POLITEKNIK BANTING SELANGOR

FLYFIX SIMULATOR

NAME	MATRIC NO
MUHAMMAD FAIZAL BIN MOHD NAZEMA	24DAM23F1014
MUHAMMAD NADZIR HAKIMI BIN JAMALUDIN	24DAM23F1012
MUHAMMAD MUNIR AJWAD BIN FAUZAN	24DAM23F1036
AMNA NAFEESA BINTI MOHD NAJAH	24DAM23F1016

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:

MRS. SHALHAYUNI BINTI SARIPUDEN

REPORT ENDORSEMENT

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All praise and thanks are due to God Almighty for granting us the strength, patience, and determination to successfully complete our Final Year Project titled FlyFix Simulator. Throughout this journey, we have gained valuable knowledge and experience despite facing various challenges along the way.

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ABSTRACT

The FlyFix Simulator is a computer-based simulation project developed to support learning in aircraft maintenance, particularly for students in the aviation maintenance field. This project aims to provide an interactive and practical learning platform that allows users to understand basic aircraft maintenance procedures in a safe and controlled virtual environment.

The simulator focuses on simulating common maintenance tasks, fault identification, and troubleshooting processes based on standard aircraft maintenance practices. By using the FlyFix Simulator, students can improve their technical understanding, decision-making skills, and familiarity with maintenance procedures without the risks and costs associated with real aircraft operations.

The development of the FlyFix Simulator follows a structured approach, including requirement analysis, system design, development, and testing. The system is designed to be user-friendly and suitable for students with basic aviation knowledge. Testing results show that the simulator functions as intended and helps users better understand maintenance concepts and workflows.

In conclusion, the FlyFix Simulator serves as an effective supplementary learning tool for aircraft maintenance education. It enhances students' learning experiences by combining theoretical knowledge with simulated practical applications and has the potential to be further improved with additional aircraft systems and maintenance scenarios in the future.

CERTIFICATION OF PROJECT

ORIGINALITY & OWNERSHIP NAME	MATRIC NO
MUHAMMAD FAIZAL BIN MOHD NAZEMA	24DAM23F1014
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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Aircraft maintenance involves a variety of activities, including inspection, repair, modification, overhaul, and servicing, to ensure an aircraft is safe and reliable for flight. These actions are crucial for maintaining airworthiness and preventing potential issues that could lead to safety concerns. In this era of globalization, aircraft maintenance technicians are needed to ensure the safety and good condition of the aircraft. In this case, FLYFIX SIMULATOR can help attract students to study in the field of aircraft maintenance in order to increase the number of technicians for aircraft.

Figure 1.1 shows an application that is useful for students called “FLYFIX SIMULATOR”. The current method is hands-on lab sessions but at low risk. It involves real-world task training on training aircraft but is only used in gadgets. For example, Students perform visual inspection, locking devices and engine section work. In addition, the project limitation must have internet, gadgets like smart phones or computers and only used for student aircraft maintenance.

> “**A competent team of certified mechanics, avionics specialists, and engineers is the backbone of any maintenance service. These professionals diagnose issues, perform repairs, and ensure compliance with regulatory standards. Regular training keeps technicians updated on the latest technologies, safety protocols, and best practices. For instance, understanding the intricacies of composite materials or *advanced avionic system* is essential.”**

Based on the statement above, it shows the importance of improving technician skills to reduce human error while doing work. Also, this shows the continuous training to upgrade skilled technicians to be more experienced.

1.2 PROBLEM STATEMENTS

Aircraft maintenance students at POLITEKNIK BANTING often struggle with practical training due to limited access to real aircraft, tools, and learning kits. Without adequate practical experience, they find it difficult to apply theoretical knowledge to real-world maintenance tasks. This lack of practice leads to knowledge gaps, reduced confidence, and a higher probability of making mistakes while working on real aircraft.

Furthermore, maintenance errors can have serious consequences, including safety risks, increased operating costs, and the possibility of accidents. Inexperienced students are more likely to make mistakes when transitioning from theory-based learning to actual maintenance work. Theory classroom methods fail to provide an engaging, interactive and risk-free environment in which students can develop their skills before handling real aircraft components.

Figure 1.1: Application that is useful for students called “FLYFIX SIMULATOR”

FLYFIX SIMULATOR addresses this challenge by providing a realistic game-based learning platform designed to enhance students’ understanding of aircraft maintenance. Inspired by mechanics-based simulation games like Wrench, this simulator allows students to apply their theoretical knowledge in a virtual environment where they can practice maintenance procedures, troubleshoot, and learn from mistakes without the risks of real- world exposure. By offering a safe space to try, fail and improve, the FLYFIX SIMULATOR helps students build confidence. It develops problem-solving skills and strengthens their understanding of aircraft maintenance. This reduces the likelihood of costly and dangerous errors in real-life situations, ultimately improving safety and efficiency in the aviation industry.

1.3 PROJECT OBJECTIVES

1.3.1 General Project Objectives

The project objectives are:

• To design aircraft personal safety compartment (APSC) especially for economy class passenger to get better flying experience.

• To develop APSC with high security level for economy class passenger.

• To demonstrate the function of locking mechanism.

• To evaluate user's satisfaction towards security features and comfort level using post survey.

1.3.2 Specific Individual Project Objectives

1.3.2.1 Product Structure

Main System: FLYFIX SIMULATOR Application

- Platform: Unity Engine
- Deployment: PC & Mobile

Module 1: User Interface & Navigation

- Main Menu
- Aircraft Selection
- Progress Tracker
- Language & Settings Panel

Module 2: Learning & Training Engine

- Interactive 3D Aircraft Models
- Guided Maintenance Procedures
- Theory-to-Practice Simulations

Module 3: Maintenance Task Scenarios

- Engine Inspection
- Hydraulic System Checks
- Avionics Troubleshooting
- Landing GearDiagnostics

Module 4: Gamification System

- Levels & Challenges
- XP & Points System
- Achievement Badges
- Leaderboards (Optional)

Module 5: Safety & Compliance Engine

- Virtual Safety Checks
- Standard Operating Procedure
- Maintenance Logbook Simulator

1.3.2.2 Product Mechanisms

1. To Provide Virtual Hands-On Practice, FlyFix enables students to perform simulated aircraft maintenance tasks
2. To Bridge the Gap Between Theory and Practice, the simulator helps students apply theoretical knowledge from modules
3. To Include Interactive Modules and Assessment, the system is equipped with step-by-step instructions, interactive tools, and evaluation features
4. To Reduce Dependence on Costly Physical Resources, the simulator reduces the reliance on expensive training kits and real aircraft

1.3.2.3 Software / Programming

Unity is a platform to make FLYFIX Simulator that offers many tools for users in developing mobile and window apps. This ensures easy access to both mobile and computers. Which means, no VR needs to run simulator games. C++ to handle more complex tasks that require higher performance, such as simulating how the aircraft systems behave during maintenance. On the other hand, JavaScript will be used to manage user interactions.

1.3.2.4 Accessories & Finishing

To accurately represent technician accessories used in aircraft maintenance, we develop realistic 3D models and textures of essential tools and accessories such as torque wrenches, multimeters, safety helmets, gloves, and toolboxes, based on actual industry standards. Also, to implement correct usage of accessories in gameplay mechanics, to ensure that each tool and accessory functions appropriately within game scenarios, teaching players the correct way to use them for specific maintenance tasks (e.g., safety wire pliers for securing bolts). Moreover, to ensure user-friendly interface and feedback system, we finalize the game with clear menus, interactive tutorials, and add Aircraft Maintenance Manual (AMM) that assist players in understanding their tools and environment effectively. Last, to conduct testing and refinement of visual and functional elements, perform iterative testing of accessory features and finishing touches to identify bugs or design flaws, ensuring a smooth polished final product.

1.4 SCOPE OF PROJECT

1.4.1 General Project Scopes

This project focuses on the development of FLYFIX SIMULATOR, an educational simulation game designed for students in aircraft maintenance programs. It aims to replicate real-world maintenance environments using 3D aircraft models and step-by-step procedures.

The simulator will be made available on multiple platforms, including Android, iOS, and Windows, ensuring accessibility for a wide range of users. It will use a Boeing aircraft model to simulate maintenance tasks commonly practiced in aviation schools. The game is intended to be both a learning tool and an engaging experience, helping students build confidence and apply their knowledge in a virtual setting.

1.4.2 Specific Individual Scope

1.4.2.1 Product Structure

The product structure of the FlyFix Simulator within the project scope is designed to provide a comprehensive, interactive learning platform for aircraft maintenance students. The simulator is organized into several core modules: the Aircraft Component Interaction System, which allows users to explore and perform maintenance tasks on detailed 3D models; the Guided Tutorial Module, which offers step-by-step instructions and procedures; and the Troubleshooting and Diagnostic System, which simulates real-world maintenance problems for users to solve. Additionally, a Gamification Engine is embedded to maintain engagement through points, achievements, and levels, while the Performance Evaluation Module tracks student progress and provides feedback for continuous improvement

Figure 2 Game in Aircraft Simulation

Supporting these systems is the Realistic Flight Dynamics System, which replicates authentic aerodynamic behaviors for flight-related training, and the Dynamic HUD, displaying real-time operational data such as speed, altitude, and system statuses. The simulator is built with Platform Adaptability Features to ensure smooth performance on both PC and mobile devices, making the training tool accessible anytime and anywhere. By combining interactive practice, real-world scenario simulations, and industry-standard safety protocols into a single virtual environment, the FLYFIX SIMULATOR structure aims to bridge the gap between theoretical classroom learning and practical aircraft maintenance skills in an engaging, cost-effective manner.

1.4.2.2 Product Mechanisms

1. To Provide Virtual Hands-On Practice, FLYFIX SIMULATOR enables students to perform simulated aircraft maintenance tasks
2. To Bridge the Gap Between Theory and Practice, the simulator helps students apply theoretical knowledge from modules
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reduces the reliance on expensive training kits and real aircraft

1.4.2.3 Software / Programming

The FLYFIX stand for (FLY-FIX SIMULATOR) was developed to assist aircraft maintenance students in learning ground task techniques required for aircraft maintenance. The FLYFIX SIMULATOR is only available on the Play Store, App Store, and Windows. The goal is to make the simulator easily accessible through common devices like smartphones and laptops. The programming for this project uses only C++ and JavaScript to build the system's core functions and interactive features. C++ is mainly used to simulate real aircraft system behavior, such as hydraulic, engine, and electrical systems. Java handles the user interface and interaction, making sure students can perform tasks like inspections, part replacements, and system checks smoothly.

This simulator focuses on practical maintenance tasks using a Boeing aircraft model, giving users a realistic experience of how maintenance is done in the industry. The tasks are designed to reflect real procedures that students have learned in their Part-66 modules. By coding these features using C++ and JavaScript, the simulator helps students apply their classroom knowledge in a safe and virtual environment. It not only supports learning but also fills the gap caused by limited training aircraft or tools in the classroom

1.4.2.4 Accessories & Finishing

This section of the project focuses on the detailed design, development, and implementation of accessories (tools, PPE, uniforms) and the finishing aspects (visual polish, realism, and user interface) that contribute to the overall realism and engagement of the game. It ensures that the game's environment closely resembles actual aircraft maintenance settings to support immersive and educational gameplay.

In Scope:

1. **Modeling and Integration of Technician Accessories**
    - Create 3D or 2D assets for essential tools such as:
        - Torque wrenches
        - Safety wire pliers
        - Screwdrivers
        - Multimeters
        - Toolboxes
    - Integrate these tools into gameplay mechanics for specific maintenance tasks.
2. **Development of Personal Protective Equipment (PPE) and Uniforms**
    - Design technician uniforms based on aviation maintenance standards (coveralls, high-visibility vests).
    - Include PPE like gloves, safety helmets, goggles, and hearing protection.
    - Customize appearance based on environment (e.g., day/night shift, hangar/ramp).
3. **Interactive Tool Usage System**
    - Implement tool selection and use through user-friendly UI elements.
    - Associate each tool with specific in-game actions or tasks (e.g., tightening bolts, checking voltage).
4. **Visual Finishing and Polish**
    - Apply realistic textures and materials to all accessories and environments.

- Use lighting, shadows, and reflections to enhance realism (e.g., metallic shine on tools, fabric textures).
- Add wear-and-tear effects for authenticity (e.g., worn gloves, scratched tool surfaces).

5. **Audio and Feedback Elements**
    - Add sound effects for tool usage (e.g., clicking torque wrench, buzzing multimeter).
    - Provide visual and audio feedback when accessories are used correctly or incorrectly.
6. **UI/UX Finishing**
    - Develop a clean, professional interface for equipment selection, maintenance logs, and task tracking.
    - Ensure intuitive navigation and clear iconography for accessories.
7. **Testing and Optimization**
    - Test accessory animations, textures, and interactions across devices.
    - Optimize models and effects for performance and smooth gameplay.

1.5 PROJET IMPACT

This project aims to bridge the gap between theoretical learning and practical understanding by providing an engaging and interactive tool for students and trainees in the aviation maintenance field.

1. Educational Impact

- **Enhanced Learning Experience:**

The game provides a hands-on, visual learning method that helps students and trainees understand maintenance procedures, safety protocols, and proper tool usage

.

- **Familiarization with Real-World Scenarios:**

  By simulating actual aircraft maintenance tasks and environments, players become more comfortable with the workflow and decision-making processes in real-life settings.

- **Support for Classroom and Remote Learning:**

  The game can be used as a supplementary teaching tool in aviation training schools or self-study, helping students grasp maintenance concepts more effectively.

2. Skill Development Impact

- **Improvement of Technical Skills:**

  Players will gain knowledge of aircraft tools, accessories, and component handling through virtual task execution, improving their confidence and preparation for real-world tasks.

- **Development of Safety Awareness:**

  With built-in safety protocols and PPE usage, the game instills habits and awareness aligned with industry standards, potentially reducing real-life errors.

- **Problem Solving and Decision Making:**

  Gameplay elements involving fault identification and corrective actions help sharpen diagnostic and troubleshooting abilities.

3. Industry Impact

- **Introduction to Digital Learning Tools in Aviation Maintenance:**

  This project highlights the potential for gamified training in the aviation sector, encouraging innovation in how technical training is delivered.

4. **Potential Use in Pre-Employment Screening or Basic Orientation:** Airlines and MROs could adapt such tools in future to assess entry-level understanding or provide new technicians with a virtual orientation. **Innovation and Research Contribution**

- **Blending Aviation and Game Development:**

  This project explores a unique integration of aviation maintenance knowledge and digital technology, serving as a model for future interdisciplinary projects.
- **Baseline for Future Simulation Tools:**

  The game can act as a prototype for more complex training simulators or modules that include advanced systems like avionics, hydraulics, or troubleshooting scenarios.

5. **Team and Personal Development**

- **Project Management and Collaboration Skills:**

  Team members gain experience in planning, designing, and executing a multi-disciplinary project involving both engineering and digital content creation.
- **Portfolio and Career Growth:**

  The final product and proposal contribute to your professional portfolio, showcasing your ability to apply engineering knowledge in a creative and modern way.

6. Innovation and Research Contribution

- **Blending Aviation and Game Development:**

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CHAPTER 2

LITERATURE REVIEW

2.1 GENERAL LITERATURE REVIEW

2.1.1 Real-World Practice

When it comes to learning aircraft maintenance, students often face a big challenge they don't always get enough real-world practice. Access to real aircraft, expensive tools, and proper facilities is limited, making it tough to bridge the gap between theory and actual hands-on experience. That's why our team decided to create the FLYFIX SIMULATOR, inspired by games like CSR2 and Wrench. We wanted to build something that feels realistic but still exciting, giving students a safe space to practice maintenance procedures, troubleshoot problems, and really understand how aircraft systems work. Based on surveys we conducted, it's clear that traditional classroom learning just isn't enough anymore most students are looking for something more interactive and engaging. Using Unity, we're

focusing on creating 3D models, realistic aerodynamics, and intuitive controls that make players feel like they're actually working on real aircraft. Plus, with gamification features like challenges, rewards, and step-by-step tutorials, we're making sure that learning stays fun and motivating. From everything we've studied, game-based learning isn't just more interesting it actually helps students learn faster and remember better. With FLYFIX, we're hoping to create not just a game, but a tool that truly helps future aircraft technicians build their skills and confidence before stepping into the real aviation world.

For me, working on the FLYFIX SIMULATOR isn't just about making a cool game it's about solving a real problem that many of us as students have faced. I've always believed that

learning should be hands-on, exciting, and something you can actually feel connected to. That's why we're putting so much focus on the small details: making sure the aircraft physics feels natural, ensuring the maintenance procedures are realistic, and creating an environment where students can actually learn by doing, not just by reading. Every part of the simulator, from the movement of the aircraft to the troubleshooting systems, is designed to make students feel like they're truly part of a maintenance team. We're not just teaching theory we're helping future technicians gain the confidence and skills they'll need in real-world aviation. And honestly, seeing how much potential there is to make learning better through technology like this makes me even more excited to keep pushing the project forward.

2.1.2 Relating Aviation to FLYFIX SIMULATOR

The aviation sector is greatly dependent on trained maintenance staff to keep aircraft safe and operational. Historically, these skills are acquired through direct, hands-on experience with actual aircraft. Such training methods are usually costly, risky, and need access to aircraft, which may be scarce in academic environments. With the growth in technology, the trend is changing towards simulation learning, which allows the students to learn in actual maintenance situations within a simulated virtual environment. FLYFIX SIMULATOR adapts to this trend by offering an interactive, immersive environment in which students can perform virtual maintenance tasks. Inspired by game-based learning paradigms like CSR2, FLYFIX aims to improve learning and knowledge retention by integrating game mechanics into learning material. This revolutionary system augments flight instruction with a risk-free and economical means of acquiring necessary maintenance proficiency.

2.1.3 Evaluate Effectiveness of Simulation in Education

Game-based learning has become an effective approach in modern education, especially in technical fields such as aircraft maintenance. This method involves using games as a tool to deliver knowledge and skills in an interactive and engaging way. For aviation students, it offers a practical alternative to traditional learning methods, which are often limited to textbooks and classroom lectures.

According to Connolly et al. (2012), serious games can improve student motivation, understanding, and memory by making learning more enjoyable. This is especially useful in aviation training, where students are required to understand complicated systems and procedures. Through games, students can practice these tasks in a virtual environment that feels realistic but does not carry real-world risks.

In aviation maintenance, simulation games have already been used to train students and

technicians. For example, Virtual Maintenance Trainers (VMTs) are often used to help learners understand aircraft systems and perform troubleshooting steps safely. These tools allow for repeated practice, which helps students become more confident in their skills. Salas et al. (2009) also highlighted that simulation-based training improves teamwork and decision-making, which are important in the aviation industry. Experience maintenance procedures through a 3D interactive environment. The game focuses on accessibility, allowing students to use it on both mobile phones and computers without needing expensive VR equipment. This approach supports learning by offering a cost- effective and practical solution for hands-on training, especially when access to real aircraft is limited.

Figure 3: Game in Laptop

2.1.4 Gamification and Serious Games in Education

Gamification involves using game design elements in non-game contexts to improve user engagement and learning. **Deterding et al. (2011)** define serious games as those designed for a purpose beyond entertainment, such as training or education. Research from **Wouters et al. (2013)** indicates that serious games in vocational and technical education can:

- Improve motivation and attention.
- Enhance procedural knowledge.
- Provide a safe environment to make and learn from mistakes.

2.2 SPECIFIC LITERATURE REVIEW

2.2.1 Product Structure

When we designed the FLYFIX SIMULATOR, we wanted it to feel as close as possible to real aircraft maintenance, but in a way that's accessible, fun, and stress-free for students. The main structure of FLYFIX SIMULATOR is built around realistic 3D models of aircraft parts things like engines, hydraulic systems, avionics, and landing gear. Using Unity, we created a virtual world where students can actually interact with these components: dismantling parts, troubleshooting faults, and carrying out inspections just like a real technician would. Every step was carefully planned to match real-world maintenance procedures based on industry standards like Part 66, but without the pressure of expensive equipment or the risk of making critical mistakes.

The game is set up with different learning layers to keep players moving forward. First, there's a tutorial mode that holds your hand, guiding you through tasks with detailed steps and safety tips. Once you're comfortable, you can switch to free practice mode, where you face random faults and have to figure them out on your own just like in real maintenance work. To really test your skills, there's also an assessment mode where you get scored based on how well and how safely you perform maintenance jobs. To keep it exciting, we added gamification elements like levels, achievements, and rewards, so players stay motivated and always have something new to chase.

From a technical side, the FLYFIX SIMULATOR uses Unity's Rigid body physics to simulate real aerodynamics like how thrust, lift, drag, and gravity work together. Even small touches, like realistic turbulence or the need to follow safety checklists, are built into the system to make the experience more immersive. The user interface (HUD) is simple but informative, showing part status, repair progress, and system warnings, so players never feel lost.

At the end of the day, we didn't just want to build a game we wanted to build a proper training platform. The FLYFIX structure is all about giving students real hands-on experience in a digital space, helping them build confidence, sharpen their skills, and feel truly ready for real-world aviation maintenance.

2.2.2 Product Mechanisms

The FLYFIX SIMULATOR integrates a number of technological features aimed at maximizing user engagement and learning achievement. It is developed with Unity, one of the most used game engines due to its flexibility and ease of deployment on a wide range of platforms. The simulator works as a game with users interacting with aircraft maintenance situations through exploration and task accomplishment. Hardware support includes compatibility with laptops, touch screen devices, and standard input devices like a mouse and keyboard, thereby making it accessible to a wide population of users. The programming employed by FLYFIX utilizes both Java and Python, giving it a solid platform to work on in terms of the development of interactive and dynamic features of the game.

User input is made as user-friendly as possible, combining hand gestures, drag-and-drop capabilities, and touch controls to simulate real maintenance operations. These combined functionalities together offer an authentic, interactive, and tutorial experience suitable for students learning aircraft maintenance fundamentals.

Figure 2.2.2: Unity

2.2.3 Software / Programming

Figure 2.2.3.1: Unity

The development of the FLYFIX SIMULATOR relies on several software and programming tools that support the creation of an interactive and mobile-friendly training application. The main purpose of using these tools is to ensure that the simulator can deliver a realistic yet accessible experience for aviation students, particularly those under Category

A. Each software plays a specific role in the development process, from building the 3D environment and coding interactivity to optimizing performance for mobile platforms.

One of the main software used in this project is the Unity Game Engine. Unity is a popular platform for both 2D and 3D game development because of its flexibility and cross-platform capabilities. It allows developers to build applications for mobile, desktop, and virtual reality devices using the same environment. For FLYFIX SIMULATOR, Unity is selected because it supports 3D modeling, animations, and scripting, all within one interface. According to Zaibon (2009), students learn better when they can interact and receive feedback in real time, and Unity makes this possible through its real-time rendering engine and interactive components. The use of Unity's scripting system, written in C#, also allows developers to create procedures, scoring systems, and step-by- step maintenance tasks such as walk-around inspections and tyre replacements. Another advantage of Unity is its Asset Store, which provides thousands of ready-to-use models and materials that can help reduce development time and cost—an important factor for student-level projects. Unity's Universal Render Pipeline (URP) is also beneficial because it helps optimize graphics for mobile devices, ensuring smooth performance even on mid-range smartphones.

The programming language used in the FLYFIX SIMULATOR is C#, which is the primary scripting language supported by Unity. C# is a structured, object-oriented language that makes it easier to handle complex systems and logic flow within a simulation game. In this project, C# is used to manage user interactions, such as clicking or tapping on aircraft components, following inspection procedures, and displaying safety reminders. It is also responsible for managing the scoring and feedback system that helps students identify mistakes in their maintenance steps. C# is widely used in educational and game-based projects due to its clear syntax, strong community support, and smooth integration with Unity's system.

To develop realistic visual models for the simulator, Blender is used as the 3D modeling and optimization software. Blender is an open-source program that allows developers to create, edit, and optimize 3D assets before importing them into Unity. While some 3D assets are downloaded from external sources, Blender is used to modify these models so that they are compatible with mobile devices. Heavy, high-polygon models can cause lag and slow performance on smartphones, so Blender's optimization tools such as the

Decimate Modifier and texture baking features are applied to reduce model complexity while maintaining visual quality. Blender also allows adjustments to scale, lighting, and material, which ensures consistency with the simulator's environment.

Besides using self-made models, the FLYFIX SIMULATOR also utilizes online 3D asset libraries such as Sketchfab, Turbo Squid, and the Unity Asset Store. These platforms provide free and paid models of aircraft components, maintenance tools, and hangar environments. Using such resources saves time and cost in the development process, allowing the focus to remain on improving interactivity and educational value rather than modeling every object from scratch. However, some models from these libraries need to be optimized and retextured to match the simulator's requirements. It is also essential to check the license terms to ensure that the assets are free for educational and non-commercial use. Zaibon (2009) also highlighted that open educational resources are effective for learning tools because they help developers focus more on content delivery and student experience.

To support data management, Firebase by Google is considered as a backend system. Firebase allows real-time data storage and user analytics, which can be useful for tracking student progress and performance. Through Firebase integration, this simulator can store scores, progress, and task completion data, which instructors can later access for evaluation. The cloud database also enables the simulator to synchronize user data across different devices, making it easier for students to continue their training anytime and anywhere. Even though Firebase is an optional feature, it adds value to the project by enhancing monitoring and assessment functions for classroom use. In addition, the Android Software Development Kit (SDK) is used together with Unity to build and deploy the simulator on Android devices. The SDK provides essential tools for testing, debugging, and optimizing the game on real mobile hardware. Visual Studio or Visual Studio Code serves as the main coding environment for writing and debugging C# scripts. Both provide syntax highlighting, error detection, and debugging features that help improve development efficiency and maintain clean code.

In summary, the combination of Unity, C#, Blender, online asset libraries, Firebase, and the Android SDK provides a strong foundation for developing the FLYFIX simulator. Each

software contributes to a specific part of the process—from design and coding to optimization and deployment. These tools ensure that the final simulator is not only visually engaging but also technically efficient and accessible to aviation students. By integrating these technologies, FLYFIX SIMULATOR can effectively support hands-on learning experiences in aircraft maintenance without relying on real aircraft or expensive equipment.

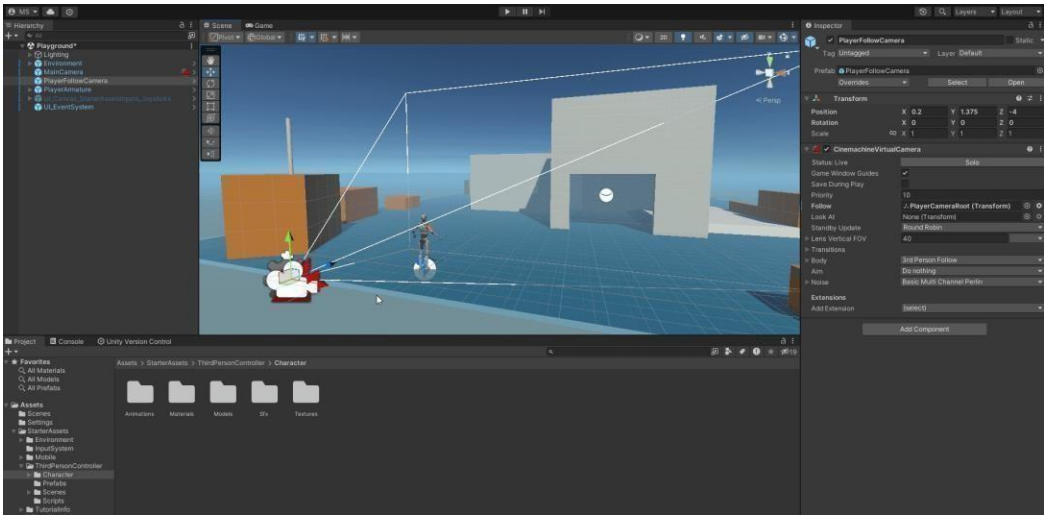


Figure 4: Entire Unity Hub

2.2.4 Accessories & Finishing

2.2.4.1 Visual Realism and Finishing in Simulation Design

"Finishing" refers to the visual quality, polish, and user experience (UX) in simulations. The **effectiveness of educational simulations** is significantly influenced by the realism of environments, tools, and character models.

According to **Chittaro & Ranon (2007)**, visual fidelity in safety training simulations can lead to:

- Higher engagement
- Lower cognitive load
- Better transfer of learning

Realistic rendering of accessories (tools and PPE) helps players associate digital experiences with physical tasks. **Unity and Unreal Engine documentation** also suggest that detailed textures, lighting, and animations contribute to immersion and perceived authenticity—key for training-based games.

2.3 REVIEW OF RECENT RESEARCH / RELATED PRODUCTS

2.3.1 Related Patented Products

Patent Title	Interactive Aircraft Maintenance and Repair Simulator
Patent Number	EP3205123A1
Country	Europe
Patent Status	Published
Summary	Simulation software allowing users to perform interactive aircraft repair tasks with real-time feedback.

2.3.1.1 Patent A

Category	Detail
Patent Title	Interactive Aircraft Maintenance and Repair Simulator
Patent Number	EP3205123A1
Country	Europe
Patent Status	Published
Summary	Simulation software allowing users to perform interactive aircraft repair tasks with real-time feedback.

2.3.1.2 Interactive Aircraft Maintenance and Repair Simulator

Patent Title	Interactive Aircraft Maintenance and Repair Simulator
Patent Number	EP3205123A1
Country	Europe
Patent Status	Published
Summary	Simulation software allowing users to perform interactive aircraft repair tasks with real-time feedback.

2.3.1.3 Aircraft Maintenance Virtual Training System and Method

Patent Title	Aircraft Maintenance Virtual Training System and Method
Patent Number	CN106652721B
Country	China
Patent Status	Granted
Summary	**This patent describes a virtual training system for aircraft maintenance. It includes modules such as virtual maintenance, disassembly or assembly simulation, fault diagnosis, virtual instruments, and self-evaluation. These modules work together to create a complete virtual learning and assessment environment**

2.3.1.4 Airbus AR Maintenance Assistance System

Patent Title	Airbus AR Maintenance Assistance System
Patent Number	EP3132954A1
Country	Europe
Patent Status	Granted
Summary	Visual instructions on real-time objects; helps correct accessory use during tasks. Guides maintenance operations visually, improving technician efficiency and reducing errors.

2.3.2 Recent Market Products

2.3.2.1 Product A

No	Market Product	Product Summary
1		• Product Name: Airplane Repair Workshop Garage • Developer: Simulation/Strategy • An Airplane Repair Workshop Garage is a specialized facility designed for the maintenance, repair, and overhaul (MRO) of aircraft. These workshops are equipped with various tools, diagnostic equipment, and skilled personnel necessary to perform a wide range of tasks to keep aircraft in optimal working condition. The garage would typically cater to both routine inspections and complex repairs, ensuring safety and compliance with aviation regulations.

2.3.2.2 Product B

Feature 2.3.2.3	Aviatech Aircraft Maintenance Sim	FLYFIX SIMULATOR
2.3.T2y.4pe 2.3.2.5 2.3.2.6	Simulation Software	Game-based Simulator
Software 2.3.2.7	Unreal Engine / Proprietary System (assumed)	Unity Engine
Engine Programming Language	Likely C++ or similar (for realism & performance)	Combination of Java, C++
Hardware Requirement	High-spec PC or VR setup	Laptop, Touchscreen, Mouse & Keyboard
Graphics Quality	High realism for professional training	Moderate, optimized for accessibility and engagement

2.3.2.8 Product C

No	Market Product	Product Summary
1	**2.3.2.9 D** 	• Product Name: Plane Mechanic Simulator • Developer: Disaster Studio, Cobble Games • Launch Date: February 14, 2024 (Full Release) Early Access began on February 13, 2019 • Plane Mechanic Simulator is a World War II-themed simulation game where players take on the role of an aircraft technician in the Royal Air Force. The game focuses on realistic aircraft maintenance tasks such as engine repairs, system checks and weapon calibration on historic British planes like the Spitfire and Hurricane.

2.3.2.13 Product D

No	Market Product	Product Summary
1		• Product Name: Aircraft Mechanic Simulator 2023 • Developer: Image Power S.A • Release year: 2023 (early access) • A detailed simulator where players inspect, repair, and maintain various aircraft models. Players dismantle aircraft components, use realistic tools, and perform maintenance tasks like engine checks and avionics repairs.

2.4 COMPARISON BETWEEN RECENT RESEARH AND CURRENT PROJECT

2.4.1 Patent A vs. Product A vs. Your Product

Product	Interactive Aircraft Maintenance and Repair Simulator	Airplane Repair Workshop Garage	FLYFIX SIMULATOR
Logo			
Purpose	To train aircraft technicians in maintenance and repair procedures through a virtual environment.	Successfully manage and grow their own repair workshop	To educate students on aircraft maintenance procedures and learn toturial how to do?
Target	Aircraft maintenance students, professional technicians, aviation industries.	Level of interest in airplanes or mechanics (casual, enthusiast, professional curious)	Aircraft maintenance students, aviation trainees, educational institutions.
Features	Realistic aircraft models, fault simulation, repair tasks, interactive feedback, step-by-step guidance.	Diagnosing airplane problems using various tools and techniques.	Virtual aircraft models, component inspection, part replacement simulations, realistic repair scenarios, VR/AR interaction.

Learning approach	Hands-on simulation with real-time error correction and skill assessment.	Increasingly complex repair challenges that require applying learned skills	Game-based learning with task-driven maintenance procedures and interactive exploration to enhance technical skills.
Platform	PC-based, VR compatible (some versions require specific VR headsets or training centers).	Mobile platforms (iOS, Android).	PC and mobile platforms (with support for touchscreen, mouse, keyboard, hand movement sensors in future updates).

2.4.2 Patent B vs. Product B vs. Your Product

Product	Interactive Aircraft Maintenance and Repair Simulator	CSR Racing 2 (CSR2)	FLYFIX SIMULATOR
Logo			
Purpose	To train aircraft technicians in maintenance and repair procedures through a virtual environment.	To entertain users with high-quality racing experiences and car customizations.	To educate students on aircraft maintenance procedures in an engaging, game-based environment.
Target	Aircraft maintenance students, professional technicians, aviation industries.	Casual gamers, car enthusiasts, mobile gamers.	Aircraft maintenance students, aviation trainees, educational institutions.
Features	Realistic aircraft models, fault simulation, repair	Car racing, car upgrading and tuning, multiplayer	Virtual aircraft models, component inspection, part
	tasks, interactive feedback, step-by- step guidance.	racing events, highly detailed car customization.	replacement simulations, realistic repair scenarios, VR/AR interaction.

Learning approach	Hands-on simulation with real-time error correction and skill assessment.	Game-based entertainment with minor mechanical customization elements (no real technical learning).	Game-based learning with task-driven maintenance procedures and interactive exploration to enhance technical skills.
Platform	PC-based, VR compatible (some versions require specific VR headsets or training centers).	Mobile platforms (iOS, Android).	PC and mobile platforms (with support for touchscreen, mouse, keyboard, hand movement sensors in future updates).

2.4.3 Patent C vs. Product B vs. Your Product

Product	Aircraft Maintenance Virtual Training System and Method	Plane Mechanic Simulator	FLYFIX SIMULATOR
Logo			FLYFIX SIMULATOR
Purpose	To provide a virtual system for training aircraft maintenance using smart glasses and interactive tools.	To simulate the life of a WWII ground crew mechanic performing realistic tasks.	To provide interactive, hands-on training for aircraft maintenance students in a modern and engaging way.
Target	Aviationtechnicians and students using advanced hardware	General gamers interested in aircraft maintenance and WWII era.	Aircraft maintenance students
Features	Smart glasses, gesture control, AR interface, virtual task guidance,error correction features.	Realistic WWII aircraft, tools, damage repair, step- by-step task gameplay.	Realistic 3D aircraft (Boeing), step-by-step tasks, troubleshooting, accessible tutorials, no VR needed.

Learning approach	Mixed reality with guided procedures and error alerts in real	Entertainment focused with some educational elements on	Simulation-based learning with strong focus on theory to practice application.

	time.	maintenance.	
Platform	Need to using on AR and VR	Need to using on PC (Windows).	Play in both Mobile (Play Store, App Store) and PC (Windows) with no VR required.

2.4.4 Patent D vs Product D vs. Your Product

Product	Airbus AR Maintenance Assistance System	Aircraft Mechanic Simulator 2023	FLYFIX Simulator
Logo			FLYFIX SIMULATOR
Purpose	Visual instruction for correct use of tools and accessories during real-time maintenance tasks.	Detailed dismantling and repairing of aircraft parts using realistic tools in a game environment.	Educational focus on correct tool/PPE use, safety awareness, and maintenance task simulation for beginners.
Target	Professional aviation maintenance technicians (real-world operation support).	General players and aviation fans interested in simulation games.	Aviation maintenance students and trainees, combining learning and gaming experience.

Features	Uses Augmented Reality (AR) to project maintenance instructions onto real- world aircraft and accessories.	Uses 3D PC-based simulation of aircraft, tools, and repairs, without AR.	Will use 2D/3D simulation (PC or mobile) focusing on realistic accessories, maintenance tasks, and educational gameplay. No AR planned

Learning approach	Very high — improves technician efficiency and reduces errors in real operations.	Moderate — teaches general aircraft knowledge but mainly for entertainment purposes.	High — designed to teach basic maintenance skills, safety procedures, and proper tool usage in an accessible game format.

CHAPTER 3

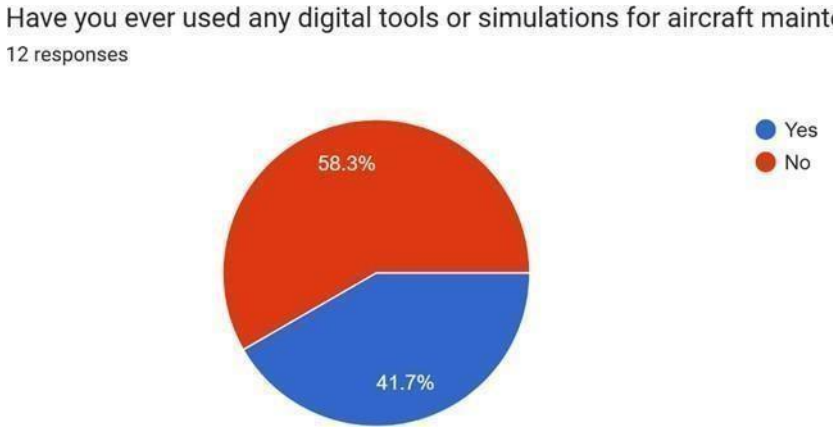
RESEARCH METHODOLOGY

3.1 DESIGN ENGINEERING TOOLS

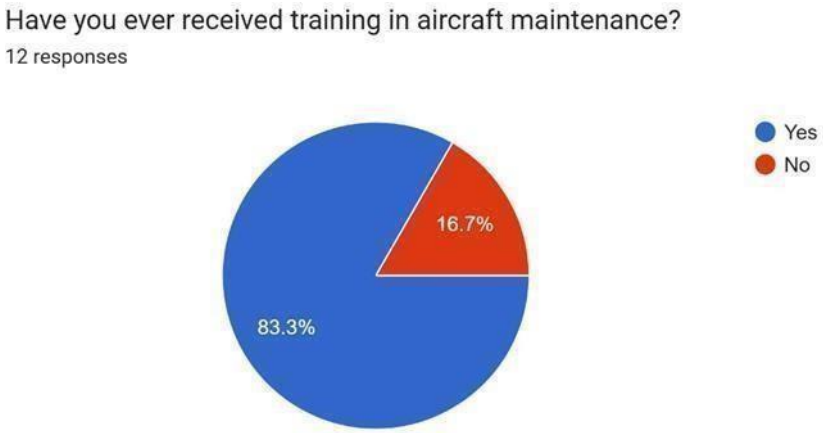
3.1.1 Design Requirement Analysis

3.1.1.1 Questionnaire Survey

We examined the questionnaire data and created charts and graphs for better understanding. The following are some of the essential questions that help us analyse the topic further from the overall questionnaire, which was completed by 26 respondents from varied backgrounds:

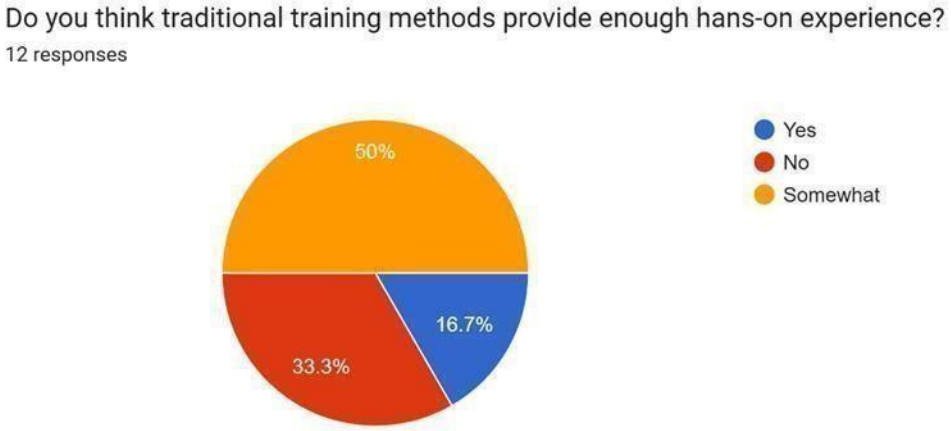


We began the data analysis by asking the users if they were familiar digital tools or samulations in the aviation industry, and the majority of the users (58.3%) responded no. The percentage of yes answers is approximately 41.7%.



Then we asking is there had received training in aircraft or not. Most people say yes.

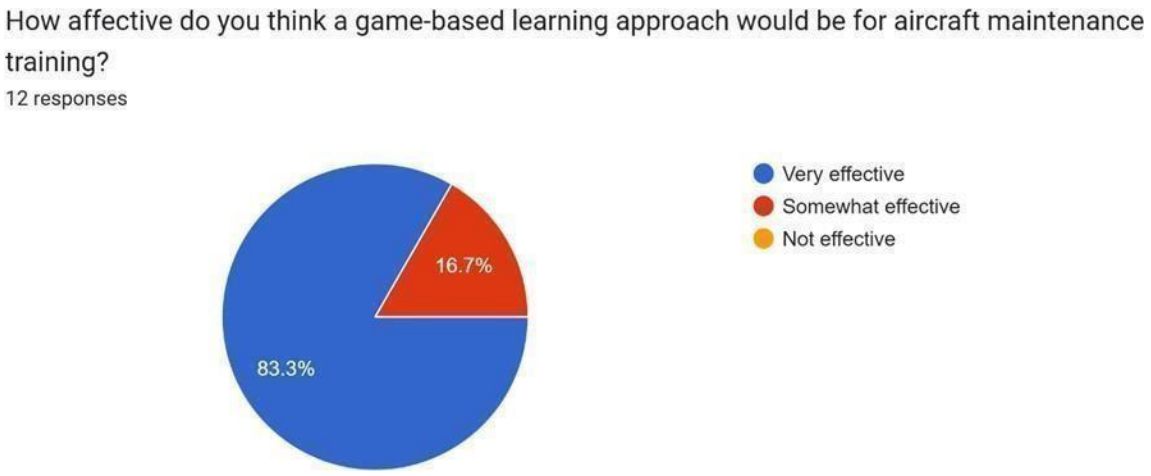
Next we asking where aircraft maintainence learn skill. We know that most people just got skill in classroom training that most people never practice teory skill in practical or in real situation.



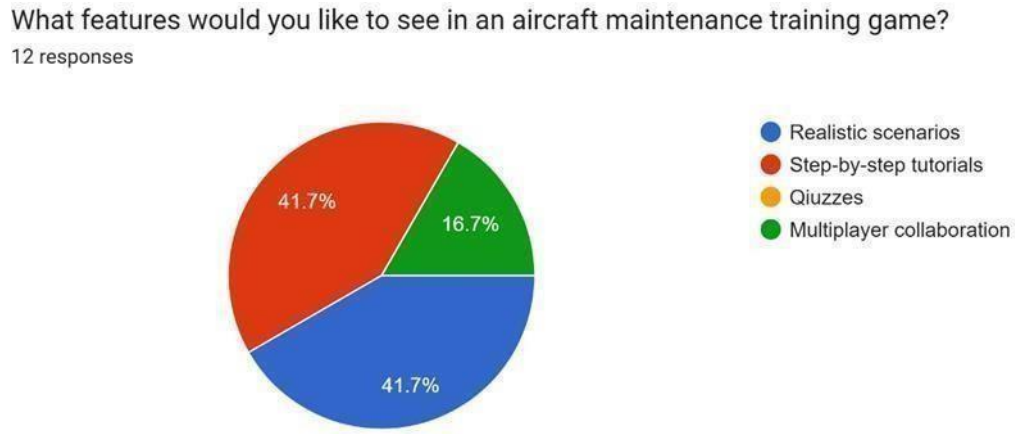
Next we asked did the traditional training method provide enough hands-on experience or not. The data collected that 50% somewhat, 33.3% no and 16.7% is yes.

Then we asked that people will instrested or not using a simulation game to learn aircraft maintainence. The data collected that most of people is interested to play simulation game. Which is the simulation game is high demand on market.

We ask what training is most challenging and we seen teory is the most challenging in aircraft maitainence training. This surely traditional training need to be improve with simulation game because they can practice what they learn in classroom.



Also we asked how affective the game based-learning. The data collected that 83.3% is very effective for maintainence training.

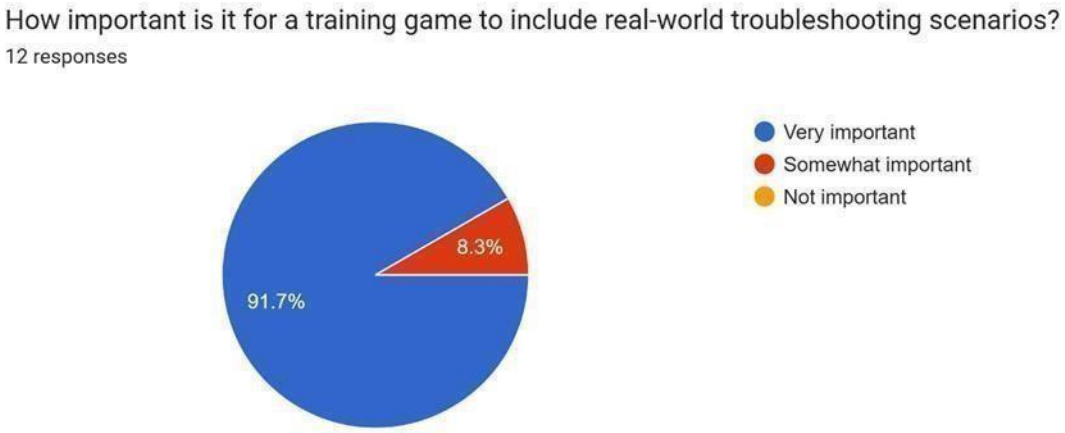


And we asked what feactures would be like to see in aircraft maintainence training game. People answer that realistic scenarios and step-by-step tutorial would be effective for the game.

Next, we asked prefer a training game that avaible on.

Then we asked what the biggest limitation of current training methods, The data collected that 41.7% is because high cost and 33.3% is lack of hands-on practice

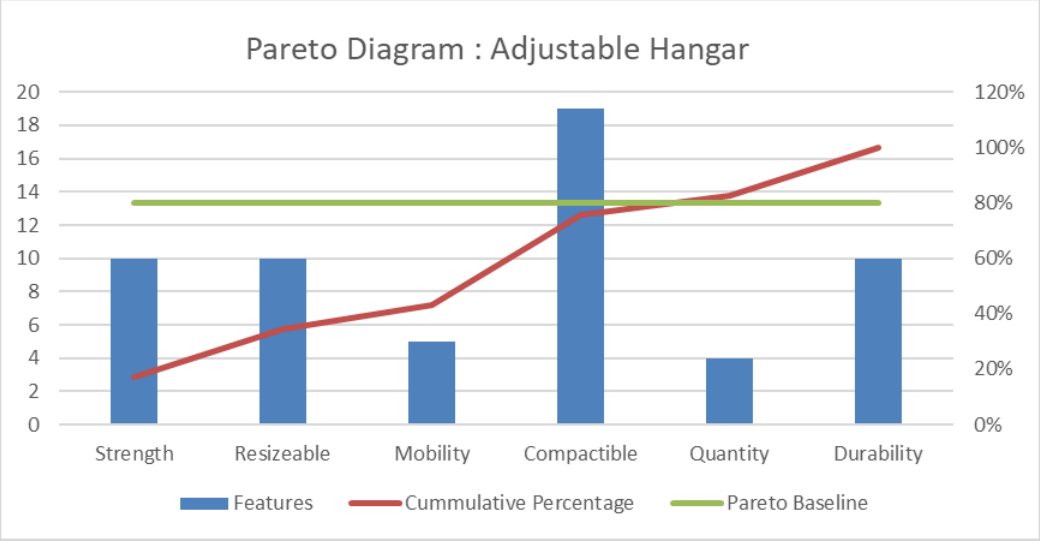
Next we know that the people is more interactive to learn skill by game-based



Lastly we asked that game is important for training game or not. Most people answer very important.

3.1.1.2 Pareto Diagram

Pareto Diagram: Adjustable Hangar			
Features	**Frequency**	**Cummulative Percentage**	**Pareto Baseline**
Strength	10	17%	80%
Resizeable	10	34%	80%
Mobility	5	43%	80%
Compactible	19	76%	80%
Quantity	4	83%	80%
Durability	10	100%	80%
kk	0	100%	80%
GRAND TOTAL	58		



3.1.2 Design Concept Generation

3.1.2.1 Function Tree

main function create a virtual simulator for aircraft maintenance

- The simulator aims to create an immersive environment where users (students) can perform aircraft maintenance tasks in a virtual setting. This function serves as the foundation for the entire project.

sub function 1 Allow user to select aircraft parts

- Display 3D Model of Aircraft Parts
- Enable User Interaction to Select Parts

sub function 2 Simulate maintenance tasks

- Simulate Replacing Parts
- Simulate Inspecting Components

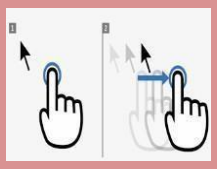
sub function 3 Provide real-time feedback on user actions

- Display Feedback on Performance
- Show Tools Required for Tasks

3.1.2.2 Morphological Matrix

3.1.2.3 Proposed Design Concept 1

FUNTION (SUB FUNTION)	IDEA 1	IDEA 2	IDEA 3	IDEA 4
TYPE	AR 	Game 	Explore 	Game 
SOFTWARE	Unity 	Unity 	Unreal Engine 	Unity 
HARDWARE	Laptop 	Touchscreen 	Mouse and Keyboard 	Mouse and Keyboard 

PROGRAMMING LANGUAGE	Java 	Swift 	C++ 	C# 
INTERACTION	Click based (touch 	Hand movement 	Click-based & Drag-and-Drop 	Hand Movement 

3.1.2.4 Proposed Design Concept 2

FUNCTION	CONCEPT 2	JUSTIFICATION
TYPE	AR	AR overlays digital elements onto the real world, allowing users to interact with virtual components in a natural environment.
SOFTWARE	UNITY	Unity is a cross-platform game engine primarily used to develop video games and simulations for PC, consoles, mobile devices and websites
HARDWARE	LAPTOP	A laptop's screen is on a hinge, which allows it to open up when in use and to close like a book to keep it safe when stowed away
PROGRAMMING LANGUAGE	JAVA	Object oriented language which gives a clear structure to programs and allows code to be reused, lowering development cost.

INTERACTION	Click based (touch)	A touchscreen is a computer screen that can be used by touching it with a finger or a stylus pen, instead of using a mouse or remote control.

3.1.2.5 Proposed Design Concept 3

FUNCTION	CONCEPT 2	JUSTIFICATION
TYPE	GAME	Learning process involving concepts, components, training about aircraft
SOFTWARE	UNITY	Allows users to create 2D and 3D games, simulations, and other interactive experiences. It's used by many industries, including gaming, film, architecture, and engineering
HARDWARE	TOUCHSCREEN	• Provides direct interaction with on-screen elements, allowing users to tap, swipe, and drag objects. • Beginner-friendly, making it easier for new users to navigate
PROGRAMMING LANGUAGE	SWIFT	Swift is a powerful and intuitive programming language developed by Apple for building software across iOS, macOS, watchOS, and tvOS platforms
INTERACTION	HAND MOVEMENT	• Clicking & Dragging Fast clicking for actions like pointing, selecting units • Hotkey Pressing Fast finger movement to activate abilities

3.1.2.6 Proposed Design Concept 4

FUNTION	CONCEPT 3	EXPLANATION
TYPE	Explore	Player can learning based on what they learn on teory classes with interactive visual
SOFTWARE	Unreal Engine	Provide more realistic graphic , making player can see more detailing in game.
HARDWARE	Mouse and Keyboard	Standard input for accessibility
PROGRAMMING LANGUAGE	C++	Primary programming language used for unreal engine development
INTERACTION	Click-based & Drag-and-Drop	Player can drag or drop items to repair the structure. It's easy easy user who is new player

3.1.2.7 Accepted Vs. Discarded Solution

FUNTION	CONCEPT 3	EXPLANATION
TYPE	Game	Players influence the game world through actions and decisions.
SOFTWARE	Unity	Provides tools to design levels, animations, and physics.
HARDWARE	Mouse and Keyboard	Standard input for accessibility.
PROGRAMMING LANGUAGE	C#	➢ Used with Unity for creating video games ➢ Good balance of beginner-friendly syntax and powerful capabilities ➢ Also used in desktop and mobile applications

INTERACTION	Hand movement	It allows users to manipulate objects, navigate menus, or perform actions naturally using
		hand gestures.

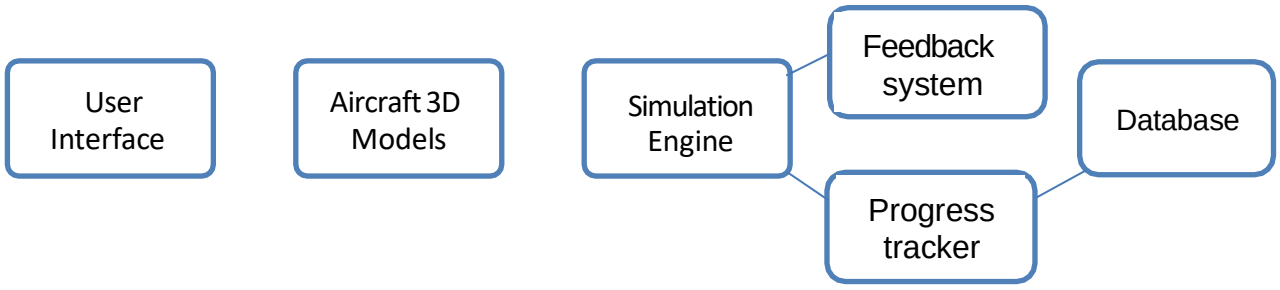
3.1.3 Evaluation and Selection of Conceptual Design

FUNTION	ACCEPTED	DISCARDED
TYPE	Game	-
SOFTWARE	Unity	Unreal Engine
HARDWARE	Mouse Keyboard and touch screen	LAPTOP
PROGRAMMING LANGUAGE	Combination of Java and C++	PYTHON
INTERACTION	Hand Movement , Click based (touch)	Click-based & Drag-and-Drop

3.1.3.1 Pugh Matrix

CRITERIA	CONCEPT 1	CONCEPT 2	AR	CONCEPT 3	CONCEPT 4
TYPE	2	1	D	1	1
SOFTWARE	2	2	A	1	2
HARDWARE	2	3	T	1	1
PROGRAMMA	2	1	U	1	1
BLE					
LANGUAGE					
INTERACTION	2	3	M	1	3
TOTAL SCORE	10	11	-	6	8
RANKING	2	2	1	4	3

3.1.4 Conceptual Design of the Proposed Product



3.2 INTERFACE LAYOUT

3.2.1 General Interface Layout

Figure 5: Interface Layout

3.2.2 Specific Interface Layout

3.2.2.1 Product Structure

Figure 6 : Product Structure

3.2.2.2 Product Mechanism

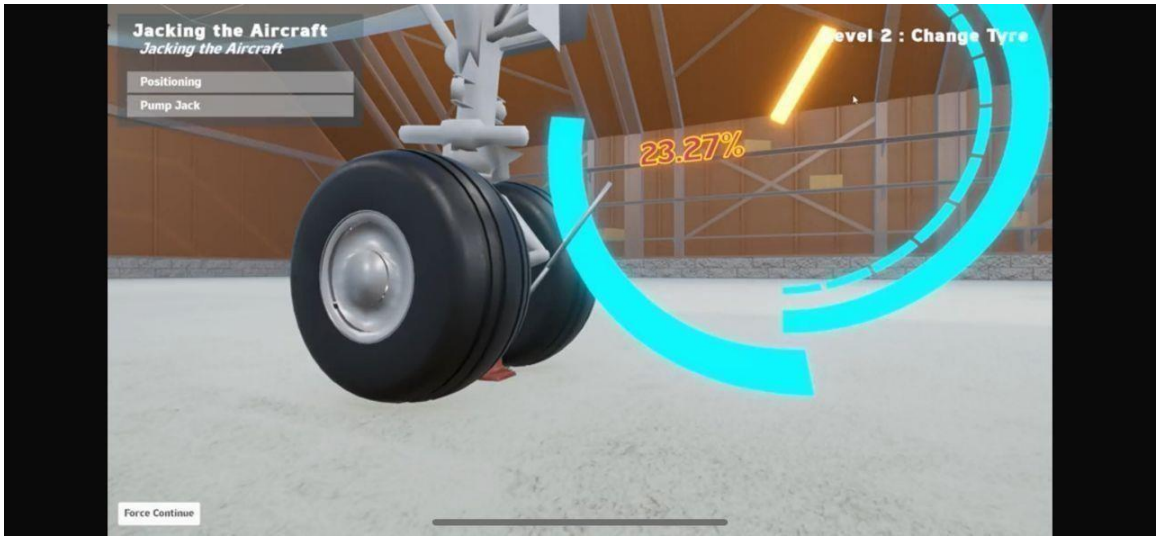


Figure 7: Product Mechanism

3.2.2.3 Software / Programming

The FLYFIX SIMULATOR incorporates a Boeing aircraft model as the core element for user interaction. The model was selected and modified using computer-aided design (CAD) software to ensure that it accurately represents key areas commonly involved in aircraft line maintenance tasks. Essential components such as the access panels, landing gear, and engine compartments were highlighted and prepared for user interaction. Although the full design was sourced from available 3D assets, further refinement was performed to adjust the complexity and optimize the model for mobile device compatibility without sacrificing important maintenance details.

The interface layout of the simulator was carefully designed to promote ease of use and intuitive operation. Upon launching the application, users are presented with a clean main menu offering options such as “Start Task,” “Settings,” and “Help.” Task selection screens display a list of available maintenance procedures with simple icons and descriptions to guide the user. Once inside the maintenance simulation, the task instructions appear at the top of the screen, while interactive buttons for inspecting, removing, or reinstalling parts are placed strategically to minimize user confusion. A settings menu is accessible at all times, allowing users to adjust graphic settings to suit their device’s performance capabilities.

The programming process flow begins when the user opens the simulator and enters the main menu. Upon task selection, the system loads a specific scenario using C++ scripts, initializing the Boeing model along with the corresponding maintenance checklist.
JavaScript handles the user interface, displaying dynamic instructions and updating task progress in real time. As the player interacts with the aircraft parts, the simulator uses object recognition techniques such as ray casting to detect selections and validate actions. If a step is completed correctly, the system records the success and moves to the next instruction; if not, feedback is provided immediately. Upon completing the entire task,

the simulator presents a summary screen showing the user's performance. Throughout the session, background scripts monitor device performance and automatically adjust graphics if needed, ensuring a smooth experience across both high-end and mobile devices. This seamless integration of CAD modeling, user-centered interface design, and detailed programming flow forms the operational backbone of the FLYFIX SIMULATOR.

3.2.2.4 Accessories & Finishing

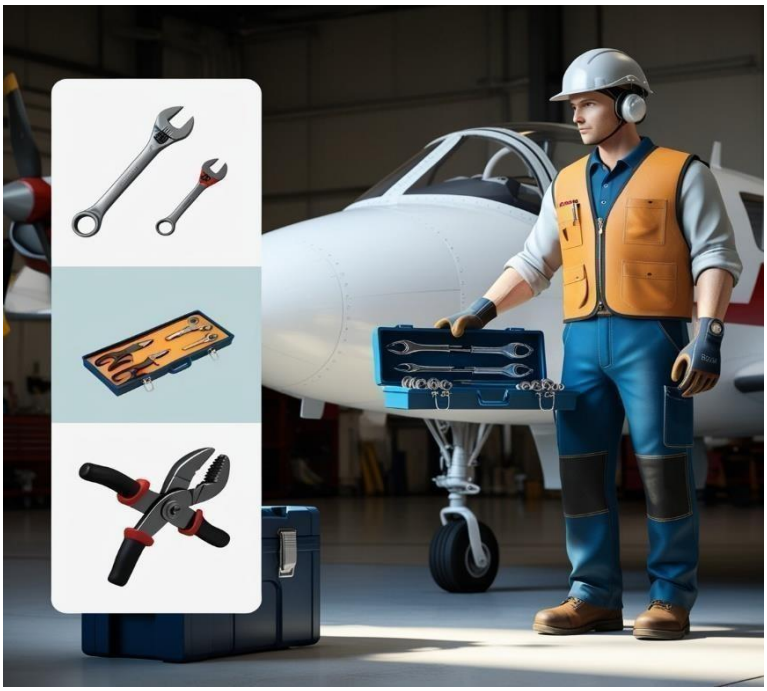


Figure 8: Aircarft Tools

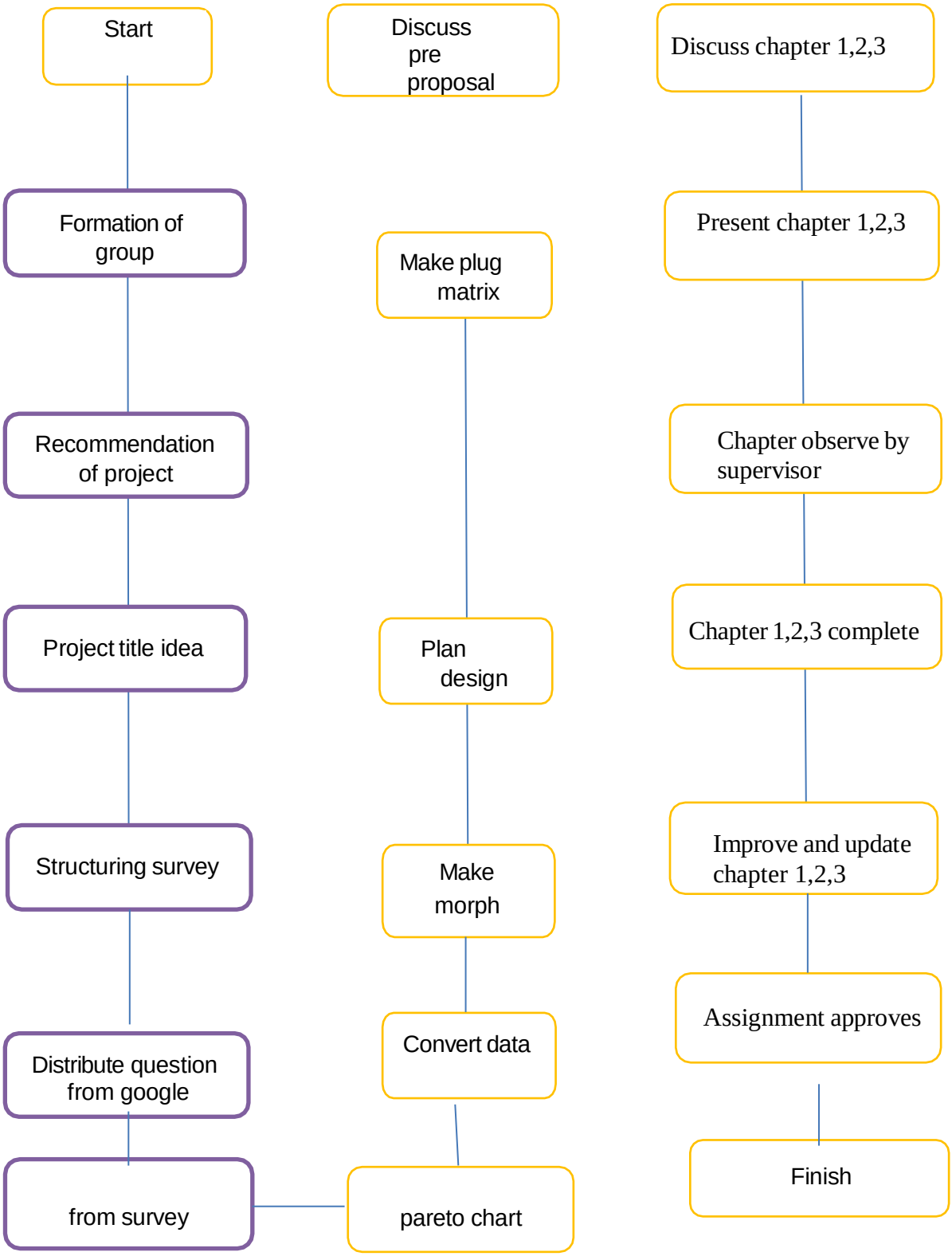
In the game interface, the main screen is divided into clear sections to guide the player effectively. At the center, the player's avatar an aircraft technician stands realistically modeled inside a spacious hangar next to an aircraft undergoing maintenance.

On the left side of the screen, a floating tool panel presents a neat grid of realistic 3D icons displaying maintenance accessories like torque wrenches, screwdrivers, pliers, and multimeters. Each tool features a short label and an interactive preview, allowing players to drag directly onto the character. On the right side of the screen, a task instruction panel provides step-by-step maintenance procedures, including safety reminders.

The environment is finished with soft hangar lighting, creating natural shadows on the floor and realistic highlights. Smooth animations show the technician interacting with aircraft components. Overall, the interface balances a clean, professional look with practical functionality, supporting both immersive gameplay and educational goals in aircraft maintenance training.

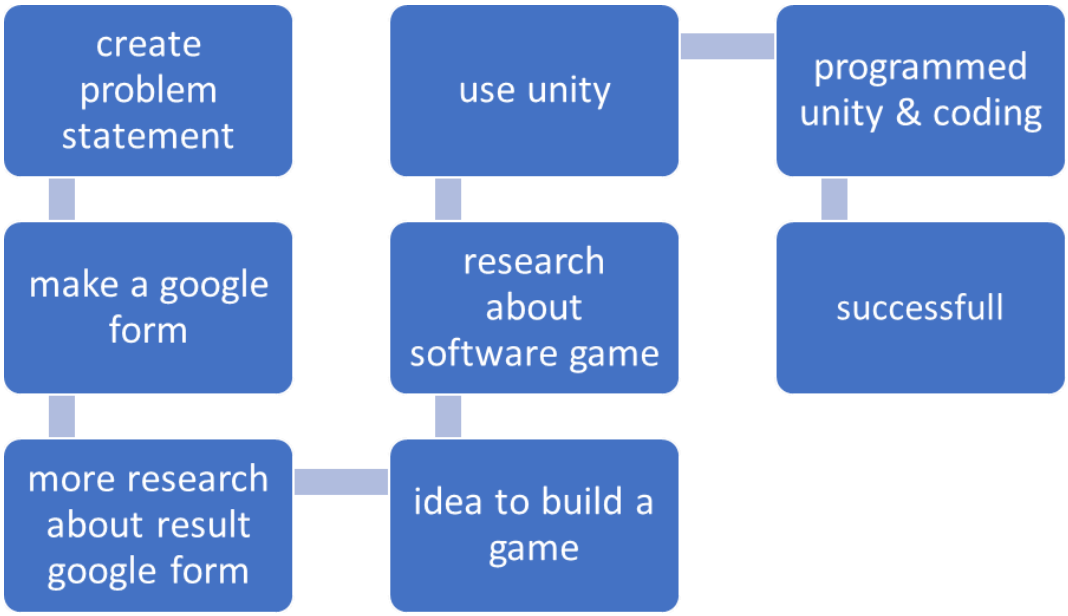
3.3 PROJECT FLOW CHART

3.3.1 Overall Project Flow Chart

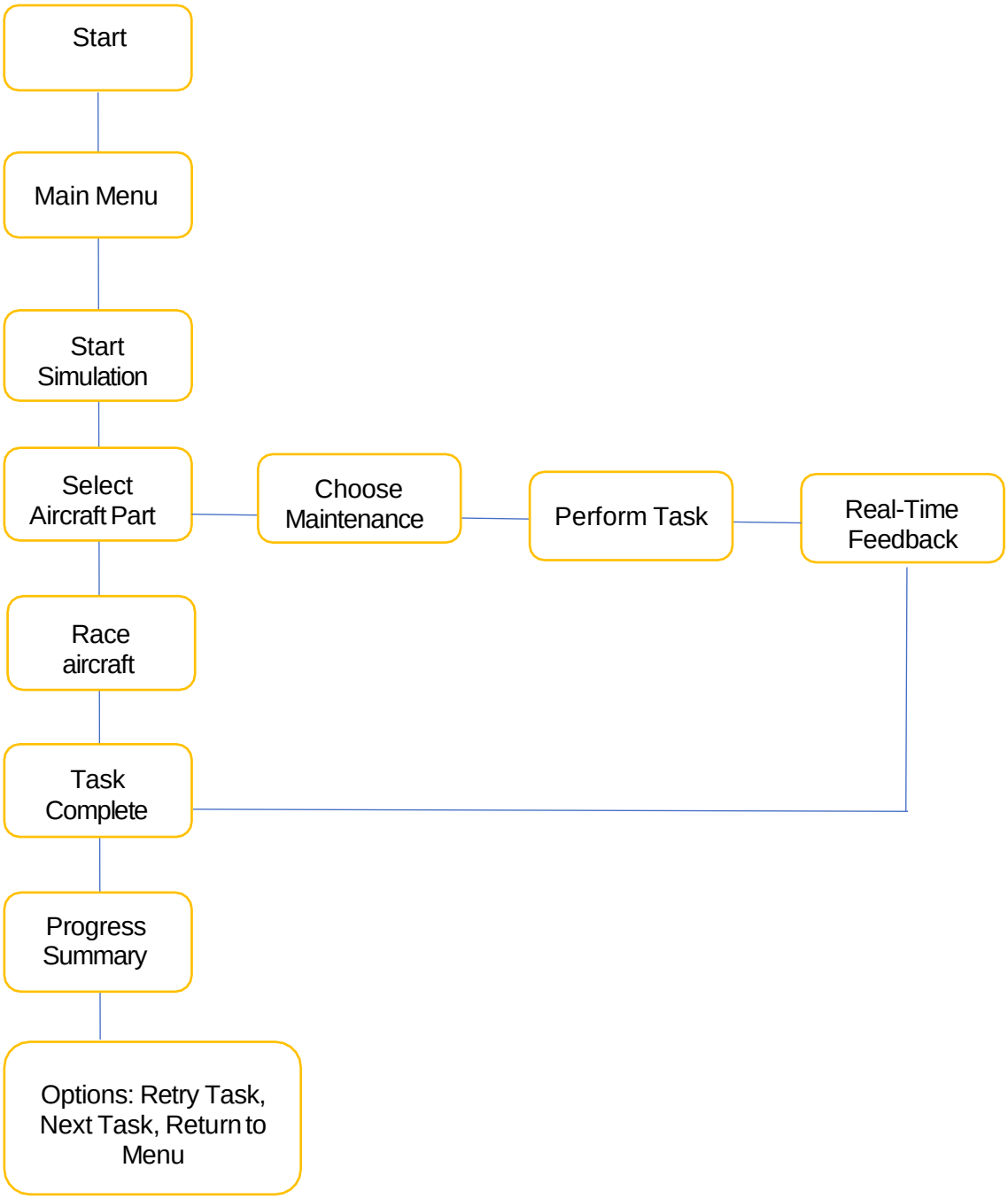


3.3.2 Specific Design/Flow Chart

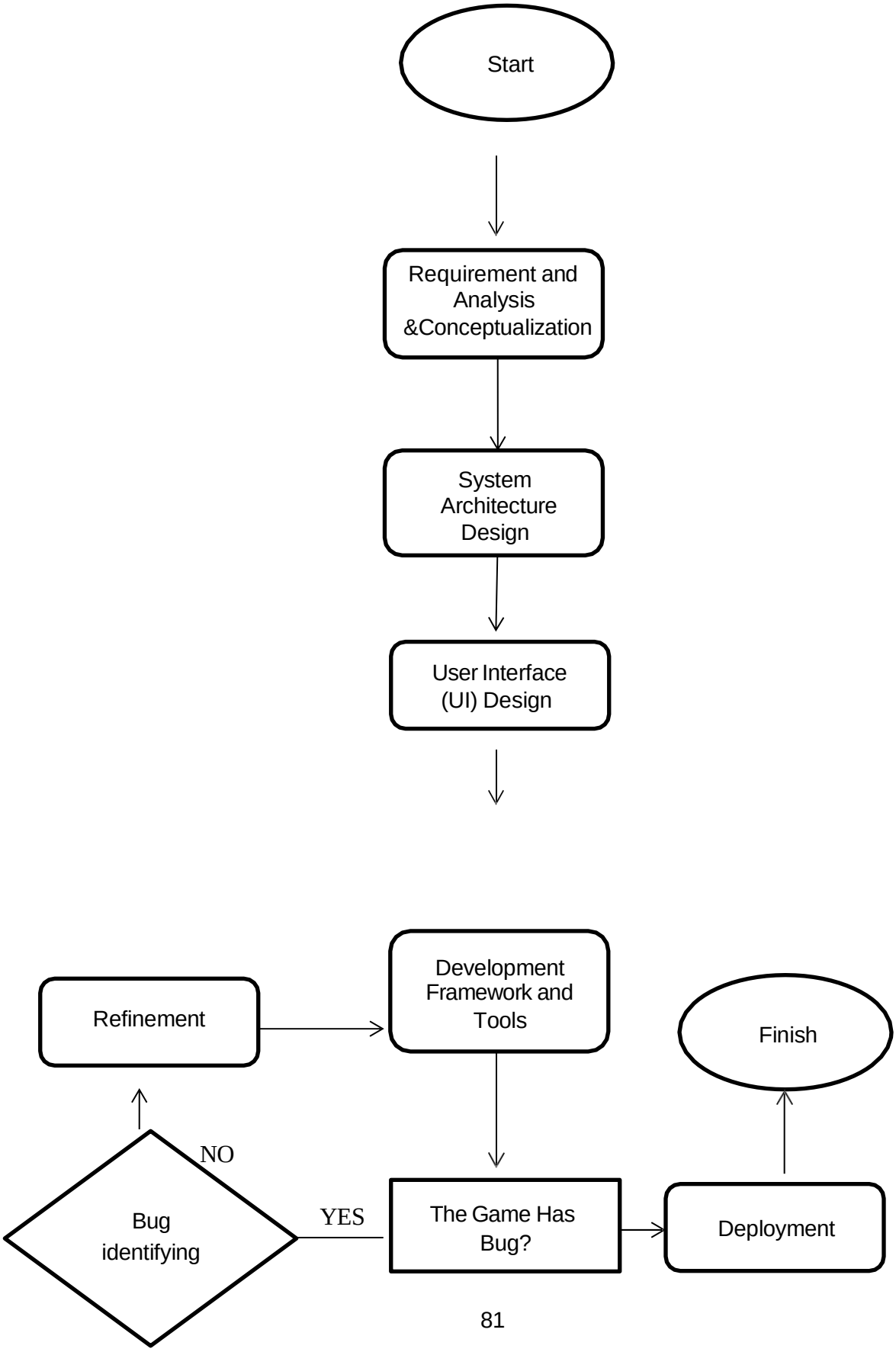
3.3.2.1 Product Structure



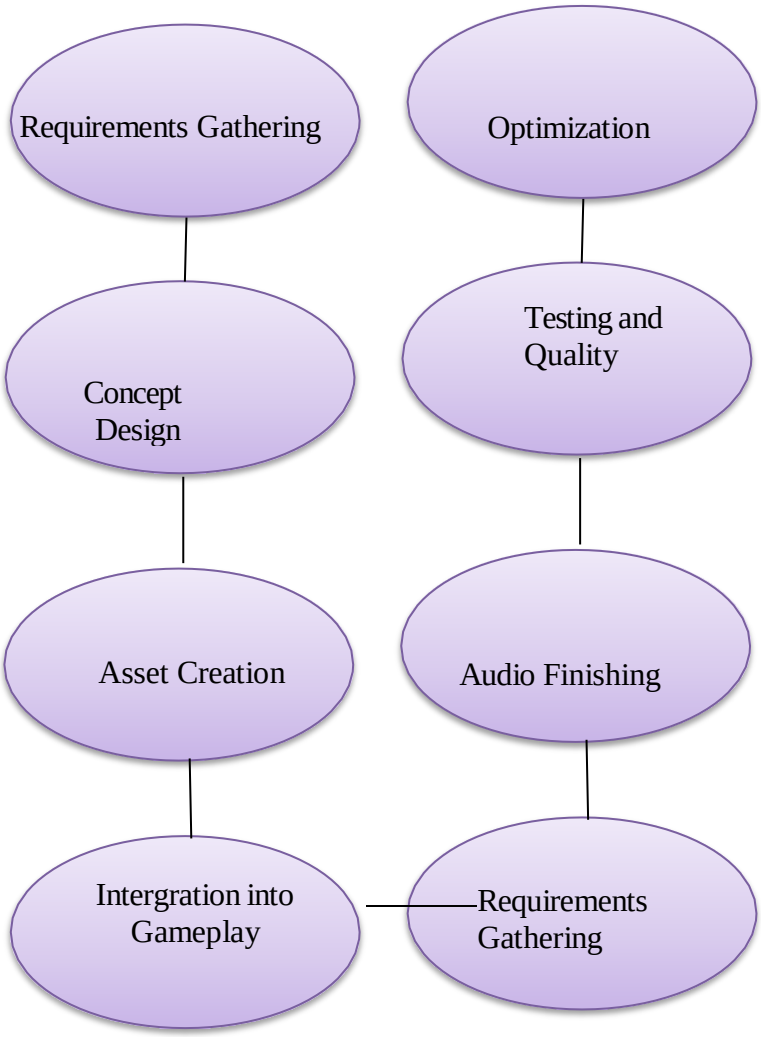
3.3.2.2 Product Mechanisms



3.3.2.3 Software / Programming


Start
Requirement and Analysis &Conceptualization
System Architecture Design
User Interface (UI) Design
Development Framework and Tools
Refinement
Finish
NO
Bug identifying
YES
The Game Has Bug?
Deployment

3.3.2.4 Accessories & Finishing


Requirements Gathering
Concept Design
Asset Creation
Intergration into Gameplay
Requirements Gathering
Audio Finishing
Testing and Quality
Optimization

3.4 PRODUCT DESCRIPTION

3.4.1 General Product Features & Functionalities

The FLYFIX SIMULATOR is designed to provide an engaging and realistic aircraft maintenance training experience through an interactive simulation game. The simulator offers hands-on virtual practice in essential areas such as engine inspections, landing gear checks, hydraulic system troubleshooting, and avionics diagnostics, using highly detailed 3D models of aircraft components. To enhance learning, it features guided tutorials and real-time feedback, allowing students to understand complex maintenance tasks more easily. The system incorporates gamification elements like challenges, levels, achievements, and rewards to keep users motivated and continuously developing their skills.

Real-world maintenance scenarios, including system malfunctions and emergency

repairs, are simulated to build students' problem-solving abilities. Accessibility is a key focus, with the simulator available on both PC and mobile platforms, enabling students to learn anytime and anywhere without the need for expensive VR devices. The project also integrates realistic flight mechanics for flying modules, accurately simulating thrust, lift, drag, gravity, stalling, and weather effects, while ensuring a smooth and immersive experience through a dynamic HUD and intuitive camera controls.

Aligned with aviation industry safety standards, the FLYFIX SIMULATOR acts as a cost-effective alternative to expensive physical training kits, providing a safe environment for students to practice and learn from mistakes without real-world risks. Additionally, the system includes performance tracking to monitor student progress and highlight areas for improvement. Overall, the FLYFIX SIMULATOR bridges the gap between theoretical and practical learning by offering an accessible, realistic, and engaging training platform for aspiring aircraft maintenance technicians.

3.4.2 Specific Part Features

3.4.2.1 Product Structure

The FLYFIX SIMULATOR is structured into several key components to ensure an effective and realistic training experience. The main feature is the Aircraft Component Interaction System, where students can select, inspect, and repair different parts of an aircraft, such as engines, landing gear, hydraulic systems, and avionics units. Each part is modeled in 3D with high accuracy to replicate real-world structures and layouts. The Guided Tutorial Module provides step-by-step instructions during maintenance procedures, helping beginners understand complex tasks and safety protocols.

Additionally, the simulator includes a Troubleshooting and Diagnostic System, where random faults are generated for players to diagnose and repair, enhancing their critical thinking and problem-solving skills. A Gamification Engine is embedded into the structure, offering levels, rewards, and achievements based on task completion and

performance quality. To track learning progress, the Performance Evaluation Module continuously monitors user actions, providing feedback and detailed analysis to highlight strengths and areas for improvement.

The simulator also integrates a Realistic Flight Dynamics System for modules involving aircraft movement, where aerodynamics forces like thrust, lift, drag, and gravity are accurately simulated. A Dynamic HUD (Heads-Up Display) presents essential flight and maintenance information such as speed, altitude, system status, and fuel levels, keeping the player informed throughout their activities. Lastly, the product structure includes Platform Adaptability Features, allowing seamless use on both PC and mobile devices without sacrificing graphics quality or simulation depth. Together, these specific parts form a complete and immersive training system tailored for aircraft maintenance education.

3.4.2.2 Product Mechanisms

The FLYFIX SIMULATOR operates through a combination of structured programming, interactive 3D modeling, and real-time feedback systems to create a functional and educational maintenance training platform. The core mechanism behind the simulator is based on a modular design. Each major aircraft system, such as engines, landing gears, hydraulic systems separated into different modules. This approach allows students to focus on specific areas one at a time without being overwhelmed by the complexity of the whole aircraft.

The simulator uses a task-based interaction system where students are given a series of step-by-step procedures to complete a maintenance job. Each task must be performed correctly to proceed to the next step. This mechanism mirrors the maintenance manual approach used in real-world aircraft maintenance operations. Incorrect actions are immediately highlighted with real-time feedback, explaining what went wrong and why, which helps students learn from their mistakes in a safe environment.

Another important mechanism is the guided tutorial system. It acts as a digital instructor by providing instructions, hints, and warnings throughout the tasks. This tutorial system is dynamic, meaning it adapts based on the user's performance. If a student struggles with a task, the simulator provides extra guidance. If the student performs well, the tutorial becomes less intrusive, allowing more independent work.

The FLYFIX SIMULATOR also includes an achievement and reward mechanism to maintain user motivation. Students earn points, badges, and unlock new levels based on the accuracy, speed, and quality of their work. This gamification approach keeps the learning experience enjoyable while

3.4.2.3 Software / Programming

The FLYFIX SIMULATOR integrates several software and programmable features designed to offer an interactive and realistic experience for aircraft maintenance training. Built using C++ and JavaScript, the simulator provides a dynamic platform where users are tasked with completing maintenance procedures typically seen in line maintenance. One of the core features is the task assignment system, which presents the player with specific tasks related to the maintenance of an aircraft. These tasks are generated and managed through C++ scripting, ensuring the tasks are relevant to real-world maintenance workflows. JavaScript is used to create a seamless user interface (UI), displaying task instructions and tracking progress throughout the maintenance procedure. This system mirrors actual maintenance work orders, thereby offering a practical learning experience.

In addition to the task system, the simulator includes an interactive Boeing aircraft model, allowing users to perform maintenance procedures on a fully interactive 3D model. This model provides multiple interaction points where players can disassemble and inspect parts, reflecting the hands-on nature of aircraft maintenance. C++ scripting controls the physical interactions, while JavaScript is used to animate certain components and guide the user through the process, making the experience feel immersive and realistic.

Furthermore, the simulator incorporates animation features to visually demonstrate the movement and functionality of various aircraft components during maintenance. This helps users understand how different parts operate, enhancing the learning process. Lastly, to ensure accessibility on mobile devices, the simulator includes a graphic adjustment setting. This feature allows the user to modify the graphics for optimal performance on mobile platforms, ensuring a smooth and responsive experience regardless of device specifications. By combining these features, FLYFIX SIMULATOR creates an engaging, educational tool that bridges theoretical knowledge with practical application in aircraft maintenance.

3.4.2.4 Accessories & Finishing

3.4.2.4.1 Accessories Features

Feature Name	Description
Tool Inventory System	A user-accessible panel showing available tools (wrench, pliers, multimeter, screwdriver,) categorized based on maintenance tasks.
Realistic Tool Models	Each tool is modeled with accurate size, shape, and texture, based on real aircraft maintenance equipment standards.
Tool Equipping Mechanism	Players can equip tools by drag-and-drop or quick-select buttons. Equipped tools appear on the technician's character visually.
Tool Usage Interaction	Tools can interact with aircraft components (torque wrench tightens bolts, screwdriver removes panels) using specific animated actions.
PPE Management System	Safety equipment (gloves, helmets, vests, goggles) must be worn before certain tasks to proceed, following safety regulations.
Accessory Condition System (Optional)	Accessories like gloves or tools show visual "wear" after heavy use dirty gloves, scratched toolbox, teaching maintenance of equipment.

Accessory-Specific Animations	Specific animations such as technician putting on gloves, adjusting helmet, or opening toolboxes for realism.

Finishing Features

Feature Name	Description
High-Quality Textures	Tools and PPE feature realistic materials like shiny metals, rubber grips, cloth fabric, and clear safety glass textures.
Dynamic Lighting and Shadows	Hangar environment uses natural light sources, with shadows reacting to technician and tools' positions, enhancing realism.
Realistic Sound Effects	Every tool has a unique sound when used (torque wrench clicking, screwdriver screeching, footsteps with/without PPE).
Visual Warnings and Feedback	If incorrect PPE is missing (no helmet during engine work), the screen flashes or gives warning messages.
Wear-and-Tear Visuals	Accessories show usage effects over time (dirty gloves, dull screwdriver tips) to simulate real working conditions.
Environmental Detail Finishing	The hangar/workshop environment includes maintenance signs, tool benches, ground markings, safety posters to enhance immersion.

3.4.3 **General Operation of the Product**

The general operation of the FLYFIX SIMULATOR is designed to provide a streamlined and intuitive experience for users, ensuring that they can focus on performing maintenance tasks without unnecessary complexity. Upon starting the simulator, the user is greeted with a main menu offering options to begin a new task, adjust settings, or access help and instructions. The task selection interface allows the user to choose from a range of line maintenance procedures that involve interacting with a detailed Boeing aircraft model.

Once a task is selected, the user is guided through a series of interactive steps. The simulator presents the maintenance tasks in a logical sequence, and the player must complete each step to proceed. This system is designed to mimic real-world maintenance scenarios, where each action is necessary for the proper functioning of the aircraft. The player interacts with the aircraft by selecting specific components and performing actions such as disassembly, inspection, and reassembly. Each task provides dynamic prompts to guide the user, ensuring that they remain on track throughout the procedure.

During the task, the simulator provides real-time feedback. If the user performs an action incorrectly or skips a step, the system immediately provides feedback, such as highlighting the correct part or showing a message explaining the error. This ensures that the user can learn from their mistakes and gain a deeper understanding of the maintenance process.

The simulator also includes graphic adjustment settings to optimize the user experience across various devices, particularly mobile platforms. These settings ensure that the simulator runs smoothly by adjusting the visual quality to match the performance capabilities of the user's device. This feature is crucial for providing a consistent experience, regardless of whether the user is playing on a high-performance computer or a mobile device.

Overall, the general operation of the FlyFix Simulator ensures that users can seamlessly transition from one task to another, receiving guidance and feedback while learning the core skills needed for aircraft line maintenance. By integrating interactive tasks, real-time feedback, and adaptable graphics, the simulator creates an engaging and effective learning environment that mimics real-world aircraft maintenance procedures.

3.4.4 **Operation of the Specific Part of the Product**

3.4.4.1 Product Structure

Each specific part of the FLYFIX SIMULATOR operates together to create a smooth, realistic, and educational experience for users. The Aircraft Component Interaction System allows users to zoom in on specific parts like engines, landing gear and perform interactive tasks such as inspections, replacing faulty parts, and following safety checklists. This system responds to user inputs by highlighting selectable components, providing detailed information, and enabling hands-on actions that mirror real-world maintenance procedures.

The Guided Tutorial Module operates by providing step-by-step instructions and pop-up hints during tasks. When a player selects a maintenance operation, the tutorial guides them through the correct sequence of actions, offering tips, safety warnings, and troubleshooting advice to ensure they learn procedures accurately and efficiently.

The Troubleshooting and Diagnostic System simulates random faults in aircraft systems, prompting players to investigate symptoms, diagnose the issues using virtual tools, and apply repairs. The system operates by generating a variety of maintenance challenges based on real-world scenarios, helping students practice problem-solving in a risk-free environment.

Meanwhile, the Gamification Engine automatically tracks player performance, awarding points, unlocking new levels, and giving achievements based on how accurately and efficiently the tasks are completed. This keeps players motivated and encourages continuous improvement.

The Performance Evaluation Module works in the background by recording every action taken by the user during a session. It evaluates task accuracy, completion time, and decision-making skills, then generates a report showing strengths and areas needing improvement, helping students track their learning progress over time.

For flying modules, the Realistic Flight Dynamics System operates by simulating aerodynamic forces. It ensures that aircraft respond naturally to control inputs, environmental factors like wind turbulence, and flight physics such as lift, drag, thrust, and gravity. Meanwhile, the Dynamic HUD provides constant real-time information like speed, altitude, system health, and alerts, keeping the user informed and connected to the aircraft status during both maintenance and flight simulations.

Finally, the Platform Adaptability Features ensure that all of these systems run smoothly on both PC and mobile devices by automatically adjusting graphics settings and control schemes to match the device being used. This guarantees a seamless, user-friendly experience for all students, regardless of their hardware

3.4.4.2 Product Mechanisms

The FLYFIX SIMULATOR operates through several interconnected mechanisms that create a realistic and interactive aircraft maintenance training experience. Each mechanism is designed to mimic real-world processes while ensuring that students can easily understand and practice essential maintenance skills.

The first major mechanism is the Interactive 3D Component System. This system uses detailed 3D models of aircraft parts such as engines, landing gears, hydraulic systems, and avionics. Students can rotate, zoom, and interact with these components using simple mouse controls or touch gestures. By clicking on a component, users can inspect, disassemble, and reassemble parts virtually. Each action is linked to a database that checks whether the steps are performed correctly, providing immediate feedback if mistakes occur.

Another important mechanism is the Guided Tutorial and Real-Time Feedback System. When a student starts a maintenance task, the simulator offers a step-by-step guide, showing what needs to be done at each stage. If the student performs an incorrect action, the system alerts them instantly with explanations, helping them understand their mistakes. This mechanism reduces frustration and promotes active learning.

The Gamification and Progression System is another key mechanism. It is responsible for keeping students motivated throughout their training. Every maintenance task completed successfully rewards the student with points, achievements, or virtual certifications. Challenges and levels are structured to gradually increase in difficulty. As students complete easier tasks, more complex scenarios like hydraulic leaks or avionics malfunctions are unlocked. This system also includes a leaderboard to encourage healthy competition among peers.

The simulator also features the Real-World Scenario Generator. This mechanism randomly or manually introduces problems such as mechanical faults, emergency repairs, or unexpected weather changes. Students must diagnose the issue, decide on the best repair

method, and execute the correct procedures. This mechanism builds critical thinking and decision-making skills that are crucial for real-world aircraft maintenance.

The Performance Monitoring Mechanism tracks each student's actions during simulations. It records task completion times, number of errors, areas of struggle, and overall skill development. Students and instructors can access detailed reports, which help in identifying strengths and areas that need improvement. This system ensures that learning is measurable and that progress can be tracked over time.

For the flying module, the Flight Physics Engine is the mechanism that controls how aircraft behave during simulation flights. It simulates real aerodynamic forces such as thrust, lift, drag, and gravity. It also models stalling effects, wind turbulence, and rain impact. Combined with intuitive camera controls and a dynamic HUD (Heads-Up Display), this mechanism ensures that students experience realistic flying conditions without needing complex flight simulators.

Finally, the Cross-Platform Accessibility Mechanism ensures that the FLYFIX SIMULATOR can operate smoothly on both PC and mobile devices. It adjusts graphic settings, controls, and user interfaces automatically based on the device used, ensuring that the experience remains consistent and user-friendly across all platforms.

3.4.4.3 Software / Programming

The operation of each specific part of the FLYFIX SIMULATOR is carefully programmed to ensure that users experience a realistic and responsive maintenance simulation. The software combines C++ for core logic and JavaScript for interface management, allowing smooth coordination between user actions and system responses.

The task assignment system operates by using a structured sequence of events programmed in C++. When a player selects a maintenance task, the simulator retrieves a predefined list of procedures related to that task. Each step must be completed in the correct order, and the system continuously monitors the player's actions. Conditional statements are used to verify if the correct component is selected and whether the correct procedure is performed. If an action matches the expected input, the system allows the player to proceed to the next step. If an error is made, the simulator generates immediate feedback through the user interface, managed by JavaScript, helping guide the player back to the correct action.

Interaction with the Boeing aircraft model is handled through object recognition techniques. When a player clicks or taps on a part of the aircraft, the simulator uses a ray casting method to detect which component has been selected. Each interactive part is assigned a unique identifier, allowing the program to track the player’s interaction accurately. Actions such as disassembly, inspection, or reassembly are tied to these identifiers, ensuring that the simulator can validate the completion of each task step properly.

The animation handling system is integrated to enhance visual feedback. Each component has associated animations, such as moving panels or rotating screws, which are triggered based on player actions. When a task requires the removal of a part, the system triggers a corresponding disassembly animation automatically. This operation is programmed using event-driven scripts that link specific tasks to the appropriate animation sequences, providing a more immersive and informative user experience.

To support different device capabilities, the simulator includes a graphic adjustment

setting. Upon accessing the settings menu, users can modify options such as texture resolution, shadow quality, and effects detail. These changes are managed through dynamic rendering scripts that adjust the graphical load according to the selected settings. This feature ensures that the simulator maintains good performance and visual quality, especially when operated on mobile devices with lower processing power.

Through the combination of these programmed operations, FLYFIX SIMULATOR effectively connects software logic with interactive training, creating an environment that supports both learning and engagement in aircraft line maintenance activities.

3.4.4.4 Accessories & Finishing

1. Overview of Accessories and Finishing Components:

Accessories and finishing parts in an aircraft are essential elements that ensure both the aesthetic appeal and functional efficiency of the aircraft. These include exterior trims and decorative elements that are also tied to safety mechanisms.

2. Role in Aircraft Maintenance:

Aircraft accessories and finishes are integral in providing comfort and safety to passengers while maintaining the aircraft's structural integrity. In maintenance scenarios, these parts are routinely inspected, repaired, or replaced to ensure the aircraft meets both regulatory and aesthetic standards.

3. Common Accessories and Their Operations

- Seat Installations: Seats are equipped with safety harnesses, adjustable features, and

are positioned according to specific weight and balance requirements. The technician must ensure all seats are securely attached to the seat rails and that seatbelts, buckles, and other components are functioning.

Cabin Overhead Storage Compartments: These are inspected for secure latching mechanisms, proper locking systems, and no signs of damage that could affect their functionality or the safety of passengers.

- Window Shades and Blinds: Ensuring that window shades and other cabin features operate smoothly without obstruction is essential to both comfort and functionality. Malfunctions in these parts are rare but need attention during regular checks.
- Cargo Hold Accessories: These parts include securing mechanisms such as straps and locking devices to ensure cargo remains in place throughout the flight. Maintenance staff need to verify the operation of these mechanisms and ensure the cargo hold is secure.

4. Finishing Components: Aesthetic and Functional Roles

- Interior Paneling: The interior panels are often inspected for cracks or damage, as these can affect both the appearance and integrity of the cabin. Additionally, technicians may need to ensure that the materials used comply with fire resistance standards.
- Exterior Finishing: This includes the paint and finishes that give the aircraft its signature appearance. Technicians check for any wear, corrosion, or cracking that could compromise the aircraft's aerodynamics or cause safety issues. This includes the application of anti-corrosion coatings, as well as ensuring any decals or markings are properly placed and legible.
- Landing Gear Components: Although landing gear systems themselves are critical, accessories like wheel fairings, tires, and strut covers require maintenance as well. Ensuring these parts are free from wear, tears, or damage is a key part of the maintenance process.
-

5. Maintenance Operations for Accessories and Finishing

- Inspection: Routine checks involve visual and physical inspections of all accessories and finishes to detect signs of wear, corrosion, or failure. Technicians use specialized tools to measure the integrity of materials and ensure that all components function properly.

  Repairs and Replacements: If any component is found to be faulty or damaged, it must be repaired or replaced immediately. For instance, if a seat's adjustment mechanism fails, it may need to be disassembled and either repaired or replaced with a new unit.
- Cleaning and Polishing: Regular cleaning is required to maintain both the aesthetic appeal and functional performance of accessories. This involves polishing surfaces, cleaning upholstery, and ensuring that all finishes remain intact. Special solutions and methods are used to clean specific materials like leather, fabric, and plastic without causing damage.
- Testing: After any repair or replacement, the accessories and finishes undergo a series of tests to ensure they meet operational and safety standards. For example, if the overhead compartments were serviced, they would be tested to verify proper latching and locking.

6. Documentation and Compliance

- Logbooks: Each maintenance operation, including those related to accessories and finishes, must be meticulously recorded. The logbook entries must indicate what components were inspected, repaired, or replaced, along with any part numbers and the results of any tests conducted.
- Regulatory Compliance: Aircraft accessories and finishes must comply with international aviation standards (such as FAA and EASA regulations). Technicians must be knowledgeable about these standards to ensure that all parts are installed and maintained to the highest safety and operational standards.
-

3.5 **OVERALL PROJECT GANTT CHART**

PROJECT ACTIVITIES	**W 1**	**W 2**	**W 3**	**W 4**	**W 5**	**W 6**	**W 7**	**W 8**	**W 9**	**W 10**	**W 11**	**W 12**	**W 13**	**W 14**	**W 15**
Briefing and Group Formation • **Create a group with 4 members** • **All members have their own idea for project**															
• **Meet supervisor and present our own idea** • **Only 1 idea accepted**															
Project Registration Form • Make a research about thief case on board															
• Make a research about type of software / programming • Make a research this project suitable for what category															

Assignment Chapter 1: Introduction • **Do background of study** • **Do problem statement** • **Do project aim, impact and scope**															
Assignment Chapter 2: Literature Review • **Do introduction of product** • **Do recent research of product** • **Do comparison of product**															
Pre-Proposal Presentation (Slides) • **Do a power point slide about the project**															
Assignment Chapter 3: Research Methodology • **Product description**															

• **Product sketching and modelling** • **List of programming** • **Expected result** • **Gantt chart**															
Final Proposal															
Final Presentation															

CHAPTER 4

4.1 PRODUCT DESCRIPTION

4.1.1 GENERAL PRODUCT FEATURES & FUNCTIONALITIES

The FLYFIX SIMULATOR is a virtual aircraft maintenance training system developed to help aviation students learn and practice basic line and base maintenance procedures in a more interactive way. This simulator is created to make aircraft maintenance training easier to access, safer, and more affordable. Since real aircraft and equipment are very expensive and sometimes not always available for students, the FLYFIX Simulator gives them a chance to practice maintenance tasks anytime using a computer or mobile device. It provides a realistic experience in a virtual environment that helps students build their understanding and confidence before working on an actual aircraft.

One of the main features of the FLYFIX Simulator is that it allows students to perform realistic maintenance activities just like in real life. Some of the main tasks included are walkaround inspection, wheel assembly removal and installation, corrosion removal, and aircraft refueling. All of these tasks are designed using 3D models and realistic visuals to make the learning experience feel more natural and engaging. The simulator also focuses

on safety practices, where students are guided step by step to follow the correct safety procedures and checklists while performing each maintenance task. This helps them learn proper working habits and understand the importance of following safety standards. Another important part of the simulator is its fault diagnosis and troubleshooting system. This feature allows users to identify problems, find out what caused them, and fix the issues in the simulation. It helps students think critically and solve problems, which are important skills in the aviation maintenance field. The simulator also offers an interactive learning environment that lets users interact with aircraft parts and tools using simple controls and gestures. This makes the learning process more active and interesting compared to just reading or watching videos.

The FLYFIX Simulator also includes an assessment and feedback system that tracks the user's progress. After each task, students can see their performance results and get feedback if they made any mistakes. This helps them understand what they did wrong and improve on their next attempt. The simulator also uses a level-based progression system, meaning students start with basic maintenance tasks and then move on to more complex ones as they gain experience. This system helps them learn gradually and build up their skills step by step.

This simulator can be used on both mobile phones and computers, making it easier for students to access anytime and anywhere. It also has the potential to support Virtual Reality (VR) and Augmented Reality (AR) in the future to make the experience even more realistic and immersive. These advanced features will help FLYFIX stay relevant with new technology trends, especially with Industry 4.0 developments in the education sector.

In general, the FLYFIX Simulator combines many important functions such as interactive task performance, fault detection, safety training, and progress evaluation. It is designed to make learning more engaging and practical while helping students understand real-world aircraft maintenance procedures in a safe and controlled environment.

Overall, the FLYFIX Simulator supports Sustainable Development Goal (SDG) 4: Quality Education, by giving students equal opportunities to gain technical knowledge through digital learning. It provides a modern way for aviation students to practice, learn, and build

confidence before entering the real aviation industry. By using FLYFIX, students are better prepared for their future roles as maintenance technicians who can perform their duties safely, efficiently, and confidently.

4.1.2 SPECIFIC PART FEATURES

4.1.2.1 PRODUCT STRUCTURE

The FLYFIX Simulator is developed based on two main structural components: the mechanism structure and the software structure. These two elements work together to form a functional and realistic aircraft maintenance simulation system. The mechanism structure focuses on the visual and interactive components of the simulator, while the software structure manages the programming, system logic, and overall functionality. Together, both components create a complete training platform that allows users to experience hands-on maintenance tasks in a safe, virtual environment. The mechanism structure represents how real aircraft maintenance activities are modeled and performed within the simulator. It includes the 3D aircraft models, equipment, environment setup, and interactive features that make the simulation feel realistic. All the aircraft models and maintenance tools are designed using Blender and then imported into the simulation engine to ensure high-quality visuals and accurate representation of real components. These models cover a variety of maintenance elements, such as wheels, engines, fuel systems, and inspection points. The environment is built to resemble an actual maintenance area, complete with hangars, ramps, and tool stations. The layout is carefully arranged to provide an easy and immersive user experience. Through the use of gesture- based controls and task-level interactions, users can perform maintenance activities like walkaround inspection, wheel assembly installation, corrosion removal, and refueling. This structure provides a hands-on learning experience that helps students practice real maintenance skills virtually, without the risks or costs of physical training. The software structure acts as the brain of the FLYFIX Simulator. It manages the system's internal functions, user interactions, and task logic to ensure smooth performance. The simulator is developed using the Unity Game Engine, with programming handled in C#, allowing it to control the gameplay mechanics, animations, and feedback systems efficiently. The software structure contains several key systems that operate together to

deliver a complete learning experience. These include the user interface (UI), simulation logic, assessment and feedback system, and data management system. The user interface manages all menus, buttons, and navigation screens, making it simple for users to access and operate the simulator. The simulation logic controls the sequence of maintenance tasks and ensures that each step follows realistic aircraft maintenance procedures. The assessment and feedback system records user progress, evaluates performance accuracy, and provides feedback to guide improvement. Meanwhile, the data management system stores important information such as task results and user achievements.

All these components work together in real time to ensure a smooth simulation experience. When a user performs a maintenance task, the software activates the corresponding animations and logic while simultaneously tracking performance data. The software also ensures that the simulator runs efficiently on both mobile and computer platforms, with optimization to prevent lag and ensure stable performance. Furthermore, the software structure is designed with scalability in mind, allowing for future integration of Virtual Reality (VR) and Augmented Reality (AR) technologies to enhance realism and user immersion.

In conclusion, the mechanism and software structures are the foundation of the FLYFIX Simulator. The mechanism provides the visual and physical representation of maintenance operations, while the software manages the logic, control, and performance of the entire system. By combining these two structures, the FLYFIX Simulator delivers a realistic, interactive, and effective virtual training experience that supports aviation students in developing both their theoretical knowledge and practical maintenance skills

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4.1.2.2 PRODUCT MECHANISMS

1. Interactive Aircraft Components

The FLYFIX Simulator lets users explore and interact with different parts of an aircraft, such as the engine, landing gear, and control surfaces. By clicking on these components, students can see how each part works and understand its role in the overall aircraft system. This hands-on interaction helps make learning more engaging, as students can visually connect what they study in theory with how it functions in a real aircraft.

2. Virtual Repair System

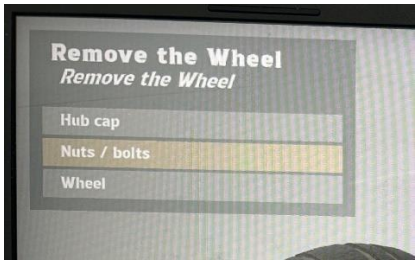
One of the most exciting features of FLYFIX Simulator is its virtual repair system. This feature allows users to carry out maintenance tasks like tightening bolts, replacing parts, and performing system checks in a safe, digital environment. It gives students the chance to practice real maintenance procedures without the risk of damaging actual aircraft components, helping them build confidence and improve their practical skills.

3. 3D Visualization

The simulator uses realistic 3D models to display aircraft structures and components in detail. Students can rotate, zoom, and view each part from different angles, allowing them to explore both the internal and external features of the aircraft. This immersive 3D experience makes complex systems easier to understand and helps students visualize how different parts are connected and function together.

4. Step-by-Step Maintenance Guide

FLYFIX Simulator includes an easy-to-follow step-by-step maintenance guide for every task. The guide combines written instructions with animations to show the correct procedures and safety steps. This helps students learn how to carryout maintenance work properly, just like they would in a real workshop. It's a great tool for beginners, as it ensures they follow each step carefully and understand why each action is important.



5. Error Detection Mechanism

The simulator is designed to give instant feedback when users make mistakes during maintenance activities. If a part is installed incorrectly or a step is skipped, the system immediately alerts the user with a warning message. This helps students recognize their errors right away and learn the correct procedure.

6. Performance Evaluation System

After completing a task, FLYFIX Simulator automatically evaluates the user's performance. The system provides scores based on accuracy, completion time, and safety compliance. This feedback helps students track their progress, identify areas they can improve, and stay motivated to perform better. It also allows instructors to access each student's understanding and skill level more effectively.

4.1.2.3 SOFTWARE / PROGRAMMING

The FLYFIX Simulator is developed as a virtual training system to support basic aircraft maintenance learning. This project focuses on software functions and programming features that allow users to practice maintenance tasks in a realistic but safe digital environment. The system guides users through proper procedures instead of using physical tools or aircraft equipment. This software-based approach helps students understand inspection steps, part handling, and task flow like in real aviation maintenance training.

In this project, the simulator uses a level system. Level 1 is designed using a first-person (FPS) concept where the user can walk around and perform a virtual aircraft walk-around inspection. This gives the experience of real physical movement around the aircraft, similar to normal pre-flight or daily inspection in aviation. For Levels 2, 3, and 4, a static interaction system is used. In these levels, the user does not move around but interacts directly with parts and components on the screen. This method is suitable for simple maintenance tasks such as inspection, removing screws, or checking a component area.

The user interface (UI) is programmed to support learning and guide the player. The UI includes a task description panel that shows the instructions for each step. There is also directional guidance in Level 1 that shows the user where to look and which parts must be inspected. To confirm inspection, the system uses a right-click interaction, where a part becomes marked as inspected once the player selects it. The simulator also includes a rotation feature where the user can rotate parts clockwise or anticlockwise to simulate screw removal or tightening. The system does not punish the user for mistakes. Instead, it provides instruction-based guidance, so the user learns by following directions rather than being forced to restart due to errors.

The program starts with a splash screen showing the FLYFIX logo. After that, the main menu appears with a “Click to Start” button and a settings option. When entering the simulation, the user must complete Level 1 before unlocking the next level. After finishing a level, a completion screen will appear, and the user will return to the level selection menu. This structure supports progressive learning and keeps the training flow organized.

During development, several bugs were found, especially in the interaction functions during gameplay. To handle this issue, a retry button was added. The retry button refreshes the task and resets the logic without closing the whole game. This makes the simulator more stable and user-friendly during practice.

In conclusion, the software programming of FLYFIX Simulator focuses on realistic task flow, clear guidance, and simple interaction functions that match beginner-level aircraft maintenance learning. The system helps students practice inspection, part interaction, and maintenance sequence in an easy-to-understand virtual

Figure 9: UI anticlockwise to jacking the aircraft

4.1.2.4 ACCESSORIES & FINISHING

1. Accessories Components (Functional Features)

Category	Example Part	Features / Game Function
Hand tools	Torque wrench, Screwdriver, spanner set	Used for tightening bolts/nuts to correct torque. Players must choose correct tool for each task
Testing equipment	Multimeter, pressure gauge, borescope	Used for diagnosing system faults, add troubleshooting element
Ground support equipment (GSE)	Tow bar, hydraulic test stand, ground power unit	Simulates maintenance environment. Allows players to perform servicing tasks
Safety equipment	Safety goggles, ear protection, gloves	Adds realism and teaches safety compliance, required before starting task
Consumables	Safety wire, grease, hydraulic fluid	Used during component servicing, teaches correct use of materials

2. FINISHING COMPONENTS (VISUAL & AESTHETIC FEATURES)

Area	Feature	Description
User Interface (UI)	Clean dashboard, maintenance panel layout	Shows tools, components, and task status clearly
Aircraft Hangar Environment	High-quality textures for walls, floor markings, lighting	Realistic hangar setting with ambient sounds (compressor noise, footsteps)
Aircraft Model Finishing	Accurate textures for metal panels, rivets, propellers	Enhances realism and visual appeal
Charaer Finishing	Technician uniform, ID tag, animation (kneel, inspect, repair)	Makes player experience more authentic
Game Finishing Touches	Logo, background music, realistic sound effects	Adds immersion and completes professional polish

3. OPTIONAL ADD-ONS

Add-On	Purpose
Achievement System	Reward players for completing maintenance tasks correctly
Component Wear Simulation	Visual wear on parts after repeated use
Tool Selection Panel	Interactive toolbox with animation
AR/VR Mode (if applicable)	Hands-on immersive repair simulation

4.1.3 GENERAL OPERATION OF THE PRODUCT

The FLYFIX SIMULATOR is designed to make learning aircraft maintenance more interactive and engaging for students. It works as a virtual training platform where users can explore aircraft parts, follow step-by-step maintenance procedures, and perform repair tasks in a safe digital environment. The simulator uses realistic 3D visuals that allow students to view and interact with different aircraft components, helping them understand how each part functions and connects. As user's complete tasks, the system provides instant feedback, highlights mistakes, and gives performance scores to help them improve. It also includes tutorials and quizzes that make learning both fun and educational. Overall, the FLYFIX SIMULATOR operates as a hands-on learning tool that combines practice, guidance, and assessment to help students gain real-world maintenance experience in a virtual way.

4.1.4 OPERATION OF THE SPECIFIC PART OF THE PRODUCT

4.1.4.1 PRODUCT STRUCTURE

The FLYFIX SIMULATOR was developed with two main structural components, namely the mechanism structure and the software structure. Both components work together to create a realistic and functional virtual environment for aircraft maintenance training. The mechanism structure focuses on how the simulator visually and physically represents real maintenance tasks, while the software structure controls the internal system, logic, and interactivity. These two aspects complement each other to provide users with a smooth, engaging, and effective simulation experience.

The mechanism structure involves all the visual and interactive elements of the simulator. It consists of 3D aircraft models, maintenance tools, and the surrounding environment designed to look like an actual maintenance area. The 3D assets were developed using Blender and then integrated into the Unity Game Engine to produce a realistic simulation layout. The environment includes hangars, ramps, and tool stations, allowing users to explore and perform maintenance operations in a familiar setup. Users can carry out various maintenance activities such as walkaround inspections, wheel assembly removal and installation, corrosion cleaning, and refueling. Each activity is designed with smooth animation and precise object interaction, giving users a hands-on learning experience similar to real maintenance work but in a safe and controlled setting.

Meanwhile, the software structure manages all the logical and functional aspects of the simulator. It is developed using Unity and programmed with C#, which handles the simulation flow, user interface, and task management. The software structure controls how each module operates, including the sequence of maintenance steps, task conditions, and error responses. It also includes an assessment and feedback system that tracks user progress and provides real-time feedback on performance. This helps users identify their mistakes and improve through repeated practice. The simulator’s data management system stores information such as task completion records and user performance for later review

Both the mechanism and software structures are designed to ensure that the simulator performs efficiently on multiple platforms, including mobile devices and computers. The system is also optimized for future upgrades, such as the integration of Virtual Reality (VR) and Augmented Reality (AR), which will make the training even more immersive and realistic.

In summary, the product structure of the FLYFIX SIMULATOR combines the visual mechanism and software logic to form a complete learning system. The mechanism structure provides the physical and visual realism, while the software structure ensures smooth operation and accurate task management. Together, they make FLYFIX a practical and reliable training tool that helps aviation students gain valuable maintenance experience in a safe, flexible, and cost-effective virtual environment.

4.1.4.2 PRODUCT MECHANISMS

The FLYFIX SIMULATOR operates through several key features that work together to create an interactive and realistic learning experience. When users launch the simulator, they can choose a specific aircraft system or component to explore, such as the engine, landing gear, or control surfaces. Each part is fully interactive, allowing students to click, drag, and perform virtual maintenance actions like removing bolts, inspecting damage, or replacing parts just as they would in real life.

The virtual repair system brings these actions to life through realistic animations and logical programming. It responds to every user input and gives immediate feedback if a step is performed incorrectly. The 3D visualization system allows users to view aircraft parts from different angles by rotating and zooming in, making it easier to study internal structures and understand how components are connected.

To support learning, the step-by-step maintenance guide provides clear instructions for each procedure, helping users follow the correct sequence and apply standard safety practices. The error detection system continuously monitors user actions and notifies them when mistakes occur for example, skipping a step or using the wrong tool. This ensures students can learn from their errors without real-world risks.

Meanwhile, the performance evaluation system tracks all user activities and generates a score based on accuracy, speed, and safety compliance. This helps students assess their own progress and identify areas to improve. The educational mode adds even more learning value by offering pop-up explanations, part details, and short quizzes that reinforce both theory and practice.

Overall, these mechanisms work hand in hand to make FLYFIX SIMULATOR an effective and engaging platform for learning aircraft maintenance. It allows students to gain real-world experience in a virtual space, building their confidence and understanding before performing actual hands-on tasks.

4.1.4.3 SOFTWARE / PROGRAMMING

For this project, the main focus is on how the software works and how each part of the game operates when the user interacts with it. The simulator runs step-by-step to guide the student through aircraft maintenance tasks in a simple and realistic way.

When the program starts, first the FLYFIX SIMULATOR logo appears on the splash screen. This is just to show the branding before the game really begins. After that, the main menu pops up, and the user can click “Start” to enter the simulation. There is also a settings button, but the first thing users usually do is press start.

Once inside, they will see the level selection screen. The system only allows Level 1 to be played at the beginning. This is done on purpose so students follow the learning order. After Level 1 is completed, the next level will automatically unlock. This makes it feel like real training you start from the basics first before moving on to harder tasks.

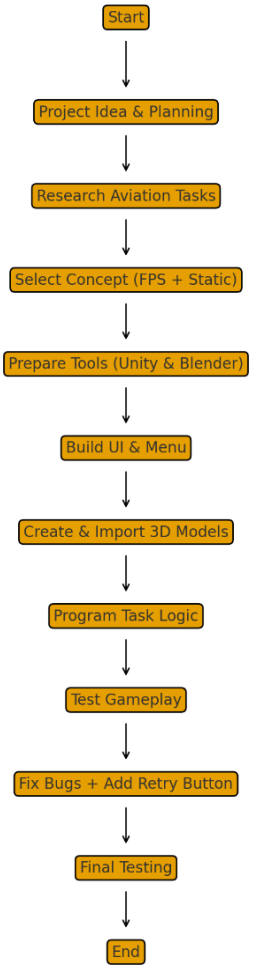
In Level 1, the camera uses FPS walking mode, so the user can walk around like they are inspecting a real aircraft on the ramp. During the inspection, the task instruction panel on the screen will tell the player what to check. There will also be small indicators or arrows to guide them to the correct parts. When the student sees the part and right-clicks it, the system marks it as inspected. This is to simulate real walk-around inspection where you visually check and confirm aircraft condition.

For Levels 2, 3, and 4, the game changes to a static view. In these levels the user cannot walk around anymore. Instead, they interact directly with the part or component on the screen. For example, when removing screws, a rotation UI appears and the user can turn it clockwise or anticlockwise. This is a simple way to mimic how screws are loosened or tightened during maintenance, but in a digital form.

When the player finishes all the required steps, a finish screen will appear and the game returns to the level selection menu. If everything is done correctly, the next level becomes available. This helps build progress and makes the learning experience more structured.

During development, there were some bugs, especially when interacting with parts. Sometimes the game would freeze or the task would get stuck. Because of that, we added a retry button. When the user presses retry, the task resets and they can continue without restarting the whole game. This makes the simulator more friendly and less stressful for beginners.

Overall, each part of the software has its own job from the menu system, to how the player interacts, to how tasks get completed. The goal is not to punish the student when they make mistakes, but to guide them step-by-step so they can learn maintenance flow in a simple and clear way.



Flow chart operation of product (Software/Programming)

4.1.4.4 ACCESSORIES & FINISHING

No.	Part Name	Operation Description	Purpose / Function
1	**Torque Wrench**	Used to tighten bolts and nuts to the correct torque value. In the game, players select the wrench and apply it; the system detects if torque is within limits.	To teach proper torque application and prevent over-tightening or under-tightening.
2	**Multimeter**	Player connects leads to test electrical circuits. The screen shows voltage, resistance, or continuity results. Diagnostic feedback appears for faults.	To simulate electrical troubleshooting procedures.
3	**Hydraulic Test Stand**	Simulates pressurized fluid system. Player connects hoses, sets pressure, and monitors readings on the display panel.	To demonstrate hydraulic testing and safety procedures.
4	**Safety Equipment (Goggles, Gloves, Ear Protection)**	Players must equip safety items before starting any maintenance task. System prevents actions if not equipped.	To promote safety awareness and standard maintenance practices.

5	**Aircraft Model Finishing**	Realistic 3D aircraft model with textures and animations. Panels can be opened or removed; propellers and parts react to player input.	To enhance realism and simulate actual maintenance operations.
6	**Hangar Environment Finishing**	The environment reacts dynamically lights, sound, and ambience change based on player actions (using tools triggers sound effects).	To create a realistic and immersive maintenance environment.

No.	**Part Name**	**Operation Description**	**Purpose / Function**
7	**Interactive Interface**	Displays tool selection, task status, and progress indicators. Provides visual feedback (torque meter rising as player tightens).	To guide players during tasks and provide a clear maintenance workflow.

4.2 PRODUCT ANALYSIS

No.	Feature / Function	User Action	Expected Output	Actual Output	Result	Remarks
1	Splash Screen	Open game	Logo appears	Logo appears correctly	Pass	Splash screen shows the FlyFix branding smoothly without delay, giving a professional introduction tothe simulator before entering the main menu.
2	Main Menu	Click "Start"	Go to level screen	Level screen displayed	Pass	The menu responds quickly and transitions smoothly to the level page. Buttons are clear and easy to understand for new users, improving accessibility.
3	LevelLock System	Tryopen Level 2 without finishing Level 1	Level locked	Level locked	Pass	This function successfully forces a proper learning sequence. Students must complete basic tasks first, which matches actual aviation training progression.
4	FPS Walk	Player uses controls to move	User can walk around	Movement smooth	Pass	Player movement in Level 1 is stable and reflects real-life walk-around inspection. Controls are simple and responsive, helping beginners feel comfortable.

5	Static View	Click objects (Level 2–4)	Object interaction active	Works correctly	Pass	Static mode is functioning well and supports more focused maintenance tasks. This approach matches realistic maintenance where technicians focus on one component at a time.
6	Inspection Logic	Right-click part	Part marked inspected	Part marked inspected	Pass	The inspection system registers clicks accurately and confirms user action. This helps teach proper inspection checklist habits in a simple way.
7	Screw Rotation UI	Rotate left/right	Screw rotates	Screw rotates normally	Pass	The rotational UI gives a realistic feel of removing aircraft screws. Although simple, it successfully introduces beginners to component removal procedures.
8	Level Completion	Finish tasks	"Finish" screen appears	Finish screen displayed	Pass	Once all steps are completed, the system acknowledges user success and returns them to the level menu. This encourages progress and creates a clear achievement feeling.

9	Retry Button	Click “Retry”	Task restarts	Task resets successfully	Pass	The retry function works smoothly and helps recover from bugs or incorrect actions without restarting the whole game, improving user experie

4.3 ANALYSIS OF PROBLEM ENCOUNTERED & SOLUTIONS

4.3.1 PRODUCT STRUCTURE

Throughout the development of the FLYFIX SIMULATOR product structure, several challenges were faced, particularly in combining both the mechanism and software elements to ensure they worked seamlessly together. Since the simulator was built using 3D models and required programming in Unity, various technical and design issues occurred during the development process that required patience, research, and teamwork to resolve.

One of the main issues encountered was difficulty in creating and importing 3D models from Blender into Unity. At first, many of the models had problems such as missing textures, incorrect scaling, and animation errors after being imported into the game engine. These issues affected the appearance and functionality of the simulator. To overcome this, I referred to several online tutorials and resources to learn the correct export and import settings between Blender and Unity. After several trials, the models were optimized and adjusted to ensure they loaded properly, looked realistic, and did not affect system performance.

Another problem was related to programming and simulation logic. Since the simulator was programmed using C# in Unity, writing scripts to control object interactions, animation triggers, and task sequences was quite challenging. At first, the scripts did not run smoothly, and the simulator occasionally froze or crashed during testing. To solve this, I studied additional Unity scripting tutorials, followed developer documentation, and sought advice from experienced programmers. Regular debugging and repeated testing helped identify and fix the logic errors, improving the stability and performance of the simulator.

Performance optimization also became a concern as the simulator grew larger with more 3D models and animations. The game started to lag, especially when tested on mobile devices. This problem reduced the smoothness of gameplay and overall user experience. To fix this, the models were simplified by reducing polygon counts, compressing textures,

and anchoring non-moving parts. These optimizations significantly improved the simulator's performance on both computer and mobile platforms.

Another challenge faced was communication among team members, especially when coordinating different parts of the simulator such as environment design, programming and testing. At times, miscommunication caused overlapping tasks and misplaced objects in the game. This was solved by organizing regular online meetings and using shared folders to keep all files and updates synchronized. Through this method, the team was able to work more efficiently and maintain progress consistently.

In summary, developing the FLYFIX Simulator product structure was not easy, but it was a very valuable learning experience. The problems faced during the creation and integration process helped improve my understanding of 3D modeling, game programming, and teamwork. Through continuous testing, research, and collaboration, the simulator was successfully developed into a functional and stable product that can help students learn aircraft maintenance in a more practical and interactive way,

4.3.2 PRODUCT MECHANISMS

During the development of the FLYFIX Simulator, our team faced a few challenges that needed to be addressed to improve the overall quality of the product. One of the main issues was the presence of software bugs, which caused some functions, such as buttons and animations, to not work smoothly. These glitches made it difficult for users to complete certain maintenance tasks. To solve this, the development team carried out debugging sessions, tested the program repeatedly, and fixed the faulty codes. After these improvements, the simulator became more stable and ran more smoothly for users.

Another problem we discovered was wrong labelling on some of the aircraft components in the simulator. A few parts were either misnamed or misplaced, which confused users when identifying components during virtual maintenance tasks. To fix this, all the component names and positions were carefully checked against actual aircraft references. Once corrected, the updated version provided accurate labels that helped students recognize aircraft parts correctly and confidently.

We also found an error in the rotation instructions for tightening and loosening parts. The directions for clockwise and counterclockwise movements were reversed, which caused confusion for users following the maintenance guide. This issue was resolved by updating the text and animation instructions to show the correct rotation direction. Additional review steps were also added to make sure similar mistakes do not happen again.

Overall, facing these issues helped the team understand how to make the FLYFIX Simulator more accurate, user-friendly, and reliable. By fixing the bugs, correcting the labels, and improving the instructions, the simulator now provides a smoother and more realistic experience for students learning aircraft maintenance.

4.3.3 SOFTWARE / PROGRAMMING

No.	Problem Encountered	Explanation	Solution Taken	Result
1	Game freeze during interaction	When clicking objects, the system sometimes froze or failed to register inspection, especially in Level 1 walk mode	Added a retrybutton function to refresh the task logic without restarting the whole game	Game continued smoothly and students could restart tasks instantly
2	FPS movement glitch	During Level 1 testing, player movement sometimes got stuck when looking around the aircraft model	Adjusted movement script and collider settings inside Unity to prevent the player from clipping into objects	Movement became smoother and users could walk freely without being stuck
3	Task instruction not updating	Task panel did not change instruction after completing a step, causing confusion	Updated script to trigger UI text change after each correct action	Task steps now update clearly and guide user properly
4	Rotation UI not responding consistently	While rotating screws, the UI sometimes did not detect player input	Improved input sensitivity and adjusted click/drag detection	Screw rotation function worked more consistently and realistic
5	Level unlocking not functioning	After completing Level 1, Level 2 sometimes remained locked	Fixed level progressionscript and added completion flag system	Level unlock worked correctly based on user progress

6	Wrong click feedback not clear	When clicking wrong area, game did nothing, players confused	Added subtle UI feedback and kept instruction panel as main guide	Users learned correct steps without frustration
7	UI overlapping and not resetting	UI elements sometimes overlapped after retrying task	Reset UI layout when retry button pressed	UI became clean and readable after each restart
8	Scene loading delay	Transition between menu and level took too long	Optimized assets and removed unnecessary objects in loading phase	Loading time shorter, feels smoother for user

4.3.4 ACCESSORIES & FINISHING

During the development of the accessories and finishing components in the aircraft technician simulation game, we faced several challenges. One main issue was that some tool functions, like the torque wrench and multimeter, did not respond correctly during interaction. This happened because of incomplete coding and incorrect trigger setup in the game engine. We solved the issue by revising the scripting and improving the tool's input detection system to ensure proper functionality. Another challenge was the visual quality of the aircraft finishing. The early textures looked flat and unrealistic, reducing the overall immersion. To address this, we added high-resolution materials and lighting effects to enhance the realism of the 3D model.Lighting in the hangar environment also posed difficulties. The scene was either too dark or overexposed, which affected visibility and gameplay. We adjusted ambient lighting, shadows, and post-processing filters to create a balanced and realistic environment. Additionally, the user interface was initially cluttered with too many icons, confusing players during tool selection. We resolved this by redesigning the interface with a simpler layout, grouping tools by category, and adding tooltips for better navigation.

We also identified some technical issues, such as safety equipment not being detected before task execution. This was due to script delays, which we fixed by adding a validation check before starting the task. Sound synchronization problems arose when effects, like torque clicks or hydraulic pump noises, did not match the animations. The team linked sound triggers directly to animation events to resolve this. Performance lag occurred when high-quality textures and lighting were loaded, so we used optimization techniques like texture compression and level-of-detail (LOD) management. Finally, aircraft panels sometimes misaligned or clipped through the model when opened. We corrected this by adjusting pivot points and applying animation constraints.

Overall, identifying and solving these problems improved the game's stability, visual quality, and user experience. This resulted in a more realistic and engaging simulation for players to effectively learn aircraft maintenance procedures.

CHAPTER 5

5.1 ACHIEVEMENT OF AIM & OBJECTIVES OF THE RESEARCH

5.1.1 GENERAL ACHIEVEMENTS OF THE PROJECT

The FLYFIX project has successfully achieved its main aim of developing a mobile and computer-based simulator for aircraft line maintenance training. The simulator provides a realistic and interactive 3D learning environment, allowing students to practice maintenance tasks in a safe virtual space without risking real aircraft damage.

The project has effectively addressed the problems identified, including the lack of training equipment, VR simulation issues, and limited features in existing mobile applications. By providing a digital platform, students now have easier access to training anytime, which also reduces the cost associated with physical equipment and aircraft usage.

Furthermore, the simulator supports fault diagnosis and troubleshooting practice, enabling students to enhance their technical skills and understanding of aircraft maintenance. The interactive nature of the platform aligns with Industry 4.0 trends, promoting digital learning in aviation.

Overall, the project successfully meets the objectives of improving student understanding, safety, accessibility, and cost efficiency in aircraft maintenance training. The FlyFix simulator demonstrates that virtual practice can effectively complement traditional training methods, providing a modern and practical solution for aviation education.

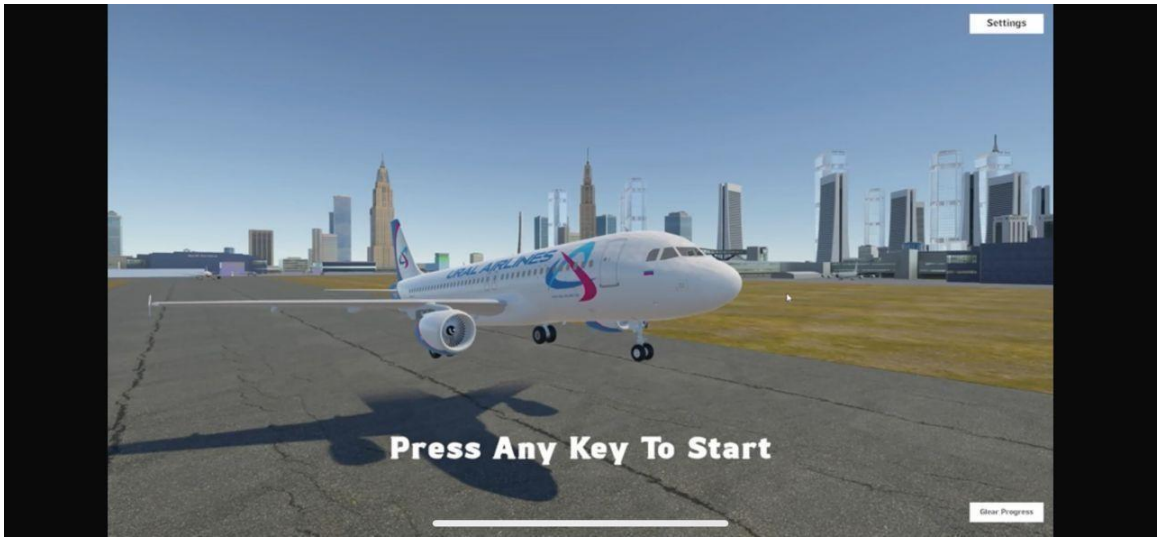


Figure 10: FLYFIX SIMULATOR Interface

5.1.2 SPECIFIC ACHIEVEMENTS OF THE PROJECT OBJECTIVES

5.1.2.1 PRODUCT STRUCTURE

The product structure of the FLYFIX SIMULATOR has successfully met the objectives outlined during the development process, particularly in delivering a realistic and interactive learning experience for aircraft maintenance training. The product structure is made up of two main parts the mechanism structure and the software structure which work together to create a functional and efficient virtual training platform. Each component played an important role in ensuring that the simulator runs smoothly, looks realistic, and supports students in understanding maintenance procedures effectively.

One of the key achievements of the product structure is the development of a realistic 3D simulation environment. The mechanism structure was carefully designed using detailed 3D models created in Blender and integrated into the Unity Game Engine. These models include aircraft components, maintenance tools, and the hangar environment, all designed to mirror real-life aviation maintenance settings. Through this environment, users can perform various maintenance activities such as walkaround inspections, wheel assembly tasks, corrosion removal, and refueling operations. This realistic setup helps students visualize actual maintenance procedures, achieving the project's goal of providing a safe and immersive virtual training experience.

Another major success is the smooth integration between software programming and system operation. Using C# scripting within Unity, the development team managed to control how each maintenance task operates from the sequence of procedures to the interactive responses and feedback system. This allowed the simulator to run maintenance operations step by step, guiding users through each process and correcting mistakes when needed. This function directly supports the project's objective of improving understanding through interactive, hands-on learning.

The FLYFIX SIMULATOR's accessibility and cost-effectiveness also reflect the achievement of

another important project objective. Because the simulator can be accessed on both mobile devices and computers, students are able to practice anywhere and at any time without the need for actual aircraft or expensive equipment. This feature makes training more flexible and inclusive, especially for institutions with limited resources. In addition, optimization efforts during development ensured that the simulator performs smoothly on different devices, preventing lag or crashes.

The assessment and feedback feature built into the software structure also contributed significantly to achieving the project goals. Students receive immediate feedback whenever an error occurs, helping them recognize mistakes and improve their performance in the next attempt. This process supports continuous learning and skill development, allowing students to apply theoretical knowledge in a more practical and engaging way.

Lastly, the FLYFIX Simulator's expandable design achieved the project's long-term objective of supporting future innovation. The product structure was developed with flexibility in mind, allowing for potential upgrades such as Virtual Reality (VR) and Augmented Reality (AR) integration. This makes the simulator adaptable to new educational technologies and aligns it with the current digital transformation in the aviation industry.

In summary, the product structure of the FLYFIX Simulator has successfully achieved its intended objectives. The mechanism structure provides the physical and visual foundation of the simulator, while the software structure ensures logic control, interactivity, and feedback. Together, these elements create a reliable and effective learning platform that helps aviation students gain practical experience in a safe, engaging, and cost-efficient manner.

5..1.2.2 PRODUCT MECHANISMS

The FLYFIX SIMULATOR has successfully achieved its main objectives by creating an

engaging and realistic way for students to learn aircraft maintenance. One of the biggest accomplishments is the development of a mobile and computer-based simulator that allows students to practice line and base maintenance tasks anytime and anywhere. This helps overcome common challenges like limited access to aircraft, high training costs, and space constraints in workshops.

The simulator also succeeded in creating a 3D interactive learning environment, giving users a realistic view of aircraft parts and systems. Through detailed visuals and animations, students can perform tasks such as walkaround inspections, wheel assembly, corrosion removal, and fueling. This makes learning more hands-on and helps students better understand real maintenance procedures in a safe and controlled virtual space.

Another important achievement is improving safety and cost efficiency in aviation

training. Because all activities take place virtually, students can learn and make mistakes without causing real damage to aircraft or tools. This approach also helps institutions save money while still offering high-quality, practical learning experiences.

In addition, the assessment and feedback system allows students to receive instant responses after completing each task. This feature helps them recognize errors, understand what went wrong, and improve their performance over time. The simulator also includes fault diagnosis and troubleshooting activities, making the experience more interactive and realistic.

Overall, the FLYFIX Simulator achieved its purpose by combining education and technology to create a smart, cost-effective, and enjoyable training tool. It not only helps students build technical skills and confidence but also supports digital learning in aviation, aligning with the goals of Industry 4.0.

5.1.2.3 SOFTWARE / PROGRAMMING

For the software part of the FLYFIX project, we successfully developed a working simulator that can be used on both mobile and computer devices. The program allows students to practice aircraft maintenance in a virtual 3D environment, making learning more interactive and realistic.

We added key features like fault diagnosis, troubleshooting exercises, and safety practice, so students can learn by doing, without worrying about damaging real aircraft. The software is easy to navigate, with clear instructions and responsive controls, making it user-friendly for everyone.

The program also gives feedback on mistakes, helping students understand what went wrong and how to improve. It runs smoothly and efficiently on different devices, showing that the simulator is reliable for learning purposes.

Overall, we achieved the software objectives by enhancing students' skills and understanding, providing a safe and accessible platform for aircraft maintenance training.

5.1.2.4 ACCESSORIES & FINISHING

The accessories and finishing section of the project met its goals by improving both the function and visual quality of the aircraft technician simulation game. One major success was the integration of interactive tools like the torque wrench, multimeter, and hydraulic test stand. These tools work accurately and respond to user input, allowing players to complete realistic maintenance tasks and learn about real-world aircraft servicing procedures. This supports the project goal of providing an educational and practical experience for students in aircraft maintenance.

Another key achievement was the creation of high-quality finishing for the aircraft model and hangar environment. We added realistic textures, lighting effects, and detailed 3D models to create an authentic maintenance setting. These finishing improvements greatly increased user immersion and visual realism, which aligned with the aim of producing a professional and engaging simulator.

Additionally, the user interface (UI) was designed with a clear and organized layout. Players can easily select tools, monitor task progress, and interact with components thanks to the intuitive interface. This design ensures smooth operation and easy navigation throughout the simulation. Safety features, such as requiring protective equipment before starting tasks, were also effectively included, raising awareness of standard maintenance safety practices.

Finally, optimizing visual and sound finishing elements led to stable system performance with minimal lag or graphical errors. Adding synchronized sound effects, improving lighting balance, and managing textures properly enhanced the overall realism of the game. Together, these achievements show that the accessories and finishing objectives were met, supporting the project's aim of developing a realistic, educational, and interactive aircraft maintenance simulation.

5.2 CONTRIBUTION OR IMPACT OF THE PROJECT

This project provides significant contributions to both the educational field and the aviation maintenance industry. The development of the aircraft technician simulation game introduces an innovative and interactive approach to learning, allowing students to gain practical knowledge and experience without the need for physical aircraft components. It serves as an effective training platform where users can perform virtual maintenance procedures, understand system operations, and practice troubleshooting in a safe and controlled environment.

Academically, the project enhances the learning process by combining theoretical knowledge with hands-on simulation. It helps students visualize complex aircraft systems, develop problem-solving skills, and apply standard maintenance procedures in realistic scenarios. The game also promotes safety awareness by integrating proper maintenance practices and the use of protective equipment, preparing students for real-world tasks in the aviation industry.

From a technological standpoint, the project showcases the use of modern 3D modeling, animation, and interactive design to create an immersive educational tool. It contributes to the digital transformation of technical education, demonstrating how game-based learning can improve understanding, engagement, and retention among students.

Overall, this project impacts both students and institutions by providing a cost-effective, accessible, and innovative training solution. It not only supports the development of skilled and competent future aircraft technicians but also promotes the use of simulation technology as a sustainable method for aviation maintenance training.

5.3 IMPROVEMENT & SUGGESTIONS FOR FUTURE RESEARCH

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5.3.1 PRODUCT STRUCTURE

Even though the FlyFix Simulator achieved its main objectives, there are still several aspects of the product structure that can be improved to make the simulator more effective, realistic, and beneficial for future users. Both the mechanism structure and the software structure have strong foundations, but further enhancements would allow the simulator to reach higher standards of quality, performance, and educational value.

One of the main areas that could be improved is the realism of the 3D models and simulation environment. At this stage, the simulator already provides a functional virtual representation of aircraft maintenance tasks, but the visual details can be enhanced. In the future, higher-quality 3D models, better lighting effects, and more accurate animations can be developed to make the simulator environment more lifelike. This improvement will not only increase user engagement but also give students a clearer understanding of the actual appearance and movement of aircraft components during maintenance work.

Another suggested improvement involves expanding the variety of maintenance tasks available in the simulator. The current version mainly focuses on basic activities such as walkaround inspections, wheel assembly tasks, corrosion removal, and refuelling. For future development, more complex procedures like electrical diagnostics, engine servicing, or avionics testing can be added. This would make the simulator more comprehensive, exposing users to a wider range of maintenance operations and better preparing them for real-world scenarios.

The interactivity and control system can also be improved in future updates. At present, the simulator uses standard keyboard and mouse controls. To create a more immersive experience, the use of gesture-based controls, touchscreen interaction, or even Virtual Reality (VR) and Augmented Reality (AR) integration could be introduced. These technologies would allow users to perform tasks using physical movements, enhancing

realism and improving the hands-on learning experience. In terms of system optimization, future versions of FLYFIX could focus on maintaining smooth performance even as more features and graphical elements are added. This could be achieved by optimizing 3D assets, refining code efficiency, and improving rendering quality. Regular system updates and compatibility testing with newer devices and software versions would also help keep the simulator stable and accessible across different platforms.

The assessment and feedback system within the software structure can also be expanded to provide more detailed performance reports. Instead of showing only completion results or basic feedback, future versions could include progress tracking, detailed scoring, and personalized learning analytics. This would help students monitor their development over time and allow instructors to evaluate their strengths and weaknesses more effectively.

For future research, collaboration with aviation experts, training centers, and educational institutions is highly recommended. Working with professionals in the aviation maintenance field could help verify that all procedures in the simulator follow real industry standards. This collaboration could also lead to the creation of certified training modules that can be used as part of formal aviation courses.

In summary, while the FLYFIX SIMULATOR product structure has successfully achieved its initial goals, continuous improvement is essential to keep it relevant and impactful. Enhancing the realism of the visuals, expanding maintenance tasks, improving interactivity, optimizing performance, and strengthening the feedback system will make future versions more powerful and effective. With these improvements and further research, the FLYFIX SIMULATOR has the potential to become a leading virtual training tool that supports innovation and excellence in aviation maintenance education

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5.3.2 PRODUCT MECHANISMS

Improvement is to enhance system stability by reducing software bugs and improving performance. This can be achieved by conducting more extensive testing, refining the coding structure, and upgrading the simulator's framework to support smoother gameplay and faster response times.

Another important improvement is to increase the accuracy of labelling and instruction details. Future updates should include a thorough review of all part names, procedures, and directions (such as clockwise and counterclockwise movements) to ensure that they fully match real aircraft maintenance manuals. This will help users gain more accurate technical knowledge and prevent confusion during training.

The simulator can also be improved by adding more maintenance tasks and aircraft systems, such as avionics, hydraulics, and electrical systems. This expansion would allow students to experience a wider range of real-world maintenance operations, increasing the simulator's educational value.

In addition, implementing advanced VR (Virtual Reality) and AR (Augmented Reality) features would make the simulator even more immersive. These technologies could allow users to interact with parts using hand gestures or headsets, simulating a true workshop environment. This aligns well with Industry 4.0 and modern aviation training trends.

For future research, the project could explore multi-user or collaborative modes, where students can perform maintenance tasks together in real time. This would promote teamwork and communication, both essential skills in the aviation maintenance industry.

Finally, it is recommended to perform user testing and feedback analysis regularly.

Gathering feedback from aviation instructors, students, and industry professionals will help identify weaknesses and guide continuous improvement.

5.3.3 SOFTWARE / PROGRAMMING

1. **More Realistic VR-Like Simulation with Cost Efficiency**

   In the future, we can improve the simulator to be more realistic like VR training, while keeping the 3D graphics cost-effective. By optimizing textures and models, it is possible to give students a more immersive experience without requiring expensive hardware or software.

2. **Enhanced Animated User Interface**

   The UI can be upgraded with more animations and interactive elements, making it easier and more enjoyable for both young students and older learners. A friendly interface will encourage users to explore the simulator and learn naturally, reducing learning barriers.

3. **Expanded Task Variety and Free Movement**

   We suggest adding more tasks and first-person perspective (FPS) movement, allowing students to explore different parts of the aircraft freely. This could also be extended to explore other vehicles like ships or helicopters, increasing versatility and engagement in virtual training.

4. **Realistic Tool Interaction**

   Currently, some tools do not behave like real ones. Future versions can include anti-clockwise and clockwise rotation for tools, realistic weight and grip simulation, and proper interactions so that users experience how real tools feel and operate.

5. **Integration of Feedback and Scoring System**

   Adding a real time feedback and scoring system can help students track their performance and progress. This encourages self-assessment and motivates learners to repeat tasks until they master them.

6. **Multi-User Collaboration Mode**

   Future research can explore multi-user or collaborative mode, where students can train together in the same virtual environment. This encourages teamwork and

prepares students for real-life maintenance scenarios where coordination is required.

7. **Cross-Platform Compatibility and Cloud Saving**

   Making the simulator compatible with more devices and allowing progress to be saved in the cloud would enable students to continue training anywhere and ensure their progress is never lost.

5.3.4 ACCESSORIES & FINISHING

Although the accessories and finishing aspects of the project achieved the intended objectives, several improvements can be made to enhance the realism and functionality of future versions. One recommended improvement is to upgrade the tool interaction system by incorporating more precise physics-based responses, such as realistic torque feedback or vibration effects when using tools like wrenches and drills. This would make the simulation more immersive and closer to real-life maintenance experience.

In terms of visual finishing, the aircraft model and hangar environment could be enhanced with advanced lighting systems such as ray tracing or dynamic shadows to create more realistic reflections and depth. Future development could also include weather variations, different lighting conditions (day/night cycles), and environmental sounds to further increase immersion.

For user interface improvements, additional features such as voice-guided instructions, interactive tutorials, and customizable control layouts can be implemented to improve user experience and accessibility. Integrating augmented reality (AR) or virtual reality (VR) technology in future research would also enhance the training experience by allowing users to interact with components more naturally and intuitively.

Lastly, performance optimization should continue to be a focus in future research. Techniques such as texture compression, adaptive rendering, and cloud-based processing can be explored to ensure smooth performance on various hardware devices. Overall, continuous improvement in both accessories and finishing aspects will help transform the simulation into a more advanced, realistic, and effective training platform for future aircraft maintenance education.

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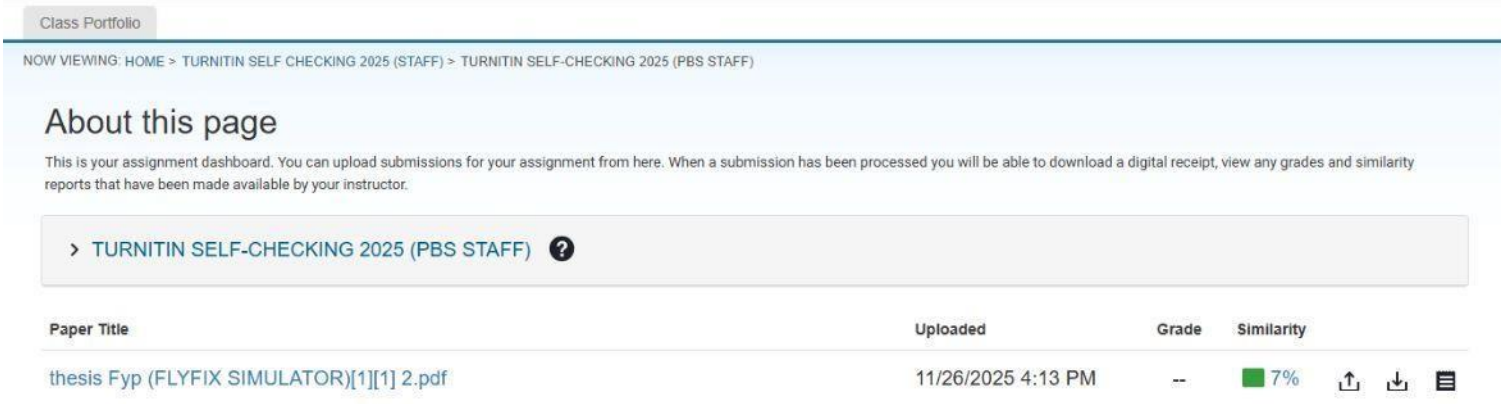
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