POLITEKNIK BANTING SELANGOR

VR HONEYCOMB REPAIR TRAINING KIT

NAME	MATRICS NO.
NURUL UMAIRAH BINTI MOHAMMAD NORISHAM	24DAM23F1001
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DEPARTMENT OF AIRCRAFT MAINTENANCE ENGINEERING

SESSION 1: 2025/2026

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A REPORT SUBMITTED TO DEPARTMENT OF AIRCRAFT MAINTENANCE ENGINEERING IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR A DIPLOMA IN AIRCRAFT MAINTENANCE ENGINEERING

SUPERVISOR:

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CERTIFICATE 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

The Virtual Reality Honeycomb Structure Repair Kit seeks to provide an authentic and interactive learning platform for aircraft maintenance students in training on the repair of honeycomb structures. This system was designed as a virtual reality training kit that allows users to visualize and safely perform repair procedures within a virtual environment. Unity Engine and C# were used to develop this product by incorporating 3D models of tools, materials, and aircraft parts with the aim of replicating actual steps involved in repairs, which are required by the Structural Repair Manual. Various development processes were covered: from the design of the environment to scripting tool interactions, flow programming of simulations, to its internal testing using a VR headset. The kit had been implemented to improve understanding, accuracy, and engagement in the learning process with two modes: Training Mode and Challenge Mode. The trainees can repeat these processes without requiring physical materials at all, thereby reducing training costs and safety risks significantly. Full user testing is planned during later stages. However, early tests show smooth performance of the entire system with realistic tool behaviour. Overall, the project reflects an affordable, safe, and sustainable aviation education approach, suiting the Industrial Revolution 4.0 and Sustainable Development Goal 4, Quality Education, through immersive virtual reality technology

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LIST OF ABBREVIATIONS

3D	3-Dimensional
VR	Virtual Reality
NDT	Non-Destructive Testing
MacOS	Machine Operating System
Heatcon	Heatcon Composite Systems
ACRATS	Aircraft Composite Repair and Training Solution
EASA	European Union Aviation Safety Agency
SASSOFIA	Sofema Aviation Service
SAE AIR 6671	Standardized Composite Training Program
NASA	National Aeronautics and Space Administration
AR	Augmented Reality
HTC Vive	High Tech Computer Corporation
MRO	Maintenance, Repair, Overhaul
SRM	Structure Repair Manual
AI	Artificial Intelligence
AMOLED	Active-Matrix Organic Light Emitting Diode
UI	User Interface
XR	Extended Reality

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Honeycomb structures are essential components in modern aircraft due to their high strength-to-weight ratio. They are typically made from lightweight materials such as aluminium, Nomex, or fiberglass, arranged in a hexagonal pattern. This structure allows the material to absorb impact and distribute loads efficiently without adding unnecessary weight. Honeycomb panels are widely used in control surfaces, fuselage panels, and flooring systems.

The honeycomb design provides excellent stiffness and energy absorption, which are crucial for maintaining aircraft performance and safety. However, when damaged by lightning strikes, bird strikes, or stress fractures, honeycomb structures are difficult to repair and require specialized skills. The repair process involves several stages, including damage inspection, removal of the damaged core, bonding of new materials, and non-destructive testing (NDT) for quality assurance. These technical procedures are challenging to master without sufficient hands-on practice.

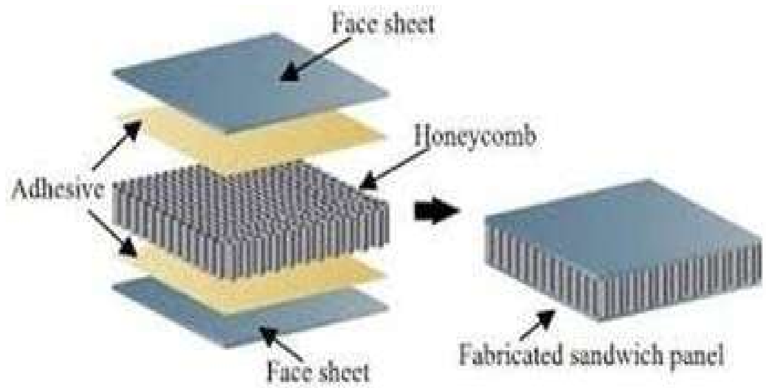


Figure 1: Honeycomb structure in aircraft.

Traditional classroom training often limits students' exposure to real repair tasks due to high equipment costs, safety restrictions, and limited availability of damaged components. As a result, many students graduate without full confidence in performing actual honeycomb repairs.

Virtual Reality (VR) offers a modern and effective solution to these challenges. VR is a computer-generated 3D environment that allows users to interact and perform tasks similar to real-world operations. It has been widely applied in aviation, medicine, and education to enhance practical learning.

Figure 2: Virtual Reality (VR) in education.

Through VR-based training, students can repeatedly practice repair procedures, receive immediate feedback, and learn safely without using physical materials. Research has shown that VR improves engagement, understanding, and memory retention by allowing learners to see, perform, and repeat tasks in an interactive environment.

Therefore, applying VR to honeycomb structure repair helps bridge the gap between theory and real practice. It reduces training costs, enhances safety, and improves student confidence. In conclusion, a VR-based honeycomb structure repair training kit provides an innovative and efficient approach to developing technical competency among aviation maintenance students.

1.2 PROBLEM STATEMENT

Based on surveys and feedback from students and instructors in aircraft maintenance engineering education, several major issues have been identified that hinder the effectiveness of teaching and learning related to honeycomb structure repair.

Honeycomb structures are widely used in aircraft due to their high strength-to-weight ratio, but their complex geometry and material composition make them difficult for students to understand. Without direct exposure to actual components, students find it challenging to visualize the internal configuration of the structure and the process of how it reacts during repair. This lack of physical interaction limits their understanding of how the structure functions and behaves under stress or damage.

The repair process of honeycomb structures is another major challenge for students. It requires precise techniques, specialized tools, and deep knowledge of materials such as aluminium or Nomex. Students often face difficulties in performing the repair due to insufficient practice and limited understanding of the procedures. Since honeycomb repairs demand accuracy and attention to detail, even small errors can result in serious structural defects, leading to a lack of confidence among learners.

Furthermore, students have limited opportunities for hands-on training. Traditional learning approaches such as lectures, videos, and demonstrations can only provide theoretical understanding, but not the real sense of handling materials, using tools, or performing each step of the repair procedure. This lack of exposure affects students' ability to connect theory with actual maintenance tasks and limits their readiness for real-world aircraft repair work.

In addition, the current conventional teaching methods are ineffective for complex repair topics such as honeycomb structures. Classroom-based learning and textbook study are not sufficient to demonstrate the three-dimensional nature of the structure or to replicate the dynamic process of inspection and repair. Consequently, students often struggle to visualize the procedures and fail to develop the required technical competency. This situation leads to low engagement, reduced motivation, and poor learning outcomes.

Therefore, there is a critical need to introduce a more effective and interactive learning method that allows students to gain real-time experience in a safe and controlled environment. The integration of Virtual Reality (VR) technology offers a promising solution to overcome these challenges. VR provides immersive 3D visualization and interactive simulations that can replicate real-world repair scenarios without physical risks or material costs. This innovation can enhance students' understanding, improve confidence, and strengthen the overall effectiveness of honeycomb structure repair training in aircraft maintenance education.

1.3 PROJECT OBJECTIVES

1.3.1 General Project Objectives

These project objectives are:

- To design a virtual training environment that allows users to view, interact, and perform repair procedures on honeycomb structures in a 3D setting.
- To develop a step-by-step training process that demonstrates proper repair stages, tool usage, and techniques for honeycomb structure repair.
- To evaluate the usability and effectiveness of the VR training kit in terms of user interaction, navigation, and learning experience.

1.3.2 Specific Individual Project Objective

1.3.2.1 Product Structure

This project aimed:

- To design a modular VR hangar environment with damaged honeycomb structure and digital workbench.
- To integrate virtual repair tools such as core cutter, scraper, adhesive gun, and patch applicator.
- To guide users through inspection, removal, bonding, and testing stages in a structured workflow.
- Product Mechanism

This project aimed:

- To design a virtual repair station equipped with damaged panels, workbenches, and repair tools.
- To develop an interaction system that allows users to pick up, use, and return tools realistically.
- To demonstrate an effective repair process through an interactive and realistic VR experience.

1.3.2.2 Software Programming

This project aimed:

- To develop the VR application using C# for high performance and efficient data handling.
- To ensure the software is compatible across multiple platforms such as Windows, macOS, and Android.
- To provide smooth navigation and user-friendly control for effective training.

1.3.2.3 Accessories & Finishing

This project aimed:

- To apply detailed textures, lighting, and surface effects for realistic VR visualization.
- To calibrate VR headset and controller setup for accurate tool handling.
- To ensure smooth motion tracking and stable visuals for an immersive learning experience.

1.4 PURPOSE OF PRODUCT

The purpose of this project is to develop a Virtual Reality (VR) training kit that helps aviation maintenance students understand and practice honeycomb structure repair in a safe, interactive, and affordable environment. This product is designed to replace limited hands-on training by providing a realistic 3D simulation where users can learn repair steps, use virtual tools, and build confidence before performing real aircraft repairs.

The VR kit aims to improve learning effectiveness, reduce training costs, and support self-paced practice for students, technicians, and engineers.

1.5 SCOPE OF PROJECT

1.5.1 General Project Scopes

This project is developed specifically for Aircraft Maintenance Engineering students to enhance their understanding of honeycomb structure repair through Virtual Reality (VR) simulation. The VR training kit focuses on one-face honeycomb panel repair, allowing users to learn detailed procedures and correct techniques interactively.

The system provides a realistic 3D environment where users can perform repair tasks using virtual tools and equipment that simulate real workshop conditions. The VR training is designed to focus only on essential functions and repair steps to ensure clarity, effectiveness, and safety during practice.

This application is compatible with standard VR hardware and aims to give students a practical learning experience that increases understanding, engagement, and confidence before performing actual repair work.

1.5.2 Specific Individual Scopes

1.5.2.1 Product Structure

This VR training module focuses on creating a detailed yet simplified 3D model of the honeycomb aircraft structure, including the cellular core, face sheets, and adhesive layers. The simulation aims to help students clearly understand the structure and repair process through accurate visualization. It also features an interactive repair sequence covering damage inspection, core removal, replacement, and bonding procedures. All models are optimized for smooth VR performance while maintaining realistic appearance.

1.5.2.2 Product Mechanisms

This project focuses on designing a virtual repair station that includes damaged panels, a work bench, and repair tools. Users can interact with the tools by picking up, using, and returning them as in real life. The simulation provides realistic repair steps such as cutting, cleaning, and patching, allowing students to practice safely in a virtual environment without using real aircraft parts.

1.5.2.3 Software Programming

This project uses C# as the main programming language to ensure efficiency, performance, and compatibility. The software will support cross-platform use on Windows, macOS, and Android systems. It will be designed with a user-friendly interface and modern programming techniques to provide smooth interaction, clear visuals, and compatibility with current VR technologies.

1.5.2.4 Accessories & Finishing

This section focuses on virtual accessories that enhance realism during honeycomb repair training. The system allows users to use tools such as sanding blocks, adhesive applicators, brushes, and heat blankets through VR hand controllers. These accessories help simulate real finishing processes, providing students with a more immersive and hands-on learning experience.

1.6 PROJECT IMPACT

This project helps students, technicians, and engineers to understand and perform honeycomb structure repairs more effectively through a safe and interactive virtual environment. The VR training kit reduces the need for real aircraft parts and tools, saving both time and cost. It allows users to repeat each repair step confidently and improves their understanding of the overall repair process. This project also lessens instructor workload by enabling self-paced learning and better knowledge retention among users.

CHAPTER 2

LITERATURE REVIEW

2.1 GENERAL LITERATURE REVIEW

2.1.1 Education Industry in Malaysia

Malaysia's higher education sector has experienced expansion and transformation in recent decades to meet the demands of both domestic and international students. Its landscape consists of public universities, private higher educational institutions, polytechnics, and community colleges within the purview of the Malaysian Qualifications Agency and specific legislation such as the Malaysian Qualifications Agency Act 2007.

This Malaysian educational agenda therefore focuses on skilled and knowledgeable graduates, lifelong learning, increased access, enhancement of the quality of teaching, and digitization of learning. Overall, they focus on national visions for excellence and knowledge-based growth.

In this context, there is an increasing demand for innovative educational technologies that provide interactive and practical training modalities. In such a scenario where the industry is moving toward industry-relevant skills and immersive learning, the development of tools like the VR Honeycomb Structure Repair Training Kit becomes highly relevant; hence, it bridges theoretical knowledge with hands-on learning in a system of education that strives for quality, efficiency, and relevance.

2.1.2 Demand for E-Learning

In the past, aviation training took place either in the classroom, in the shop with the aircraft, or by having a scheduled practice time at a training centre. In addition, this created challenges for people working on a schedule and those living a distance away. There was classroom lecture in class, reading from a textbook or other printed material, or being taught by another person.

The growth of technology and the development of e-learning is becoming more commonplace in aviation learning and teaching, which allows a student and a trainee to learn whenever they want, and from wherever they want. This is beneficial for many individuals learning aviation subjects to fit their studies around shift work. Many aviation students can take countless courses using videos along with interactive, 3D modelling or virtual reality on their training, like aircraft maintenance training, safety check and function of systems.

Although, there are still persons that prefer classroom-based learning, many people prefer online learning because it is cheaper, easier to access, and they know they will be getting the most updated information. The resurgence of the aviation industry has created a greater need for training that is available all of the time. E-learning can help reduce the learning or training gaps by providing practical useable, contemporary, flexible training to all. According to [1], e-learning helps people access quality education more easily and supports long-term learning for industries that need constant skill updates, such as aviation.

2.1.3 Types of Training Kits and Programs for Aircraft Composite Repair

1. Heatcon – Offers hands-on composite repair training that focuses on real-world repair processes using professional-grade tools and materials, such as hot bonders, vacuum bagging systems, and curing equipment. Students learn to prepare surfaces, apply patch repairs, and carry out heat-controlled curing under supervision.

2. ACRATS – Provides professional aviation composite repair toolkits for replicating the complete setup of a workshop for certified technicians. The kits include cutting, sanding, and inspection tools, with specialized items such as adhesive films, honeycomb cores, and vacuum systems.

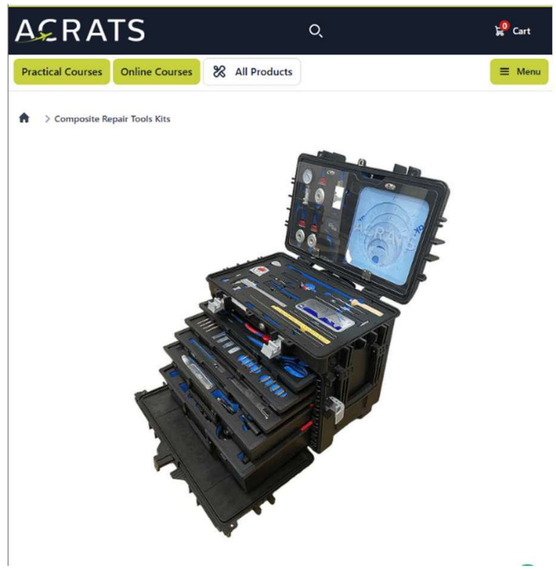


Figure 3: ACRATS Premium aviation composite repair learning tool.

3. CES Composite – Provides composite repair materials and customized training kits used in hands-on workshops and certification courses. Systems developed by the company focus on resin handling, lamination, and structural restoration in aerospace and automotive composites.
4. EASA – Conducts certified composite materials and inspection training, ensuring participants reach the European regulatory standard for maintenance and safety. Such programs typically consist of theory lessons and guided hands-on repair exercises.
5. Sofema Aviation (SASSOFIA) – Provides online courses on composite material principles, repair inspection methods, and tap testing procedures; the theoretical and regulatory elements of those are emphasized in these classes.
6. SAE AIR 6671 – It establishes standardized training guidelines for composite maintenance technicians by stipulating the level of competency and knowledge that is required for certification.

2.1.4 Evolution of Digital Learning in Aviation Industry

Digital learning has come as a revolutionizing agent in the aviation industry, bringing advantages in training delivery and effectiveness. Convenience is its biggest plus point, allowing aviation personnel in the shape of pilots, maintenance engineers, or cabin staff to learn from any place. This convenience factor is most important in an industry that operates internationally with personnel often working from disparate locations. Online training also enables standardized training content. Virtual reality (VR) some of the technologies that enable realistic and immersive environments for training, which are optimally designed for complicated procedures at no risk of real aircraft.

2.1.5 Honeycomb Structure

Honeycomb structures are widely recognized in engineering for their exceptional combination of lightweight design and high mechanical strength. They generally consist of a thin outer layer, also known as the face sheet or skin, bonded to a low-density inner core composed of hexagonally shaped cells. Such a structure enables it to have a high stiffness-to-weight ratio, hence appropriate for various applications where strength and weight reduction are critical.

According to Holley (2013), the honeycomb form effectively distributes stress and provides rigidity without excess mass, reflecting the same structural logic as it would appear in nature, like beehives [2]. NASA (2016) further elucidates that honeycomb composite materials can be manufactured by using aluminum, Nomex, fiberglass, or carbon fiber core based on the desired property, whether flexibility, strength, or resistance to heat [3]. The performance of such structures in the distribution of load, damping of vibrations, and absorption of energy is excellent, and hence they are of great importance in aerospace and other high-performance industries.

In aircraft, honeycomb structures are used in the manufacture of fuselage panels, wings, floorboards, and control surfaces. Their light yet strong features contribute to weight reduction in aircraft for fuel efficiency, while structural integrity is maintained under dynamic flight loads. According to Peyman (2025), composite materials such as carbon fiber with honeycomb core have increasingly been adopted in the aerospace industry from traditional metal structures due to their superior mechanical properties and resistance to corrosion [4]. These materials not only bring better performance but also reduce costs related to maintenance and prolong service life. Given their importance in modern aircraft design, understanding honeycomb structures is essential for maintenance engineers and students in the aviation field, as it forms a very critical foundation for effective repair, inspection, and assessment of structural integrity.

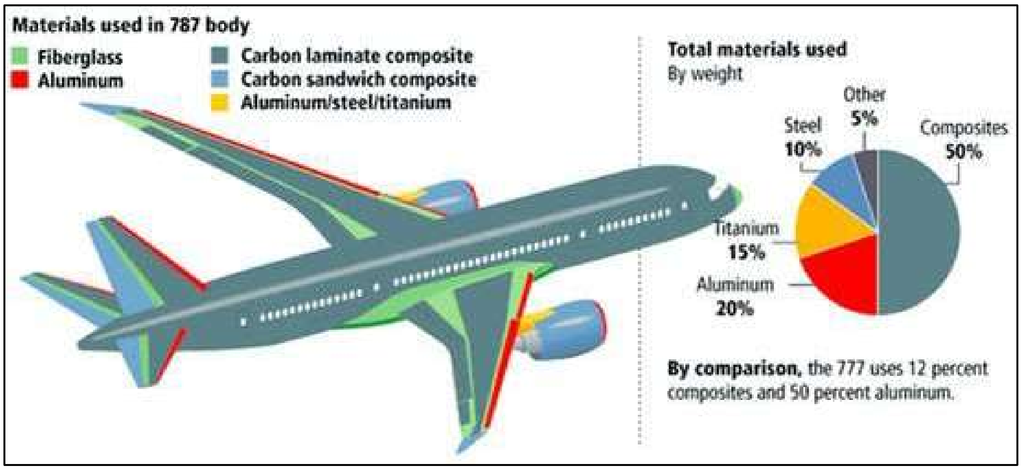


Figure 4: Material Composition of Boeing 787 Aircraft structure.

Composite materials, especially honeycomb sandwich configurations, are indispensable in the creation of lightweight and high-strength aircraft in modern aerospace design. The Boeing 787 Dreamliner is one such aircraft, with a higher percentage of composite materials in its main structure and fuselage than any of its forerunner Boeing aircraft models. As illustrated in Figure 2.1, about 80% of the structure of the Boeing 787 is made up of composites by volume, while by weight, the aircraft is made up of 50% composites, 20% aluminum, 15% titanium, 10% steel, and 5% others. This apportionment reflects the engineering shift of Boeing toward carbon fiber-reinforced plastics and honeycomb composites that significantly reduce weight and improve structural performance. Compared to conventionally designed aircraft using aluminum, the composite structure of the 787 achieves an average weight reduction of about 20%, thereby providing greater fuel efficiency with reduced maintenance.

2.2 SPECIFIC LITERATURE REVIEW

2.2.1 Product Structure

Honeycomb sandwich composites have become crucial in modern aerospace applications due to their exceptional strength-to-weight characteristics. These structures, composed of a cellular core laminated between high-strength face sheets, are considerably utilized in aircraft control surfaces, interior panels, and structural fairings. The complex nature of these components makes necessary precise maintenance protocols, making them ideal prospect for virtual reality training simulations. Recent studies (Zhao et al., 2023) demonstrate that accurate digital representation of honeycomb microarchitecture notably increase the transfer of repair skills from virtual to physical environments, especially in understanding the failure modes and repair boundaries.

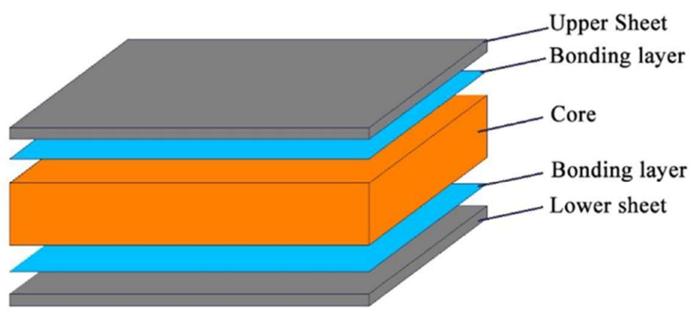


Figure 5: Formation of Sandwich Structure

The development of effective VR training systems recommends careful balance between structural integrity and computational efficiency. Modern game engines like Unity and Unreal Engine enable the creation of interactive 3D models that maintain necessary detail for educational purposes while remaining high-performances on consumer-grade VR hardware. Industry reports (TeamViewer, 2023) indicate that such optimized digital twins improve spatial comprehension and procedural memory formation, bridging the gap between theoretical knowledge and practical application. This is particularly valuable in aviation maintenance training, where access to actual aircraft components for hands-on practice is often limited.

Scholarly research in technical education suggests that strategic simplification of complex structures further improve the quality of the learning outcomes. As demonstrated by Steantycip (2023), selectively focus on damage zones while maintaining overall structural context allows trainees to focus on critical repair areas without cognitive overload. This approach aligns with the cognitive load theory in educational psychology, where organized information delivery improves skill acquisition. In the context of honeycomb repair training, this means modelling complete detail to convey material behaviour during repair processes while leaving out non-essential visual elements.

The effectiveness of VR training is further enhanced when structural models are designed for targeted interaction. Historical research from Sandia National Laboratories (1999) on non-destructive testing simulations established that zone-specific interactivity remarkably improves procedural learning. For honeycomb repair applications, this translates to modelling segmented interaction areas that permit realistic simulation of core removal, surface preparation, and adhesive bonding processes. Such an approach not only mirrors actual maintenance workflows but also enables progressive skill development through modular training exercises.

2.2.2 Product Mechanisms

Virtual Reality (VR) is a new training method for students in aircraft honeycomb structure repair. Our VR Honeycomb Repair Structure Training Kit provides students the ability to experience the repair steps in a virtual world. When a student wears a VR headset, they enter a 3D virtual workshop that looks like a real aircraft maintenance environment.

In the VR, the students will see honeycomb panels, tools and workbench. Everything in VR looks real. The students use VR handheld controllers or gloves to touch and manipulate the tools, just like in reality. They can follow the process by performing each step, when they are cutting the damaged area, cleaning it, applying the repair parts and completing the repair. Some VR systems even provide small vibrations in the hand when the students are using the tools to give a better experience.

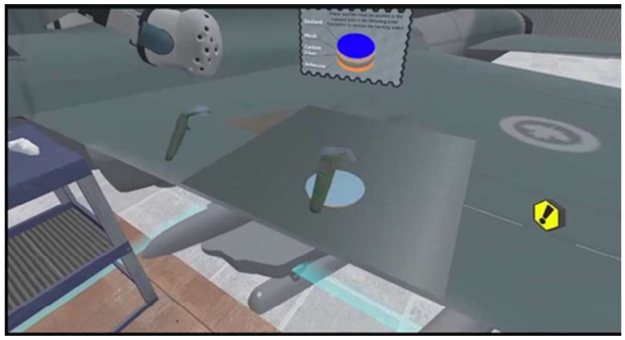


Figure 6: Product Mechanism Illustration

The VR kit utilizes intelligent software to control everything. The software controls the tools and panels to function similar to how they would in the real world. If a student makes an error, the VR will show the outcome so the student can learn then try again. The system can also display different damage and types of repairs. The training kit also provides clear support when a student is practicing. The students will get simple edit pop up messages of short text or prompts to assist them. The system observes each student's progress and assists them to learn step by step. When a student makes a mistake, then system will demonstrate how to correct it. In summary, our training kit provides all students an enjoyable, safe, and realistic way to experiment with honeycomb structure repairs, before being put into a real situation.

2.2.3 Software / Programming

In the field of virtual reality (VR) development, Unity Engine is a game development engine used to make interactive 2D & 3D content as well as virtual reality (VR) and augmented reality (AR) content. Unity was originally made for video game development but has turned into a broadly used engine that developers use for all types of industries like aviation, architecture, automotive, healthcare, education, and many more.

Figure 7: Unity Engines Company

Unity is highly regarded in VR Training and Simulation, because of its easy-to-use interface for developers, cross-platform compatibility, and a very large library of assets and tools. Developers can build realistic environments, animated characters, and physics-based interaction for training applications like the VR Honeycomb Repair Kit in order to provide functionality to be simulated.

It has primary support for C#, a powerful and beginner-oriented language nowadays unlike its other variants that make studying/creating complex simulations quite easier for students/developers. Unity has a physics engine and rendering tools that allow simulation of realistic motions/ visual effects with the inbuilt features of Unity.

In addition, Unity is compatible with a wide range of VR hardware including Oculus Quest, HTC Vive, and so on, with great ease of use for integrating hand tracking, motion controllers, and full-body tracking for VR learning experiences that require immersion and interactivity.

In conclusion, Unity Engine provides the best platform to develop aviation studies interactive training applications because of the flexibility, ease of use, and the excellent virtual reality support. Accessories and Finishing

In VR honeycomb structure repair, the one face and two face repairs are presented with flawless precision, providing trainees and students with conditions strongly resembling real-world repair of honeycomb structure. This level of detail and interactivity enhances the level of training effectiveness and realism, providing a complete package for learning.

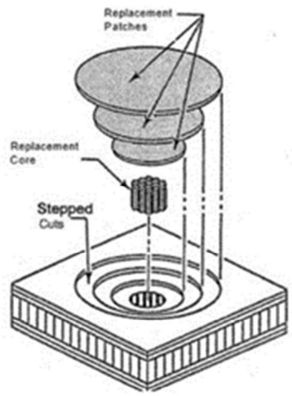


Figure 8: One face honeycomb repair.

One Face Repair: One-face honeycomb structure repair is a specialized technique commonly used in aircraft composite maintenance when damage is limited to one side of the structure and access to the opposite face is restricted. These sandwich panels, which consist of a lightweight honeycomb core bonded between two thin face sheets.

Their precise design and interactive nature of such devices in VR honeycomb structure repair, the training process is significantly enriched. By providing a realistic and immersive environment, these structure repair enable trainees to develop the skills, and confidence had to perform the practical repair safely and effectively. The integration of these accurate accessories and finishing touches in VR systems emphasize the importance of precision and realism in aviation training.

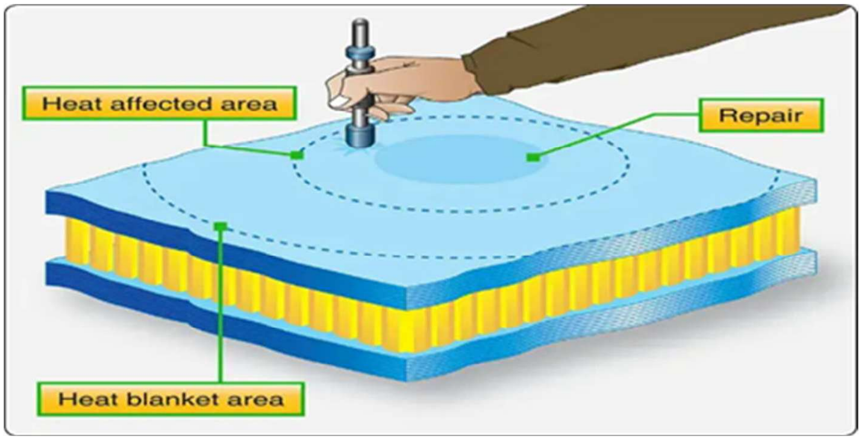


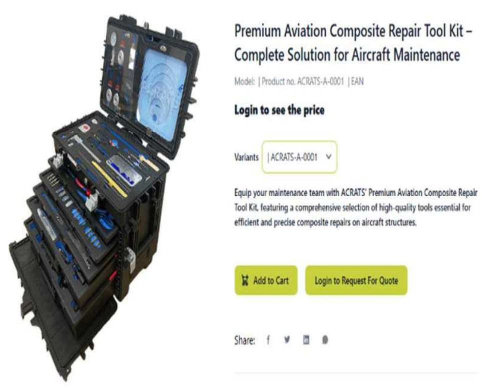
Figure 9: Accessories & Finishing Honeycomb Structure Repair

Aside from these visual representations, other VR accessories and finishes, such as dialogue box, users will be guided step by step, interactively by means of a tutorial. Each of the steps in the repair is performed correctly in the proper order by the system. It begins with the identification of the damaged area of the honeycomb panel. The dialogue box then instructs the user to proceed and cut damaged face sheet, clean the exposed core, trim the core, add adhesive film, and insert the replacement honeycomb core material in place exactly. This virtual training environment enhances learning by being fully interactive, allowing users to engage directly with tools, materials, and procedures. Real-time feedback, tips, and correctional guidance provided through the dialogue box make it a safe and effective digital platform to repair honeycomb structure with confidence.

2.3 REVIEW OF RECENT RESEARCH PRODUCT

2.3.1 Recent Market Product

Table 1: Recent Market Product

No.	Marketed Product	Patent Summary
1.	Figure 10: Heatcon composite repair system	Product Name: Heatcon Composite Repair System Date Published: 2018 Inventors: Heatcon Composite Systems, Seattle, USA Description: The course provides hands-on composite repair training using professional-grade equipment such as hot bonders, vacuum bagging systems, and curing devices. It is designed for technicians to practice precise composite repair operations in real environments.
2.	 Figure 11: ACRATS Premium Composite repair toolkit	Product Name: ACRATS Premium Composite Repair Toolkit Published Date: 2021 Inventors: ACRATS B.V., Netherlands Description: Professional composite repair kit with complete sets of specialized cutting and sanding tools, and inspection equipment for aircraft composite maintenance training. Made from high-quality, aviation-standard materials, this is mainly intended for technician certification courses and professional training in composite repair.

3.	 Figure 12: CES Composite tools & training course	Product Name: CES Composite Tool & Training Course Published Date: 2019 Inventors: Composite Repair Kit Description: Provides complete sets for composite repair training, comprising resin systems, carbon fiber laminates, and honeycomb panels. Used in aerospace and automotive education; physical kit requires material replenishment and supervision by certified instructors.
4.	 Figure 13: EASA Composite Maintenance Training Program	Product Name: EASA Composite Maintenance Training Program Published Date: 2020 Inventors: European Aviation Safety Agency (EASA) Description: Official training and certification program for composite materials, including theory and guided hands-on exercises in accordance with European safety standards. Available only within an authorized training center, places great emphasis on safety and standardization rather than accessibility.

2.4 COMPARISON BETWEEN RECENT MARKET AND OUR CURRENT PROJECT

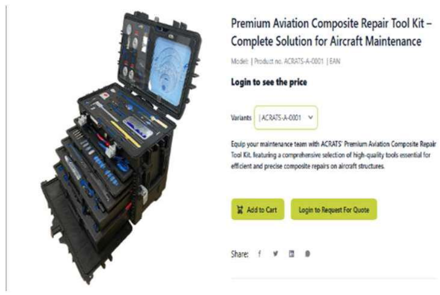
2.4.1 Product A VS. Our Product

Table 2: Product A vs. Our Product

Product	**Heatcon Composite Repair**	**VR Honeycomb Structure Repair Training Kit**
Design	ABARIS TRAINING	
Purpose	Provides hands-on composite repair training using industrial-grade hot bonders, vacuum bagging systems, and curing techniques.	Offers virtual simulation for educational and training purposes in honeycomb structure repair without the use of physical materials.
Features	Features Includes professional repair tools, temperature controllers, vacuum pumps, and composite layup materials for real repair tasks	Provides VR-based interaction, narration-guided steps, and progress tracking through an immersive, gamified environment
Target	Certified composite repair technicians and industry professional	MRO students and trainees
Platform	Physical setup and on-site workshops	Virtual Reality (Unity Engine, HTC Vive Cosmos)

2.4.2 Product B VS. Our Product

Table 3: Product B vs. Our Product

Product	ACRATS	VR Honeycomb Structure Repair Training Kit
Design		
Purpose	Provides professional-grade repair toolkits and certification-level training for aircraft composite maintenance.	Provides a digital simulation environment to practice the steps of composite repair safely and cost-effectively for students.
Features	High-quality tools are included, such as vacuum bagging systems, adhesives, and inspection kits for certified repair training	Includes virtual tool interaction, visual repair guidance, narration audio, and progress indicators within VR.
Target	Licensed technicians and aerospace maintenance facilities	MRO students and trainees
Platform	Physical toolkits with instructor-led workshops	Virtual Reality (Unity Engine, HTC Vive Cosmos)

2.4.3 Product C VS. Our Product

Table 4: Product C vs. Our Product

Product	CES Composites	VR Honeycomb Structure Repair Training Kit
Design		
Purpose	Supplies materials and training kits to teach hands-on composite repair processes.	Simulates the composite repair process in a fully virtual learning environment.
Features	Features Real composite sheets, resin systems, and mechanical tools for physical practice	Digital workbench tools, interactive repair sequences, and learning narration provide step-by-step training.
Target	Target institutions conducting physical repair practice sessions	MRO students and trainees
Platform	Physical equipment and classroom-based training	Virtual Reality (Unity Engine, HTC Vive Cosmos)

2.4.4 Product D VS Our Product

Table 5: Product D vs. Our Product

Product	**EASA Composite Material Training Course**	**VR Honeycomb Structure Repair Training Kit**
Design		
Purpose	Provides training in the regulatory and theoretical aspects of composite material inspection and repair standards	Provides a practical, hands-on simulation to understand composite repair steps in an educational setting.
Features	Features Focuses on classroom lectures, standards for certification, and review of documentation.	Interactive VR simulation in real-time feedback, audio guidance, and visual cues while learning.
Target	Certified aviation maintenance technicians seeking EASA qualifications	MRO students and trainees
Platform	Online and classroom-based learning	Virtual Reality (Unity Engine, HTC Vive Cosmos)

CHAPTER 3

RESEARCH METHODOLOGY

3.1 PROJECT BRIEFING AND RISK ASSESMENT

3.1.1 Utilization Of Polytechnic's Facilities

The facilities of the Polytechnic, in particular its Wi-Fi infrastructure and the flight instrument, were extremely important contributors to the successful creation of our educational application. Through the efficient utilization of these resources, we were able to maximize our productivity, our ability to collaborate, and our access to many important tools and information. In light of this experience, it is clear that it is essential to make effective use of institutional resources in order to maximize the results of projects and improve educational opportunities.

3.1.2 Overall Project Gantt Chart

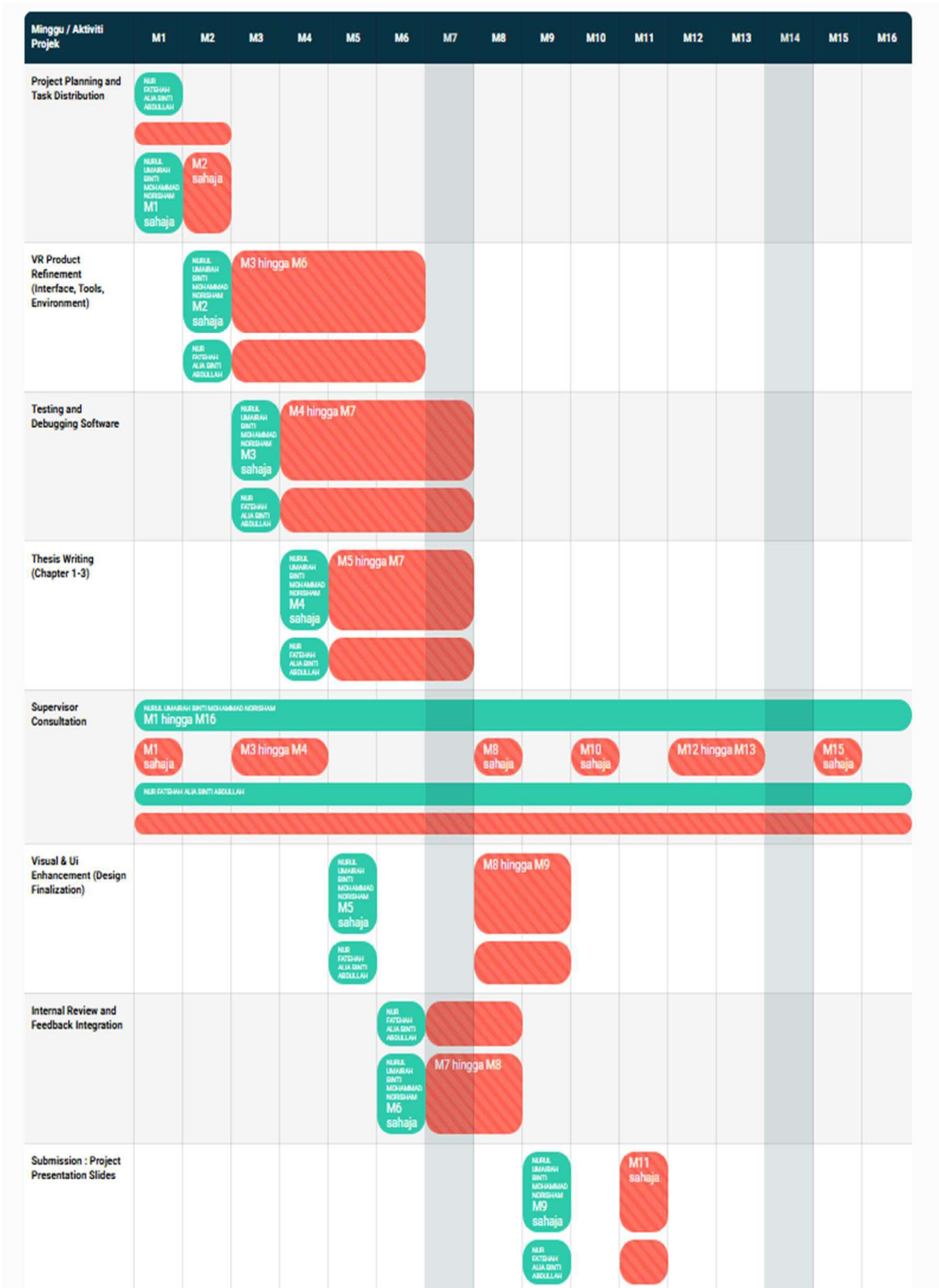


Figure 14: Overall Gantt Chart (1)

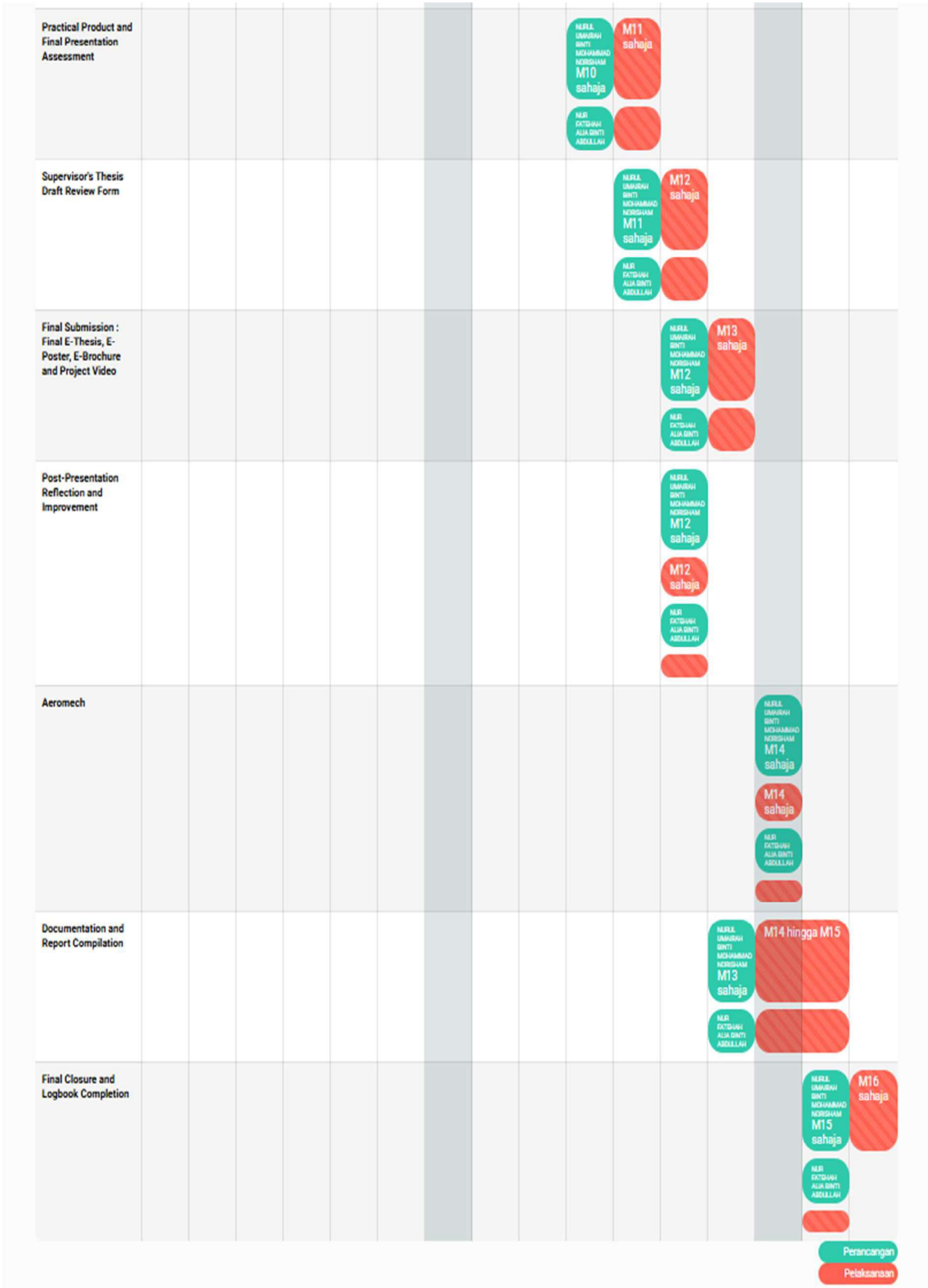


Figure 15: Overall Gantt Chart (2)

3.2 PROJECT FLOW CHART

3.2.1 Overall Project Flow Chart

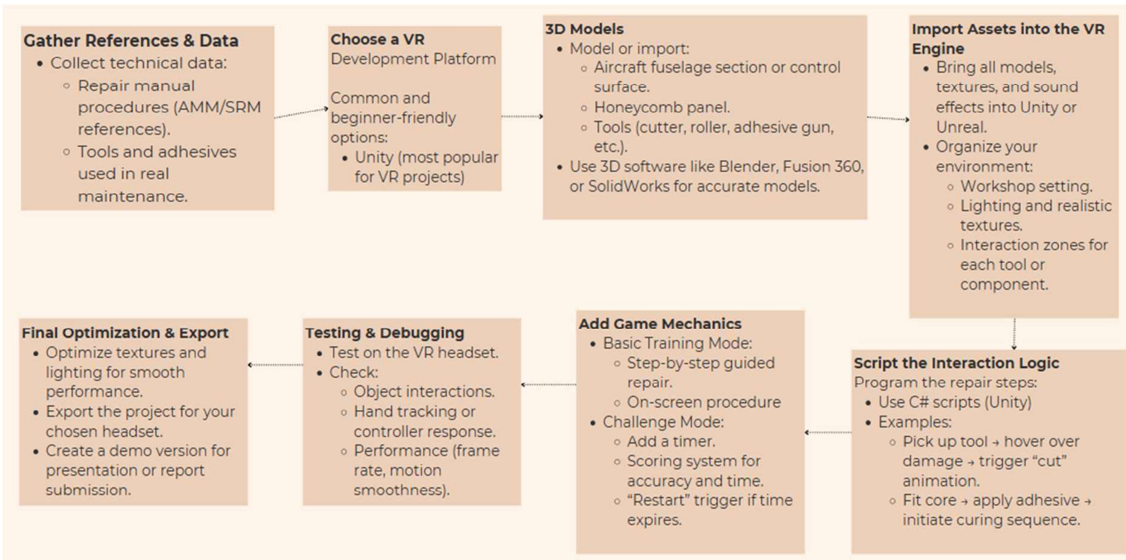


Figure 16: Overall Project Flow Chart

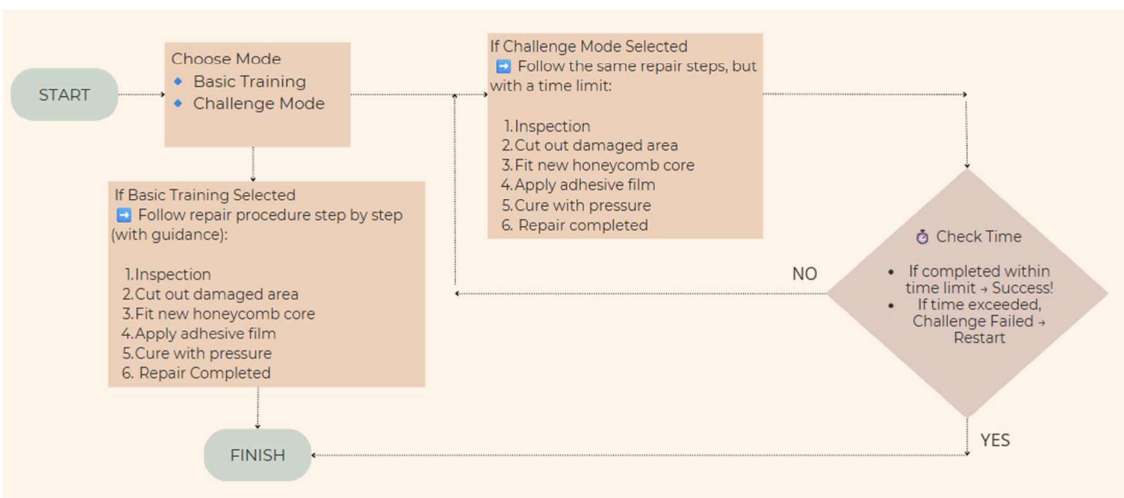


Figure 17: Overall Project Flow Chart (2)

3.2.2 Specific Project Design Flow / Framework

3.2.2.1 Product Structure

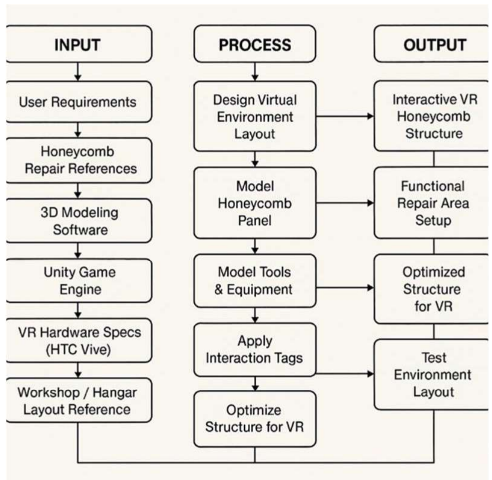


Figure 18: Product Structures Flow Chart

3.2.2.2 Product Mechanisms

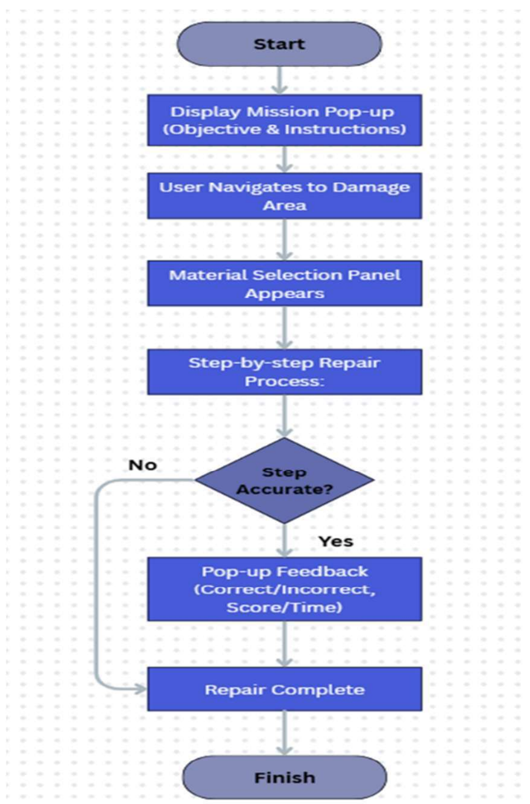


Figure 19: Product Mechanisms Flow Chart

3.2.2.3 Software/ Programming

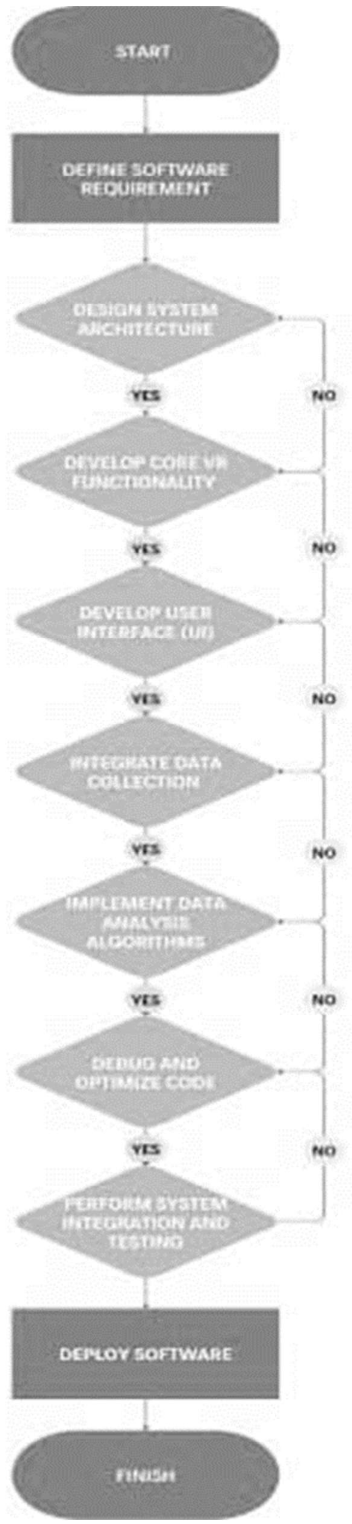


Figure 20: Software / Programming Flow Chart

3.2.2.4 Accessories & Finishing

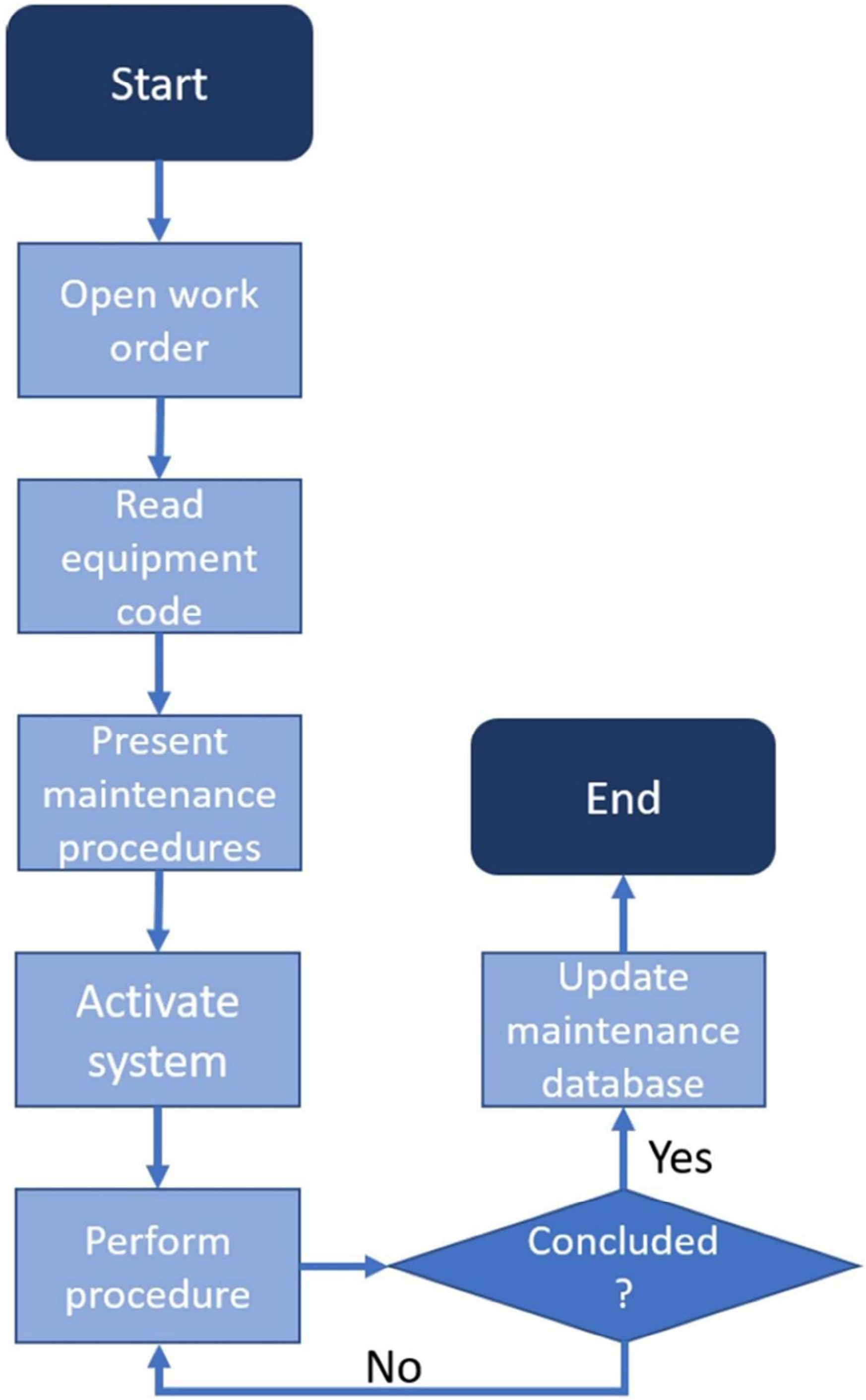


Figure 21: Accessories & Finishing Flow Chart

3.3 DESIGN ENGINEERING TOOL

3.3.1 Design Requirement Analysis

3.3.1.1 Questionnaire Survey

A. Knowledge respondents about honeycomb structures repair.

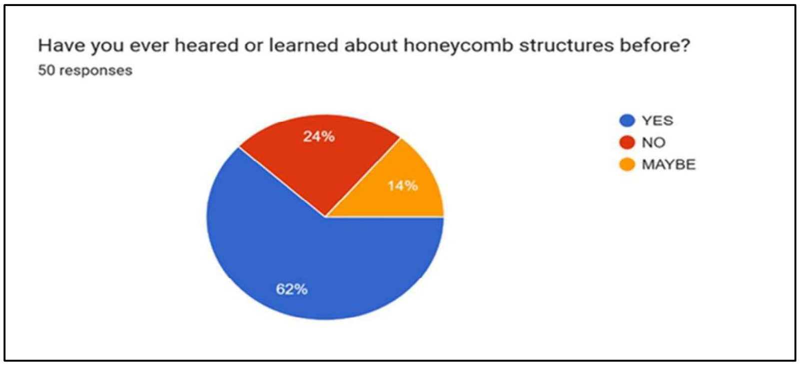


Figure 22: Respondent that heard and learned about honeycomb structure.

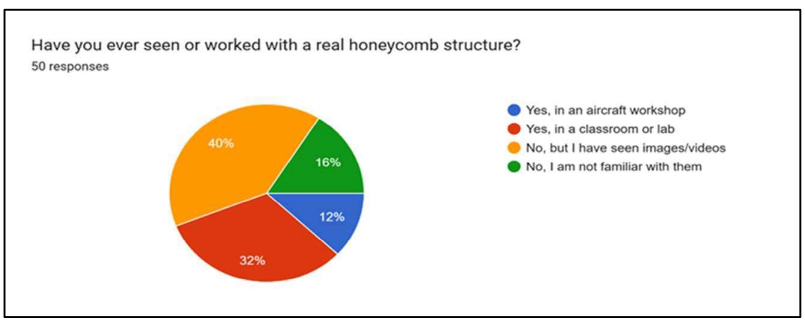


Figure 23: Respondent that seen/worked with real honeycomb structure.

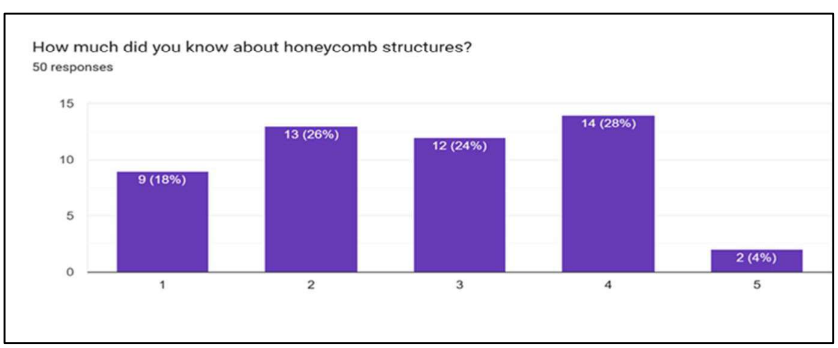


Figure 24 : Respondent that seen/worked with real honeycomb structure.

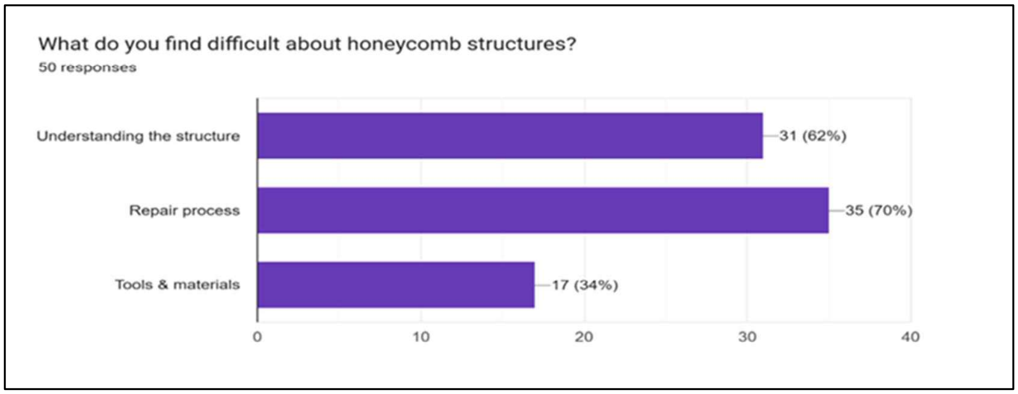


Figure 25 : Respondent difficulties on honeycomb structure.

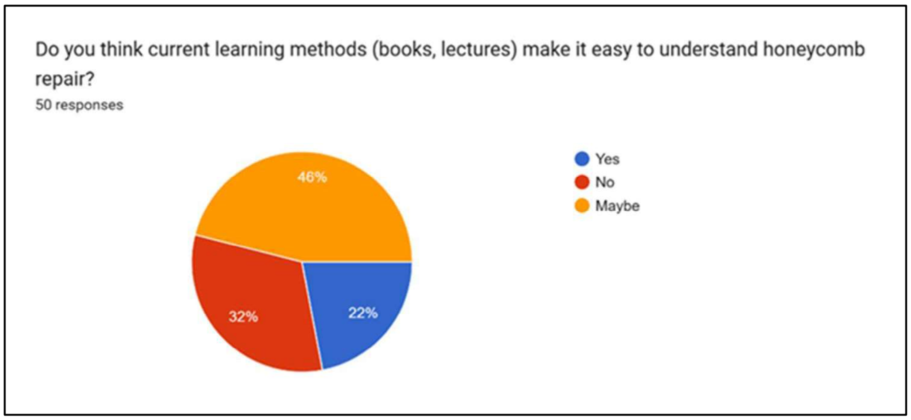


Figure 26 : Respondent understanding using book/lectures method.

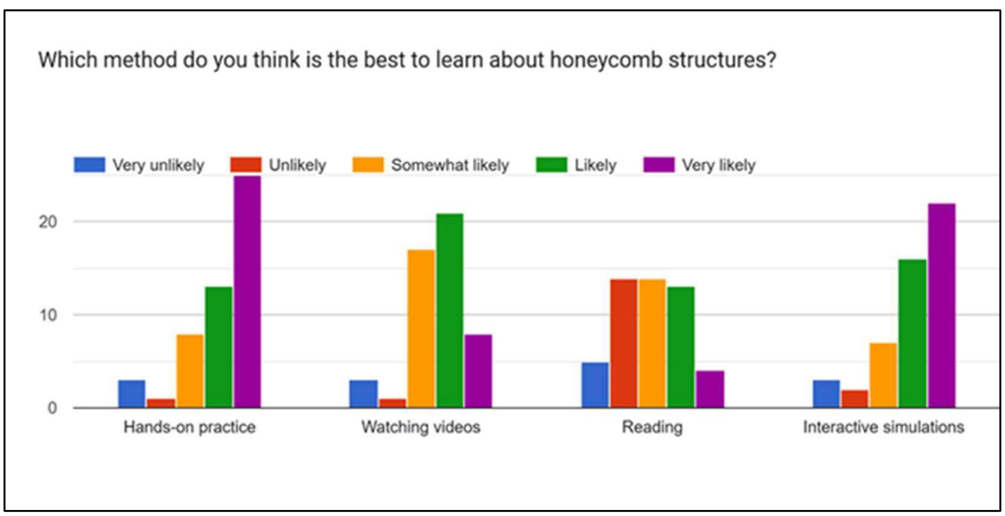


Figure 27 : Respondent best method to learn honeycomb structure repair.

B. Knowledge respondents about VR in honeycomb structure repairs.

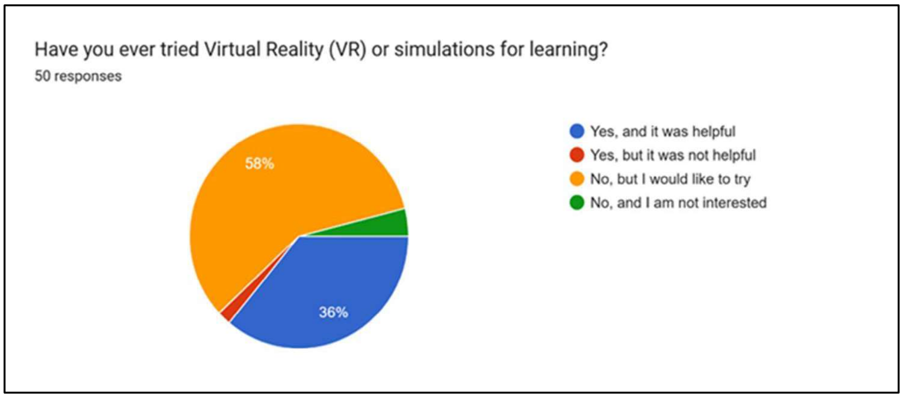


Figure 28 : Respondent experience on VR/Simulations for learning.

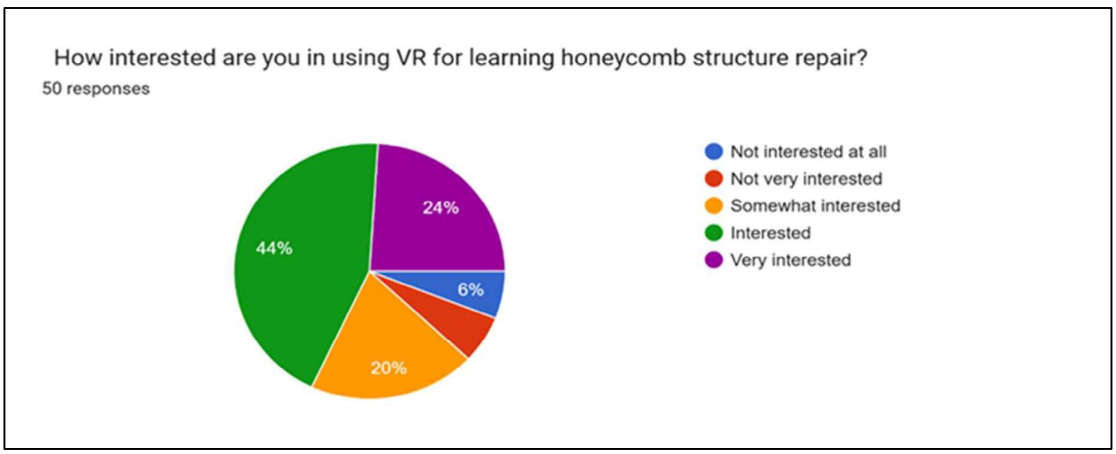


Figure 29 : Respondent interested in using VR.

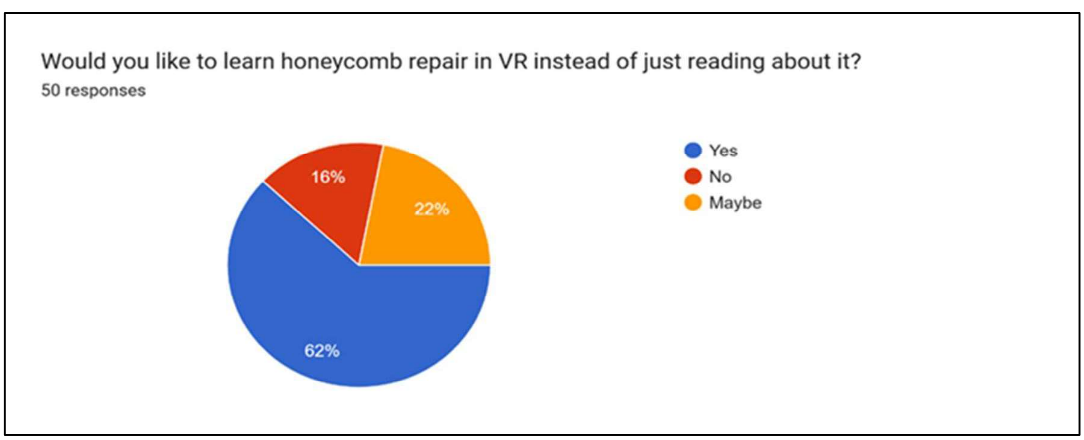


Figure 30 : Respondent interest in learning honeycomb structure instead just reading.

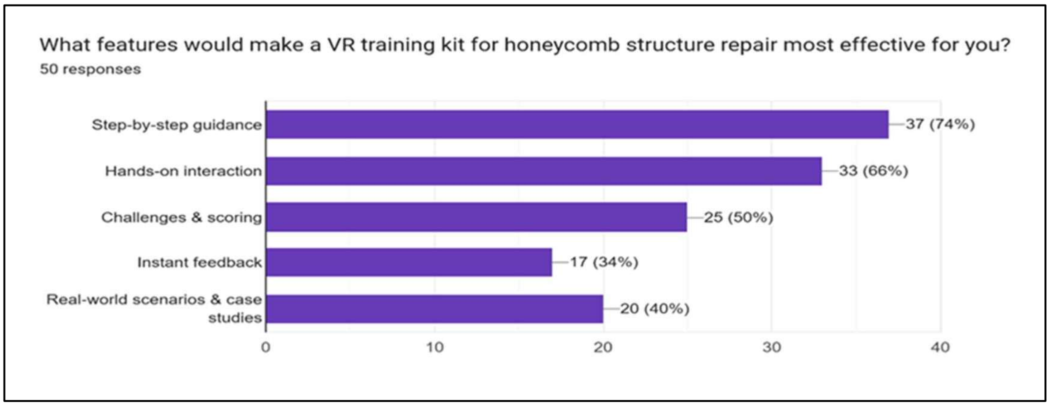


Figure 31 : Respondent most effective feature would make in VR.

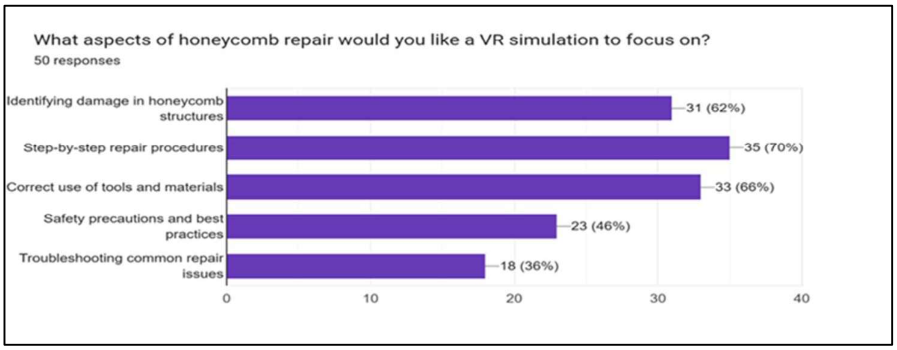


Figure 32 : Respondent aspect needs to focus on in VR simulation.

C. Product Improvement

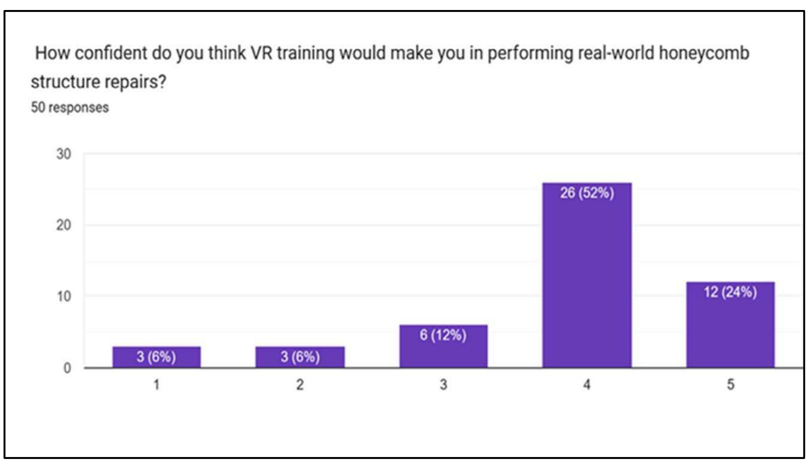


Figure 33 : Respondent confident on VR training performing in real world.

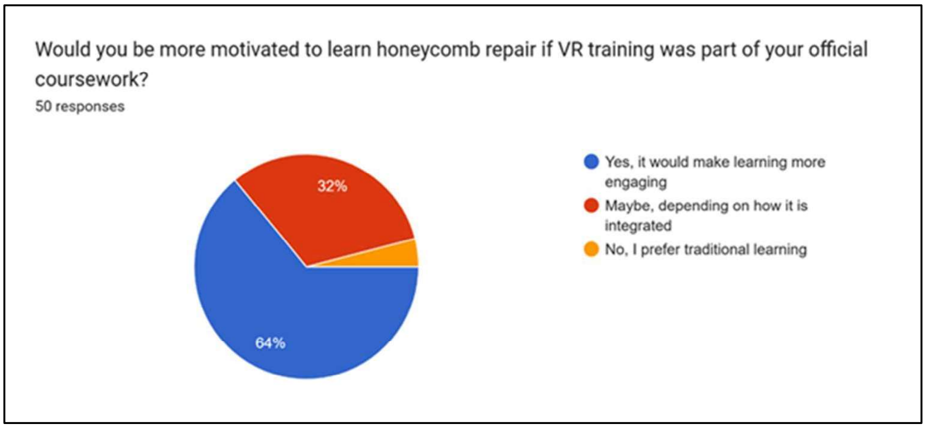


Figure 34 : Respondent motivation in learning VR in official coursework.

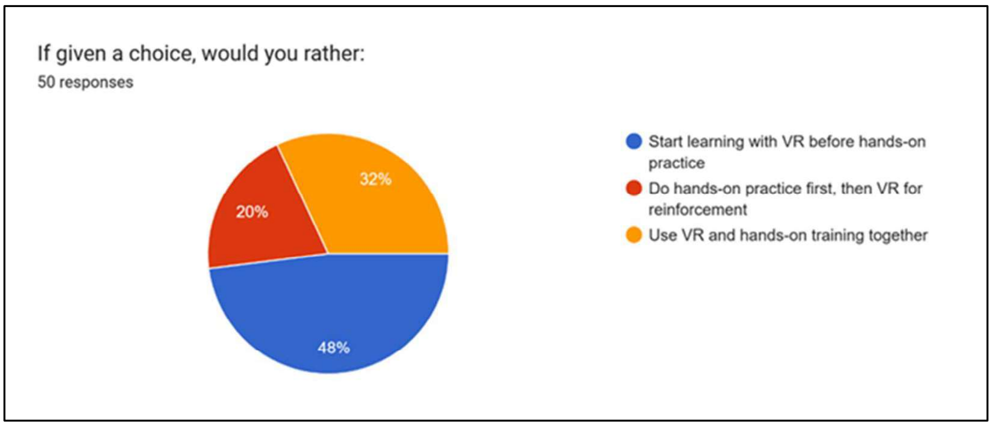


Figure 35 : Respondent choice in learning VR on honeycomb repair.

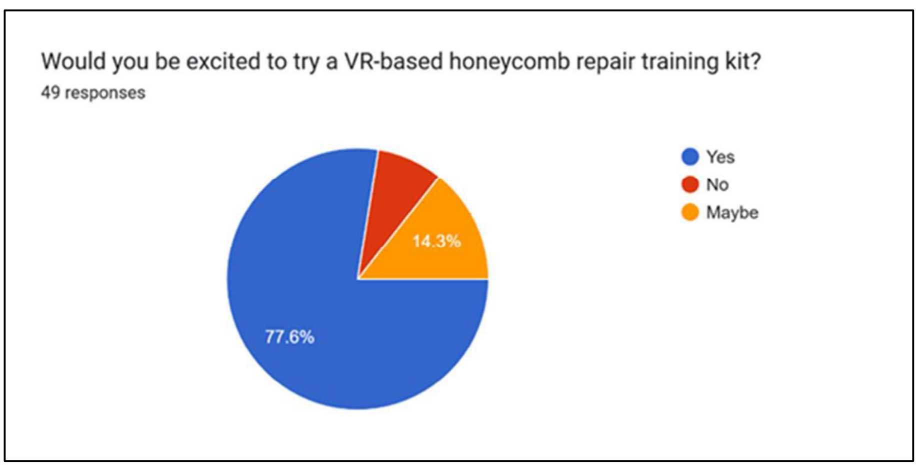


Figure 36 : Respondent excitement to try VR based honeycomb repair.

3.3.1.2 Pareto Diagram

Table 6: Pareto Data Features VR

Features VR	Total Method	Total Percentage	Cumulative Percentage	Pareto Baseline
Repair process	35	70%	70%	80%
Understanding the structure	31	62%	92%	80%
Tools and materials	17	34%	100%	80%

The Pareto analysis table means that the relative importance of the components of the virtual reality training module has been identified. The feature "Repair process" is clearly the most important, with 35 methods contributing to 70%. While this total does not fully meet the traditional 80% Pareto baseline, which accounts for all the other issues, it clearly demonstrates the most significant focus editor and should be reacted to first in development of the virtual reality (VR) software. The second most important feature (relating to the "Repair process") is "Understanding the structure," which contains 31 methods, and contributes to a total impact of 62%. Systematically these two features provided and cumulative percentage of 92%, enough to identify that how the training module might address the bulk of user needs and training effectiveness. The last feature "Tools and materials," had a total of 17 methods, and a total contribution of 34%, making the cumulative total equal to a 100%. The tools and materials, while important for the completeness of the training, clearly have a lesser impact and can be considered of lesser priority. Overall, the Pareto analysis confirms that the focus of the virtual reality would generate the most user benefit and value is consistently on the repair process and understanding the structure. It is important to note that an important project proposal goal was to develop a high impact virtual reality solution that met user requirements. In this case clearly training purpose was the most likely to generate high value.

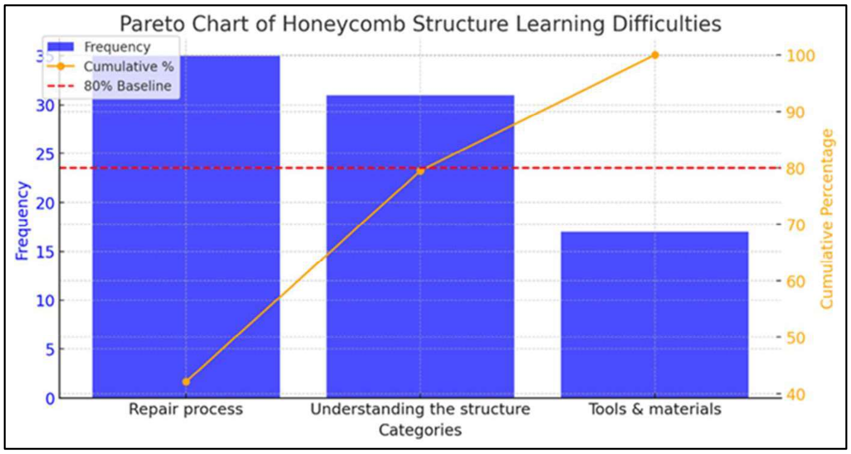


Figure 37 : Pareto Chart of Honeycomb Structure Learning Difficulties

The Pareto chart depicting honeycomb structures learning difficulties affords an overview of primary learning challenges that users experience when working with VR-based training. The chart presents three major classifications of challenges: Repair Process, Understanding the Structure, and Tools & Materials. The blue bars denote the frequency rates of each difficulty where Repair Process demonstrated the highest frequency followed by Understanding the Structure with Tools & Materials being least frequent. The orange cumulative percentage line increased rapidly after the last two categories ending at 92%- well above the Pareto baseline of 80% marked in the chart as a red dashed line. This indicates that the majority of user learning difficulties are found within the first two obstacles, Repair Process and Understanding the Structure, meaning by focusing on these two features of the VR training module, the researcher would be addressing where most user learning challenges occur. The Tools & Materials, while not totally insignificant, does not warrant a high prominence, as there are less than half of the participants (101 of 244) identified this as an obstacle and would likely be a lower priority. So overall, the chart reassures the researcher that improving user comprehension of the structurally related repair process and structural concepts will significantly improve the VR training experience.

3.3.2 Design Concept Generation

3.3.2.1 Function Tree

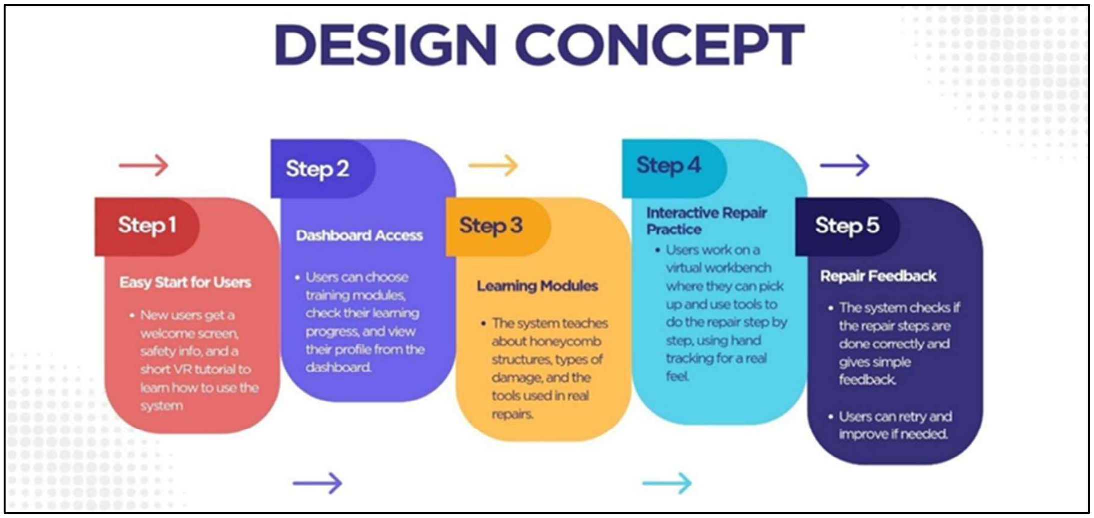


Figure 38 : Function Tree

The VR Honeycomb Repair Training Kit provides users with an immersive, hands-on experience of honeycomb structure repairs in virtual reality simulation. The training experience is functionally equivalent to working on real aircraft components using realistic tools and images. Users will be provided with clear, step-by-step instructions on how to go through every aspect of the honeycomb structure repair process. Users have the opportunity to repeat procedures as many times as they like and receive basic feedback to determine what they did correctly and what needs improving.

The training kit can be used with a wide variety of VR headsets and computers, as well as mobile devices. The menu is simple to navigate for users to find and select training lessons to use. The VR Honeycomb Repair Training Kit allows the user to participate in learning modules and repair simulations that can be both effective in learning and improving repair skills.

It is particularly beneficial for aviation training schools with already defined training standards, allowing students to practice repair techniques they would use in the real world in a safe and cost-effective manner using reusable virtual reality components instead of expensive aircraft parts.

3.3.2.2 Morphological Matrix

Table 7 : Morphological Matrix

FUNCTION (SUB-FUNCTION)	UMAIRAH IDEA 1	FATEHAH IDEA 2	CHUNG IDEA 3	FARHAN IDEA 4
TYPE	Game-Based Training 	Explore 	Explore & Game 	Game 
PROGRAMMING LANGUAGE	C#	C#	C#	C++
SOFTWARE	Unity	Unity	Unity	Unreal Engine
HARDWARE	Oculus Quest 2 (Meta Quest 2) 	Oculus Quest 2 	HTC VIVE Pro 	Motion Controller 
INTERACTION	Hand Tracking + Motion Controllers 	Hand Movement 	Hand movement 	Full body tracking 

3.3.2.3 Proposed Design Concept 1

Table 8 : Design Concept 1

FUNCTION	CONCEPT 1	JUSTIFICATION
TYPE	Game-Based training	Gamification keeps students interested by making learning lively and engaging.
PROGRAMMING LANGUAGE	C#	Compared to C++, C# is simpler, works better with Unity, and offers lots of free tutorials for beginners.
SOFTWARE	Unity	Compared to Unreal Engine, Unity can be more cost-effective, has plenty of free resources, and is less difficult to learn.
HARDWARE	Oculus Quest 2 (Meta Quest 2)	Wireless, reasonably priced (about MYR 1500), and with the ability of hand tracking without the need for additional sensors
INTERACTION	Hand Tracking + Motion Controllers	Makes training more realistic by letting students to interact, grab, and fix things naturally in virtual reality.

3.3.2.4 Proposed Design Concept 2

Table 9 : Design Concept 2

FUNCTION	CONCEPT 2	JUSTIFICATION
TYPE	Explore	Encourages users to freely explore and interact, enhancing engagement and learning.
PROGRAMMING LANGUAGE	C#	A powerful programming language known for high performance, commonly used in game and VR development.
SOFTWARE	Unity	Unity is a versatile game engine that supports VR development, providing tools and resources for interactive experiences.
HARDWARE	Oculus Quest 2	A standalone VR headset with built-in tracking, offering a wireless and immersive experience.
INTERACTION	Hand movement	Users can interact using hand tracking, allowing for a more natural and immersive experience.

3.3.2.5 Proposed Design Concept 3

Table 10 : Design Concept 3

FUNCTION	CONCEPT 3	JUSTIFICATION
TYPE	Explore and Game	Explore and interact with objects, locations, and scenarios from a first-person perspective with adding games that can be highly interactive, involving movement, decision-making, and problem-solving.
PROGRAMMING LANGUAGE	C#	Is a modern, object-oriented programming language developed by Microsoft, widely used across various domains.
SOFTWARE	Unity	Unity provides a user-friendly interface, a strong physics engine, and cross-platform compatibility,
HARDWARE	HTC VIVE Pro 2	Designed for professional applications, including simulation training, engineering, and gaming. It offers high-resolution displays, precise tracking, and ergonomic comfort,
INTERACTION	Hand movement	Allows users to grab, manipulate, press, and interact with virtual objects using controllers or hand tracking.

3.3.2.6 Proposed Design Concept 4

Table 11 : Design Concept 4

FUNCTION	CONCEPT 4	JUSTIFICATION
TYPE	Game	It is more interesting and easier to learn
PROGRAMMING LANGUAGE	C++	Primary language for unreal engine software user and high-performance applications
SOFTWARE	Unreal Engine	High-quality graphic and realistic visual, it a top choice for AAA games and photorealistic project
HARDWARE	Motion Controller	Hardware accessories that allow users to take action in mixed reality
INTERACTION	Full body tracking	Users can enjoy using full body tracking. Full body tracking sensors can capture user's movement

3.3.2.7 Accepted vs Discarded Solution

Table 12 : Accepted Design Concept

FUNCTION	CONCEPT 5	JUSTIFICATION
TYPE	Game-Based Training	Gamification keeps students interested by making learning lively and engaging.
PROGRAMMING LANGUAGE	C#	Compared to C++, C# is simpler, works better with Unity, and offers lots of free tutorials for beginners.
SOFTWARE	Unity	Unity provides a user-friendly interface, a strong physics engine, and cross-platform compatibility.
HARDWARE	HTC VIVE	Designed for professional applications, including simulation training, engineering, and gaming. It offers high-resolution displays, precise tracking, and ergonomic comfort
INTERACTION	Hand Movement	Allows users to grab, manipulate, press, and interact with virtual objects using controllers or hand tracking. Designed for professional applications, including simulation training, engineering, and gaming. It offers high-resolution displays, precise tracking, and ergonomic comfort

3.3.3 Evaluation & Selection of Conceptual Design

3.3.3.1 Pugh Matrix Concept 1 as A Datum

Table 13 : Concept 1 as A Datum

CRITERIA	CONCEPT 1	CONCEPT 2	CONCEPT 3	CONCEPT 4	CONCEPT 5
TYPE	D	1	1	1	2
PROGRAMMING LANGUAGE	A	2	2	1	2
SOFTWARE	T	2	2	1	2
HARDWARE	U	2	3	1	3
INTERACTION	M	3	3	1	3
TOTAL SCORE	-	10	11	5	12
RANKING		3	2	4	1

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

3.4.3.2 Pugh Matrix Concept 2 as A Datum

Table 14 : Concept 2 as A Datum

CRITERIA	CONCEPT 1	CONCEPT 2	CONCEPT 3	CONCEPT 4	CONCEPT 5
TYPE	3	D	2	3	3
PROGRAMMING LANGUAGE	2	A	2	1	2
SOFTWARE	2	T	2	1	2
HARDWARE	2	U	3	1	3
INTERACTION	1	M	2	1	2
TOTAL SCORE	10	-	11	7	12
RANKING	3		2	4	1

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

3.3.3.2 Pugh Matrix Concept 3 as A Datum

Table 15 : Concept 3 as A Datum

CRITERIA	CONCEPT 1	CONCEPT 2	CONCEPT 3	CONCEPT 4	CONCEPT 5
TYPE	3	3	D	2	3
PROGRAMMING LANGUAGE	2	2	A	1	2
SOFTWARE	2	2	T	1	2
HARDWARE	1	1	U	1	2
INTERACTION	1	2	M	1	2
TOTAL SCORE	9	10	-	6	11
RANKING	3	2		4	1

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

3.4.3.4 Pugh Matrix Concept 4 as A Datum

Table 16 : Concept 4 as A Datum

CRITERIA	CONCEPT 1	CONCEPT 2	CONCEPT 3	CONCEPT 4	CONCEPT 5
TYPE	2	1	2	D	3
PROGRAMMING LANGUAGE	3	3	3	A	3
SOFTWARE	1	1	1	T	3
HARDWARE	3	3	3	U	3
INTERACTION	1	3	3	M	3
TOTAL SCORE	10	11	12	-	15
RANKING	4	3	2		1

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

3.4 PRODUCT DRAWING / SCHEMATIC DIAGRAM

3.4.1 General Product Drawing Group Writing

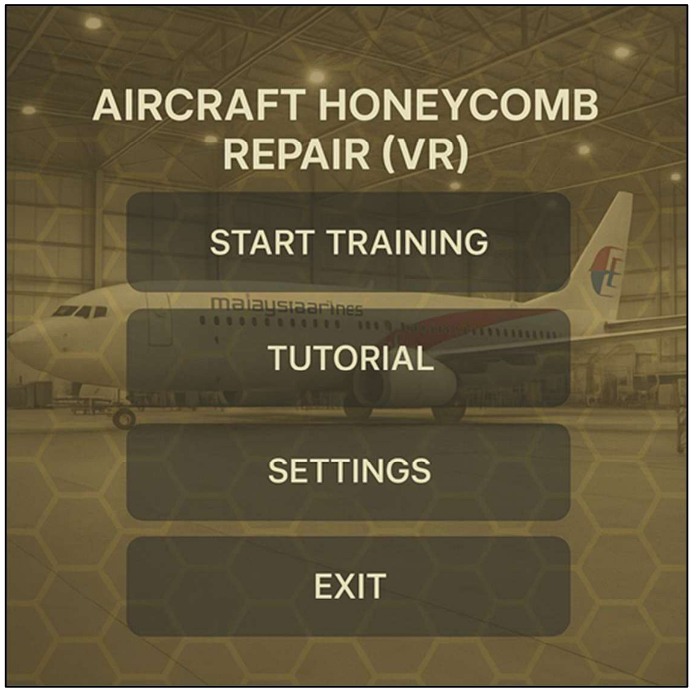


Figure 39 : Example Gameplay Main Menu

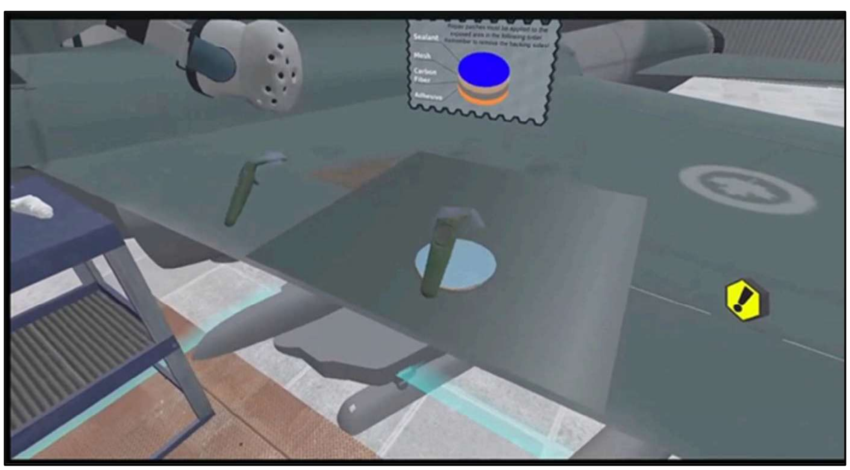


Figure 40 : Example Gameplay Repairing with Guide

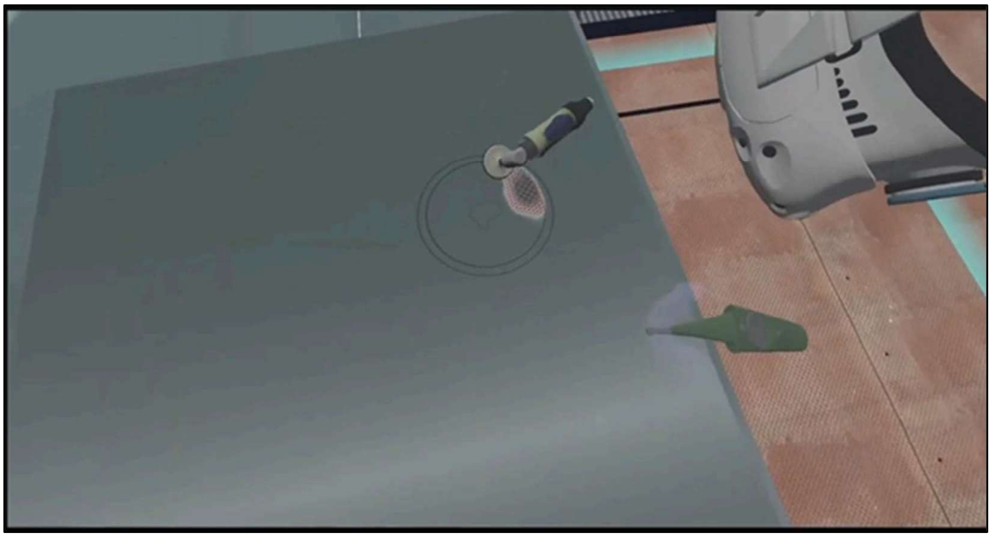


Figure 41 : Example Gameplay Repairing

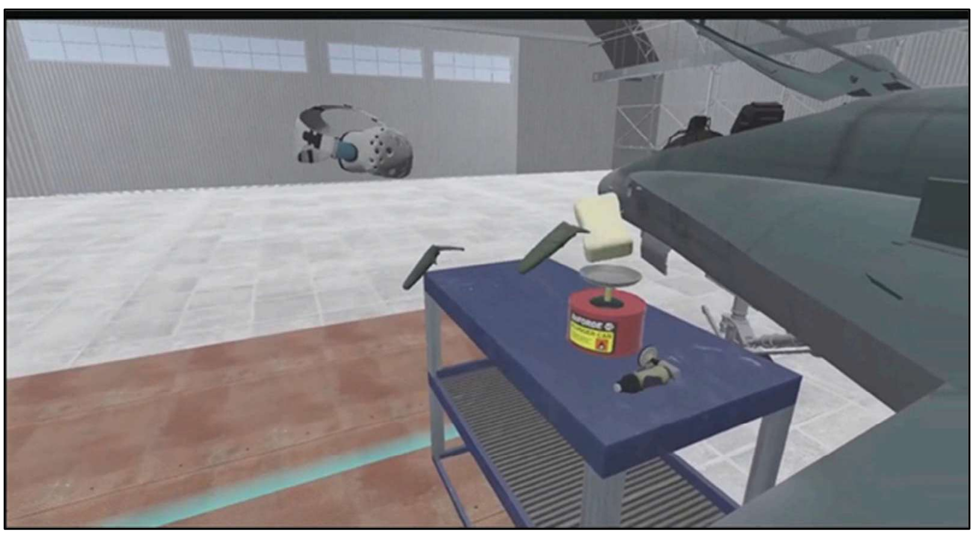


Figure 42 : Example Gameplay Tooling

3.4.2 Specific Part Drawing / Diagram

3.4.2.1 Product Structure (Tutorial Game)

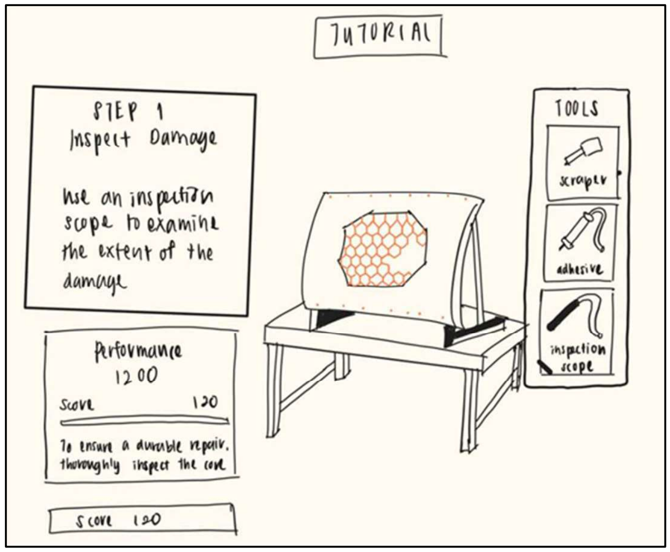


Figure 43 : Example sketching tutorial game layout.

3.5.2.2 Product Mechanisms (Objectives Game)

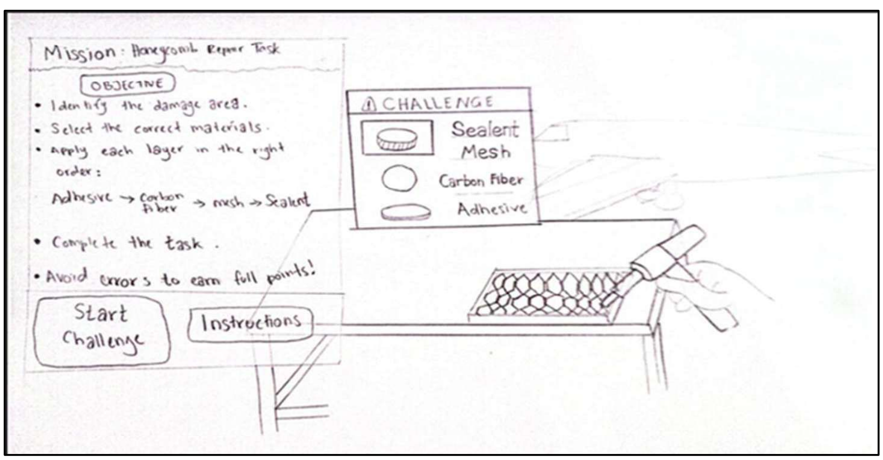


Figure 44 : Example Sketching Objective Gameplay Layout

3.4.2.2 Software / Programming (Type of Repairing)

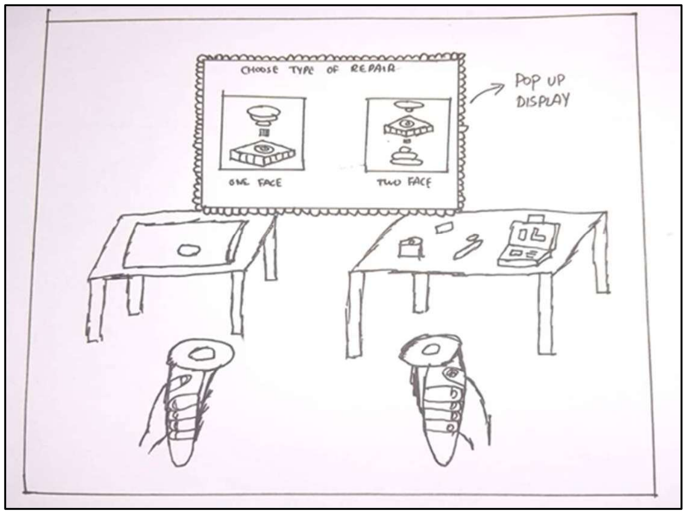


Figure 45 : Example Sketching Repairing Type Layout

3.4.2.3 Accessories & Finishing (Step-by-step guide)

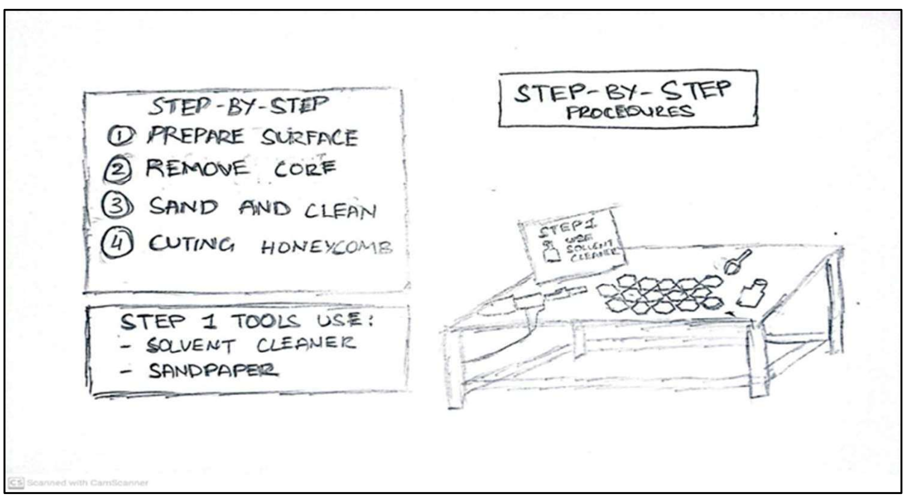


Figure 46 : Example Sketching Step-By-Step Guide Layout

3.5 PROTOTYPE / PRODUCT MODELLING

3.5.1 Prototype / Product Modelling

Figure 47 : Aircraft 3D Model.

To Simulate Real Maintenance Environment in the 3D aircraft model and is used to place trainees in a realistic hangar scenario, practice approaching the aircraft safely and learn aircraft part identification (tail, wing, doors, belly area, etc.) This improves familiarity with the aircraft layout.

Figure 48 : Hangar 3D Model.

To Create a Realistic Maintenance Environment in the hangar model for simulates the real workspace where aircraft maintenance is performed. It helps trainees get familiar with a typical MRO environment, understand bay layout, lighting, and safety markings and feel immersed in a real aircraft maintenance setting.

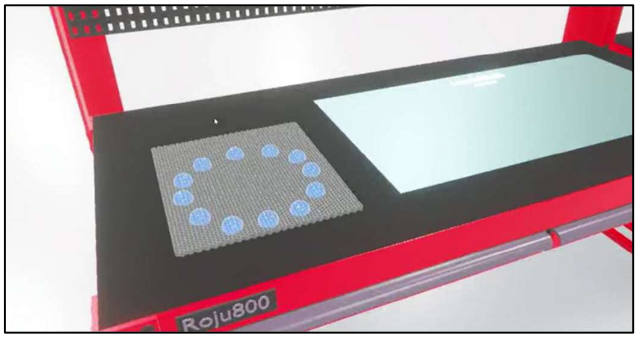


Figure 49 : Aircraft Honeycomb Structure

3D Model of Honeycomb Sandwich Structure used to allow trainees to see the internal structure (skin → adhesive → honeycomb core). Practice cutting out the damaged section, replace core material before bonding the patch and understand how composite layers interact.

Figure 50 : Tools 3D model for repairing.

3D Model of Repair Tools examples: cutter, drill, sander, vacuum pump is used to let trainees practice handling tools virtually and simulate correct tool techniques (e.g., cutting depth, sanding angle) and teach safe handling before touching real equipment.

3.5.2 Prototype Development

Figure 51: Main Menu Layout

The Main Menu is the first interface the user sees when launching the VR Honeycomb Repair Training Kit. Its purpose is to provide a clean, easy-to-navigate starting point for trainees before entering the simulation.

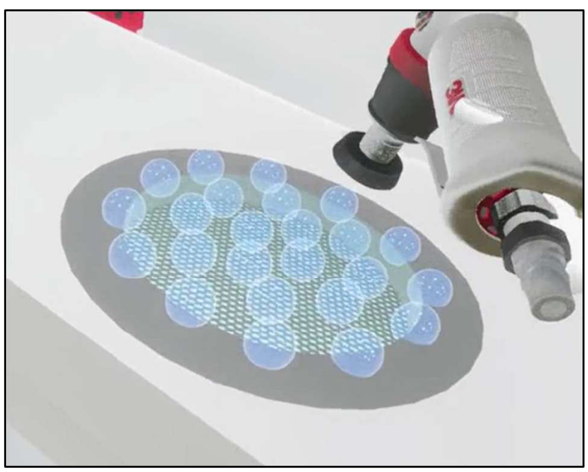


Figure 52 : Repairing Process With tools.

The honeycomb repair procedure involves removing damaged material, preparing the area, installing a new core, and bonding a patch. Above is the full workflow with tools used at each stage, just like in real aircraft composite maintenance.

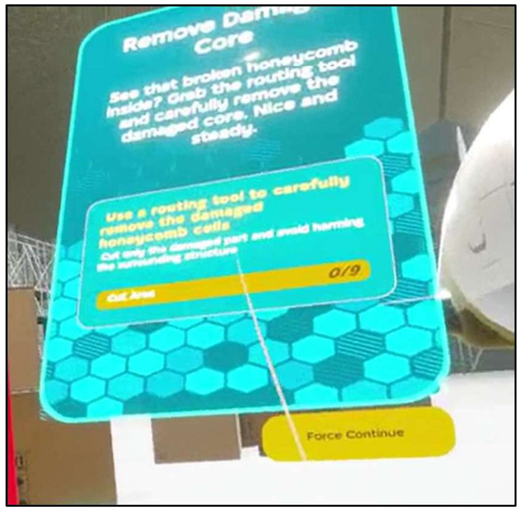


Figure 53 : Dialogue Box With procedure.

The Dialogue Box is an on-screen instructional window that appears in the VR environment to guide trainees through each step of the honeycomb repair process. It acts like a virtual “SRM helper,” giving real-time instructions while the trainee performs tasks.

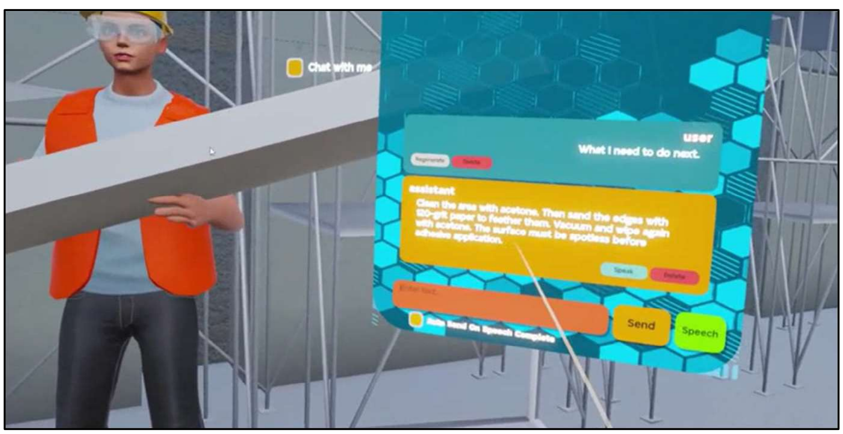


Figure 54 : Chat Box for QNA and Feedback

The Chat Box with Q&A is an interactive AI-driven support feature built into the VR training system. It acts like a virtual instructor that trainees can talk to anytime during the simulation. The chat box helps answer questions, give clarifications, and provide additional explanations about the honeycomb repair process.

3.6 DEVELOPMENT OF PRODUCT

3.6.1 Material Acquisition

Table 17 : Material Acquisition

Material	Description
Unity software	Used for creating, designing, and coding the VR application.
Sketch Fab	To get ready-made 3D models of the hangar, engine components and aircraft model.
Polytechnic Materials Hardware Notes	To get technical data or design references to ensure accuracy in VR simulation development.
Canva	A platform that we used to create infographics

3.7.2 Machines and Tools

Table 18 : Machines and tools

Tools and Equipment	Description
HTC VIVE PRO VR HEADSET 	The HTC Vive Pro is a high-end, (VR) headset primarily aimed at professional users, and serious VR enthusiasts. Its featuring dual AMOLED screens that provide a combined resolution of 2880 x 1600 pixels (1440 x 1600 per eye), drastically reducing the "screen-door effect".
HTC Vive Pro controller 	The HTC Vive Pro controller (the wand) is highly effective for accurate, room-scale tracking and versatile interaction, using its core combination of a precise trackpad, a dual-stage trigger, and robust Lighthouse tracking.
HP PC 	HP PC is a widely varied Windows-based computer platform that ranges from highly budget-conscious models for basic tasks to super-premium workstations and gaming rigs, all identifiable by their distinct series names.
Battery 	HTC Vive Pro controller (the "wand" controller) uses a battery to power its tracking sensors, haptics, and inputs.

3.7 PRODUCT TESTING / FUNCTIONALITY TESTS

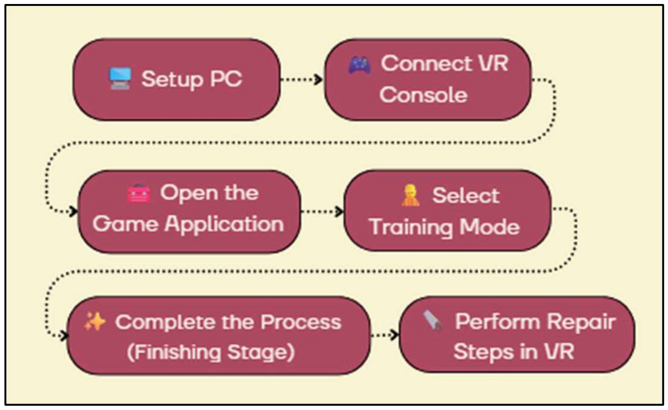


Figure 55 : VR Operating Procedure

The flowchart illustrates a six-step process for engaging in a VR training simulation, likely for repair or technical tasks. The sequence starts with setting up the PC and connecting the VR Console (hardware preparation). This is followed by opening the Game Application and specifically selecting the Training Mode (software initialization and selection). The main activity is then to Perform Repair Steps in VR, which concludes when the user Completes the Process (Finishing Stage), signifying the successful execution of the simulated task.

3.8 LIST OF MATERIALS & EXPENDITURES

Table 19 : Materials and expenditures

MATERIALS	PRICE
UNITY ASSETS Game Task: Quest System	RM65
HTC VIVE Cosmos VR Headset (Polytechnic Assets)	FREE
GitHub	FREE
SketchFab	RM500
Battery AA Everyday Heavy duty	RM40
Canva	FREE
TV (Polytechnic Assets)	FREE
HP PC Computer (Polytechnic Assets)	FREE
TOTAL	RM605

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 PRODUCT DISCRIPTION

4.1.1 General Product Features and Functionalities

This VR Honeycomb Repair Training Kit system integrates interactive 3D environments, realistic aircraft models, and guided repair modules to enhance the learning experience of aircraft maintenance trainees. The main interface of the system, as illustrated in Figure 4.1, features options include Start Training, Challenge, Settings, and Exit. To complete and develop this application, many elements from many applications were used. We hope that our presentation will provide you with a clearer understanding of our project.

4.1.2 Specific Part Features

4.1.2.1 Product Structure P

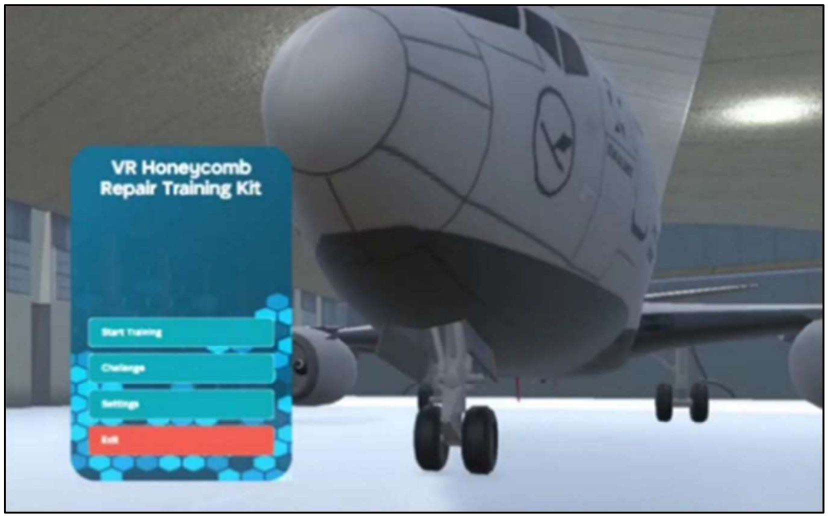


Figure 56 : Main Menu Layout screen.

1. Interactive Main Menu Interface

   The main menu provides straightforward access to different modules of the system. Its layout is designed with simplicity and clarity to ensure smooth navigation. The buttons such as Start Training, Challenge, Settings, and Exit enable users to quickly begin or adjust their training sessions.

2. Immersive Aircraft Hangar Environment

   The simulation environment replicates a real aircraft maintenance hangar, complete with a detailed 3D model of an aircraft. This realistic atmosphere helps users become familiar with the typical workspace setting used in actual aircraft maintenance activities.

3. Start Training:

   The Start Training module is designed to build procedural competence and user confidence in honeycomb structure repair. Its primary objectives are to teach the correct sequence of repair tasks, familiarize trainees with tools and materials, and allow repeated, low-pressure practice until basic proficiency is reached. When the user selects Start Training, the virtual hangar and aircraft panel are presented with interactive hotspots indicating inspection points. Instruction panels, workbench, tools, and honeycomb structures appear in the user's field of view. The instruction panel provides step-by-step repair procedures. Written in short, clear sentences and advances either automatically after actions or manually when user chooses "Next."

4. Challenge Mode:

   The Challenge mode shifts the focus from instruction to assessment: it evaluates a trainee's ability to apply repair procedures under time pressure while still offering minimal guidance. The objectives are to test procedural retention, improve speed and decision-making, and quantify performance for grading or competition. On Challenge Mode, the system presents the scenario of the aircraft has been attacked by lightning strikes and there are engineers who remove the panel that affected. This challenge mode has a configurable timer. The trainee must complete the repair before the timer expires. The remaining time is displayed prominently and counts down in real time.

5. Customizable Settings

   The Settings menu enables users to adjust audio guidance and visual quality. This customization helps improve comfort and adaptability according to the user's preferences or training requirements

6. User Friendly Accessibility

   The interface design prioritizes simplicity, ensuring that even beginners with limited VR experience can interact with the system efficiently. The menu layout, control scheme, and step-by-step procedures are optimized for intuitive learning.

4.1.2.2 Product Mechanisms

The VR Honeycomb Repair Training Kit has a combination of technology, data management, and user interaction to deliver its functionality. Common product mechanisms for apps include:

1. Technology Integration

   The product uses a VR headset and hand controllers connected to a computer that runs the Unity 3D engine as its main development platform. Through Unity's built-in physics, lighting, and 3D modeling systems, the simulation can realistically replicate the aircraft's hangar environment and repair tools. The hardware tracks the user's hand and head movement, which is then synchronized with the virtual scene, allowing trainees to perform repair activities. This mechanism ensures high realism, interactivity, and responsiveness between the trainee and the virtual workspace.

2. Data Management

   Plays an essential role in recording, processing, and storing all user actions during the simulation. Every movement, tool selection, completion time, and error is automatically logged by the system. This data is compared to a database of correct repair steps to determine accuracy and procedural compliance.

3. User Interaction

   In Training Mode, how the trainee communicates with and controls the virtual environment. Using VR controllers, the user navigates menus, selects repair tools, and interacts with the honeycomb structure. A dialogue box appears within the user's field of view to provide instructions and procedural guidance. In contrast, the Challenge Mode provides only short prompts with a visible timer, testing the trainee's ability to recall procedures independently.

4. Feedback and Evaluation

   Ensures that trainees receive immediate and meaningful responses based on their actions. This mechanism transforms the VR training kit into both a learning and assessment tool, supporting continuous improvement through experiential learning.

4.1.2.3 Software/Programming

The software programming of the VR Honeycomb Repair Training Kit is fully developed using the Unity game engine, which provides the tools needed to create immersive and interactive training experience. Unity serves as the core development platform where all 3D models, animations, and VR interactions are integrated to simulate realistic honeycomb repair procedures.

Through C# scripting, the project implements interaction systems that allow users to pick up tools, handle materials, and perform repair tasks such as trimming damaged areas, sanding surfaces, applying adhesive, and installing repair patches. The training flow is controlled using Unity's event-based logic, ensuring that each repair step must be completed correctly before the next action becomes available. A custom user interface (UI) is designed within Unity's Canvas system to present step-by-step instructions, dialogue boxes, progress indicators, and warnings when incorrect actions are taken.

Unity's XR Interaction Toolkit is used to handle VR input, hand tracking, grab mechanics, teleportation, and tool manipulation, providing a smooth and intuitive user experience. Additional scripting is implemented to track user performance, measure time during challenge mode, and record completion of accuracy for evaluation. Lighting, physics, and environment design are optimized within Unity to maintain high realism while ensuring stable performance in VR. Overall, the use of Unity enables the development of a structured, efficient, and highly interactive training simulation that accurately represents the real-world honeycomb repair process.

4.1.2.4 Accessories and Finishing

The accessories and finishing elements of the VR Honeycomb Repair Training Kit focus on enhancing usability, immersion, and the overall training experience. Accessories such as VR controllers, hand-tracking features, and optional haptic feedback devices support realistic tool manipulation and improve the user's sense of presence during the simulation.

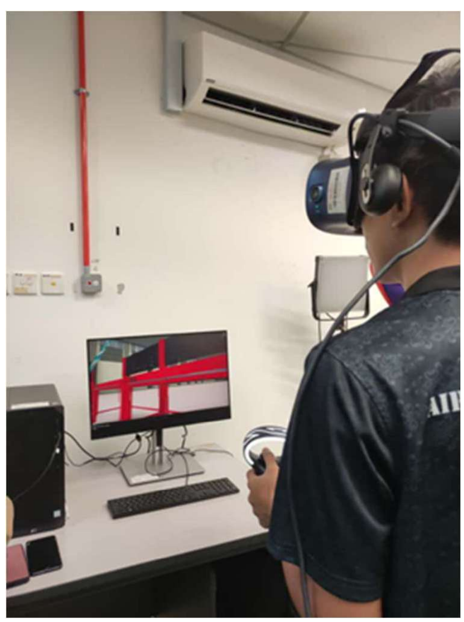


Figure 57 : VR Testing Demonstration

These accessories allow trainees to interact with virtual tools, handle materials, and perform repair actions with higher precision and engagement. In terms of finishing, the virtual environment is refined through detailed texturing, realistic lighting, and smooth animations to closely replicate an actual aircraft maintenance workspace.

The UI finishing includes professional, clean interface layouts with clear labels, color-coded indicators, and intuitive navigation to ensure clarity during training and challenge modes. Sound design, such as tool operation noises and feedback prompts, is also incorporated to reinforce user actions and improve realism. Together, these accessories and finishing touches create a polished, immersive, and user-friendly VR experience that supports effective learning and professional training standards.

4.1.3 General Operation of the Product

The VR Honeycomb Repair Training Kit operates as an interactive simulation system that allows users to learn and practice aircraft honeycomb structure repair procedures in a fully immersive virtual environment. The system begins when the user launches the application and enters the main menu interface, where options such as Start Training, Challenge, Settings, and Exit are displayed.

Upon selecting the Start Training mode, the user is transported into a virtual aircraft hangar containing a damaged honeycomb panel model. Using VR hand controllers, the user can interact with virtual tools and materials, such as sanders, cutters, and composite patches, to perform repair activities. Throughout the training session, a dialogue box provides step-by-step guidance, explaining each procedure in sequence including inspection, surface preparation, material application, curing, and final finishing. This guided instruction helps the trainee understand proper repair techniques and develop confidence in handling the process.

In Challenge Mode, the general operation follows a similar structure but introduces time-based and performance-based elements. The dialogue box still provides basic instructions, but with less guidance, requiring the user to recall and apply previously learned steps independently. A countdown timer is displayed to track task completion time, encouraging accuracy under pressure and simulating real-world maintenance conditions. The system monitors user actions, such as tool usage, repair accuracy, and task completion, to provide performance feedback at the end of each session.

The entire operation integrates motion tracking and interactive physics within the VR environment to create realistic tool handling and component interaction. The simulation intuitive interface ensures that all operations from navigation to task execution can be performed naturally through hand gestures and VR controller input. Through this system, users can repeatedly practice honeycomb structure repair safely, without consuming real materials or risking damage to aircraft components. Overall, the general operation of the VR Honeycomb Repair Training Kit enhances technical understanding, hands-on proficiency, and readiness for real-world maintenance tasks in line with Industry 4.0 digital learning advancements.

4.1.4 Operation of The Specific Parts of the Product

4.1.4.1 Product Structure (Main Menu Navigation)

When the application is launched, the user is greeted with the main menu containing four options: Start Training, Challenge Mode, Settings, and Exit. The user interacts with these menu buttons using VR hand controllers by pointing and selecting the desired option. The menu layout is centralized within the user's field of view to ensure easy navigation and smooth transition into the training environment.

4.1.4.2 Product Mechanisms (Start Training Mode)

In this mode, users begin the guided honeycomb repair simulation. A dialogue box appears to guide the user step-by-step through the repair stages, including inspection, cleaning, cutting, patching, bonding, and finishing. Each step provides clear visual and text instructions, helping trainees understand the correct procedure and use of tools. The system tracks user actions and displays hints or prompts if incorrect steps are performed, reinforcing learning through feedback.

4.1.4.3 Software/ Programming Challenge Mode

The challenge mode allows users to apply the skills learned during training with minimal guidance. A countdown timer is displayed at the top of the screen to measure completion time and simulate a real-world work environment. The dialogue box provides only brief task reminders instead of detailed guidance. Upon completion, the system evaluates performance based on time, accuracy, and procedure correctness, displaying the final score or result summary.

4.1.4.4 Accessories & Finishing Virtual Tool Interaction

Users interact with various virtual tools, such as sanders, cutters, and bonding applicators, using motion-tracked VR controllers. The system detects hand and tool movements in real-time, creating realistic tool handling and operational response. Haptic feedback (controller vibration) is triggered when users contact materials, enhancing realism and engagement. Each tool has a specific function linked to the repair sequence, allowing the user to understand its practical application.

4.2 PRODUCT OUTPUT ANALYSIS

4.2.1 Survey Questions

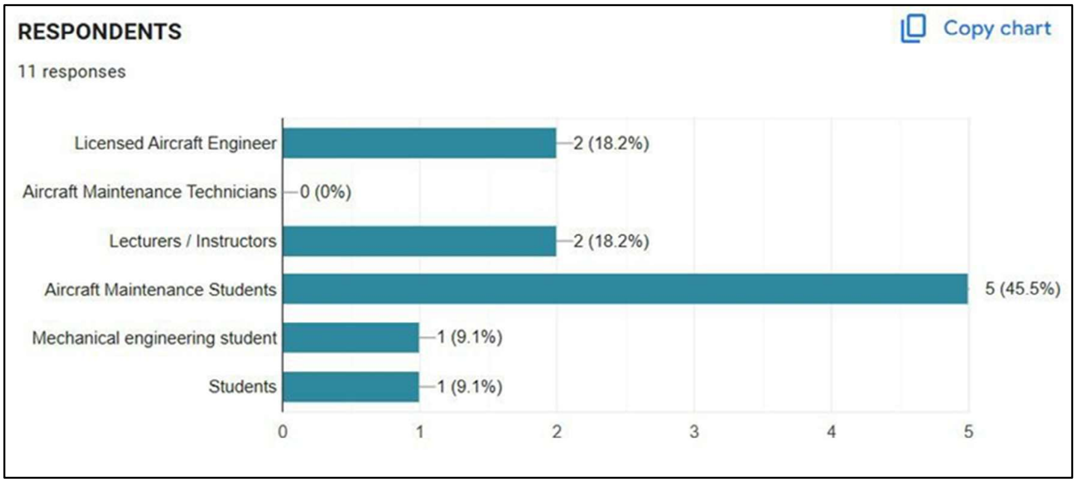


Figure 58 : Backgrounds of Respondents

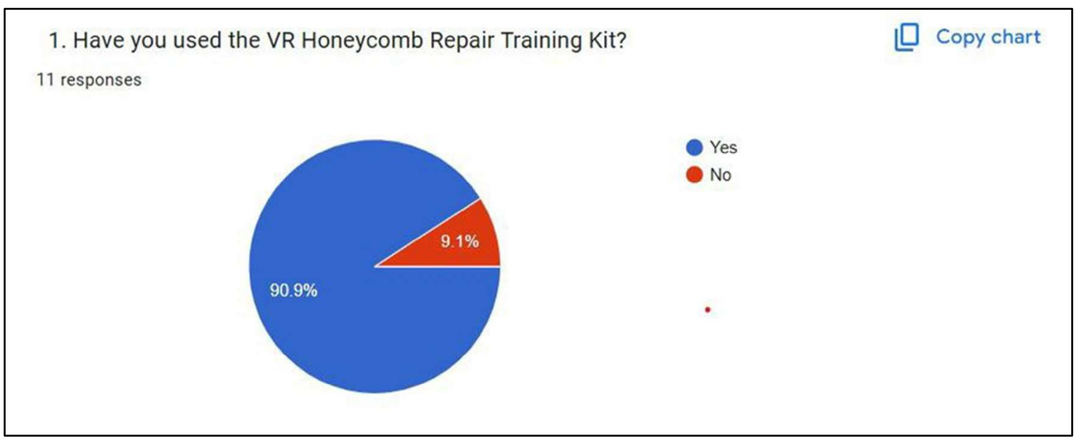


Figure 59 : Respondents Prior Usage of The Training Kit

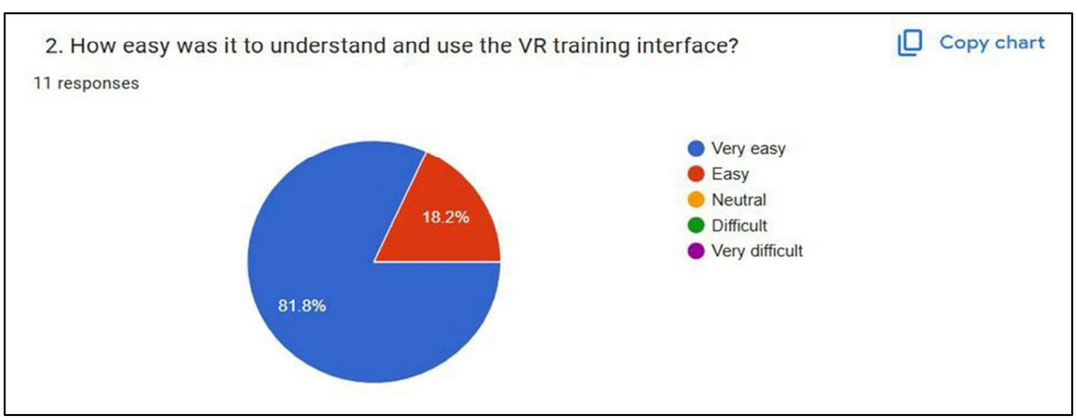


Figure 60 : Respondents Clarity and Comprehensibility of The Training Kit

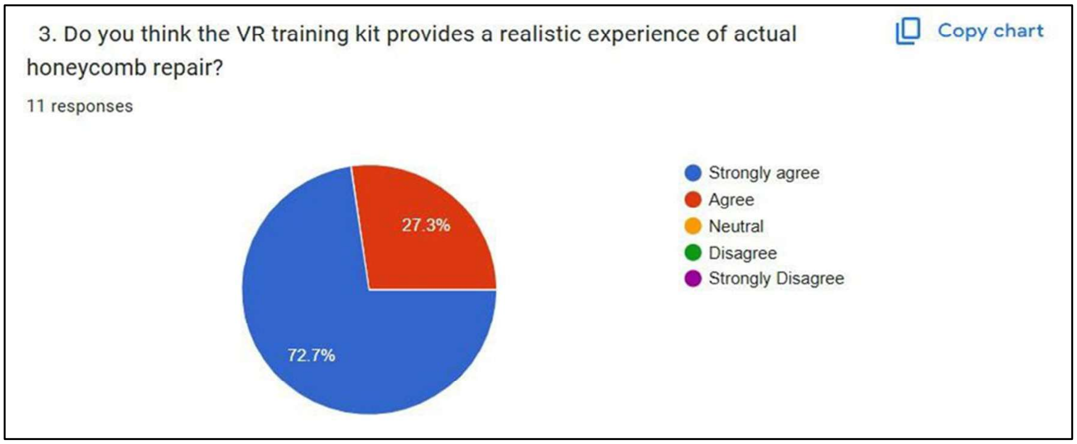


Figure 61: Respondent's Experience of The Training Kit

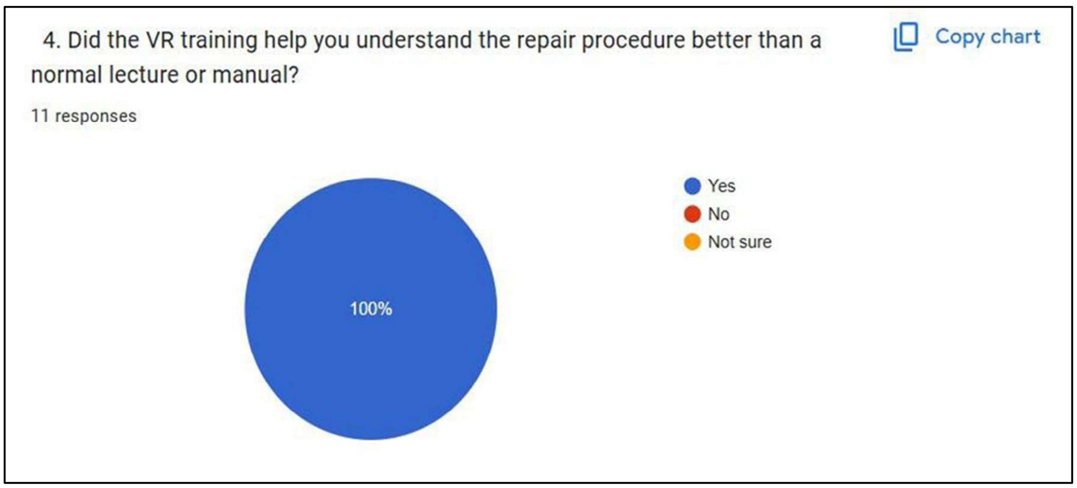


Figure 62 : Respondent's Understanding of the Training Procedure

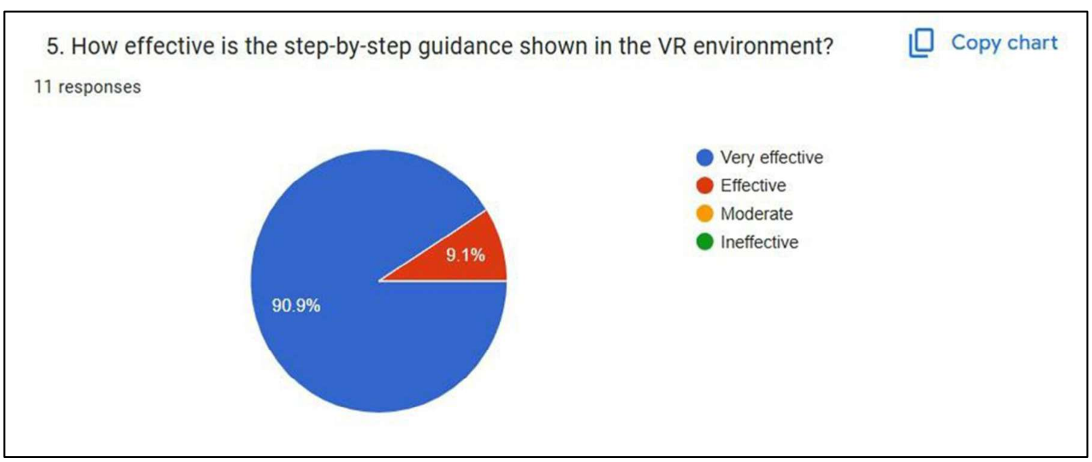


Figure 63: Effectiveness of Guidance Given During Training

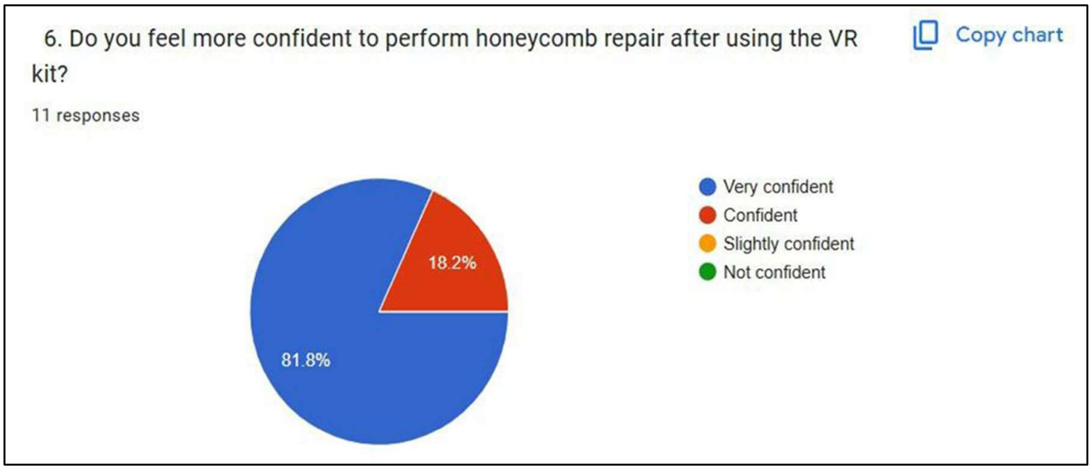


Figure 64: Respondent's Confidence to Perform Honeycomb Repair

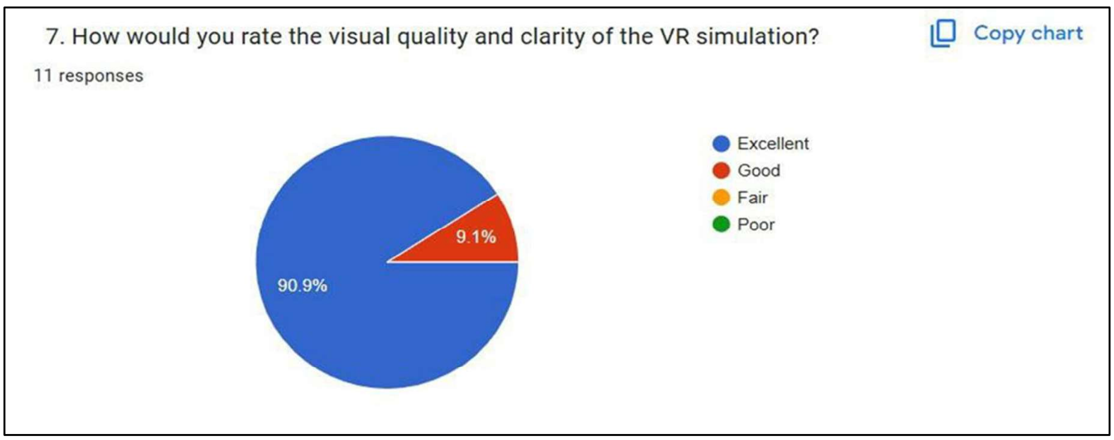


Figure 65 : Rating the Resolution and Sharpness

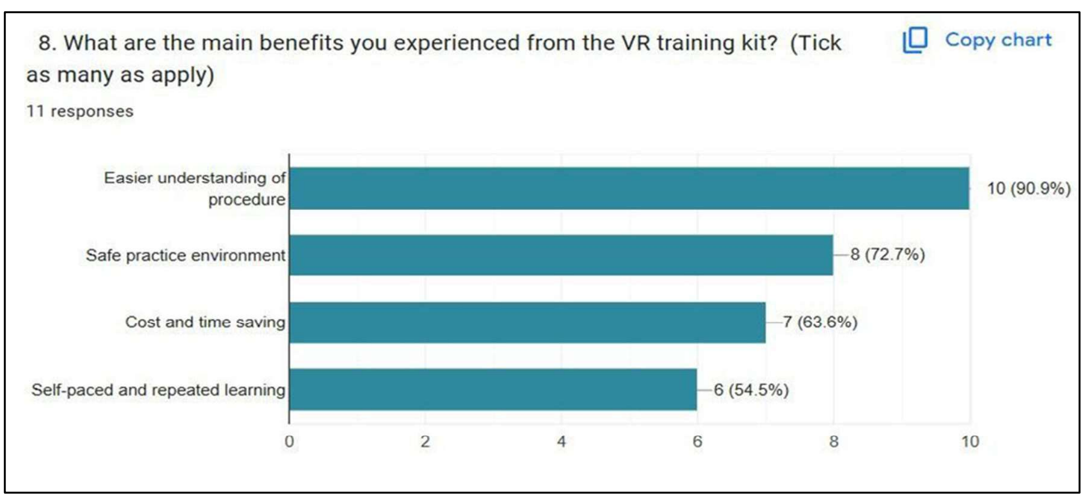


Figure 66 : Main Benefits Gain from Experiencing The Training Kit

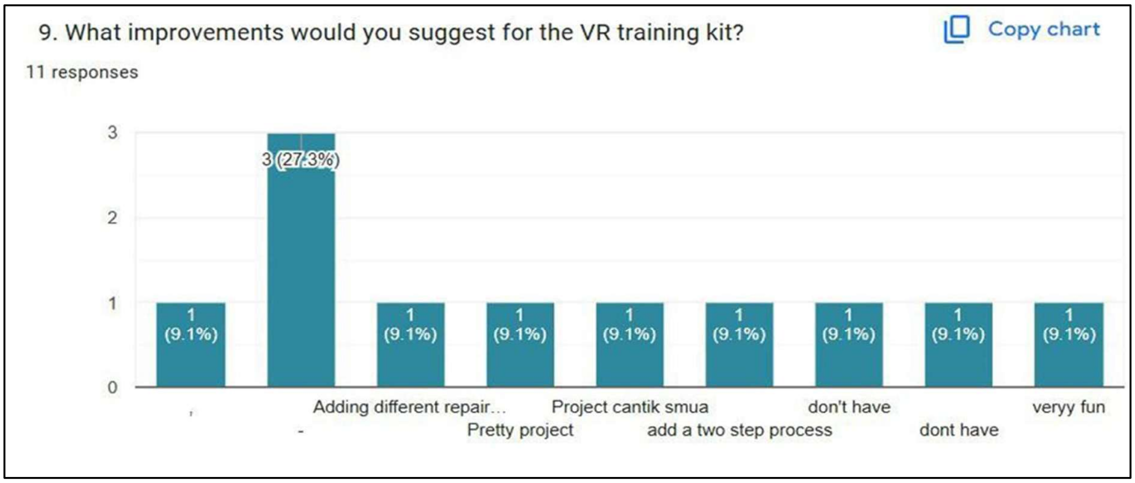


Figure 67 : Improvements Suggestion from Respondent

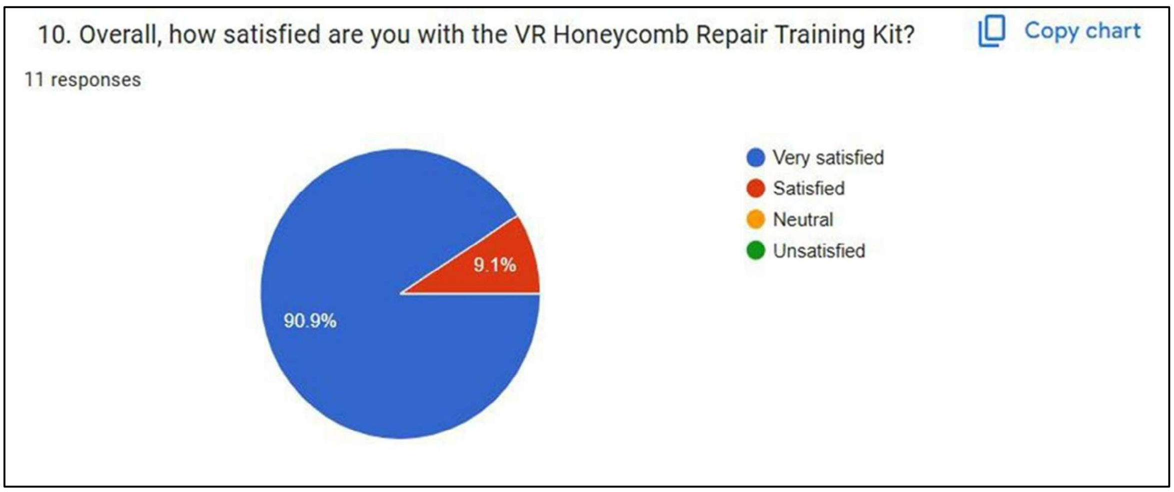


Figure 68 : Overall Satisfaction of The Training Kit

4.3 EVALUATING THE IMPACT OF VR HONEYCOMB REPAIR

The impact of the VR Honeycomb Repair Training Kit can be evaluated through its effectiveness in enhancing learning outcomes, improving practical skill development, and supporting modern aviation training methodologies. One of the most significant impacts is the system's ability to provide a realistic and risk-free environment for students to practice honeycomb repair procedures. Through guided instructions, tool interactions, and structured repair sequences, students gain a deeper understanding of the steps involved in composite repair without the need for physical materials or workshop access. This contributes to improved procedural knowledge, increased confidence, and reduced dependency on physical training sessions.

In addition, the VR system demonstrates a positive impact on training efficiency and cost management. Traditional honeycomb repair training requires expensive materials, specialized tools, and repeated preparation of workshop setups. The VR kit reduces these costs by allowing unlimited practice sessions, minimizing material consumption, and eliminating the risk of equipment damage. The inclusion of training and challenge modes also supports different learning styles where guided learning enhances understanding and challenge-based tasks to encourage critical thinking and performance accuracy. This contributes to more efficient skill acquisition and better student retention of repair techniques.

The project also has a notable impact on the integration of Industry 4.0 technologies into aviation education. By incorporating VR, interactive mechanics, and digital workflows, the training kit demonstrates how digital transformation can be applied to maintenance training programs. This strengthens the readiness of institutions to adopt modern simulation-based learning tools and prepares students for technologically advanced working environments. The project further contributes to improving safety awareness among trainees, as mistakes made in VR do not pose any real-world risks.

Overall, the VR Honeycomb Repair Training Kit provides substantial impact in terms of educational effectiveness, cost savings, safety enhancement, and technological advancement. By evaluating these outcomes, it is evident that the project plays an important role in transforming traditional honeycomb repair training into a modern, accessible, and efficient learning experience.

4.3.1 Product Structure

1. Realistic Virtual Workspace Layout

   The VR Honeycomb Repair Training Kit creates a highly realistic simulation of an actual aircraft maintenance bay, complete with proper lighting, tool arrangement, and workstation setup. This detailed environment helps trainees understand how a real repair area is organized, allowing them to familiarize themselves with the spatial layout before performing actual maintenance tasks.

2. Proper Tool Awareness

   The VR system displays all tools in their correct positions and demonstrates how each item should be used during honeycomb repair procedures. As trainees interact with these tools in a three-dimensional space, they gain a stronger understanding of where equipment should be placed and how to move around the workspace efficiently.

3. Trainees Visualize

   The simulation allows trainees to observe and experience the full repair setup including the damaged panel, the tools required, and the step-by-step repair stages before they attempt the procedure in the real world. This visualization helps reduce uncertainty and anxiety, especially for beginners who may be unfamiliar with composite repair.

4.3.2 Product Mechanism

1. Repair Step-by-step

   One of the critical advantages of the VR honeycomb repair training kit is its ability to reinforce correct procedural discipline. Aircraft maintenance requires strict adherence to established sequences of repair procedures, as skipping steps or performing actions out of order can compromise safety and structural integrity.

2. Challenge Mode

The inclusion of a challenge mode in the VR kit enhances trainee engagement by introducing competitive elements, time constraints, or scenario-based challenges.

This gamified approach motivates trainees to actively participate and improves focus during training sessions.

3. Competency Improvement

The VR training kit also provides immediate feedback through performance scoring and step validation. Each action performed by the trainee is monitored and evaluated against standardized procedures, ensuring that errors are identified and corrected in real time.

4.3.3 Software/Programming

1. Real-Time Responsiveness

The software is designed for real-time responsiveness, ensuring that any input from physical control is immediately reflected in the VR environment. By utilizing high-performance VR engines like Unity, the system provides a responsive and immersive experience for students, enhancing their interaction with virtual honeycomb repair.

2. Performance Optimization

To prevent lag or performance issues in the VR honeycomb, various optimization techniques, such as repair procedures, are implemented. These methods help ensure that the VR environment remains stable and engage students to learn about honeycomb structure repair.

3. Continuous Testing

Ongoing testing of the VR Honeycomb Repair software under various conditions guarantees stability and responsiveness. This testing process allows developers to identify and fix any inconsistencies or bugs, resulting in a reliable learning platform that students can depend on for accurate and important training experiences.

4.3.4 Accessories & Finishing

1. Accessory Integration

   VR controllers are selected for their ergonomic, wireless designs, allowing students to engage with honeycomb repair without bulky attachments. These accessories ensure seamless compatibility with the VR Honeycomb Repair, providing students with an intuitive and immersive way to manage virtual repair in the workshop setting.

2. Battery Life and Charging

   The accessories are crafted with extended battery life and rapid charging capabilities, guaranteeing that both students and instructors can enjoy uninterrupted sessions. The wireless design minimizes clutter, while dependable power options improve the usability and accessibility of the system during practical training sessions.

3. Finishing and Realism

   Top quality materials and life like textures are utilized in the finishing of the VR to elevate its professional appearance and feeling. Anti-glare and matte coatings enhance visual clarity, while realistic instrument labels and soft-touch surfaces contribute to a refined, immersive experience that feels genuine for aviation training.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 ACHIEVEMENT OF AIM & OBJECTIVES OF THE RESEARCH

5.1.1 General Achievements of the Project

The VR Honeycomb Repair Training Kit successfully achieved all key objectives of the research through the effective completion of its product design, mechanism development, software programming, and finishing elements. Each component contributed significantly to fulfilling the project's overall aim of creating an immersive, realistic, and educational VR simulation for aircraft maintenance students learning honeycomb repair procedures.

5.1.2 Specific Achievement of Project Objectives

5.1.2.1 Product Structure

The objective related to designing a functional and realistic VR training environment was fully achieved. The project successfully developed detailed 3D models of the honeycomb panel, tools, workspace, and repair materials that closely represent real-world aircraft maintenance equipment. The interface layout was also completed with clear menus, guided instructions, and challenge mode options, ensuring smooth navigation for users. The product design effectively transformed complex repair knowledge into an intuitive and well-structured VR learning platform, demonstrating that the visual and structural elements fully support the training process.

5.1.2.2 Product Mechanisms

The project met its objective of developing an operational mechanism that supports step-by-step repair training and performance evaluation. The mechanisms including user interaction systems, gesture recognition (tool picking and material handling), guided procedural flow, and challenge mode timer were successfully implemented. The system ensures that every repair stage follows the correct sequence, reinforcing procedural discipline. Data tracking and feedback mechanisms also function effectively to monitor user accuracy and completion time. These achievements prove that the product mechanism was successfully designed to simulate real repair logic and workflow, fulfilling its intended instructional purpose.

5.1.2.3 Software and Programming

The software development objective, focused on creating a stable VR system using Unity, was fully achieved. The project implemented the Unity engine along with C# scripting and the XR Interaction Toolkit to deliver realistic tool interaction, environmental physics, and immersive training sequences. The dialogue-based guidance system, UI overlay, animation handling, lighting optimization, and task-trigger logic were all successfully integrated. The inclusion of both Training and Challenge modes demonstrates that the programming framework supports dynamic learning and performance-based evaluation.

5.1.2.4 Accessories and Finishing

The objective to enhance user experience through accessories and finishing elements was also successfully accomplished. VR controllers and hand interaction systems were effectively integrated to allow natural tool manipulation. The finishing touches such as realistic textures, accurate sound effects, user-friendly UI placement, lighting refinement, and optimized animations—significantly improved the sense of immersion. These elements ensure that the final product not only functions correctly but also provide a polished, professional training experience suitable for aviation education. The successful completion of this component confirms that the project meets industry expectations for realism and usability.

5.2 CONTRIBUTION OR IMPACT OF THE PROJECT

The VR Honeycomb Repair Training Kit provides significant contributions to both aviation education and digital learning technologies. One of the most important impacts of this project is its ability to enhance technical training through an immersive and interactive learning environment. By simulating the complete honeycomb repair process, the project enables students to understand complex maintenance procedures without the need for physical materials or workshop access. This contributes to more efficient learning, improved comprehension of aircraft structure repair, and greater readiness for real-world maintenance tasks.

The project also contributes to safety and cost-effectiveness in aviation training. Through VR simulation, students can practice high-risk or delicate repair procedures in a controlled virtual environment, minimizing material waste and preventing potential tool-related accidents. Institutions benefit from reduced training costs as the VR kit eliminates the need for consumables such as honeycomb panels, adhesives, and specialized tools that are typically expensive to replace. This positions the VR kit as a sustainable and economical training alternative.

From a technological standpoint, the project significantly supports the adoption of Industry 4.0 in the aviation maintenance field. The integration of Unity-based VR programming, realistic 3D modeling, and interactive mechanisms demonstrates how digital transformation can modernize traditional training methods. This project contributes to the growing field of virtual training tools and showcases how immersive technology can be applied to technical education, especially in niche areas like composite and honeycomb structure repair.

Additionally, the project creates a meaningful impact on student engagement and confidence. With guided step-by-step training and challenge mode, users develop a deeper understanding of repair techniques, improve decision-making skills, and build confidence in performing maintenance tasks. The gamified elements and user-friendly interface also promote self-paced learning and increase motivation among aviation students.

Overall, the VR Honeycomb Repair Training Kit contributes to educational innovation, safety improvement, cost reduction, and technological advancement in aviation maintenance training. It stands as a valuable tool that enhances learning effectiveness and supports the future direction of digital and immersive education.

5.3 IMPROVEMENT AND SUGGESTIONS FOR FUTURE RESEARCH

5.3.1 Product Structure

Future improvements to the product structure should focus on enhancing the realism, scalability, and modularity of the VR environment. The current structure provides an effective training layout, but additional aircraft components and more detailed workshop surroundings can further enrich immersion. Future research may also include developing multiple honeycomb damage types, such as crushed cores, delamination, moisture ingress, or impact damage, to allow trainees to experience a wider range of repair scenarios. Creating modular panels that can be swapped or modified within the VR system will provide more flexibility for instructors to design custom training exercises. Improving the visual quality of textures, material behaviors, and lighting accuracy will also bring the virtual environment closer to real-world conditions, leading to a more authentic training experience.

5.3.2 Product Mechanisms

There is substantial potential to refine the internal mechanisms that control user interactions and procedural workflow. Future research should explore more advanced interaction physics, including realistic tool weight simulation, resistance feedback, and material responses during cutting or sanding. Enhanced assessment mechanisms can also be developed, such as automated error detection that identifies incorrect tool angles, improper adhesive application, or missing repair steps. Another recommendation is to incorporate adaptive learning mechanisms that adjust training difficulty based on the user's performance.

5.3.3 Software and Programming

From a software perspective, future advancements should aim to improve system stability, cross-platform compatibility, and interactive intelligence. While Unity provides strong performance, future research can explore multi-platform builds, such as versions optimized for standalone VR devices like Meta Quest, Pico, or HTC standalone headsets, increasing accessibility and portability. Artificial intelligence (AI) could be integrated to provide smart tutoring functions, such as voice-based guidance, adaptive feedback, and automated scoring using machine learning.

5.3.4 Accessories and Finishing

Enhancements to accessories and finishing touches can further elevate the training quality and immersion of the VR kit. Future research may consider integrating haptic gloves or vibration-enabled controllers to provide tactile responses when handling tools or interacting with materials. This would significantly increase realism and improve user skill development. Additional finishing improvements include more detailed sound design, such as tool-specific audio, environmental ambience, and responsive sound cues that correspond to user actions. Improving UI design with more intuitive icons, clearer color coding, and customizable interface layouts will also enhance accessibility.

LIST OF REFERENCES

1) W. E. Services, “The Malaysian Higher Education System - An Overview,” StudyMalaysia.com, Mar. 14, 2022. https://studymalaysia.com/international/the-national-education-system/the-malaysian-higher-education-system-an-overview
2) Robert Holley, “The Great Metal Tube in the Sky,” Material Strategies, Jan. 08, 2013. https://arch5541.wordpress.com/2013/01/08/the-great-metal-tube-in-the-sky/ (accessed Nov. 08, 2025).
3) W. Gov, “K-12 GRADES Museum in a BOX Museum in a BOX.” Available: https://www.nasa.gov/wp-content/uploads/2016/08/composites_k-12.pdf
4) Peyman, “Application of Composite Material in Aircraft industries,” Scribd, 2025. https://www.scribd.com/document/420329917/Application-of-Composite-Material-in-Aircraft-industries (accessed Nov. 08, 2025).
5) “ACRATS B.V. | Product Detail,” Acrats.com, 2025. https://acrats.com/product-detail/premium-aviation-composite-repair-tool-kit-complete-solution-for-aircraft-maintenance (accessed Nov. 08, 2025).
6) “Boeing 787 Series Specialist Composite Training.” Accessed: Nov. 08, 2025. [Online]. Available: https://northcomposites.co.uk/787%20repair%20courses.pdf
7) “Advisory Circular Subject: Development of Training/Qualification and Certification Programs for Composite Maintenance Technicians.” Accessed: Nov. 08, 2025. [Online]. Available: https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_65-33A.pdf
8) J. D. Anderson, *Fundamentals of Aerodynamics*, 6th ed. New York, NY, USA: McGraw-Hill Education, 2017.
9) J. D. Mattingly, *Elements of Gas Turbine Propulsion*. New York, NY, USA: McGraw-Hill Education, 2006.
10) M. P. Boyce, *Gas Turbine Engineering Handbook*, 4th ed. Oxford, UK: Butterworth-Heinemann, 2011.
11) Y. A. Çengel and J. M. Cimbala, *Fluid Mechanics: Fundamentals and Applications*, 4th ed. New York, NY, USA: McGraw-Hill Education, 2018.
12) F. M. White, *Fluid Mechanics*, 9th ed. New York, NY, USA: McGraw-Hill Education, 2016.
13) J.-H. Kim and H.-S. Lee, “Development and Application of a Gas Turbine Educational

Training Kit," *Journal of Technical Education Research*, vol. 18, no. 2, pp. 1–18, 2018.

14) R. M. Felder and R. Brent, *Teaching and Learning STEM: A Practical Guide*, Jossey-Bass, 2016.
15) M. Prince, "Does active learning work? A review of the research," *J. Eng. Educ.*, vol. 93, no. 3, pp. 223-231, 2004.
16) S. Freeman *et al.*, "Active learning increases student performance in science, engineering, and mathematics," *Proc. Natl. Acad. Sci.*, vol. 111, no. 23, pp. 8410–8415, 2014.
17) National Research Council, *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*, National Academies Press, 2012.
18) J. J. Duderstadt, *Engineering for a Changing World: A Roadmap to the Future of Engineering Practice, Research, and Education*, Millennium Project, 2008.
19) S. D. Sheppard, K. Macatangay, A. F. Colby, and W. M. Sullivan, *Educating Engineers: Designing for the Future of the Field*, Jossey-Bass, 2009.

E. Lumsdaine and M. Lumsdaine, *Creative Problem Solving and Engineering Design*, McGraw-Hill Education, 2015.

APPENDIX A: TASK SEGREGATION

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1.3.2	SPECIFIC INDIVIDUAL PROJECT OBJECTIVE
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1.5	SCOPE OF PROJECT
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1.6	PROJECT IMPACT

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	MUHAMMAD REZA FIRDAUS CHUNG BIN MUHAMMAD RIDHWAN CHUNG
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