist in conventional learning approaches and enhance general academic performance within the area of gas turbine engineering

1.3.2.2 Product Mechanisms

- To develop virtual reality for gas turbine engine training purposes that is easily accessible to everyone.

- To engage students by facilitating the design and verification of assembly operations for aircraft turbine engines through the use of Virtual Reality (VR) models.

- To provide realistic practice in a safe and controlled environment so that it can be used over a long period of time by anyone.

- To provide initial exposure training in a fraction of the time, and without travel required so that it can be learned at any time.

1.3.2.3 Software / Programming

- To build each selected engine part by learning the easy way to design in virtual reality.
- To use software that offers various facilities needed to design such as being able to access various types of virtual reality for free without payment.
- To software can be downloaded easily on existing devices that follow the appropriate specifications to connect VR headset with gaming laptop

1.3.2.4 Accessories & Finishing

Accessories:

- **VR Controllers:** Navigate and interact with the virtual world naturally.
- **Tracking Enhancements:** External stations or body trackers for precise movement, especially in full-body VR.
- **Stability Solutions:** Weighted vests or anti-slip mats improve balance and presence in VR, especially for active experiences.
- **Sanitary Covers:** Maintain hygiene and comfort for multiple users or long VR sessions.

Finishing:

- **VR Inserts & Facial Interfaces:** Enhance comfort, hygiene, and reduce fogging during extended VR use.
- **Haptic Feedback Gear:** VR gloves or vests add a sense of touch, letting you feel virtual objects and actions.
- **Spatial Audio Solutions:** Head-tracked headphones create a dynamic and location-specific soundscape in VR.
- **VR Locomotion Platforms:** Treadmills or omnidirectional platforms allow for natural walking or running in VR.

1.4 PURPOSE OF PROJECT

This purpose of project, targets the design of a VR-based platform to improve teaching and learning related to the study of gas turbine engines within the Polytechnic Banting Selangor. In this context, the system will try to resolve some of the major problems that have been identified, including a shortage of turbine engines, a shortage of appropriate training facilities that are safe and well-equipped, a shortage of teaching staff and a limited application of sophisticated technologies for learning. The project provides students with realistic VR gas turbine engine models in an immersive and innovative way, allowing them to investigate the engine in depth in a completely safe and controlled environment. The platform will reduce reliance on physical resources, shorten the time taken to train, and facilitate early exposure to complex processes, thereby enhancing the confidence level, ability, and preparedness of students for real-life applications in the aviation sector.

1.5 SCOPE OF PROJECT

1.5.1 General Project Scope

This project will create an efficient way and be supporting student to learn about turbine engine. The VR can provide students with immersive interaction by enabling users to interact with the VR models in a realistic and intuitive way and step-by-step guidance on disassembling and assembling turbine engines. Other than that, the project will also be a user-friendly interface for navigating the VR environment and accessing training modules.

1.5.2 Specific Individual Scope

1.5.2.1 Product Structure

The goal of this project will be to create a VR-based application for the exploration of the gas turbine engines, which will help the students to better understand its parts. They are developing realistic 3D recreations of the engine and its separate elements; adding features whereby users can rotate, move around, or break down and assemble the engine; and including additional data and learning resources. It will contain a simple user input interface, a tutorial and an assessment part for user convenience in learning the application. Performance analysis and testing will also be performed in order to enhance the usability of the application. By applying VR in this project, it also solves several problems associated with the conventional study methods including limited engine access, lack of safe practice areas, insufficient instructors and teachers to teach, and inadequate exploitation of VR technologies, all leading to creation of an effective and enhanced learning device for students of Polytechnic Banting Selangor.

1.5.2.2 Product Mechanism

The development of VTE software contributes to the ability for users to interact with and control engine parts just like they would in real life. Users are better able to comprehend the functionality and structure of the engine based on this virtual experience. For instance, user can rotate, move, and disassemble engine parts inside the virtual reality environment to learn more about how each part functions and linking with the others. By offering a realistic and simple method to investigate the mechanics of turbine engines, this immersive technique improves learning.

1.5.2.3 Software/Programming

Create virtual reality (VR) models of turbine engines using 3D modelling software that creates accurate and realistic digital versions of the engines. This process involves building each engine component in virtual space, ensuring that all parts are accurately represented. Detailed models allow users to explore and interact with the engine in VR and see how each part fits together and works, just like in real life. This realistic visualization helps users better understand the structure and operation of turbine engines.

1.5.2.4 Accessories & Finishing

The success of VR simulations for gas turbine engines hinges on high-fidelity 3D models. These models should be highly detailed and accurate representations of real engines, including all components, textures, and lighting effects. To further enhance realism and user immersion, VR simulations should incorporate realistic soundscapes associated with gas turbine engines, such as the whine of the turbines, the hiss of hydraulics, and the clanging of tools. Finally, procedural guidance can be programmed into VR simulations to guide users through the inspection process step-by-step. This guidance can include highlighting specific components for inspection, providing checklists, and offering instructions on using virtual tools.

CHAPTER 2

LITERATURE REVIEW

2.1 GENERAL LITERATURE REVIEW

2.1.1 Overview of the Gas Turbine Engine Industry

The gas turbine engine is often called a jet engine and has a great history that goes back to the early 1900s. Although, its conceptual origins can be traced back to the late 19th century. The first practical gas turbine engine was developed by Sir Frank Whittle in Great Britain and Hans von Ohain in Germany in 1930s. Their inventive efforts culminated in the first operational jet aircraft in the 1940s have bringing in the jet age. After World War II, gas turbine engines developed rapidly and were widely used especially in aviation. The introduction of commercial aircraft such as the de Havilland Comet and the Boeing 707 in the 1950s revolutionized air travel offering unprecedented speed and efficiency. Meanwhile, the military is integrating gas turbines into fighter jets, bombers, helicopters and naval ships. In the second half of the 20th century, innovations in materials science, aerodynamics, and thermodynamics significantly improved the efficiency, reliability, and effectiveness of gas turbine engines, contributing to the growth of commercial aviation and the development of more efficient and versatile military aircraft.

In the 21st century, the gas turbine engine industry continues to evolve with increasing demands for fuel efficiency, environmental sustainability and technological advancement. The primary trend is to focus on the development of engines that consume less fuel and emit less emissions due to regulatory requirements and market demand for greener technologies. Examples of these efforts include innovations such as replaceable turbofans and high-bypass engines. In addition, the industry is exploring hybrid electric and all-electric engines. Although these technologies are still in the development phase, they have the potential to significantly reduce the carbon footprint of the aviation industry. Digitization is another major trend and the integration of technologies such as predictive maintenance, real-time data analytics and digital twins is becoming commonplace. These advances enable advanced monitoring of engine performance, failure prediction and optimization of maintenance schedules, reducing operating costs and downtime. The Asia-Pacific region is also seeing significant growth in the commercial and military aviation sectors, fueled by a growing middle-class population, increasing demand for air travel and significant investment in defense capabilities.

The gas turbine engine industry is dominated by a number of key players, each contributing to constant innovation and development. General Electric Aviation (GE) is a leading manufacturer of commercial and military jet engines, and the LEAP engine incorporates advanced materials and technologies that improve fuel economy and reduce emissions. Known for its Trent engine families, Rolls-Royce is a major player in the wide-body aircraft market and invests in hybrid electric and sustainable aviation technologies. Pratt and Whitney, a subsidiary of Raytheon Technologies, is known for its geared turbine engines (GTFs), which offer significant fuel efficiency and noise reduction. Safran Aircraft Engines plays a vital role in the development of advanced jet engines such as LEAP in collaboration with GE through the CFM International joint venture and is involved in research in sustainable fuels and electricity. Specializing in smaller gas turbine engines for regional jets, business jets and helicopters, Honeywell Aerospace is also a leader in auxiliary power units (APUs) and advanced avionics. MTU Aero Engines is a key supplier and partner in many international engine programs, focusing on advanced components, maintenance and services that contribute to engine performance and longevity.

2.1.2 Trends in Virtual Reality (VR) Applications in Education

Development of VR Technology has evolved significantly since its conceptual beginnings in the mid-20 a century. Early VR development was characterised by rudimentary immersive environments, such as Morton Heilig's Sensorama in the 1960s, which offered a multi-sensory experience. The term "virtual reality" was coined in the 1980s by Jaron Lanier, whose company VPL Research developed the first VR hardware and software. In the 1990s, more sophisticated VR systems were introduced, mostly for military and flight simulations, although these early systems were expensive and limited by low resolution and high latency. The turn of the 21st century saw significant advances in computing power, graphics processing and display technology that made VR easier and more effective. The introduction of affordable VR headsets such as the Oculus Rift in 2012 was an important milestone that democratized VR technology and sparked interest in various fields, including education and training.

Adoption of VR in technical education has accelerated in recent years due to its ability to provide an immersive, interactive and risk-free learning environment. VR allows trainees to interact with complex machines and systems in a controlled virtual space, improving understanding and retention of technical concepts. This is particularly useful in industries such as aerospace, medicine and engineering, where hands-on experience is essential but often limited by cost, safety or logistical constraints. In aviation, VR is widely used for pilot training, maintenance simulations and air traffic control exercises. Trainees can practice emergency procedures, handle equipment and room orientation without the risks associated with actual training. Similarly, VR allows surgeons in medicine to perform virtual operations, improving their skills before real operations. Engineering education benefits from VR through virtual labs where students can conduct experiments and interact with virtual models of complex systems such as gas turbine engines.

Several case studies illustrate the effectiveness of VR in engineering education. For example, the Institute for Creative Technologies at the University of Southern California has developed a VR training program for the US military that allows soldiers to practice maintenance and repair of various machines. The program's immersive environment significantly improved soldiers' understanding, and performance compared to traditional training methods. Another notable case is the VR training program that Airbus implemented for its engineers. This program includes virtual simulations of aircraft assembly processes that allow engineers to practice and develop their skills in a virtual environment before applying them to real-world scenarios. The use of VR reduced training and errors, which increased the efficiency and safety of aircraft production. In addition, the Center for Advanced Manufacturing Research at the University of Sheffield has integrated VR into its engineering curriculum, allowing students to interact with digital twins of complex manufacturing systems. This hands-on experience with virtual models improves their understanding of complex design concepts and prepares them for real-world applications.

2.1.3 Virtual Reality in Aviation

Figure 2.1: Person Try on VR with Hand Controller

For turbine engine mechanics and technicians, VR platforms could provide immersive simulations of engine components, systems, and maintenance procedures. Trainees could interact with virtual engines, disassemble and reassemble components, and troubleshoot potential issues, all within a realistic digital environment. This approach eliminates the need for physical engine access, reducing costs associated with maintaining engine replicas and minimizing downtime for real aircraft.

Moreover, VR simulations can be tailored to specific turbine engine models, allowing trainees to familiarize themselves with various engine types without the need for separate physical training setups. This flexibility enhances training efficiency and adaptability, particularly in environments where multiple engine models are in use.

Figure 2.2: Some peoples Try on VR in a Safe Enlosed Room

In terms of cabin crew training, understanding turbine engine operations and potential emergencies related to engine failure is crucial. VR simulations can replicate scenarios such as engine malfunctions or fires, providing cabin crew with hands-on experience in responding to these situations. By immersing crew members in realistic simulations, VR training instills confidence and preparedness, ensuring swift and effective responses during actual emergencies.

Furthermore, ground crew training can benefit from VR technology in turbine engine maintenance and repair. Virtual simulations can guide technicians through complex engine repair procedures, allowing experts to remotely provide guidance and assistance. This remote collaboration capability, similar to the Fountx headset by TAE Aerospace, streamlines the training process and ensures consistent and accurate maintenance practices across different locations.

Overall, integrating VR technology into turbine engine training offers numerous advantages, including cost savings, enhanced efficiency, and improved safety. By providing immersive and realistic learning experiences, VR simulations empower trainees to acquire essential skills and knowledge while minimizing risks associated with traditional training methods. As the aviation industry continues to embrace technological innovations, VR stands poised to revolutionize turbine engine training, ensuring the proficiency and readiness of turbine engine personnel worldwide.

2.2 SPECIFIC LITERATURE REVIEW

2.2.1 Product Structure

2.2.1.1 Applications of VR in Engineering Education

The use of VR technology also has a special significance in learning since it allows better perception of space, interactivity, and attraction (Akçayır & Akçayır, 2017). Research has suggested that the use of VR in education yields positive effects on the students' understanding of concepts across the different disciplines (Dede, 2009), which emphasizes the viability of using VR in the training of turbine engines.

In the context of engineering education, VR has been used effectively to recreate realistic situations, promote practical applications and provide deeper understanding of the instituted concepts (De Paolis & Mongelli, 2018). In using VR, students can have an actual feel of the functionalities of turbine engines or parts, diagnose problems, and carry out training and tests on the engines without the risk of affecting the real engine.

2.2.1.2 Virtual Assembly of an Airplane Turbine Engine

At the front of the engine, the fan is installed with a function to suck and compress great volume of air. A major part of this air merely circulate around.
A large fan is more efficient in terms of thrust and noise, but there are problems, namely its weight and the torque it creates (Rolls-Royce plc, 2007).

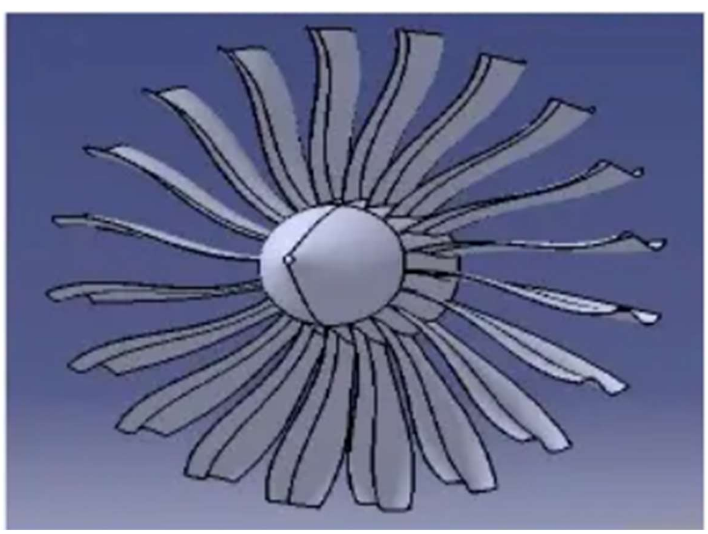


Figure 2.3: Fan System

The compressor delivers high pressure air to the combustor. The more the air is compressed the more power can be extracted inside the turbines. Some of this compressed air is used for secondary tasks such as cooling hot components.

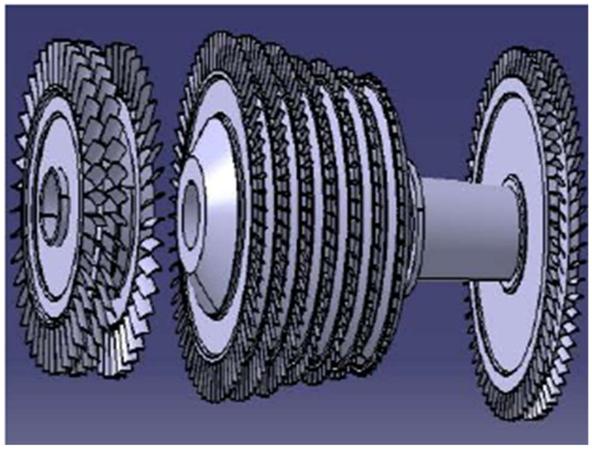


Figure 2.4: Compressor Assembly Parts.

The combustor burns fuel with air fed from the compressor. The combustor must generate a large amount of energy in order to drive the turbines. The challenge is to generate the maximum amount of the heat from the smallest amount of fuel with the lowest emissions.

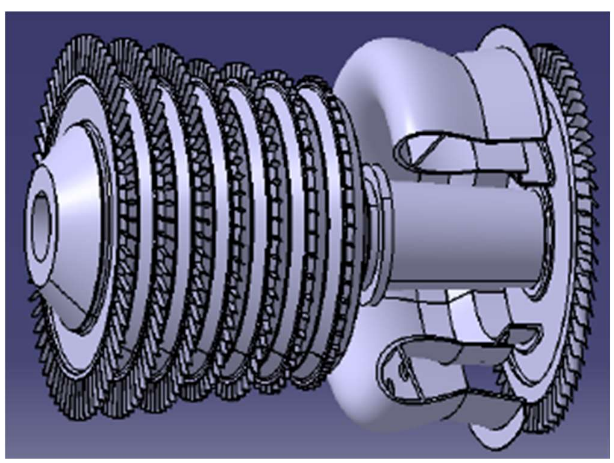


Figure 2.5: Combustor with Compressor.

Turbine is the component which gets energy from hot gases supplied by the combustor. This power is used to drive such as the fan as well as the compressor. Thus, the primary duty for the turbine blades is to work under a highly adverse condition, including high temperature and large centrifugal forces (Rolls-Royce plc, 2007).

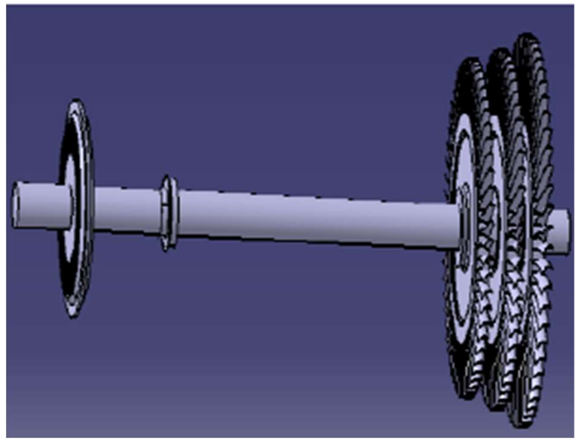


Figure 2.6: Turbine Assembly Part

2.2.2 Product Mechanism

2.2.2.1 Types of Tracking and Input Devices

Tracking and input devices are critical components of VR systems that facilitate user interaction in the virtual world environment. There are a number of tracking and feeding devices, each with their own advantages and limitations. Internal tracking uses cameras and sensors mounted on VR headsets to track users' movements, eliminating the need for external sensors and increasing mobility and ease of installation. This method is used by popular VR headsets such as Oculus Quest 2 and Microsoft HoloLens, making them ideal for unconnected experiences and portable VR solutions. In contrast, external monitoring is based on external sensors placed in the environment, which are known for high accuracy and low latency and are suitable for applications that require accurate monitoring, such as complex technical simulations.

Systems like the HTC Vive and the original Oculus Rift use external tracking, although they involve a more complex setup and limit users to the area covered by the sensor. Hybrid tracking combines both in-out and in-out methods, improving the accuracy and flexibility of advanced VR systems. VR input devices include handheld controllers, gloves, and motion sensors that allow the user to interact with the virtual environment. Hand controllers, such as those used with the Oculus Rift provide buttons, triggers, and joysticks for navigation and interaction. The data gloves provide a more immersive experience by capturing hands and fingers, allowing precise manipulation of virtual objects. Motion sensors like the Leap Motion controller track hand movements without physical controls, providing a more natural method of interaction.

2.2.2.2 Types of Processing Units

Processing units in VR systems are responsible for rendering the virtual environment, tracking the user's movements and real-time processing of inputs. There are two main types of processing units used in VR systems which is central processing units (CPUs) and graphics processing units (GPUs). Processors handle general computing tasks and are crucial in managing the overall performance of the system. High-performance processors with multiple cores and high clock speeds are essential for VR systems for complex simulations and real-time computing. On the other hand, GPUs are specialized processors designed to perform the intensive graphics calculations required to render virtual environments. Modern VR systems rely heavily on powerful GPUs to produce high-resolution graphics and consistent frame rates, and NVIDIA and AMD are the leading manufacturers of GPUs for VR applications. The choice of GPU has a significant impact on the visual quality and performance of a VR experience

2.2.2.2.1 Selection of GPUs for VR systems

Selection of GPUs for VR systems is very important to ensure a high quality and immersive user experience. There are several factors to consider when choosing a GPU for VR, including performance, compatibility, and price. The GPU must be able to render high-resolution images with a fast refresh rate to avoid motion sickness and ensure a smooth experience. VR systems typically require a refresh rate of at least 90 Hz and a resolution of at least 1080 x 1200 per eye. Advanced GPUs such as NVIDIA GeForce RTX 3080 and AMD Radeon RX 6800 XT are suitable for demanding VR applications, offering excellent performance and advanced features such as ray tracing and DLSS (Deep Learning Super Sampling). Compatibility is also crucial, as the GPU must support the necessary ports and connectors, such as HDMI or DisplayPort, and meet the specific requirements of the VR software. High-end GPUs offer the best performance. But they are premium. Mid-range GPUs like the NVIDIA GeForce RTX 3060 or AMD Radeon RX 6700 XT offer a good balance between cost and performance, making them suitable for most VR applications.

2.2.3 Software / Programming

2.2.3.1 Unity for Virtual Reality

Unity is a powerful and versatile platform that has become synonymous with virtual reality (VR) development, offering a comprehensive suite of tools and features tailored to creating immersive VR experiences. With its intuitive interface and robust development environment, Unity provides developers with the flexibility to design, prototype, and deploy VR applications across various platforms, including Oculus Rift, HTC Vive, and PlayStation VR. Its extensive support for VR hardware and peripherals enables seamless integration of motion controllers, hand tracking devices, and haptic feedback systems, allowing developers to craft immersive and interactive experiences that engage users on multiple sensory levels

Additionally, Unity's rich ecosystem of assets, plugins, and community resources further enhances the VR development process, providing developers with access to a wealth of pre-built components, scripts, and libraries to accelerate development and optimize performance. From gaming and entertainment to training, education, and beyond, Unity empowers developers to unlock the full potential of VR technology, pushing the boundaries of what's possible in virtual reality experiences.

2.2.4 Accessories & Finishing

Figure 2.7: USB-C to DisplayPort 8K

Utilizing a USB-C to DisplayPort/Mini DP/VGA adapter to connect a VR headset to a gaming laptop offers a practical and versatile solution for users seeking portability and compatibility. The compact and lightweight design of the adapter facilitates easy transport, making it ideal for users who wish to enjoy VR experiences while on the move. Its support for multiple display interfaces, including DisplayPort, Mini DP, and VGA, ensures compatibility with a wide range of VR headsets and gaming laptops, eliminating the need for multiple adapters or cables.

Moreover, the prevalence of USB-C ports in modern gaming laptops ensures seamless connectivity, while the adapter's support for 8K resolution guarantees crisp and detailed visuals, enhancing the immersive VR experience. Additionally, the use of USB-C connections provides reliable data transmission and low latency, contributing to smooth and uninterrupted VR gameplay. Overall, a USB-C to DisplayPort/Mini DP/VGA adapter offers a convenient and reliable solution for connecting a VR headset to a gaming laptop, enabling users to enjoy immersive VR experiences wherever they go.

2.3 REVIEW OF RECENT RESEARCH / RELATED PRODUCTS

2.3.1 Related Patented Products

2.3.1.1 Patent A

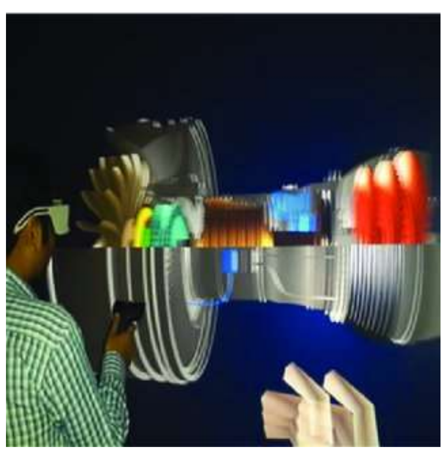


Figure 2.8: Semi-Immersive Virtual Turbine Engine

Title: Semi-Immersive Virtual Turbine Engine Simulation System

Abstract: Assembly sequences must be specified and validated to facilitate planning activities of product assembly operations. Today, virtual prototyping has experienced good growth and it is now at a maturity when the existing environments support complex and interactive interaction between designers and models through stereo vision, voices, and touch. This paper focuses on identifying the advantages of establishing and employing Virtual Reality models for the purpose of assembly process confirmation. This paper focuses on conventional assembly (CA) of an Aircraft Turbine Engine, as well as on holistic assembly (Hybrid Assembly or H. A) of the same engine. The TPS assembly parts and sequences are discussed by the use of a virtual reality design system. It also supports stereoscopic video, surround audio, and extensive and natural navigation and interaction with developed models. Important is to clarify how the assembly parts and the assembly sequence can be described in VR with a special software architecture. What is done here is that a mechanism of collision detection is used to offer the visual feedback to ascertain interference between some or all of them. The system is validation for the use of virtual prototype and for determining assembly sequences for a turbine engines. Here, the authors prove that the above-discussed developed system is rather comprehensive in terms of the VR feedback mechanisms such as visual, auditory, tactile, and force feedback systems. It is demonstrated that the system is useful and provides a proper validation of optimised assembly design, part design, and operational.

2.3.2 Recent Market Products

2.3.2.1 Product A

Virtual reality for Aircraft Engines Maintainability

No.	Market Product	Product Summary
1.		**Product Name:** Revima **Launch Date:** September 19th, 2022 MRO Asia Pacific, Singapore Absract: The VR System, called REVIMA, is used for maintainability simulation in Aeronautics. This entails the physical element as well as the software, coupled with modular integration. The necessity of returning to the issue was needed due to the situation that the company called REVIMA demanded the development of the totally new haptic system. It is used to detect hand movements and, in reaction, to give force feedback that would allow the user to feel as if they were working with a replica. The main software modules are: more specifically, it relate to image generation, collision detection and control. System integration is done by connecting two PCs through a LAN connection where the two different tasks are divided inter

		Actually, the Imagine system integration involves two PCs connected through a LAN to enable sharing of the two different tasks and information. We have utilized least graphics systems for the development of the visualization module, and we have explained this problem in detail to address the drawing frame rate that is appropriate for a simulation analysis. These consist of over two thousand different items that would take approximately two million polygons to portray the forms of the models. Various approaches have been exercised in order to address the issue of real simulation strategy in organizations. We also get hold of the various vim-based visualization algorithms which we have employed.

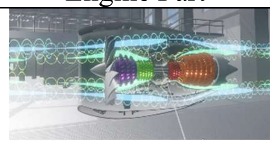
2.3.2.2 Product B

Virtual Reality Maintenance Training Software

No.	Market Product	Product Summary
1.		**Product Name:** Virtual Reality Maintenance Training Software **Launch Date:** April 2019 Rolls-Royce Corporation 2023 Abstract: The system operates by simulating the maintenance process of AE2100 engines in an immersive virtual environment, aiming to enhance student engagement and improve troubleshooting skills as stated by Rolls-Royce. It is also pointed out that the VR system will enhance efficiency and lower the expenses involved in the training process. The system enables maintainers to safely take out, inspect, and replace AE2100 engine parts without causing harm to the equipment, the engine, or risking personnel injuries. Maintainers have the flexibility to train and hone their skills at any time and in any place, allowing them to acquire practical experience without causing any disruptions to ongoing missions.

Table 2.2: Recent Market Product

2.4 COMPARISON BETWEEN RECENT RESEARCH AND CURRENT PROJECT

Product	Virtual Turbine Engine: Immersive Exploration of Engine Part	Revima	Virtual Reality Maintenance Training Software
Appearance			
Purpose	To give early exposure of training in a fraction of the time, and with no travel needed.	Used for maintainability simulation in Aeronautics	To enhance student engagement and improve troubleshooting skills as stated by Rolls-Royce.
Target	Aviation student and Industry	Aerospace Industry	Aerospace and Defense Sector
Platform	Unity	Unreal Engine	Unity
Features	Realistic cross-section, assembly and dissembly of the internal part of the engine	Immersive Training Experience	Specific and certificate focused training
Environment	In Hangar	Engine Workshop	Engine Workshop

CHAPTER 3

RESEARCH METHODOLOGY

3.1 PROJECT BRIEFING & RISK ASSESSMENT

In order to achieve the project goals, our team decided with our supervisor to bring in a consultant from an external company, Otaiz.com. To guarantee the smooth development of VR for the successful implementation of the VR turbine engine simulation. In order to streamline the development process, Unity was selected as the main platform, while Google Meet was utilized as a virtual collaboration hub. This platform facilitated the team in exploring different facets of VR simulation design, delving into the complexities of turbine engine components, and crafting a captivating, interactive learning journey. Through the use of Google Meet, our team ensured a smooth and engaging setting for exchanging ideas, receiving feedback, and collaboratively molding the vision of the simulation.

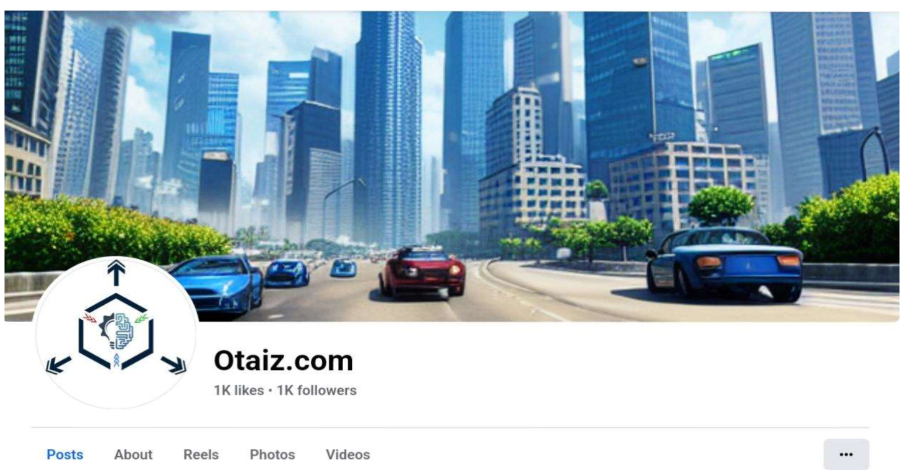


Figure 3.1: Official FB Page of Otaiz.Com

3.2 OVERALL PROJECT GANTT CHART

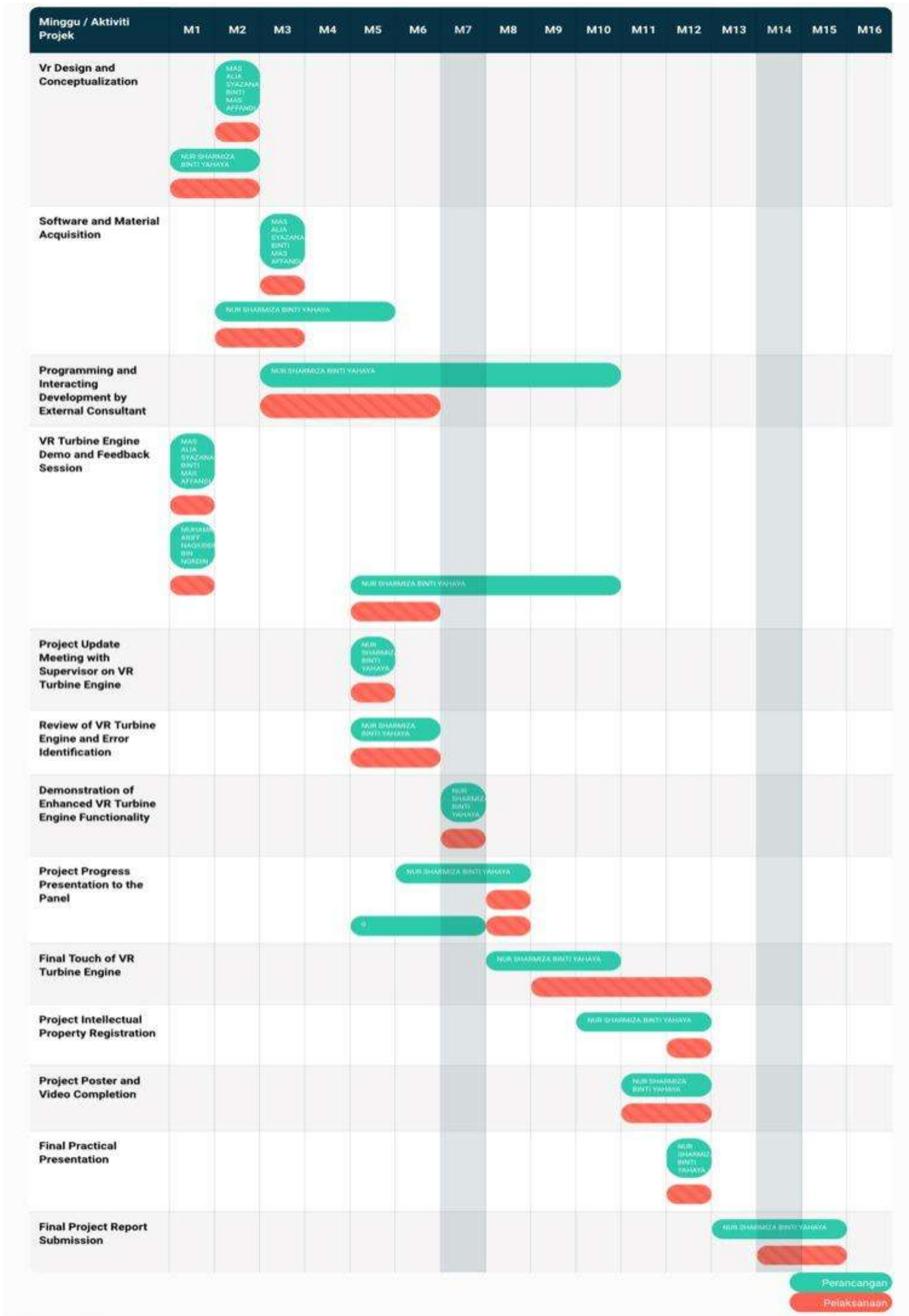


Figure 3.2: Gantt Chart

3.3 PROJECT FLOW CHART

3.3.1 Overall Project Flow Chart

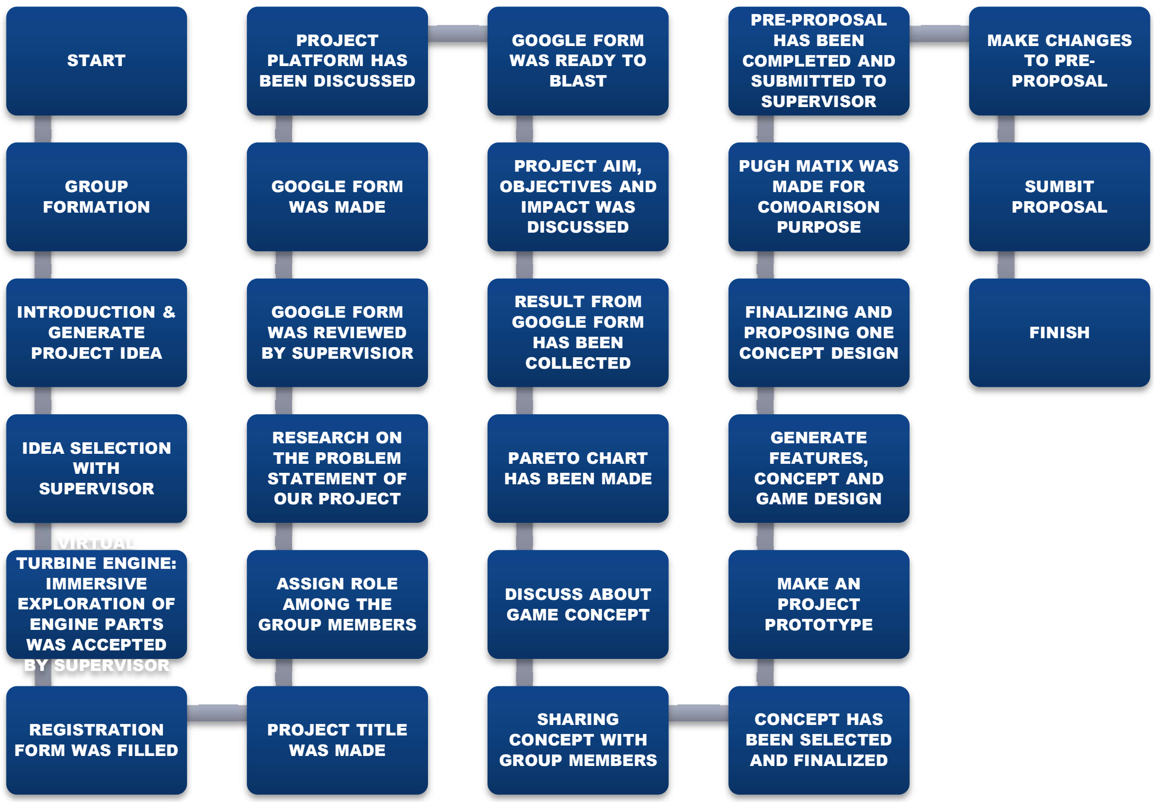


Figure 3.3: Project Flow Chart

3.3.2 Specific Project design Flow

3.3.2.1 Product Mechanism

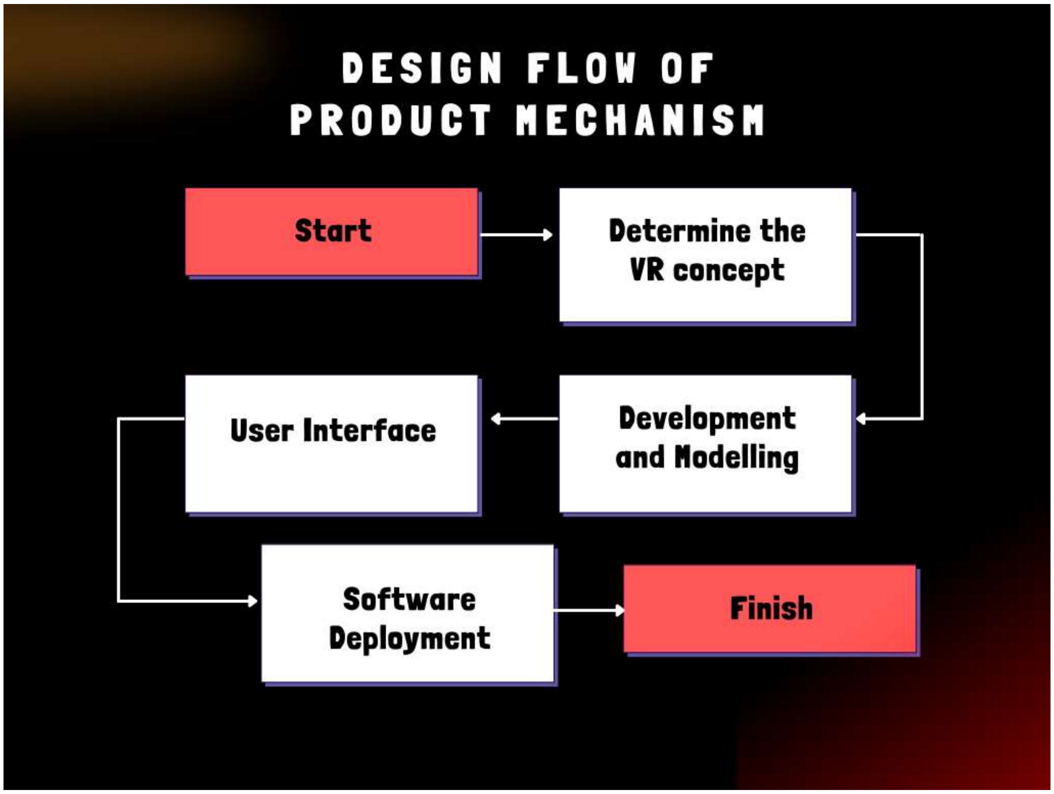


Figure 3.4: Design Flow of Product Mechanism

3.3.2.2 Software/Programming

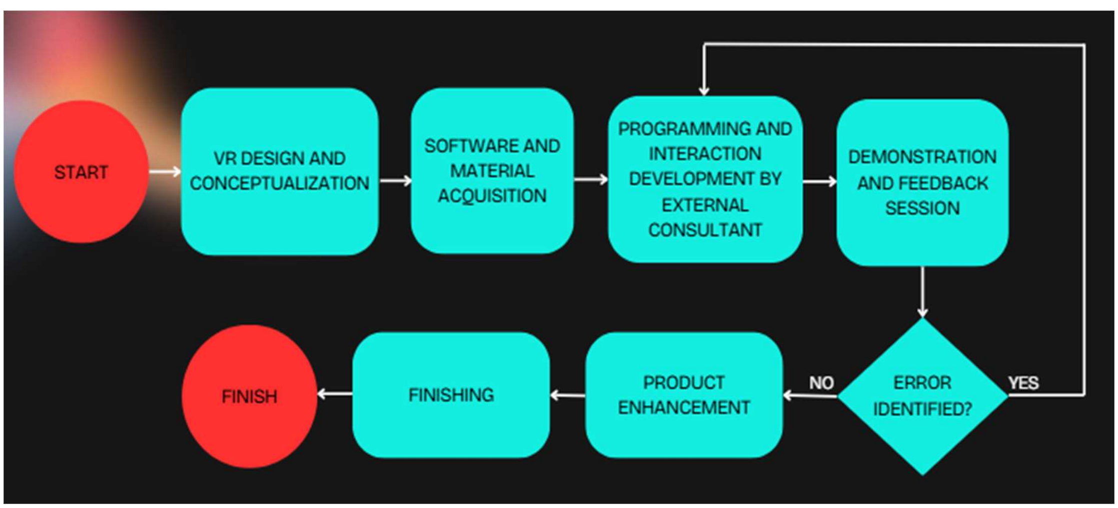


Figure 3.5: Design Flow of Software/Programming

3.4 DESIGN ENGINEERING TOOLS

3.4.1 Design Requirement Analysis

3.4.1.1 Questionnaire Survey

We did some questionnaire in order to collect information if we get support on developing the project and to know its demand from 50 respondents.

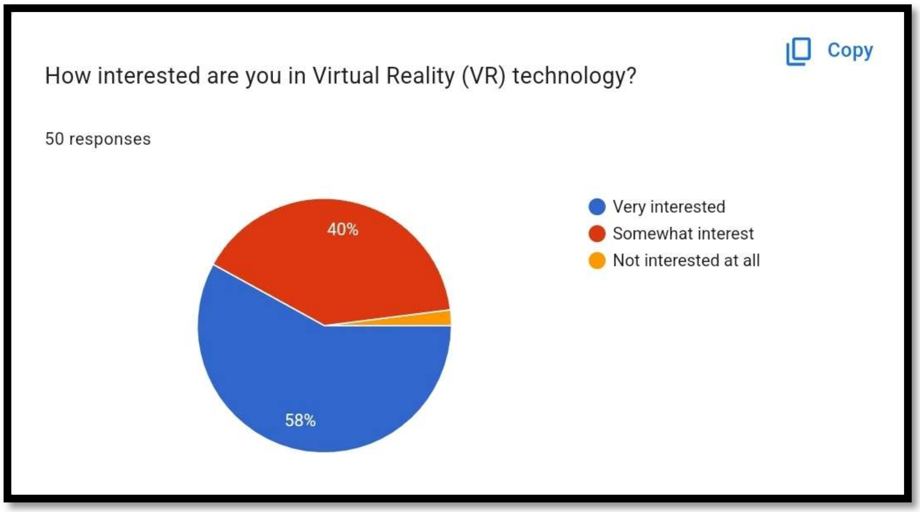


Figure 3.6: Pie Chart 1

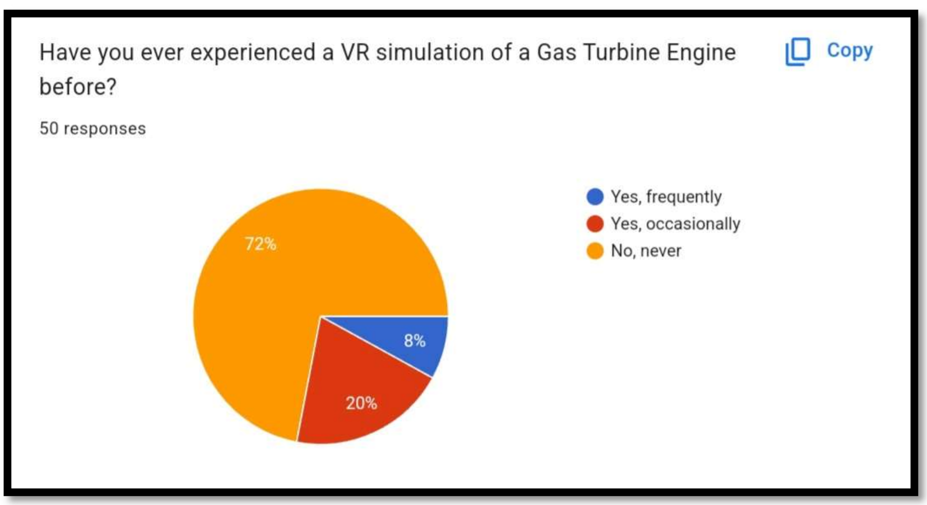


Figure 3.7: Pie Chart 2

From Figure 3.6 and Figure 3.7, we found that most of the respondents have an interest in VR technology but only a few people have ever used VR simulation related to gas turbine engines. *Figure 3.8: Pie Chart*

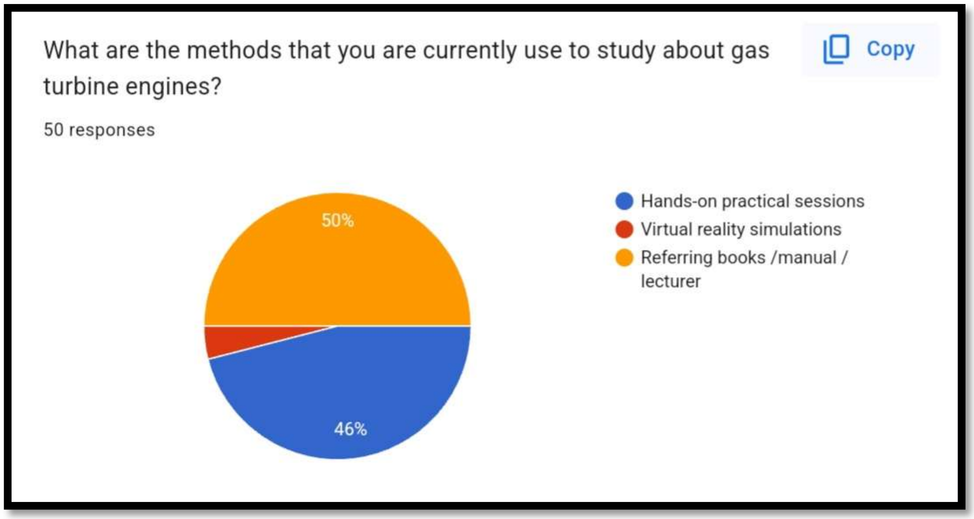


Figure 3.8: Pie Chart

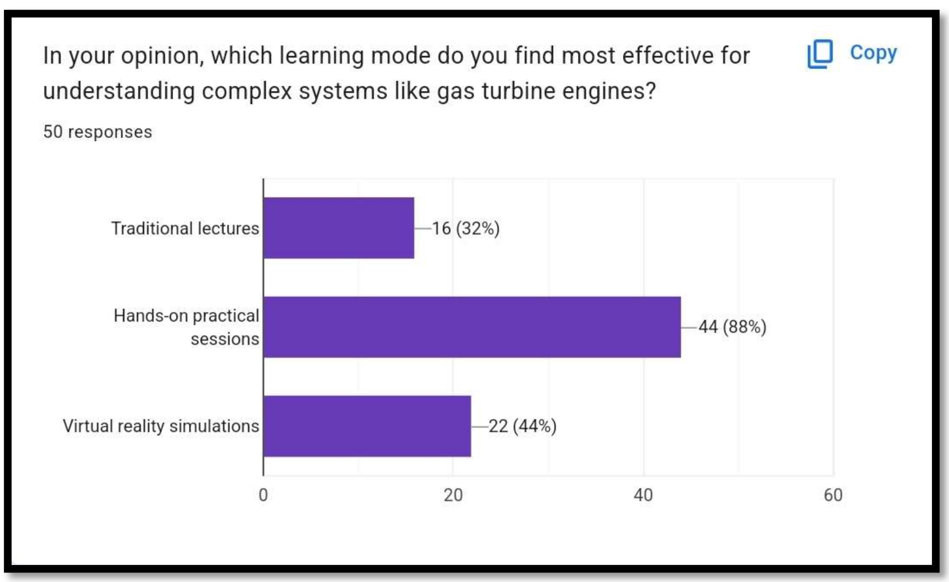


Figure 3.9: Bar Chart

From Figure 3.9, we can conclude that VR simulation was chosen as the second effective learning method out of three steps to understanding a difficult system like GTE but only 4% of them are currently using that method.

3.4.1.2 Pareto Diagram

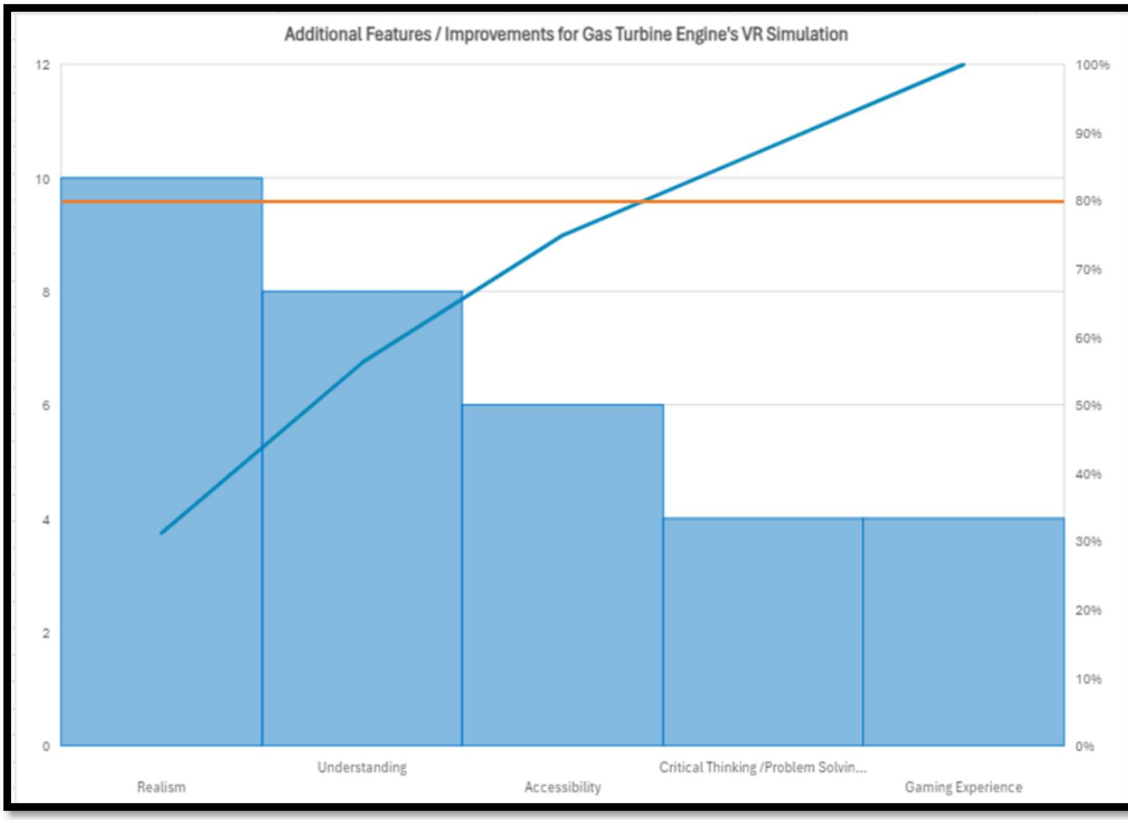


Figure 3.10: Pareto Diagram

For the excellent quality of our product development, we did ask the respondents either if any additional features needed to be included or they have any suggestions regarding how the VR simulation of GTE can be improved, based on their previous experience using VR.

After summarizing the responses, we found that mostly they ask for realism such as using hangar's environment, followed with complete explanation provided as per training manual. Also, easy accessibility like affordable pricing and helping equipments. The lowest votes were about critical thinking / problem solving skills and including gaming experiences.

3.4.2 Design Concept Generation

3.4.2.1 Function Tree

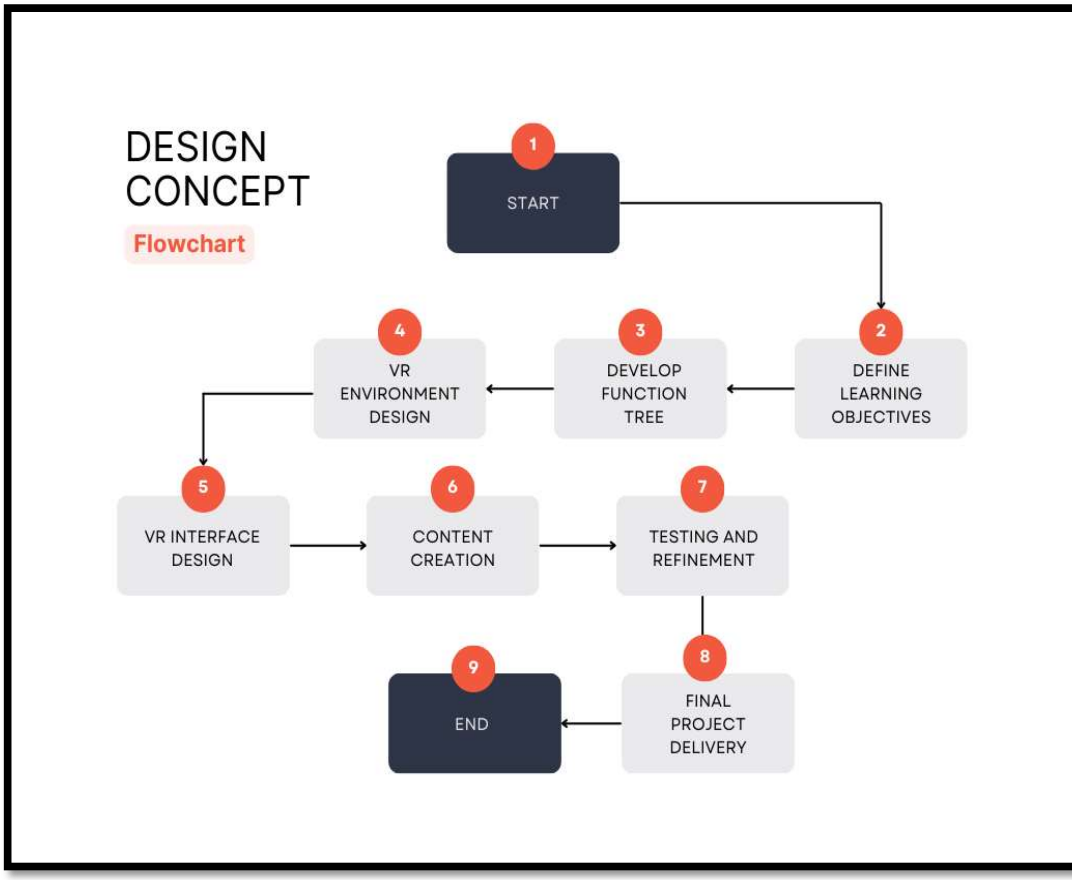


Figure 3.11: Design Concept Flowchart of Virtual Turbine Engine: Immersive Exploration of Engine Part

Based on our design concept, we decided that this is our design concept for Virtual Turbine Engine Immersive Exploration of Engine Part

3.4.2.2 Morphological Matrix

Component	IDEA 1	IDEA 2	IDEA 3	IDEA 4
Type of Virtual Reality (VR)	Oculus Rift S	Quest 2	Quest	Oculus Rift S
Assembly Parts	USB C to DisplayPort MiniDP VGA Adapter Portable TypeC 8K 60Hz Converter Thunderbolt3 laptop smartphone monitor projector	USB C to DisplayPort MiniDP VGA Adapter Portable TypeC (15cm) 4K 60Hz Converter Thunderbolt3 laptop smartphone monitor projector	UGREEN Type-C Male to DP Female Cable 8K 60Hz Nylon 10cm USB-C to DP1.4 Adapter	USB C to DisplayPort MiniDP VGA Adapter Portable TypeC 4K 60Hz Converter Thunderbolt3 laptop smartphone monitor projector
Software Architecture	Unity Hub and Oculus	Unreal Engine and Oculus	Unity Hub and Oculus	Unreal Engine and Oculus
Device Specification	Asus Tuf Gaming F15 2022 FX507Z-C4HN027W FX507Z-C4HN028W i5-12500H/512GB M.2/ RTX 3050 4GB/ 15.6" FHD 144Hz/ W11	Asus ROG Zephyrus G14 GA401I-IHE102T – Ryzen 5-4600HS |Ram 8GB | 512GB SSD | GTX 1650Ti 4GB |Laptop 14″ FHD IPS 120HZ,Windows 10 Home	Lenovo legion y520 1tb 16 ram intel i5 7th gen nvidia geforce gtx 1050 t	Fast-switch LCD 2560×1440 (1280×1440 per eye) @ 80 Hz, Integrated speakers, 6DOF inside-out tracking through 5 built-in cameras and 2nd generation Oculus Touch motion tracked controllers.

Table 3.1: Morph Matrix

3.4.2.3 Proposed Design Concept 1

FUNCTION	CONCEPT 1	JUSTIFICATION
Type of Virtual Reality (VR)	Oculus Rift S	➢ high resolution display and reduced screen-door effect ,provides crisp and detailed visuals enhancing immersion in VR environments. ➢ convenient setup ➢ includes integrated audio speakers within the headband ➢ already available
Assembly Parts	USB C to DisplayPort MiniDP VGA Adapter Portable TypeC 8K 60Hz Converter Thunderbolt3 laptop smartphone monitor projector	➢ support for 8K resolution at 60Hz, the adapter can transmit high-quality video signals, delivering crisp and clear images on compatible displays. ➢ RM27.80
Software Architecture	Unity Hub and Oculus	➢ Beginner-friendly ➢ Free to download and use
Device Specification	Asus Tuf Gaming F15 2022 FX507Z-C4HN027W FX507Z-C4HN028W i5-12500H/512GB M.2/ RTX 3050 4GB/ 15.6" FHD 144Hz/ W11	➢ Equipped with NVIDIA GeForce RTX 3050 GPU which provides solid graphics performance, capable of handling VR content and games with reasonable fidelity and frame rates. ➢ The Intel Core i5-12500H processor offers strong CPU performance, capable of handling VR applications and multitasking without significant bottlenecks.

Table 3.2: Proposed Design Concept 1

3.4.2.4 Proposed Design Concept 2

FUNCTION	CONCEPT 2	JUSTIFICATION
Type of Virtual Reality (VR)	Quest 2	➢ Wireless design. ➢ Has a high-resolution, high-refresh rate and bright display. ➢ Has huge library of dedicated games and Supports lot of PC VR games ➢ RM955.15
Assembly Parts	USB C to DisplayPort MiniDP VGA Adapter Portable TypeC (15cm) 4K 60Hz Converter Thunderbolt3 laptop smartphone monitor projector	➢ Supports 4K resolution at 60Hz refresh rate and providing high-quality visuals for a seamless viewing experiences. ➢ RM25.90
Software Architecture	Unreal Engine and Oculus	➢ Take time for beginners in learning engines's interface, scripting language (Blueprints or C++) and various subsystems like rendering, physics and AI.
Device Specification	Asus ROG Zephyrus G14 GA401I-IHE102T – Ryzen 5-4600HS |Ram 8GB | 512GB SSD | GTX 1650Ti 4GB |Laptop 14″ FHD IPS 120HZ,Windows 10 Home	➢ Equipped with an NVIDIA GeForce RTX 2060 Max-Q graphics card, which provides excellent graphics performance for VR gaming and applications. ➢ Its GPU, CPU, and RAM may not be optimal for a smooth and immersive VR experience

Table 3.3: Proposed Design Concept 2

3.4.2.5 Proposed Design Concept 3

FUNCTION	CONCEPT 3	JUSTIFICATION
Type of Virtual Reality (VR)	Quest	➢ RM2287.70
Assembly Parts	UGREEN Type-C Male to DP Female Cable 8K 60Hz Nylon 10cm USB-C to DP1.4 Adapter	➢ Support for DisplayPort 1.4 and 8K resolution at 60Hz, the cable can transmit high-quality video and audio signals, delivering crisp and clear images on compatible displays. ➢ RM50.49
Software Architecture	Unity Hub and Oculus	➢ Beginner-friendly ➢ Free to download and use
Device Specification	Lenovo legion y520 1tb 16 ram intel i5 7th gen nvidia geforce gtx 1050 t	➢ Larger storage ➢ Smooth graphic ➢ Reasonable price for gaming laptop

Table 3.4: Proposed Design Concept 3

3.4.2.6 Proposed Design Concept 4

FUNCTION	CONCEPT 4	JUSTIFICATION
Type of Virtual Reality (VR)	Oculus Rift	➢ Only meant to play PC VR games. ➢ RM1950
Assembly Parts	USB C to DisplayPort MiniDP VGA Adapter Portable TypeC 4K 60Hz Converter Thunderbolt3 laptop smartphone monitor projector	➢ Supports 4K resolution at 60Hz refresh rate and provides high-quality visuals for a seamless viewing experience. ➢ RM25.90
Software Architecture	Unreal Engine and Oculus	➢ Take time for beginners in learning engines's interface, scripting language (Blueprints or C++) and various subsystems like rendering, physics and AI.
Device Specification	Intel i5-4590 or better CPU, an Nvidia GTX 970 or AMD Radeon R9 290 or better video card, at least 8GB of RAM, an HDMI 1.3 output, three USB 3.0 ports, and one USB 2.0 port.	➢ Ease of use and lower barrier to entry. ➢ produces an immersive, crisp virtual reality experience that will continue to improve with the development of new software

Table 3.5: Proposed Design Concept 4

3.4.2.7 Accepted Vs. Discarded Solution

From all the four concepts above, we decided to choose Concept 1 as a solution rather than Concept 2,3 and 4 due to its excellent ratings regarding to the price, accessibility and realism display.

3.4.3 Evaluation & Selection of Conceptual Design

3.4.3.1 Pugh Matrix

CRITERION	FACTOR	CONCEPT 1	CONCEPT 2	CONCEPT 3	CONCEPT 4
COST	0.3	3	2	D	1
ACCESSIBILITY	0.2	3	2	A	2
UNDERSTANDING	0.2	2	3	T	3
REALISM	0.3	3	2	U	2
TOTAL SCORE	1.0	2.8	2.2	M	1.9
RANKING	-	**1**	**2**	-	**3**

Table 3.6: Pugh Matrix Concept 3 as DATUM

CRITERION	FACTOR	CONCEPT 1	CONCEPT 2	CONCEPT 3	VIRTUAL TURBINE ENGINE: IMMERSIVE EXPLORATION OF ENGINE PART	CONCEPT 4
COST	0.3	3	2	1	D	1
ACCESSIBILITY	0.2	3	2	3	A	2
UNDERSTANDING	0.2	2	3	3	T	3
REALISM	0.3	3	2	3	U	2
TOTAL SCORE	1.0	2.8	2.2	2.4	M	1.9
RANKING	-	**1**	**3**	**2**	-	**4**

Table 3.7: Pugh Matrix Virtual Turbine Engine: Immersive Exploration of Engine Part as DATUM

All concepts are rated according to for criteria: cost, accessibility, increase understanding and realism.

3.4.3.2 Conceptual Design of the Proposed Product

FUNCTION	CONCEPT 1	JUSTIFICATION
Type of Virtual Reality (VR)	Oculus Rift S	➢ high resolution display and reduced screen-door effect ,provides crisp and detailed visuals enhancing immersion in VR environments. ➢ convenient setup ➢ includes integrated audio speakers within the headband ➢ already available
Assembly Parts	USB C to DisplayPort MiniDP VGA Adapter Portable TypeC 8K 60Hz Converter Thunderbolt3 laptop smartphone monitor projector	➢ support for 8K resolution at 60Hz, the adapter can transmit high-quality video signals, delivering crisp and clear images on compatible displays. ➢ RM27.80
Software Architecture	Unity Hub and Oculus	➢ Beginner-friendly ➢ Free to download and use
Device Specification	Asus Tuf Gaming F15 2022 FX507Z-C4HN027W FX507Z-C4HN028W i5-12500H/512GB M.2/ RTX 3050 4GB/ 15.6" FHD	➢ Equipped with NVIDIA GeForce RTX 3050 GPU which provides solid graphics

	144Hz/ W11	performance, capable of handling VR content and games with reasonable fidelity and frame rates. ➢ The Intel Core i5-12500H processor offers strong CPU performance, capable of handling VR applications and multitasking without significant bottlenecks.

Table 3.8: Table of Proposed Concept 1

For the proposed product, the conceptual design involves four concepts of the product; however, concept 1 has been selected because it has all the desirable features. Students can manipulate the turbine engine in a 3D space when using VR; hence the learning process is made more fun and interactive. Also, Unity Hub is one of the most popular cross-platform game development applications that can be used to create realistic 3D games along with respective environments. It has a massive population and many source materials such as tutorials and asset stores that can be used to bolster VR turbine engine simulation. Moreover, The Oculus Rift S has a high resolution on the display and high-end tracking system to make it easier and comfortable to use in the VR environment. An example of a VR headset is the Oculus Rift S; it is easy to use and easy to set up this device is perfect for a classroom setting. The Oculus Rift S offers its motion controllers and tracking options for natural command and control of the virtual turbine engine. Integrating the benefits of using VR technology with the facility of Unity Hub and with the support of Oculus Rift S, educators can produce realistic and efficient environment to teach the students about the turbine engines. It further promotes not only effective comprehension and powerful memory but also the simplification of complicated engineering concepts to enable students to truly comprehend the knowledge.

3.5 Interface Layout

3.5.1 General Project Interface Layout

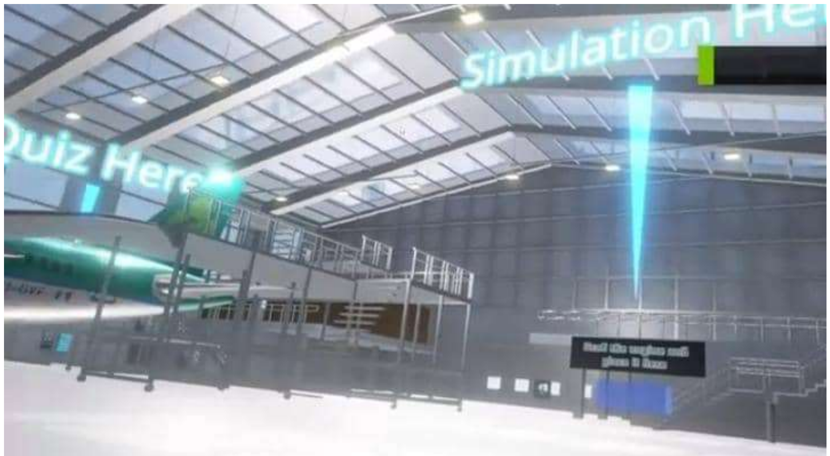


Figure 3.12: VTE environment

The picture shows a simulated environment in our software, created for educational and training purposes in a hangar setting. The environment includes designated sections like "Simulation Here" and "Quiz Here," which serve as interactive spaces for exploring different learning modules.

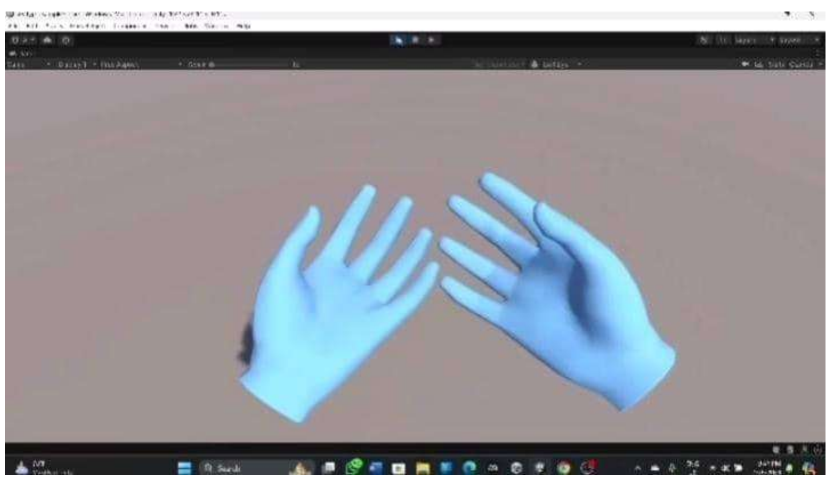


Figure 3.13: Hand Design

The picture displays a 3D representation of virtual hands, probably designed for interacting within the simulated environment. The virtual hands symbolize the user's interaction and engagement within the virtual realm, guided by tools like VR controllers or hand-tracking sensors.

3.6 DEVELOPMENT OF PRODUCT

3.6.1 Material Acquisition

Material	Description
Unity software	Used for creating, designing, and coding the VR application.
SketchFab	To get ready-made 3D models of the hangar, engine components and aircraft model.
CFM56-5B Training Manual	To get technical data or design references to ensure accuracy in VR simulation development.
Gas Turbine Engine Study Notes	To include current syllabus of study in the VR simulation.

3.6.2 Tools and Equipments

Tools and Equipment	Description
Asus TUF Gaming F15 2022 	Equipped with NVIDIA GeForce RTX 3050 GPU which provides solid graphics performance, capable of handling VR content and games with reasonable fidelity and frame rates. In addition, it has the Intel Core i5-12500H processor which offers strong CPU performance, capable of handling VR applications and multitasking without significant bottlenecks.
Oculus Rift S Headset 	Has high resolution display and reduced screen-door effect, provides crisp and detailed visuals enhancing immersion in VR environments. Also, it requires convenient setup and includes integrated audio speakers within the headband. Plus, this Oculus Rift S was already available to be used at our place.
Oculus Rift S Hand Controllers 	Allow users to interact with the virtual environment, such as pointing, grabbing, and manipulating virtual objects within the engine.

USB C to DisplayPort MiniDP VGA Adapter Portable TypeC 8K 60Hz Converter Thunderbolt3 laptop smartphone monitor projector 	Supports for 8K resolution at 60Hz. Other than that, the adapter can transmit high-quality video signals, delivering crisp and clear images on compatible displays.
Google Meet	As a platform to conduct discussion with external consultant.

3.7 PRODUCT TESTING / FUNCTIONALITY TESTS

3.7.1 VR Operating Procedure

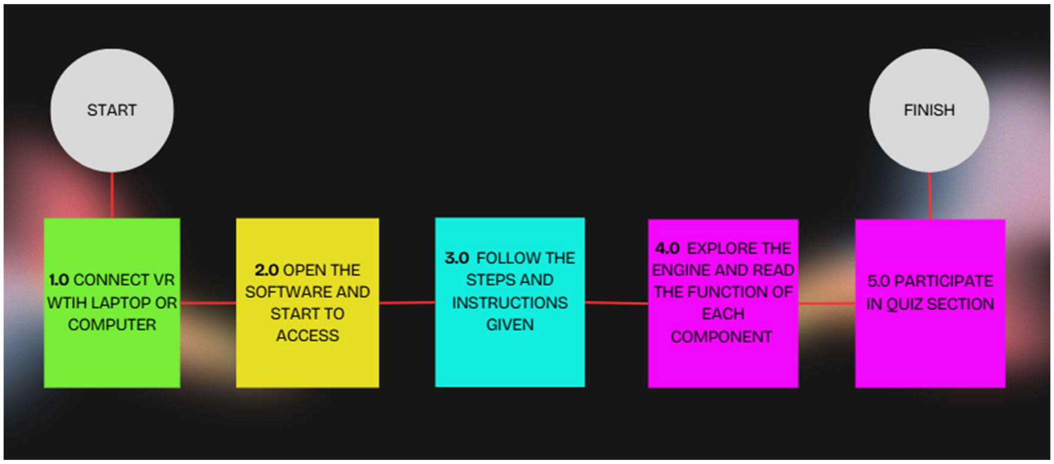


Figure 3.14: VR Operating Procedure

Users must follow the steps and instructions outlined in the Virtual Turbine Engine: Immersive Exploration of Engine Parts to complete the tasks. Additionally, they can explore the engine and review the notes for each engine main component for better understanding. They also can participate in quiz section that has been provided.

3.8 LIST OF MATERIALS AND EXPENDITURES

VR AND ACCESSORIES				
NO	**ITEMS DETAILS**	**UNIT**	**PRICE/UNIT(RM)**	**TOTAL(RM)**
1.	Oculus Rift S VR Headset	1	SPONSORED	0
2.	Oculus Rift S Hand Controller	2	SPONSORED	0
3.	Asus TUF Gaming F15 Laptop	1	SPONSORED	0
4.	USB C to DisplayPort MiniDP VGA Adapter Portable TypeC 8K 60Hz Converter Thunderbolt3 laptop smartphone monitor projector	1	27.80	27.80
SOFTWARE				
1.	Unity Hub	1	SPONSORED	0
CONTENT CREATION				
1.	3D Model	1	SPONSORED	0
DEVELOPMENT'S SUPPORT				
1.	Development Personnel	1	800	600
GRAND TOTAL				827.80

Table 3.9: List of Materials and Expenditures

CHAPTER 4

RESULT & DISCUSSION

4.1 PRODUCT DESCRIPTION

4.1.1 General Product Features & Functionalities

The developed Virtual Turbine Engine: Immersive Exploration of Engine Part gives a unique manner of learning to augment the student's comprehension of real-life engineering at its finest. Some main characteristics are a high level of details of the visualized engine components, possibility to interact with the visualized environment and to watch the video simulations of real-life situations, and informative texts containing animations and descriptions of the visualized objects. Being easily navigable, with built-in quizzes and challenges into the learning process, greatly enhances learner engagement. Also, the software is designed in multiple-user modes for collaborative learning and is operational with different types of VR devices, therefore it can be quite useful for educational purposes and serves as an effective tool for migration from the course theory to practical application.

4.1.2 Specific Part Features

4.1.2.1 Product structure

Virtual Turbine Engine: Immersive Exploration of Engine Part offers a comprehensive and interactive platform for users to engage with the intricate components of a gas turbine engine. This kind of product structure will help the users to have a clear understanding of the main engine component and its working, orientation, and interaction with other elements in the system. This means that the VR environment enables the user to move virtually from the outer casing of the engine to the inner core flow path to see the part in virtual reality and rotate it as if in a physical world. In this way, the utilization of the identified features contributes to the creation of the virtual turbine engine, which can be considered as an effective learning tool to improve the learning processes of the students and to facilitate the transformation of the collected data into practice in the gas turbine engineering field.

a) The Environment

The concept of VTE is designed to simulate a realistic background of a typical hangar from where a user can directly explore the parts of the engine. This virtual hangar makes it easy for users to understand the different layouts and capabilities of the various parts of an engine.

Figure 4.1: Hangar Interior in VTE

Figure 4.2: Aircrafts in VTE Hangar

The quiz section in engine training room of the Virtual Turbine Engine (VTE) is intended to provide a comprehensive learning environment for users. This room uses virtual reality to provide an immersive experience that improves comprehension of turbine engine component and operation.

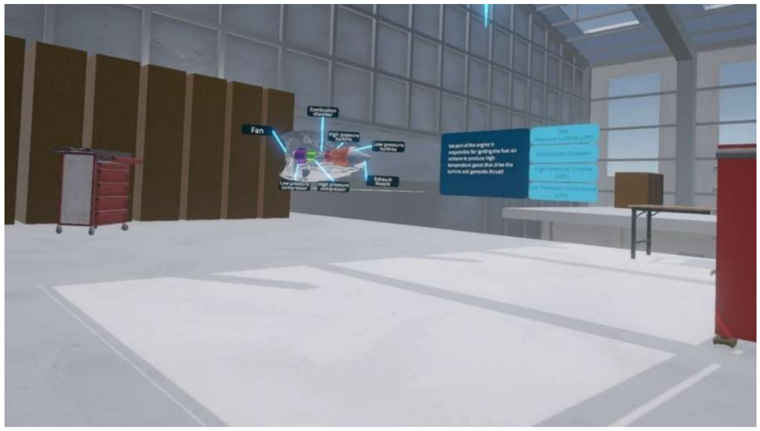


Figure 4.3: Engine Training Room in VTE

4.1.2.2 Product Mechanism

VTE software offers a virtual reality platform that aims to deliver a comprehensive and engaging experience for individuals looking to learn about gas turbine engine assembly and maintenance. The software seamlessly incorporates vital functionalities to guarantee efficient training and boost user interaction.

1. Built-in notes.

   The software contains digital study notes taken from the CFM56-5B engine manual, along with extra learning resources. The notes offer detailed descriptions, easy-to-follow instructions, and important safety tips. The notes are conveniently provided within the VR environment to guarantee that the training content meets study criteria and offers precise, industry-standard information. The incorporation of this integration elevates the accuracy and dependability of the training process, all the while upholding a strong emphasis on safety and comprehension.

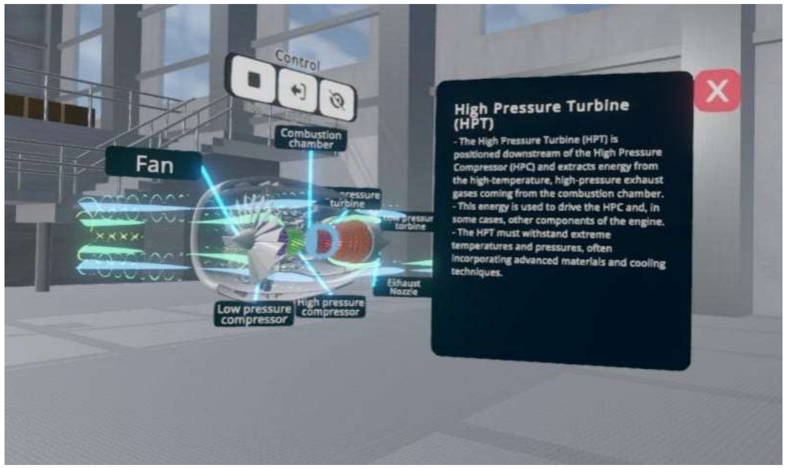


Figure 4.4: Built-in notes in VTE

2. Executing the task.

   The software offers detailed virtual procedures to smoothly assist users in exploring turbine engine components. The emphasis is placed on guiding users in recognizing the key engine components, grasping their positioning, and gaining insights into their operations and uses, rather than carrying out conventional assembly and maintenance duties. The 3D animated models enable users to see how the airflow and internal processes work within the engine, helping them grasp the significance of each component in the entire system. This engaging exploration enhances understanding of turbine engine systems in a secure virtual setting, all while reducing the risk of mistakes or confusion.

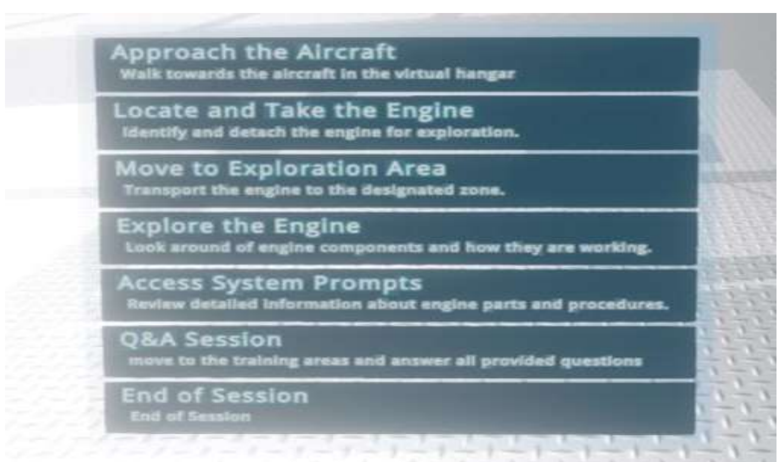


Figure 4.5: List of Task Provided in VTE

4.1.2.3 Software/ Programming

Unity was chosen as a platform on which highly detailed 3D models of the elements that make up the turbine engine would be developed, with everything highly accurate and eventually interactive. All this was detailed to show how the sections carrying the fan, compressor, and turbine were structured and functioned. The program made it possible to view these pieces in real-time VR: rotation, disassembling, and reassembling as part of learning. It included guidance and assessment for step-by-step, structured, and effective learning. By incorporating these, the software allowed interaction among a wide range of features that merged theoretical knowledge with practical understanding in an easy and seamless way, thus fulfilling the aim of the project: enhanced learning on turbine engines with immersive VR technology.

4.1.2.4 Accessories /Finishing

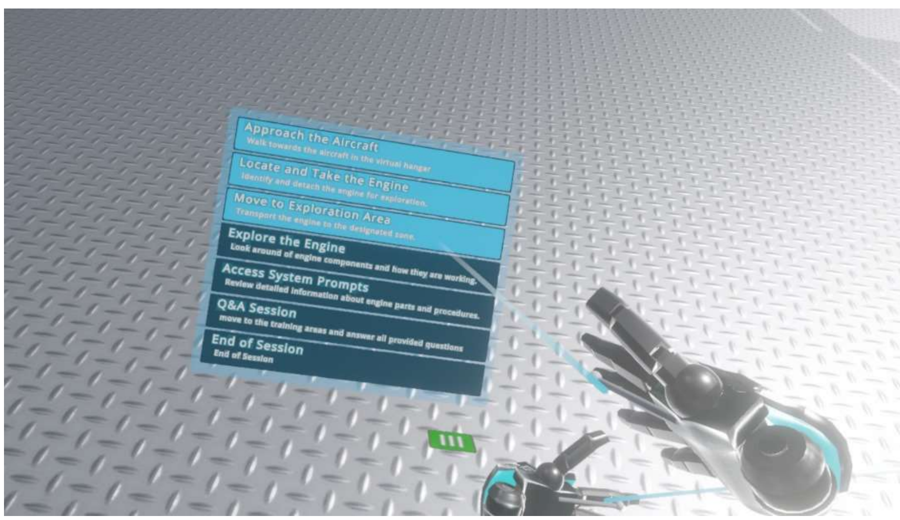


Figure 4.6: Special Features of The List of Task

The finishing design of the software involves a color-coding scheme to represent the status of tasks, as seen in the above figure: light blue represents those tasks already marked or completed for clear visual confirmation of the progress made; dark blue represents those tasks that are pending to be marked or completed, so that users may know how to spot pending activities. That's an extremely thoughtful use of colour that enhances the user interface by offering intuitive feedback, making sure users can navigate and manage their tasks effectively in the VR environment.

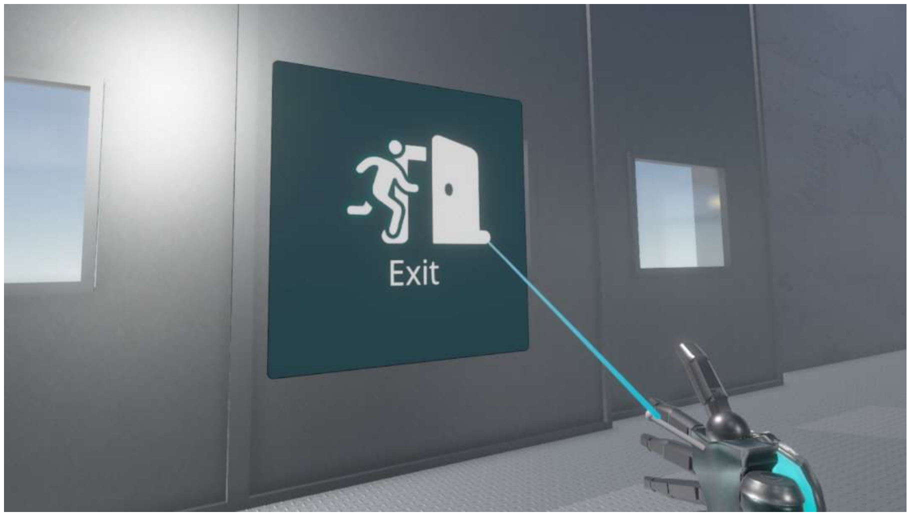


Figure 4.7: Exit door

The direction of exit shown in the picture is planned in a pattern so that users easily can understand. It includes a universally acknowledged symbol of a running figure and the clear text "Exit." The color used on the sign is of high contrast, whereas the simplicity in layout and design elements makes the key information quite simple to recognize. The combination of easily recognizable symbols, clearly legible text, and a properly designed layout in an exit sign gives the users with a wide range of variability an easily comprehensible view that embodies the message of "exit" and guides them through the appropriate direction.

Figure 4.8: Engine placement area

The picture shows an explicit and crystal-clear instruction in the form of a large screen that displays, "Grab the engine and put it here." That sums up a simple directive to the user as to what must be done, and very explicitly so, with absolutely no margin for misinterpretation. Its simplicity ensures that there is no over-complication in the simplicity of the instruction for the user to understand what is being asked of them. A blue box outlines the designated area where the engine should be placed; it serves as a good diagram helper to further explain where exactly it should go. This will be a good guide to make sure the user has the engine placed within set boundaries. This clear textual instruction with a visual indicator makes the use of the application easy and efficient. The image hence serves with both textual and visual hints that provide the required information for the user to perform a successful complete of the task.

CHAPTER 5

CONCLUSION & RECOMMENDATIONS

5.1 ACHIEVEMENT OF AIM & OBJECTIVES OF THE RESEARCH

5.1.1 Product Structure

The research was achieved in its goal of creating an improved Virtual Turbine Engine: Immersive Exploration of Engine Part software tool to deliver the visual, and dynamic experience of a gas turbine engine that is intended to close the loop between theory and practice. This new concept greatly enhances the visualization and comprehension for both students and engineering practicing in the industry. Also, shortcomings of conventional teaching are resolved. It is suggested that the institutions include this VR tool as part of the conduct users' training seminars, and work with aviation industries to update content to be appropriate and useful. Further updates on the content of this information based on the feedback of users will make the resource more useful in the teaching of engineering.

5.1.2 Product Mechanism

The aim of research was successfully met through the creation of a user-friendly virtual reality (VR) training platform specifically designed for the assembly of gas turbine engines. This innovative platform enables students to engage with lifelike 3D models of the engine parts. The VR training created a secure setting for users to hone assembly skills without any potential harm to actual equipment. It provided students with practical experience in a shorter amount of time, giving them the freedom to learn at their own speed, whenever and wherever they choose, eliminating the requirement to travel. This strategy enhanced the training experience by making it efficient and engaging, while also guaranteeing long-term usability.

5.1.3 Software/Programming

The goals of this project were achieved through the latest software and programming expertise that would deliver an ultimate VR experience. Unity was selected to create the VR since it is a broad, flexible, and powerful 3D creation engine that is utilized in the interaction with 3-D models and simulation of components of the turbine engines. This allowed for clear insight into ensuring that the parts of the engine can be rotated, disassembled, and assembled within a virtual environment. The program ensured the VR application was well integrated with an Oculus Rift S VR Headset and Controllers to move and interact in a straightforward and intuitive way in a virtual environment. Besides, the system was designed to be user-friendly, with accessible software that can easily be downloaded and run on supported devices, thus making it widely usable and cost-effective. These few achievements are evidence of how software and programming successfully apply to enhancing learning and training efficiency in education related to gas turbine engines.

5.1.4 Accessories & Finishing

The project placed much emphasis on accessories, thereby increasing the overall effectiveness and immersion of the VR training system. Key accessories included an Oculus Rift S VR headset and hand controllers that provided high-resolution visuals, along with intuitive interaction with the virtual environment. Other components, such as USB-C to DisplayPort adapters, ensured seamless connectivity with the gaming laptop for smooth performance and crisp imagery. It included features like VR inserts and facial interfaces that will make wearing easier and prevent fogging during the extended use of the device for finishing. Haptic feedback equipment and spatial audio solutions will create an artificiality of tactile and auditory realism for training. Accessories and finishes like these furthered the degree of immersion and usability, fitting perfectly into meeting the project's objective that is the delivery of a useful and interactive training aid for learning about gas turbine engines.

5.2 CONTRIBUTION OR IMPACT OF THE PROJECT

The project "Virtual Turbine Engine: Immersive Exploration of Engine Parts" presents the virtually enabled exploration of gas turbine engines in a novel manner, via the technology of Virtual Reality. Developed in Unity, this tool is installed, enabling students and trainees to use a very interactive, and real-life simulation, which helps them explore the components, working principles, and structures of a gas turbine engine without any hazards.

In this project, the focus is on learning through interaction as the users are required to touch and play with 3D images of engine parts, see how the parts work together, and how to learn other things through some teaching guidance. The equipment combines elements of augmented reality and offers an active type of training which is based on the engine's working principles, but it is risk-free, and does not require investing in expensive machines.

This VR tool is also advantageous from an educational standpoint since it familiarizes students with the concepts of aviation and engineering, providing the latter with a motivation through interesting and easy to grasp instruction. Due to the fact that it makes subjects such as gas turbine engines fun and easy, this project motivates students to enroll in more courses, hence assisting with the application of theory in practice.

In the end, not only does the project Virtual Turbine Engine serve as a training instrument but it is a learning evolution of sorts. It shows how much promise VR has in the education and training of people on systems that are quite complex in nature and hints of what the future holds for the education sector in aviation and all engineering related fields.

5.3 IMPROVEMENT & SUGGESTIONS FOR FUTURE RESEARCH

5.3.1 Product Structure

To improve on the developed virtual reality (VR) software for teaching gas turbine engine some modifications and recommendations for future studies are proposed as follows. First, get rid of listening to users will enable to fine tune the interface as well as the overall usability. One way is to expand the content in order to cover more each function and describe complex situations, the other is to make the content more interactive. Further, the study of other engineering branches applying VR and the punctual execution of longitudinal research concerning the benefits of utilizing VR settings will disclose its significance. Last but not the least, collaboration with industry partners will ensure the content is contemporary with the existing practices hence improving the training potential of VR tools in engineering education.

5.3.2 Product Mechanism

1. Improved engagement and practical experience.

   The current VR software is primarily centered on exploring components and comprehending their functions, however, upcoming versions may incorporate more engaging activities like virtual assembly or disassembly. Enabling users to carry out maintenance tasks or address engine issues remotely could provide a more interactive learning experience and enhance their skills to a greater extent.

2. Bringing additional engine variants.

   The current focus is on the CFM56-5B engine, however, there is potential to expand the software to encompass other turbine engine models. This expansion of learning resources would enhance the skills of students and staff in mastering different engine systems, thus boosting the software's flexibility and usefulness.

5.3.3 Software/Programming

Several enhancement recommendation steps might be taken in order to strengthen the ‘Virtual Turbine Engine: Immersive Exploration of Engine Parts’. One of them is the main problem of this game which is being unable to add more tasks to the game. The game is very simple as there are no requirements to perform detailed actions on the tasks. For example, visual cross section of the engine and its main parts as the main server of the game. There is no detailed gear rotor, fuel nozzle or igniter plug on the engine. The game will be more educational and will prove the real mechanisms and the working structure of the aircraft part if there are such features. The integration of Aircraft Maintenance Manual (AMM) and other maintenance references on the game could greatly enhance the user's ability to gain knowledge from the game especially aircraft maintenance course students as most of them lack referring to the physical engines for study. Improving the UI/UX could also help with the user’s experience. Streamline the user interface with clear instructions, task prompts and tooltips to assist players in understanding their objectives. Additional Quizzes and Knowledge checks can also include the understanding and post-game experience of the user. Integrate periodic quizzes on aircraft systems and safety procedures. Players must pass these to unlock new aircraft engine or task. Besides that, time-based challenges can help where players need to complete inspections within a set timeframe to simulate real-world pressure scenarios.

5.3.4 Accessories & Finishing

To ensure a polished and user-friendly product, some of the improvement for the Virtual Turbine Engine: Immersive Exploration of Engine Parts must incorporate carefully designed accessories and finishing touches that can enhance the overall experience. These elements aim to maximize usability, interactivity, and engagement for students and trainees:

- Ergonomic VR Setup: It is also compatible with the major VR accessories for VR that makes using the system comfortable and easy. The accessories are high quality VR headsets, motion controllers and other accessories for safe connection to laptop or PC.

- Simplified User Interface: As I began my discussion of the software, it has a user-friendly interface with pop-up instructions to help the user open the engine part and understand the learning material. This way the users are able to learn with minor interferences of technical issues.

- Interactive Information Overlays: Every part of the engine has corresponding fact annotations that appear as tooltips with additional information and descriptions when the user navigates through it, adding in real time additional data of how and why a specific component functions or is designed.

- Polished Visuals and Realism: Additional details are detailed modeling of the internal components of the engine in 3D space with the textures applied on the model, as well as a fine visualization of the relative position of the components that make up a gas turbine engine.

- Durability and Compatibility: The design ensured that such connections such as the display port adapter used in the VR system are long lasting and free from technical breakdown throughout the exercise.

The Accessories & Finishing are brothers in arms to ensuring a professionally produced educational apparatus. Such enhancements enhance the practicality of the VR immersion, guaranteeing the students' learning process happens as smoothly as is possible when they are exposed to a complex world of gas turbine engines immersed in the VR setting.

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APPENDICES

APPENDIX A: DECLARATION OF TASK SEGREGATION

SUB-CHAPTERS	**DESCRIPTION**
	MAS ALIA SYAZANA BINTI MAS AFFANDI
1.2	Problem Statement
1.3.1	General Project Objective
1.3.2/1.3.2.1	Specific Individual Project Objective: Product Structure
1.4.2/1.4.2.1	Specific Individual Scope: Product Structure
2.2.1	Specific Literature Review: Product Structure
2.2.1.1	Applications of VR in Engineering Education
2.2.1.2	Virtual Assembly of an Airplane Turbine Engine
2.3.1.1	Related Patented Products: Patent A: Semi-Immersive Virtual Turbine Engine Simulation System
2.3.2.1	Recent Market Products: Product A: Revima Virtual reality for Aircraft Engines Maintainability
2.4	Comparison Between Recent Research and Current Project
3.3.2.1	Specific Project Design Flow: Product Mechanism
3.1.4	Design Concept Generation: Design Concept Flowchart
3.4.3	Evaluation & Selection of Conceptual Design Pugh Matrix
3.4.3.2	Conceptual Design of the Proposed Product

3.7/3.7.1	Product Testing / Functionality Tests: VR Operating Procedure
4.1.1	General Product Features & Functionalities
4.1.2/4.1.2.1	Specific product Structure: Product structure
5.1/5.1.1	Achievement Of Aim & Objectives of The Research: Product Structure
5.3/5.3.1	Improvement & Suggestions for Future Research: Product Structure
	NUR SHARMIZA BINTI YAHAYA
1.1	Background of Study
1.3.2.2	Specific Individual Project Objective: Product Mechanism
1.5.2.2	Specific Individual Scope: Product Mechanism
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2.1.2	Trends in Virtual Reality (VR) Applications in Education
2.1.3	Virtual Reality in Aviation
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2.2.2.1	Types of Tracking and Input Devices
2.2.2.2	Types of Processing Units
2.2.2.2.1	Selection of GPUs for VR systems
2.3	Comparison Between Real Life & Virtual Reality of Gas Turbine Engine Study
2.3.2.2	Recent Market Product: Product B: Virtual Reality Maintenance Training Software
3.1	Project Briefing & Risk Assessment
3.2	Overall Project Gantt Chart
3.4.1.1	Design Requirement Analysis: Questionnaire Survey
3.4.1.2	Pareto Diagram
3.4.2.2	Morphological Matrix

3.4.2.4	Proposed Design Concept 2
3.5/3.5.1	Interface Layout: General Project Interface Layout
3.6	Development of Product
3.8	List of Materials and Expenditures
4.1.2.2	Specific Part Features: Product Mechanism
5.1.2	Achievement Of Aim & Objectives Of The Research: Product Mechanism
5.3.2	IMPROVEMENT & SUGGESTIONS FOR FUTURE RESEARCH: Product Mechanism
	MUHAMMAD SHAMIM BIN SHARIFF
3.3	Project Flow Chart
3.3.1	Overall Project Flow Chart
5.2	CONTRIBUTION OR IMPACT OF THE PROJECT
5.3.2	IMPROVEMENT & SUGGESTIONS FOR FUTURE RESEARCH: Product Mechanism
5.3.3	IMPROVEMENT & SUGGESTIONS FOR FUTURE RESEARCH: S IMPROVEMENT & SUGGESTIONS FOR FUTURE RESEARCH: Software/Programming
5.3.4	IMPROVEMENT & SUGGESTIONS FOR FUTURE RESEARCH: Accessories & Finishing
	MUHAMMAD ARIFF NAQIUDDIN BIN NORDIN
4.1.2.3	Software & Programming
4.1.2.4	Accessories & Finishing
5.3.3	Software & Programming
5.3.4	Accessories & Finishing

PPENDIX B: A PATENT ABOUT SEMI-IMMERSIVE VIRTUAL TURBINE ENGINE SIMULATION SYSTEM

DE GRUYTER Int J Turbo Jet Eng 2017; aop

Mustufa H. Abidi*, Abdulrahman M. Al-Ahmari, Ali Ahmad, Saber Darmoul and Wadea Ameen

Semi-Immersive Virtual Turbine Engine Simulation System

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Abstract: The design and verification of assembly operations is essential for planning product production operations. Recently, virtual prototyping has witnessed tremendous progress, and has reached a stage where current environments enable rich and multi-modal interaction between designers and models through stereoscopic visuals, surround sound, and haptic feedback. The benefits of building and using Virtual Reality (VR) models in assembly process verification are discussed in this paper. In this paper, we present the virtual assembly (VA) of an aircraft turbine engine. The assembly parts and sequences are explained using a virtual reality design system. The system enables stereoscopic visuals, surround sounds, and ample and intuitive interaction with developed models. A special software architecture is suggested to describe the assembly parts and assembly sequence in VR. A collision detection mechanism is employed that provides visual feedback to check the interference between components. The system is tested for virtual prototype and assembly sequencing of a turbine engine. We show that the developed system is comprehensive in terms of VR feedback mechanisms, which include visual, auditory, tactile, as well as force feedback. The system is shown to be effective and efficient for validating the design of assembly, part design, and operations planning.

Keywords: Virtual Reality, virtual prototyping, assembly operations, airplane turbine engine

PACS® (2010). (SEE LINK https://www.aip.org/publishing/pacs/pacs-alphabetical-index)

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Introduction

Globally, there is a strong competition between the big manufacturing firms; each of them are looking for proficient technological solutions that lead to mitigation in product development cycle time, and drive down production costs. Conventional mechanical and manufacturing process design is initialized with concept development, followed by process plan development and demonstration, and is concluded with product design [1]. Today's aerospace industry endeavor to be economical and competent in the market. Decrease in the product development cycle time and cost have been identified as areas of strategic focus [2]. To achieve these objectives, the industries are looking for novel technologies that can reduce product development time and cost.

With the recent advancements in Virtual Reality (VR) technology, the manufacturing industry has received novel solutions and VR applications to product and process design, prototyping, assembly operations, manufacturing process evaluation, etc [3–12]. VR is an efficient tool for analyzing the overall performance of a product, and it can overcome the shortcomings of traditional design processes [13]. VR is an advanced design concept that provides applied means in the field of machine design and manufacturing [14]. In the VR environment, designers and engineers employ geometrical and physical information of several components provided in a computer aided design (CAD) system to create a realistic three-dimensional (3D) model of the entire product in a computer-generated environment. This 3D model is termed as digital mockup [15]. The interaction between the operator and the virtual model can be achieved by means of several devices such as stereoscopic glasses, gamepads, head mounted displays (HMDs), gloves, 3D mice and flock of birds etc. VR environments save time

APPENDIX C: PRODUCT A ABOUT VIRTUAL REALITY FOR AIRCRAFT ENGINES MAINTAINABILITY

Virtual Reality for aircraft engines maintainability

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Abstract : REVIMA is a virtual reality system for maintainability simulation in Aeronautics. It comprises both hardware and software developments, plus system integration. REVIMA required the design of a new haptic system. It is used both to track hand movements and to return force feedback that provides the sensation of working with a physical mock-up. The main software modules are: image generation, collision detection and control. System integration is based on two LAN connected PCs that share the different tasks and data.

The visualization module has been built using low-cost graphic systems, and we have thoroughly analyzed this problem to achieve a drawing frame rate acceptable for simulation analysis. The models comprise more than two thousand different elements that require about two million polygons to describe their shapes. Different organization strategies have been tested in order to achieve the real simulation goal. We also present the different visualization algorithms we have used.

Keywords : virtual reality, real time visualization, maintainability, haptic.

1- Introduction

In the field of Aeronautics the term Maintainability is defined as "the ability of an element to keep in service or to be returned to adequate status in order to develop its function, after being maintained at conditions previously established, using the personnel, the means and adequate procedures" [1].

One of the most relevant aspects of maintainability concerns man and tool accessibility task analysis, which is undertaken in order to calculate paths and assembly-disassembly sequences and times. Design based on electronic mock-up is widely used in the creation of engine externals (piping, harnesses and installations) by the aeronautics industry. Pipes and harness are routed over these parts and accessories are installed by means of a workstation network. This allows a group of designers to work quasi-concurrently over an assembly, copying and automating the original process. This technology is known in the industry as DMU/DPA (Digital Mock Up / Digital Pre-Assembly).

DPA/DMU technology has overcome the need for a hard mock-up for design purposes, significantly decreasing time-to-market and thereby saving money. However, nowadays the use of a physical mock-up is mandatory in order to evaluate the maintainability of externals during the development stage. Although these mock-ups can be used for other applications, the ultimate purpose of the construction is to check the maintainability. The expenses of these mock-ups led ITP (Industria de TurboPropulsores) to research an alternative using haptics. ITP is the exclusive supplier of low-pressure turbines for Rolls-Royce engines of greater than 35,000lbs of thrust - primarily the Trent engine family. It is also the Spanish participant in the EJ200 engine for the Typhoon Eurofighter, and earlier this year became a 13.6% shareholder in the TP400 engine programme for the A400M European military transport aircraft.

The tracking system provides a workspace similar to the size of a turbo-engine. The whole system gives the user a realistic feedback. Even more, as we will explain later on, the reachable workspace can easily be shifted to different positions and orientations. This allows the simulation of different relative positions between the model and the operator, to study ergonomic aspects of the simulated tasks.

Using our device the user movements are the same ones that are done when testing physical mock-ups. This fact provides an enhanced sense of real manipulation and can lead to important reduction in costs in the development of new aircraft engines.

APENDIX D: MyIPO CERTIFICATE OF COPYRIGHT NOTIFICATION

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CERTIFICATE OF COPYRIGHT NOTIFICATION
[Subregulation 8(2)]

Notification Number	:	**CRLY2024W07263**
Title of Work	:	**VIRTUAL TURBINE ENGINE (VTE): IMMERSIVE EXPLORATION OF ENGINE PART**
Category of Work	:	**LITERARY**
Date of Notification	:	**04 NOVEMBER 2024**
Date of Creation	:	**04 NOVEMBER 2024**

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APPENDIX E: PRE-IMPLEMENTION SURVEY OF VTE BY USING GOOGLE FORM (QUESTION & FINDINGS)

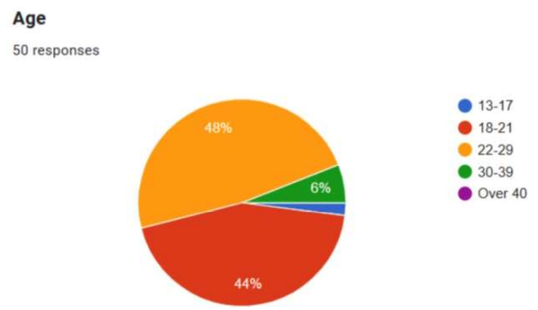


Figure 1

We found that mostly our respondents are between 18-29 years old.

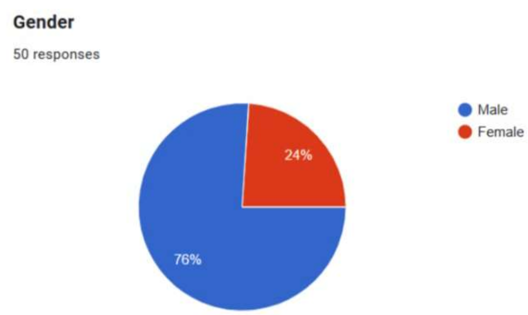


Figure 2

We found out that most of our respondents are male.

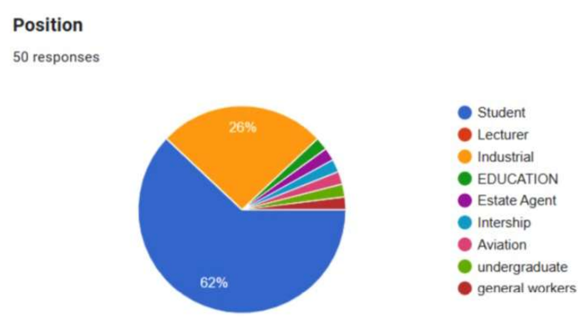


Figure 3

We got respondents from different backgrounds. However, mostly there was our targeted persons obviously they who into aviation, which included student, lecturer, industrial, internship and undergraduate.

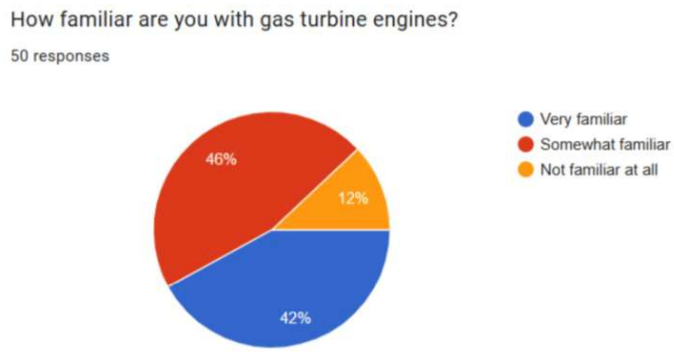


Figure 5

We begin the data analysis by identifying the respondent's level of knowledge regarding gas turbine engines and the majority of them were familiar with it.

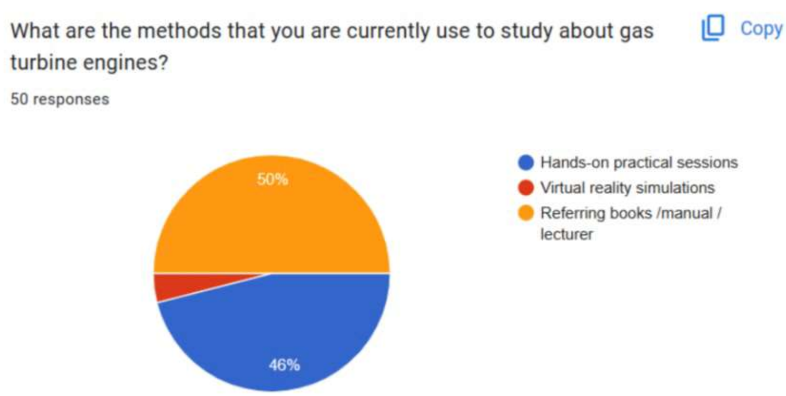


Figure 6

We then asked the respondents about how they are studying gas turbine engines and 50% of the respondents were referring to traditional learning methods, 46% doing hands-on practical session and by using VR is only 4% persons.

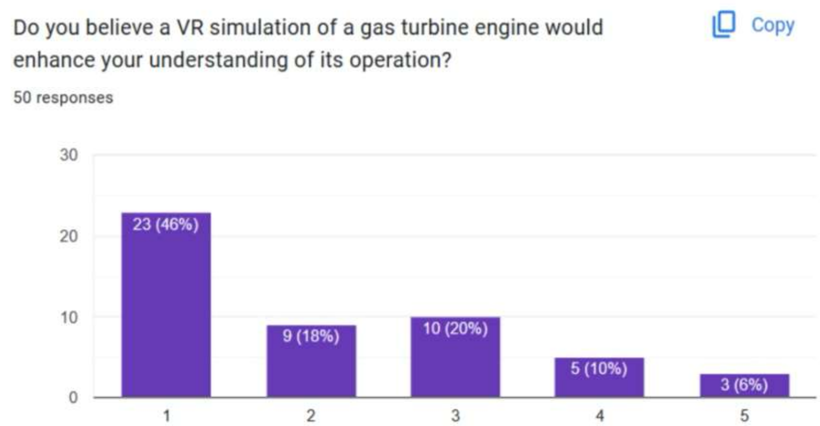


Figure 7

The next question asked how far the respondents believe that VR simulation can help on enhancing their understanding about gas turbine engine operation. Majority of them strongly agree to that.

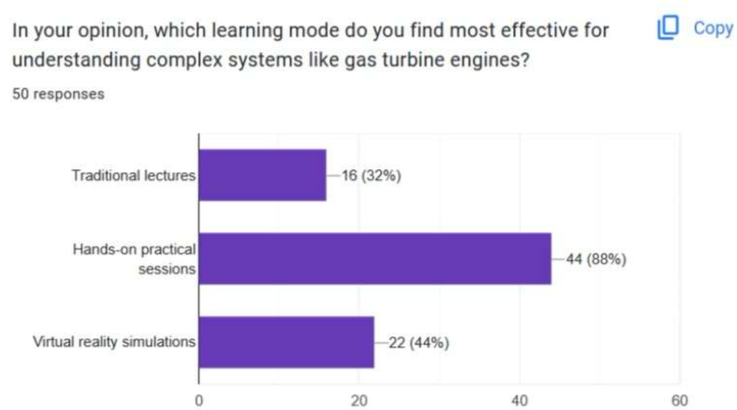


Figure 8

After that, we asked them which learning modes do they find effective on studying a complex systems and majority chose hands-on practical sessions (60%), followed by virtual reality simulations (44%). The rest of them chose traditional lectures (32%).

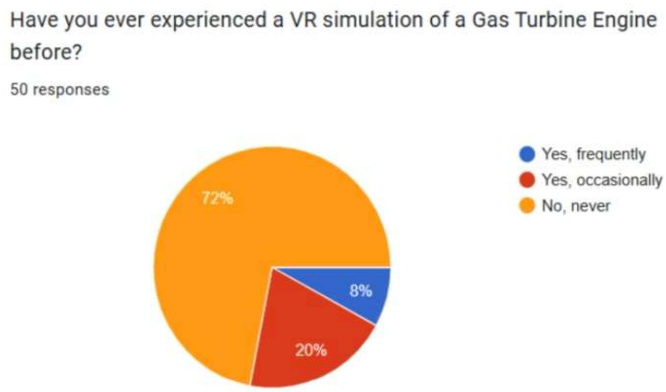


Figure 9

Most of our respondent had stated that they have zero experience on using VR stimulation of GTE. Only 28% of them had the experience.

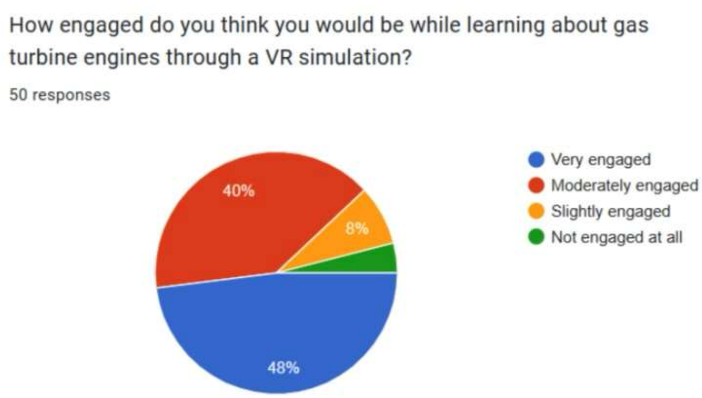


Figure 10

In order to know the functionality level of this project development, we also asked about how engaged they would be when learning about GTE through VR simulation. As much as 48% thinks very engaged, 40% moderately engaged and 8% slightly engaged. Nevertheless, the The rest of them (4%) think they would not engage at all.

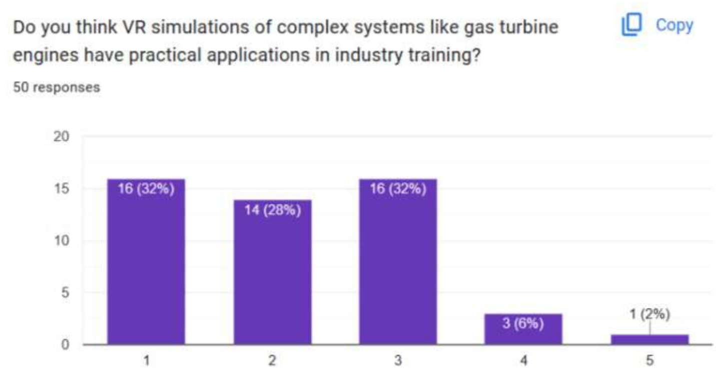


Figure 13

On the next question, we found out that 92% from the respondents have a thought that VR simulations of complex systems like GTE will have practical applications in industry training.

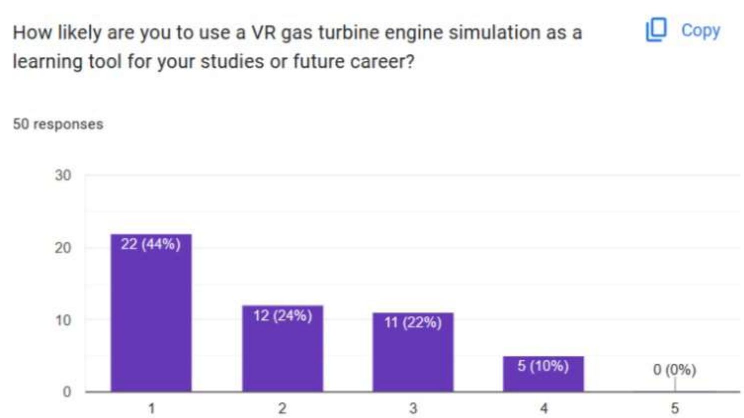


Figure 14

Lastly, we got 90% positive answers when asking if our respondents like to use a GTE's VR simulation as a learning tool for their studies and future .

For the excellent quality of our product development, we did ask them either if any additional features needed to be included or they have any suggestions regarding how the VR simulation of GTE can be improved, based on their previous experience using VR.

What additional features or aspects would you like to see included in a VR simulation of a gas turbine engine for educational purposes? (Open-ended)

28 responses

Aircraft maintenance manual in vr
A console to monitor gas turbine i.e temperature, oil pressure. Make a full sequence from battery to start the engine
to be affordable and open to all student,
Must have detail explanation for each and every part of engine
clear images and explanation
Different types of gte available
More detailing information
Smooth the program and make it variant
None
VR using apple vision pro
-
Can control the vr and by ur hand can simulate the use of the engine
Realistic enchanted VR program
involving game such as puzzle-solving
nothing
include interactive gameplay for exploring
Live demonstration
NOTHING
tooling calibration
It can be recorded while doing the task, so then student can be revise from that clip rather than need to redo all the procedures.
create realistic environments where gas turbine engines are commonly used such as aircraft hangars
Voice of explanation for GTE
Futureistic
allow players to interact with objects and navigate within the virtual environment by using controller
provides some gaming experience
Finishing Step
N/A
The essential features of a gas turbine itself

Figure 12

If you have any suggestions or comments regarding how the VR gas turbine engine simulation can be improved, please share them here.

17 responses

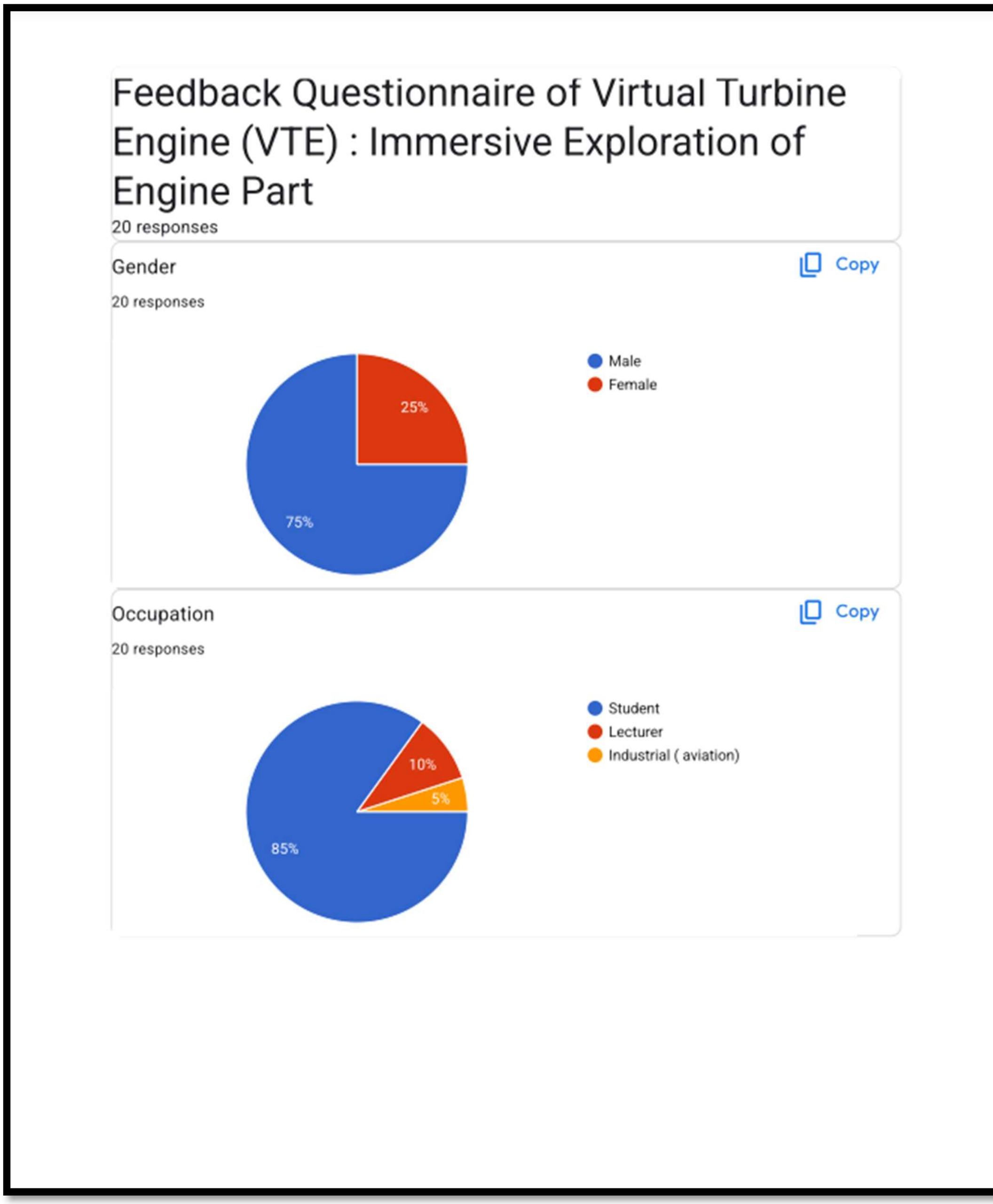
Nothing
hands on is more better
nil
Consider enhancing realism by incorporating more detailed physics models for combustion, airflow, and mechanical components.
Best project
Exploded view of the gte and also interactive parts (names and the function)
VR gas turbine engine simulation is a very immersive method for learning, make it fun and attractive for the users
Add on explanation about the part of turbine and how it's functioning
no suggestion
make it a great training kit especially a complex sytem such this gas turbine engine
Focus for crucial part
Make it more accessible
N/A
none
The real environment should be included in the simulation as well.
None
If u used the vr how do u want to improve ur skill w ithout do mistakes, thrust me the vr will halp u do the basic but the critical problem will not

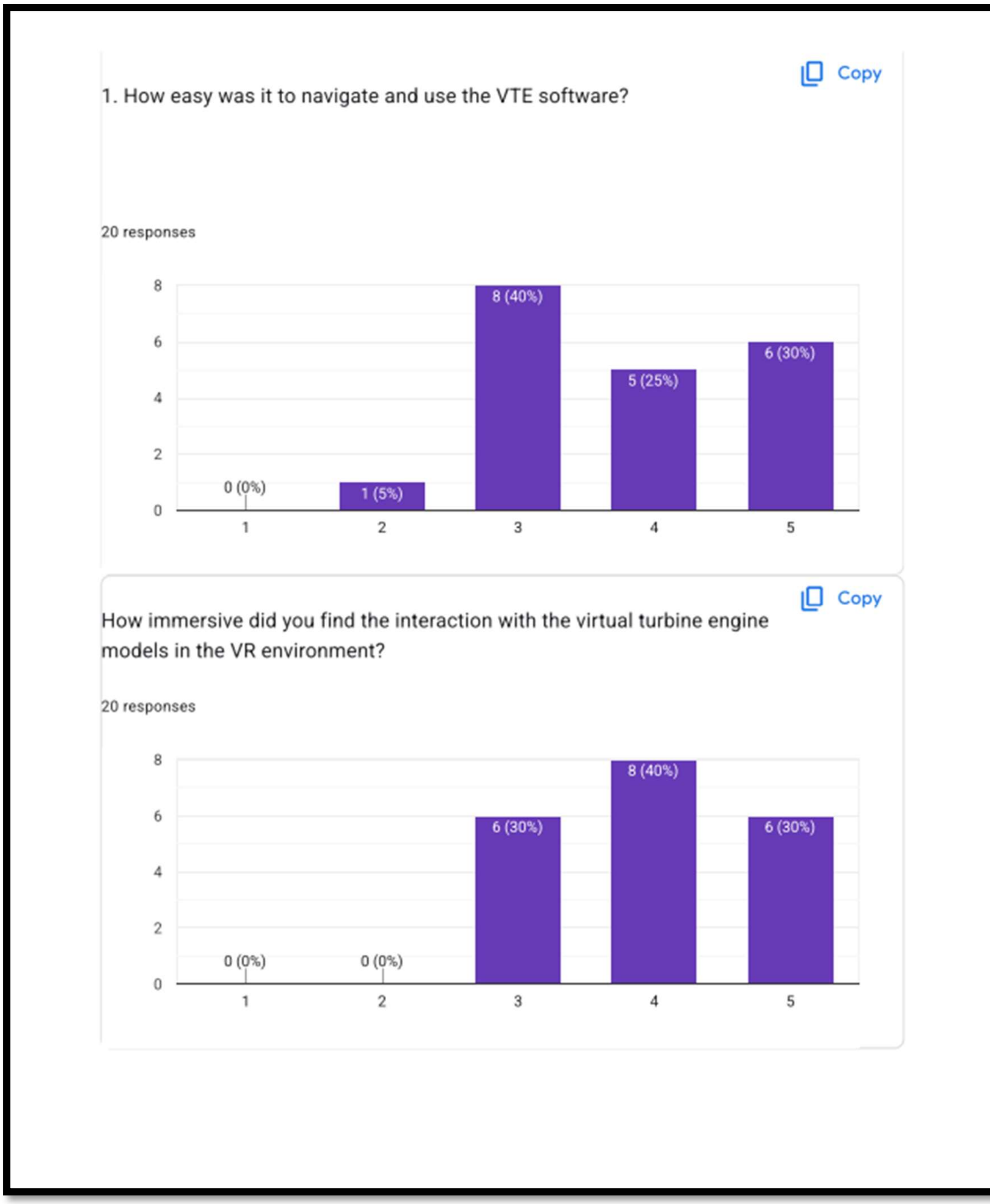
Figure 13

As a result, we can summarize that most of their request includes:

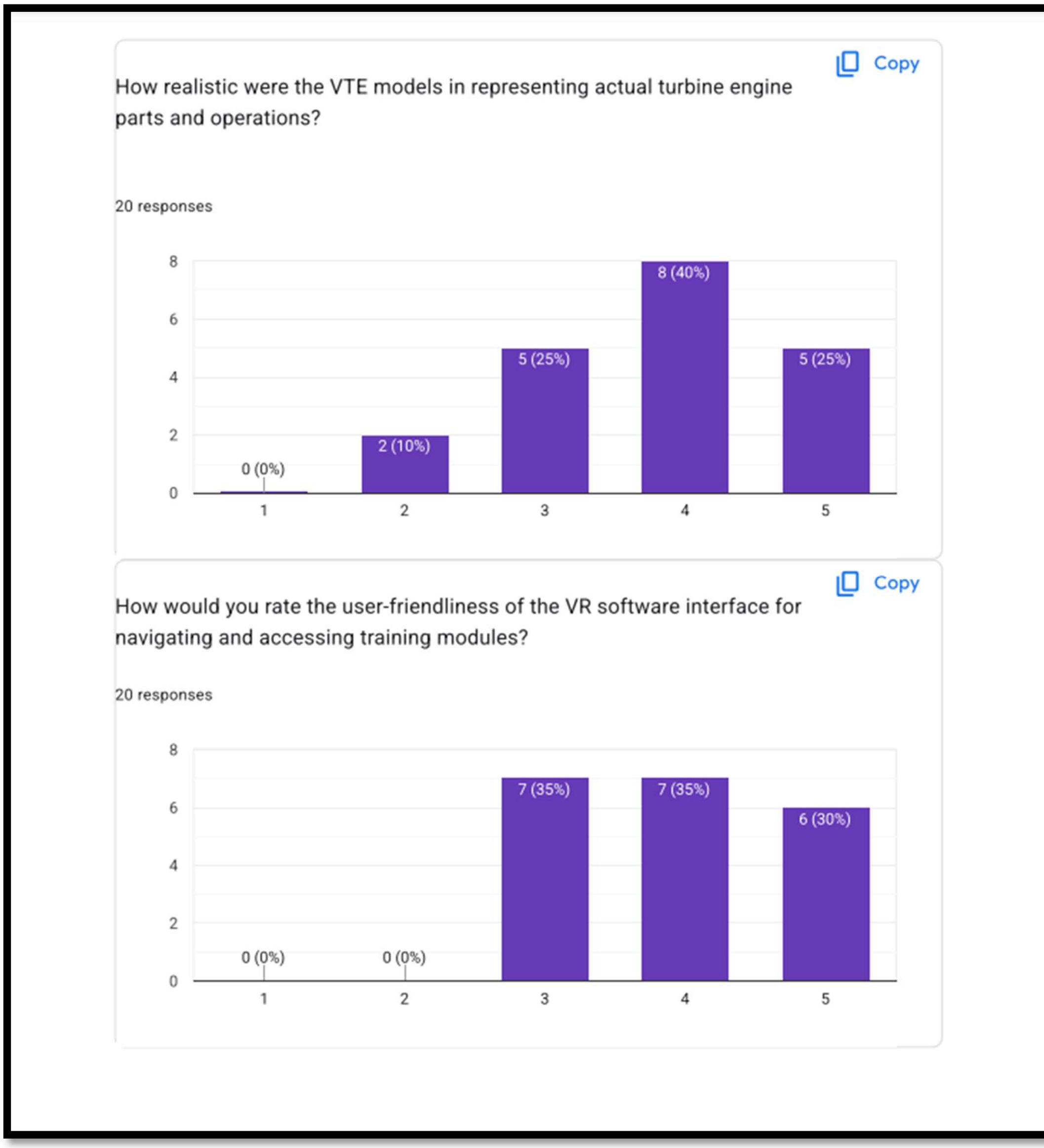
- Realism
- Complete explanation / guidance
- Accessibility
- Critical Thinking / Problem Solving Skills
- Gaming Experience

APPENDIX F: POST-IMPLEMENTATION SURVEY OF VTE BY USING GOOGLE FORM





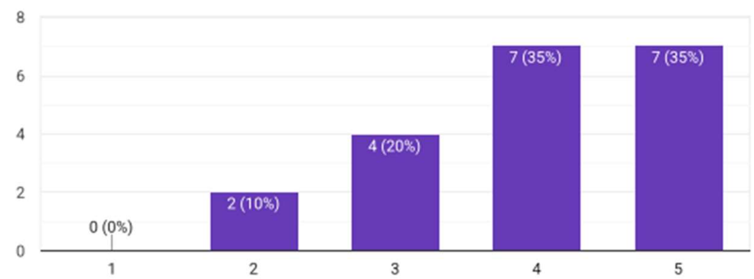
Copy
1. How easy was it to navigate and use the VTE software?
20 responses
8
6
4
2
0
0 (0%)
1 (5%)
8 (40%)
5 (25%)
6 (30%)
1
2
3
4
5
Copy
How immersive did you find the interaction with the virtual turbine engine models in the VR environment?
20 responses
8
6
4
2
0
0 (0%)
0 (0%)
6 (30%)
8 (40%)
6 (30%)
1
2
3
4
5


Copy
How realistic were the VTE models in representing actual turbine engine parts and operations?
20 responses
8
6
4
2
0
0 (0%)
2 (10%)
5 (25%)
8 (40%)
5 (25%)
1
2
3
4
5
Copy
How would you rate the user-friendliness of the VR software interface for navigating and accessing training modules?
20 responses
8
6
4
2
0
0 (0%)
0 (0%)
7 (35%)
7 (35%)
6 (30%)
1
2
3
4
5

Copy

Do you agree that the VTE provides a safe and practical alternative to real-world engine training?

20 responses



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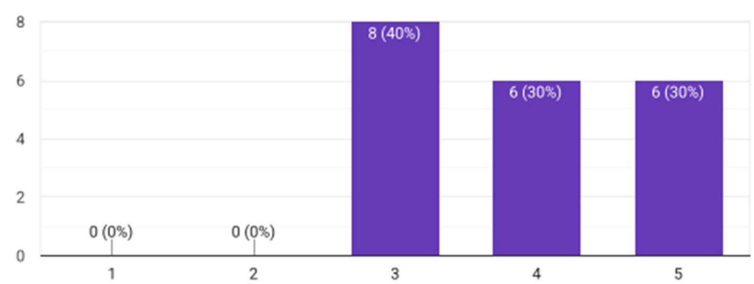
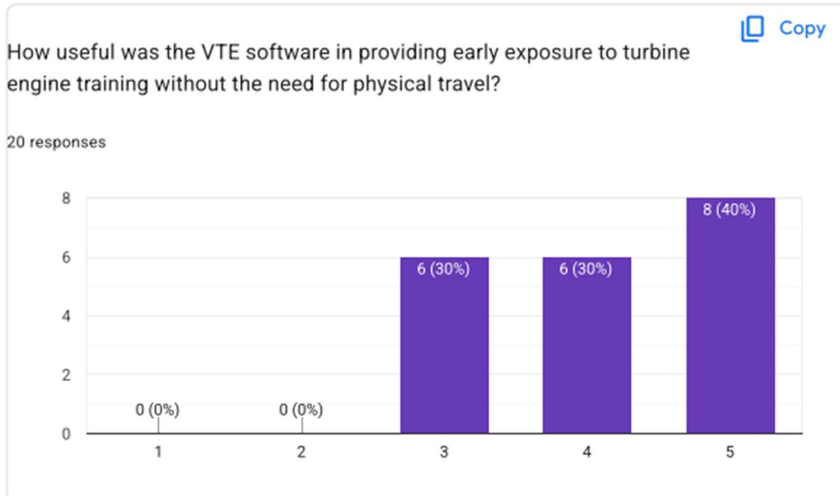
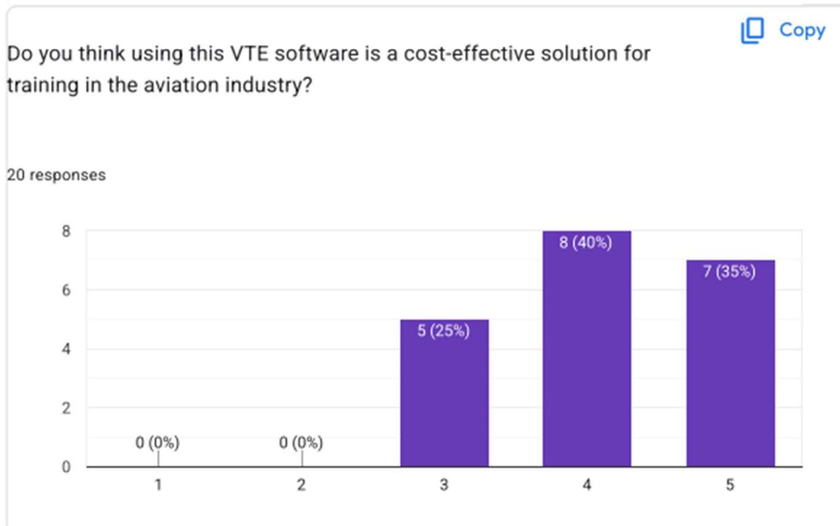
How well did the VTE simulation help you understand the different engine parts, functions and their operations?

20 responses



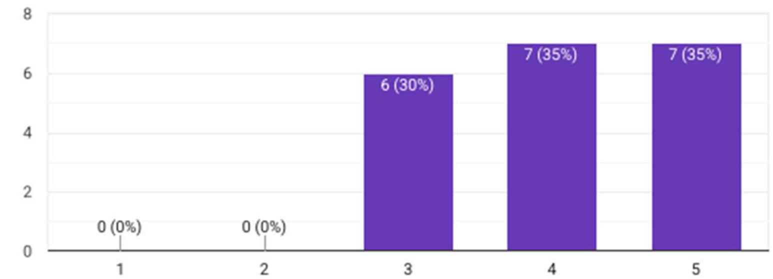

Copy
How useful was the VTE software in providing early exposure to turbine engine training without the need for physical travel?
20 responses
8
6
4
2
0
0 (0%)
0 (0%)
6 (30%)
6 (30%)
8 (40%)
1
2
3
4
5


Copy
Do you think using this VTE software is a cost-effective solution for training in the aviation industry?
20 responses
8
6
4
2
0
0 (0%)
0 (0%)
5 (25%)
8 (40%)
7 (35%)
1
2
3
4
5

Copy

How would you rate your overall experience with the VTE software?

20 responses



What additional features or improvements would you suggest for the VTE software?

6 responses

realistic

N/A

MORE IMPRESIVE

n/a

-

addition of accesories drive would be great

APPENDIX G: SUMMARY OF SIMILARITY REPORT

Final e-Thesis VTE.pdf

ORIGINALITY REPORT

13%	9%	5%	8%
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