POLITEKNIK BANTING SELANGOR

NON-DESTRUCTIVE TESTING (NDT) INSPECTION SIMULATOR

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MUHAMMAD NIZAM BIN ZAINAL ABIDIN	24DAM23F1023
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DEPARTMENT OF AIRCRAFT MAINTENANCE

SESSION 1 2025/2026

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

SUPERVISOR
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REPORT ENDORSEMENT

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

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Date : 12th DECEMBER 2025

CERTIFICATION OF PROJECT ORIGINALITY & OWNERSHIP

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

SIGNATURE: WRITER 1

SIGNATURE: WRITER 2

SIGNATURE: WRITER 3

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ABSTRACT

This project deals with the design of a gamification-based NDT inspection simulator for aircraft maintenance students, focusing on ET training. ET is one of the common NDT techniques used for detecting both surface and near-surface defects in conductive materials. In general, practical training in this technique has been quite limited because of the availability of equipment, safety considerations, and operational costs. The project presents a digital simulator intended to be useful for students to learn and practice in an interactive, safe, and inexpensive virtual environment.The simulator developed on the Morph Matrix platform embeds a number of core gamification elements: scoring, guided tasks, interactive prompts, and instant feedback. In fact, these were some of the features to be embedded to enhance user engagement while attempting to reinforce correct inspection behaviour. The simulation is endowed with realistic 3D components, virtual manipulation of probes, and defect indication responses that emulate real ET behaviour. By interacting with these, users will be guided to learn the principles of electromagnetic induction and the importance of lift-off, probe orientation, and proper scanning techniques.The project applied several data-gathering methods in order to make sure the simulator fits actual training needs: questionnaire surveys, interviews with instructors, and documentation analysis of existing ET training procedures. The feedback received during development proved helpful in refining the user interface, inspection flow, and instructional clarity. The final system provides structured guidance for learners who may have limited exposure to real ET equipment, thus allowing them to practice repeatedly without time constraints or resource limitations.Feedback from using the simulator suggests that there is an improvement in the student's understanding of the basics of ET, defect detection methodologies, and signal response interpretation. Users were more confident in carrying out the inspection activities, such as probe handling, scanning sequence, and identification of defects. The virtual environment also reduces the risk associated with equipment misuse and eliminates the need for repeated use of costly ET test pieces.This project therefore highlights how gamification is integrated with simulation-based learning to enhance Eddy Current Testing knowledge retention, practical skills, and learner motivation. The NDT Inspection Simulator proves a useful addition to traditional training and reinforces the learning in the Diploma in Aircraft Maintenance Engineering program.

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CHAPTER 1
INTRODUCTION

1.1 BACKGROUND OF STUDY

Accuracy is what ensures safety in aviation, and it is through the use of Non-Destructive Testing (NDT) that aircraft integrity can be ensured. Every aircraft part must meet severe safety standards, and NDT allows inspectors to detect hidden faults without causing harm. It is subject to a lot of challenges to master the processes of NDT, for example, limited training facilities, huge cost, and access to practical defect samples. They hold back trainees and students from gaining experience practically before they actually enter the sector. Traditional learning methods rely upon expensive physical tools and direct monitoring, and both of them are limiting the level of access and exposure to trainees (Challa, K. T., Sayed, A., & Acharya, Y. (2021).

As a team of diligent Aircraft Maintenance students at Politeknik Banting Selangor, we Muhammad Nizam bin Zainal Abidin (24DAM23F1023), Pradon A/L P Gunalan (24DAM23F1019), Muhammad 'Azim Bin Hamdan (24DAM23F1026), and Dania Amal Humairah Binti Saharudin (24DAM23F1027) recognized such challenges and decided to revolutionize NDT training with technology. Our NDT Inspection Simulator Based on Gamification final year project aims to enhance the learning process by incorporating digital simulations and game-based training methods. By developing a real-world and interactive simulator, we provide learners with an affordable, accessible, and immersive training solution where they can gain valuable hands-on expertise in a simulated, controlled environment (Iqbal, M. Z., & Campbell, A. G. (2023).

Gamification is a powerful approach that utilizes game-like characteristics such as challenges, scoring mechanisms, and interactive scenarios to increase learning engagement. Our simulator will include real-life defect detection scenarios so that students can practice detecting different kinds of defects common in aircraft components (Kumar, S., Gopi, T., Harikeerthana, N., Gupta, M. K., et al , (2023).It will also include performance tracking, where users are scored based on their accuracy, speed, and decision-making skills. In addition, the simulator will provide virtual hands-on training by allowing students to practice NDT methods such as Eddy Current testing in a simulated environment. These features will allow students to learn problem-solving skills critically and reinforce theoretical concepts through practical experience.

The aviation industry heavily relies on skilled NDT inspectors to maintain aircraft safety and regulatory compliance. However, due to the increased demand for qualified personnel, more efficient and affordable training solutions are needed. Our NDT simulator can serve as a hands-on learning tool not just for students but also for aircraft maintenance engineers and professionals in the industry needing refresher courses. With the application of technology for refreshed training, this project enhances the student learning experience and helps shape the future of NDT education. We are confident that our simulator will decrease the cost of training, enhance skill acquisition, and make learning NDT more fun and effective for future aircraft maintenance experts (Krishnamoorthy, R. R., & Marius, D. (2025).

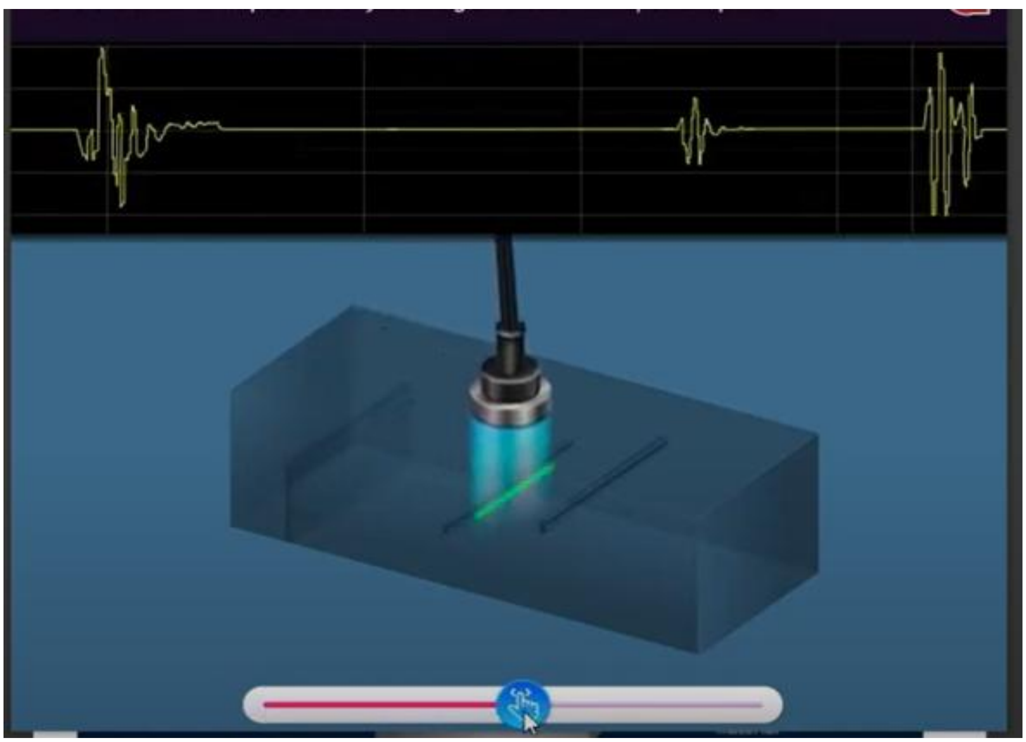


FIGURE 1: SIMULATED NDT INSPECTION ENVIRONMENT

1.2 PROBLEM STATEMENT

Non-Destructive Testing (NDT) is a critical aspect of aircraft safety, yet current NDT training fails to deliver interactive and realistic platforms for hands-on learning for students and practicing professionals. Traditional training relies on physical equipment, direct supervision, and availability of real aircraft parts, which are typically costly and difficult to obtain. Thus, the majority of the trainees do not acquire hands-on experience and real-time decision-making capabilities, which are necessary to identify defects accurately in aircraft maintenance (Matthews, D. M. (2023).

The lack of accessible, immersive training products creates a gap between theoretical knowledge and practical proficiency (Bizami, N. A., Tasir, Z., & Kew, S. N. (2023). Students and trainees are often restricted to textbooks and instructor-led classroom demonstrations, which fail to accurately reflect the challenges of real-world inspections. This dilemma extends to professionals already employed in the industry who require continuous skill maintenance but may lack access to cost-effective refresher training. Without realistic simulation-based training, the aviation industry risks producing NDT inspectors who are less prepared for real-world defect detection, potentially compromising aircraft safety and regulatory compliance (Folino, A. (2023).

To bridge this gap, innovative technology-based solutions are needed to supplement NDT training. With interactive simulations and gamification, trainees will be able to practice realistic defect detection scenarios, which will improve problem-solving, accuracy, and efficiency (Zhai, J. (2024).The development of a virtual hands-on learning experience will not only bridge the gap between theory and practice but also make NDT training more accessible, affordable, and engaging for students and industry professionals.

1.3 PROJECT OBJECTIVES

1.3.1 GENERAL PROJECT OBJECTIVES

The project objectives are:

1. To identify the needs and wants for NDT training and gamification to achieve maximum learning effectiveness.

2. To design an interactive game-based training simulator for NDT training that provides real-world defect detection simulation scenarios.

3. To develop an operational NDT training simulator that uses gamification features to increase engagement.

4. To evaluate the effectiveness of the NDT simulator in enhancing hands-on learning, cost savings, and training effectiveness.

1.3.2 SPECIFIC INDIVIDUAL PROJECT OBJECTIVES

1.3.2.1 PRODUCT STRUCTURE

The project proposes the data-building of an interactive simulator for practical learning experience in virtual learning environments. This simulator incorporates NDT techniques like Eddy Current Testing (ET), and real-time simulators for air vehicle component modules such as fuselages, wings, and engine blades.

Integrate performance analytics and reporting modules: The platform shall have systems that monitor learner progress and furnish insights into skill development with everything from visualized performance metrics.

Ensure conformity with industry standards: The training content will be adapted to the aviation NDT regulations and certification requirements so that the simulator will be compliant with aviation maintenance requirements and safety.

1.3.2.2 PRODUCT MECHANISMS

- To develop an interactive NDT training simulator that closely replicates real inspection techniques, giving a realistic and interesting learning experience.
- To include more defect scenarios and test techniques that represent real NDT practices, enlarging trainees' experience in flaw detection and evaluation.
- To periodically update and improve the simulator based on user response and emerging developments in NDT technology, delivering a challenging and effective training tool for students.

1.3.2.3 SOFTWARE / PROGRAMMING

- Develop app on Unity using C# programming language.
- Design programming on Unity game logic, mechanics, physics, UI, and animations.
- Ensure every movement is tally with instruction given from the input.

1.3.2.4 ACCESSORIES & FINISHING

- The overall design of the user interface will be intuitive, simple, and visually appealing. This involves making all menus, icons, and buttons clear and readily accessible. The interface will be made to resemble actual NDT equipment and tools, enabling a seamless transition from the simulator to actual aircraft maintenance.

- Accessories and completion step will also include enhancing feedback systems utilized by the simulation. This includes auditory and visual cues that guide the user while under examination and alert the user of errors, hence providing timely and pertinent instructions without slowing down the user.

- The simulation would be given the final touches on the NDT tools used in the system such that they are adequately represented in terms of their function and appearance. This includes the integration of features like ultrasonic probes, eddy current tools, and radiographic inspection tools to replicate their real counterparts.

1.4 SCOPE OF PROJECT

1.4.1 GENERAL PROJECT SCOPE

The project aims to develop a Non-Destructive Testing (NDT) Training Inspection Simulator Based on Gamification, which will be an interactive and fun tool for young students, learners, and any individuals interested in aviation engineering and maintenance. The simulator will be utilized as an instructional tool to introduce users to NDT principles and inspection techniques so that they can learn and practice implementing various NDT methods such as ultrasonic testing in a simulated environment (Mix, P. E. (2005).

Traditional NDT training methods are equipment-intensive, instructor-led, and environment-controlled to ensure effective learning. However, hands-on training might not be easily available to students and beginners due to budget constraints, safety concerns, and logistical problems (Muzata, A. R., Singh, G., Stepanov, et al (2024, November). Through the introduction of a game-based learning framework, the project aims to bridge the gap between theory and practice by offering an inexpensive and scalable solution that provides realistic defect detection scenarios in a virtual environment.

The NDT Training Inspection Simulator will feature a user-friendly interface and interactive dynamics to accommodate learners of varying skill levels from beginners with no NDT background to more advanced students who wish to refine their inspection skills. The simulator will be equipped with step-by-step tutorials, guided practice, and real-time feedback mechanisms, so trainees will experience structured training and instant performance evaluations (Yazdi, M. (2024). In addition, to enhance user engagement, the simulator will have gamification elements such as achievement badges, time-based competition, and interactive quizzes, which will make learning enjoyable and rewarding.

One of the most important aspects of the project is the simulation of real-world inspection environments, where users can virtually inspect defects in aircraft components, perform inspections according to different NDT techniques, and report their findings just as they would in an actual working scenario. The system will offer high accuracy and realism using advanced material simulations, different inspection environments, and defect types to replicate real-world scenarios (Jaber, A., Sattarpanah Karganroudi, S., Meiabadi et al. (2022).

The project will be developed on a cross-platform system, which will make it available on different devices such as PCs, tablets, and other devices that can run the Unity Engine Platform. The availability will enable students and learners from different backgrounds to take NDT training without the need for specialized hardware, hence making it more accessible and convenient to many (Sulaiman, F., & Eldy, E. F. (2023, April).

Beyond its educational merit, the project also aims to raise awareness of NDT as an important discipline in aviation maintenance and engineering so that more students will be inspired to become professionals in the field. With the application of digital learning and gamification, the NDT Training Inspection Simulator will be an engaging and interactive experience that will render NDT learning more accessible, practical, and enjoyable for a new generation of students.

1.4.2 SPECIFIC INDIVIDUAL SCOPE

1.4.2.1 PRODUCT STRUCTURE

This also provides fair flexibility and scalability for training program development that meets various devices like desktop, mobile, and VR systems. (Parisi, T. (2015). The underlying technology would be developed in Unity and used to simulate aircraft maintenance tasks within a virtual environment. Actual virtualized digital models of aircraft components such as wings, fuselage sections, turbine blades, etc. in the depth of the system will allow users to perform Non-Destructive Testing (NDT) under various testing methods such as Ultrasonic Testing, Radiographic Testing, and Eddy Current Testing. In addition to this, the simulated tests instruments will also replicate a real-time instrument both in terms of appearance and functioning to provide highly realistic experiences. (Schütz, W. (1994)

Another important characteristic of the product is the presence of real-time feedback mechanisms. Users will receive feedback as soon as they perform an action, noting both the right things they have done and the issues that need improvement. (Damodaran, L. (1996) This enables continuous learning and self-assessment. Furthermore, instructors will access a separate interface for assigning tasks, monitoring progress, and customizing the training pathway according to each learner's performance. The system will have inbuilt analytics tools for tracking individual progress, task accuracy, and learning trend visibility. (Peña-Ayala, A. (2018)

Starting with some basic inspection tasks, the training will proceed through different levels to more advanced challenges. To maintain interest and motivation, there would be leveling so that learners can tackle specific levels in the program and earn points and achievement badges for successful completion of various phased activities. Each module will employ scenario-based simulations to reproduce real-life inspection problems (Chou, Y. K. (2019). At may be found in the aviation sector. These scenarios will allow users to practice recognizing and analyzing structural defects, thereby practicing their decision-making and problem-solving skills. (Mirel, B. (2004)

1.4.2.2 PRODUCT MECHANISM

The structure of a game-based NDT training simulator is aimed to provide an interactive and immersive learning platform that mimics real-life non-destructive testing (NDT) inspection protocols. The simulator will focus on engine casings as the primary item for inspection, and the trainees will be given hands-on experience in detecting cracks,and structural defects critical for aircraft safety (Aust, J., Mitrovic, A., & Pons, D. (2021).

To enhance realism, the simulator will be located in a workshop environment that closely mimics actual aircraft maintenance facilities. The environment will allow users to perform inspections in an efficient, professional setting that is focused on the industry best practices. The user interface will be mouse and keyboard controlled, providing accurate control and easy access for a large number of users (Andreas, D., Six, H., Bliek, et al (2022).

The learning mode incorporates real-life scenarios that are designed to immerse trainees in problem-solving situations. The scenarios will induce critical thinking by exposing the users to various inspection scenarios, which they will be required to apply their NDT skills accordingly (Larouze, J., Martin, E., & Calmon, P. (2023). For support in learning, visual feedback mechanisms such as color-coded indicators, animations, and highlighted regions will provide immediate identification of defects, promoting engagement while reducing cognitive load.

Moreover, the simulator draws upon existing NDT inspection simulations, using gamification elements in terms of scoring systems, achievement badges, and real-time performance feedback to make the learning experience both educational and engaging (Zhai, J. (2024).

To ensure the simulator remains up-to-date and functional, continuous testing and calibration will be performed from user feedback. Regular updates will synchronize the simulator with NDT technology developments so that it is always up-to-date with current industry standards (Si-Mohammed, S., Bardou, A., Begin, T et al (2024). Community involvement would be key to the project's sustainability, allowing a collaborative learning environment where users can share and contribute ideas for making the simulator even more improved.

With the inclusion of actual inspection processes, interactive learning environments, and game methods, this NDT training simulator will be a futuristic, dynamic educational program, increasing accessibility, making training more appealing and effective to learners and professionals, and providing educational content on-demand.

1.4.2.3 SOFTWARE / PROGRAMMING

This project involves the development of an educational game utilizing Unity, a widely used game development platform (Blackman, S. (2013). The primary focus of the software and programming scope is to implement game mechanics and interactive features that align with the principles of gamification. These features are designed to enhance user engagement and support learning objectives through a structured and interactive environment (Zanjani, N. (2017).

The programming language used in this project is C# (C-Sharp), which is fully supported by the Unity engine. C# is a modern, object-oriented language known for its readability, scalability, and efficiency in handling complex logic. Its robust integration with Unity's development framework makes it an ideal choice for creating dynamic and responsive game behaviours.

In the context of this project, C# scripts are responsible for controlling a wide range of functionalities, including user input handling, character or object movement, score tracking, state management, and animation triggering Sturm, O. (2011). These scripts are attached to game objects within the Unity environment and dictate how those objects respond to user actions and game events.

The programming language serves as the medium through which logical instructions are translated into real-time behaviour within the game (Hancock, C. M. (2003). For example, a C# script may detect when a user completes a task correctly and responds by updating the score, providing visual feedback, or progressing to the next level. Through such interactions, the code ensures that the game remains both engaging and educational (Amory, A. (2007)

1.4.2.4 ACCESSORIES & FINISHING

Completing the user interface (UI) of the layout, button, menus, and icons. The aim is to have an intuitive UI that resembles actual NDT tools and equipment and is user-friendly as well as realistic (Chua Ying Kit, J. (1996).

Enabling proper integration of visual and audio feedback mechanisms that provide instructions to the user. This includes feedback for correct actions, e.g., successful inspections, and warnings or alerts for errors, e.g., misuse of tools or inability to detect defects. The feedback should be informative as well as non-intrusive in nature to maintain the continuity of the training process.

Completion of the 3D models and interactive elements of the NDT tools used by the simulator. These comprise probes for ultrasonics, eddy current testers, as well as radiographic machines and making sure they represent themselves correctly and are interactive via the simulation.

Enhancing the environment of the simulation by putting finishing touches to texture, light, and ambient effects to create an exact real-world NDT test environment, e.g., an aircraft hangar or laboratory. This will enable users to become immersed within a realistic environment that simulates true inspection processes.

1.5 PROJECT IMPACT

Gamification-Based NDT Training Inspection Simulator will change the way NDT inspection techniques are learned by students and practitioners alike through the use of game-based learning on a virtual training environment. The project aims to bridge the theory and practice divide, offering an enjoyable and interactive interface that enhances skill acquisition for aircraft maintenance (Starr, L. T., Shorts, K., & Vans, M. (2024).

By simulating real inspection conditions, the simulator will allow the users to conduct Eddy Current testing on engine casings. By simulating real workshop conditions, the trainees will be able to detect cracks, and structural defects, enabling them to comprehend NDT processes better in a safe environment (Chen, J., Yu, Z., & Jin, H. (2022).

Gamification aspect, e.g., visual cues, immediate feedback, and interactive exercise, will improve user engagement and retention. Utilizing mouse and keyboard as the inputs, the simulator offers precision and ease of use, providing ample accessibility to multiple learners. Providing the training in digital format, the project increases access to NDT training beyond a physical classroom setting (Fernandez Orozco, R. S. (2021)

Unlike existing flight-simulation games that are primarily employed for the purpose of flying simulation, this project introduces a novel tool for aircraft maintenance inspection, which is critical in the absence of existing digital learning tools (Cross, J., Boag-Hodgson, C., Ryley, T. (2022). With feedback-based optimization integrated into the simulator, it will also learn and evolve with advances in NDT technology and industry standards.

Ultimately, this project will not only provide a new and effective learning platform but also improve aviation safety by ensuring that future NDT professionals are well-trained in accurate defect detection and maintenance procedures. The shared learning environment provided by this simulator will allow for continuous knowledge sharing and skill enhancement, shaping the next generation of NDT professionals in the aviation industry (Vrana, J., & Singh, R. (2021).

CHAPTER 2
LITERATURE REVIEW

2.1 GENERAL LITERATURE REVIEW

2.1.1 THE ROLE OF SIMULATION IN TEACHING NON-DESTRUCTIVE TESTING FOR AVIATION

Non-Destructive Testing (NDT) simulators have considerable potential as effective training tools in aircraft maintenance programs. (Dela Peña, A. (2024) However, traditional NDT training often fails to simulate hands-on experience with realistic inspection procedures, limiting what students can experience and learn. NDT simulators provide a safe, interactive training environment in which students can master techniques such as dye penetrant or eddy current testing with no risk to equipment or safety. (Mix, P. E. (2005)

Gamification components such as points and challenges are also able to boost student engagement and motivation. (Alsawaier, R. S. (2018). Software such as Roblox and Unity allows creating realistic virtual space for ongoing practice and consistent results of learning. As aviation maintenance has high demands on skills and precision, simulators for NDT help prepare students better prior to entering the industry.

2.1.2 ADVANCING LEARNING IN AVIATION MAINTENANCE WITH NDT TOOLS

Non-Destructive Testing (NDT) simulators are outstanding teaching tools in aircraft maintenance training. They allow the student to learn and practice inspection techniques in a safe, controlled environment without endangering or wasting actual equipment. By simulating real-world situations, the students are better able to understand procedures of Eddy Current testing. The use of interactive elements and gamification provides an added layer of learning by making it interesting and memorable. Therefore, NDT simulators are a practical way to bridge theory and practice in aviation maintenance education.

2.1.3 IMMERSIVE LEARNING IN NDT TRAINING

NDT simulators provide a unique opportunity to boost student participation and immersion in airplane maintenance training. Traditional classroom teaching may sometimes disappoint students or be devoid of experience. But with simulation-based resources, students get the opportunity to interact with simulated airplane parts and perform inspection tests in a safe, real-like environment. The addition of gamified elements such as scoring, timed practice, and scenario-based challenges adds a sense of motivation and fun, encouraging active participation. This interactive learning process not only helps students retain technical details more effectively but also builds confidence in the application of their skills to real-life situations.

2.1.4 Enhancing User Reach Through Inclusive and Accessible Design

To be effective and highly usable by a wide range of users, the project emphasizes the principles of inclusion and accessibility. As such, an NDT simulator will be developed on a broadly accessible platform, e.g., Roblox (for example only), which will enable smooth playing on multiple devices, including PCs, laptops, tablets, and smartphones. With these provisions, students of various economic backgrounds can undergo NDT training without incurring costly equipment. The design also includes options to enhance usability for the disabled, including adjustable font sizes, colorblind-friendly options, audio instructions, subtitles, and keyboard navigability for motor or visual impairment.

The simulator, besides being physically accessible, also addresses language and cultural diversity through multi-language support and neutral design elements that accommodate as wide a range of users as possible. The simulator acknowledges that the learners prefer different environments and abilities and thus offers three modes-tutorial, practice, and scenario-based assessments-to accommodate both novices and advanced learners. With these modes, a visual learner, auditory learner, or hands-on learner could still flourish. Moreover, the virtual environment gives the students a chance to fail and learn in a low-stakes safe environment without actual damages to components or equipment. This additional inclusivity feature guarantees that the simulator is not just a cheap and scalable solution but one that also ensures all learners will build their confidence and competence in acquiring highly essential NDT skills.

2.1.5 IMPACT OF NON-DESTRUCTIVE TESTING ON CAREER OPPORTUNITIES IN AVIATION

The integration of Non-Destructive Testing (NDT) technologies in the aviation and aerospace industries has created a great influence on career aspirations for students and engineers in aircraft maintenance and engineering fields. NDT methods which is eddy current testing, have become essential for the safety, reliability, and longevity of aircraft parts. For students pursuing diplomas or degrees in aviation-related programs, proficiency in NDT not only incorporates technical skills but also enhances career prospects.

With the increasing reliance on NDT for routine maintenance and safety-critical inspection, many students view NDT training as a steppingstone to more specialized, higher-paying jobs in the aerospace sector. The growing need for experienced NDT practitioners translates into more job opportunities, as companies seek experts who can apply these techniques to guarantee aircraft maintenance and repair without compromising structural integrity. Furthermore, the innovative character of NDT technologies, e.g., the development of simulation tools and automation, encourages students to think ahead, hence becoming more sensitive to emerging industry trends.

2.1.6 NON-DESTRUCTIVE TESTING (NDT) EDUCATIONAL INSPECTION SIMULATOR USING A GAMIFICATION-BASED PLATFORM

Trans-NDT through the virtual platforms trained judges and notifies users about innovative teaching approaches: an instrument of education in Non-Destructive Testing-NDT. This is critical in achieving all necessary checks to determine whether aircraft components have been damaged structurally. The limited potential of traditional classroom learning, which was combined with a highly expensive world of training, is wanted for a simulator that would take students in aircraft maintenance into a virtual, interactive learning medium.

The platform-fully gamificated simulator contains lovely game elements, such as the tracking of progress, scoring systems, feedback loops, and challenges with scenarios, to learning practice that is both effective and delightful. Users can carry out simulated NDT procedures: Eddy Current testing on virtual aircraft parts such as engine casings, fuselage panels, and landing gear. The student is thus able to practice in realistic simulations without the risk and costs of dealing with actual aircraft components.

The simulator's purpose is thus not simply that of providing entertainment; it is sufficiently pedagogically organized towards deep understanding and the development of skills. Step-by-step instructions, guided tutorials, and assessment modules embedded into the software are designed to help users in mastering aspects of the inspection process. Immediate feedback and performance evaluation allow learners to understand their mistakes and reinforce correct techniques at a steady pace.

Accessibility and inclusivity are also core design principles for the simulator. It runs on a multiplicity of devices and platforms, i.e., PC, tablet, mobile, and extends to features for learners with disabilities or different learning styles to have quality NDT education for more people. With the introduction of gamification and simulation technologies, the training of any learner in NDT becomes more accessible, engaging, and effective as they join those already in aviation maintenance.

2.1.7 SUPPORTING STUDENT LEARNING THROUGH RESOURCE ACCESSIBILITY

For the complete educational outcome of the Non-Destructive Testing (NDT) Teaching Inspection Simulator, the possibility is maximized by ensuring that students are availed with resources needed in their travel toward being empowered learners. This project aims at developing diversified, accessible, and interactive scaffolding learning materials that go parallel to the simulator experience and aid in knowledge retention.

A range of student resource support, including digital manuals, quick-reference guides, instructional videos, and interactive tutorials, will be provided for the simulator. These resources are designed for pre-learning and post-learning purposes, allowing students to review NDT concepts, procedures, and safety guidelines at their own pace. All of the materials will be easily accessibly taught within the simulator or through an online portal, with 24/7 access to learners.

In addition, an integrated help center, and in-game hint system will serve as just-in-time support tools for students having difficulty performing a specific task or process during simulation. These features enhance independent learning by providing convenience in time and reduction in constant instructor supervision. Peer teamwork and community resourceful sharing are promoted through discussion forums or group missions within the simulation, strengthening both teamwork and communication, which are crucial in the real aviation maintenance environment.

2.2 SPECIFIC LITERATURE REVIEW

2.2.1 PRODUCT STRUCTURE

The assembly of a product is a hierarchical and modular organization of the components in that product and states how the subsystems and features are integrated to achieve the desired functions (Salvador, F. (2007). A definite product structure in simulation-based training environments, especially the AI-driven ones, is important for ensuring system effectiveness, maintainability, and scalability.

Training simulators must have product structures that support modular developments, which mean that the components like user interface, AI engine, and feedback system would have to be developed and successfully tested separately (Soni, J. (2022). This would bring in greater upgrading flexibility and more easy incorporation of other test methods like additional NDT for non-destructive testing techniques.

In that manner, it is totally a layered product structure-user interaction layers, simulation logic, data processing modules, and finally AI algorithms-which simplifies the whole thing in terms of functionality and user experience (Gomes, G. C. (2018). In an AI-enabled NDT simulator, the structure of the product will have clear information as what flow to follow from user inputs to simulation outputs so that it can be easily interpreted and visualized.

Furthermore, in product architecture, being adaptable is important. Educational simulators' architecture should accommodate future technological advancements (Loukissas, Y. (2012). Thus, it would mean that the new AI models, physics engines, and training scenarios would have to be plugged into existing architectures without having to redesign the whole system.

In summary, a good product structure in AI-based simulation systems must be modular, scalable, and adaptable (Ekundayo, F. (2024). This allows for usefulness in the long term, cost-effective usage, and flexibility to cater to changing training requirements, which makes it an important feature for building strong educational tools such as the NDT Inspection Simulator.

2.2.2 PRODUCT MECHANISMS

2.2.2.1 TYPE OF HINGES (VIRTUAL INTERACTION MECHANISMS)

In the world of physical aviation maintenance and NDT, hinges are a component of tools and parts that must be moved under control, such as doors, panels, inspection hatches, and test rigs. Hinges provide access and articulation, allowing inspectors to reach internal parts without dismantling the entire structure.

Inside the setting of the NDT simulator, hinges are emulated by program-controllable movement and interaction of objects. As an example, operators may emuluate opening and closing an access panel of a virtual fuselage of an aircraft or manipulating parts while inspecting. These motions are achieved through scripting within the game engine along with rotation pivots and trigger-based animation.

This virtual hinge system enhances realism by enabling dynamic object interaction, allowing users to feel like they have their hands on objects while conducting virtual inspections. By applying hinge-like behavior in simulation, students can learn how to approach real-world inspection points and work with parts safely during maintenance inspections. These mechanisms align with best practices in simulation-based technical training as reported in the literature on interactive 3D training tools (Zhao et al., 2020).

2.2.2.2 TYPE OF ELECTRICAL MOTOR (SIMULATED MECHANISM CONTROL)

In a real NDT application, electric motors are routinely used to power rotating tables, robotic arms, or scanner units for assistance with non-destructive testing. (Poole, A. (2023) Motors offer smooth action, precise control, and repeat test conditions. Real motors are not actually used within this simulator, though motor-drive system behavior and logic are emulated on the computer to mimic realistic tool movement or piece motion. (Koppak, R. (2022).

For example, when the simulator user activates a virtual ultrasonic scanner, the system can simulate the probe scanning across a surface by using time-based animations or path-following algorithms. Such simulated movements are regulated by parameters such as speed, acceleration, direction, and pause delays like motors in real-world situations. This not only adds to immersion but also gets students used to the timing and rhythm of operation of mechanical NDT equipment. (Mix, P. E. (2005)

Through gamification features, such as scorekeeping based on performance or the use of timed inspections, the simulation can also test the user to operate these simulated tools in a timely manner, simulating actual limitations in a lab or field inspection environment. Research on digital twin simulations and training programs (Li et al., 2021) cites the importance of incorporating realistic equipment response in training software in enhancing practical understanding and preparedness.

2.2.2.2.1 SELECTION OF AC MOTOR (REFERENCE FOR VIRTUAL SYSTEM MODELING)

Among different types of electrical motors, AC (Alternating Current) motors are applied most widely to aviation ground equipment due to their simplicity, less maintenance, and ability to operate on continuous load cycles. To simulate purposes, AC motor behavior is simulated digitally and modeled to simulate rotary or linear energy-dependent tool motions, e.g., revolving test specimens or moving inspection platforms.

No real AC motors are used in this software, but the decision to call AC motor specifications is a method of staying true to real hardware. Motor functionality in Unity or Morph Matrix is simulated using torque-based physics or scripted rotation movement. For instance, a turntable powered by an AC motor used in real ultrasonic inspection can be simulated by rotating a 3D object at a constant speed with user-initiated control, mimicking how the real component would respond under motor drive.

This simulation approach allows visualization of the effect of motor-based movement on the inspection process in regards to scan uniformity, probe contact, and part positioning. By simulating AC motor performance, software not only demonstrates technical realism, but also educates students equipment used in the actual aircraft maintenance procedure.

Moreover, referencing AC motors in the virtual setting stimulates understanding of electro-mechanical integration in NDT systems, an essential area of knowledge of the aviation technicians in terms of translating mechanical and electrical issues in aircraft systems.

2.2.3 SOFTWARE / PROGRAMMING

FIGURE 2:

Unity is a game development platform that supports its own programming system through the use of scripts written in the C# programming language. In order to code in Unity, developers begin by creating scripts that can be attached to GameObjects within the Unity environment. Cutumisu, M. (2009)..

A script in Unity refers to a component that contains C# code, which defines how objects in the game behave and interact with the player and the environment. Scripts are essential elements in Unity projects, as they allow developers to build the core mechanics of a game and bring static assets to life through interactivity and dynamic behaviour.

In this project, scripts serve several key functions in achieving the game's objectives. These include controlling player movement and enabling the character to freely navigate through the aircraft maintenance simulation environment. Additionally, scripts are responsible for implementing gameplay mechanics to ensure the simulation operates according to its intended logic and objectives. They also manage visual and audio effects, such as animations, lighting changes, particle systems, and sound effects, to enhance immersion and realism.

The integration of C# scripts within Unity enables the creation of an interactive and educational simulation that supports learning through engaging gameplay experiences. The scripting system provides the technical foundation needed to control the flow and functionality of the game in alignment with the project's educational and training goals.2.2.4 ACCESSORIES & FINISHING

The Specific Literature Review of Accessories & Finishing for the NDT Simulator deals with polishing the final details that bring the simulation's functionality and usability to the next level (Duernberger, E. (2023) Literature in this area focuses on the importance of a good user interface (UI) and user interaction. Literature suggests that an easy-to-use UI increases usability and engagement, which is crucial for users to be able to use the simulation with ease and apply NDT techniques (Abd El-Sattar, H. K. H. (2025). Interactive design principles emphasize the need for intuitive visual cues, sensibly organized menus, and realistic presentation of tools. Feedback systems research also emphasizes how auditory and visual feedback are important to reinforce learning, facilitate real-time correction, and lead the user through correct inspection procedures (Mathisen, P. (2012). In aesthetic finishing, the literature shows that realistic environments and tools contribute to immersion and realism that are important for engaging the user and ensuring effective training. Optimizing the performance of the simulation for smooth interactions and fast loading is also well documented, as lag or delays can be disruptive to the learning process. (Shepherd, S. P. (2014). Overall, literature emphasizes that a realistic, interactive, and polished design is the most important aspect in creating an NDT simulator that not only instructs but also motivates users to learn (Bertovic, M. (2015).

2.3 REVIEW OF RECENT RESEARCH/RELATED PRODUCTS

2.3.1 RECENT MARKET PRODUCTS

2.3.1.1 GAME 1

NO	RECENT RESEARCH GAME	SUMMARY
1	FREE EXPLORATION GAME  FIGURE 2: FREE EXPLORATION GAME	**Game name**: ROBLOX EXPLORER **Published date**: 2024 **Description**: Option 4 is a simulation-based game designed to enhance players' understanding of aerospace systems and ground operations. The game has various interactive components, including Landing Gear deployment, an Open Environment for movement and exploration, and Guided Sequences to aid the learning process. It simulates Real Situations that imitate real aviation scenarios and offers Hints to the player. A mode is given in the game named Game D: Free Exploration, which allows the interaction of users with the various elements of the simulation freely.

TABLE 1 RECENT MARKET PRODUCT GAME 1

2.3.1.2 GAME 2

NO	GAME RESEARCH	SUMMARY
1	Game C: Interactive Steps  FIGURE 3: TURBOJET ENGINE	Simulation-style learning game focused on jet engine assembly and mechanical understanding, hosted on the Roblox platform. It guides users through interactive step-by-step procedures, allowing them to simulate tasks like engine maintenance and component handling. The game features a Touch Interface and Drag-and-Drop Steps to replicate real-world processes, supporting practical learning. With a structured flow and visual interaction, it helps learners gain a foundational grasp of engineering systems in a virtual environment.

TABLE 2 RECENT MARKET PRODUCT GAME 2

2.3.1.3 GAME 3

NO	RECENT RESEARCH GAME	SUMMARY
	WORKSHOP ENVIRONMENT  FIGURE 4: WORKSHOP ENVIRONMENT	GAME NAME: Workshop Environment DEVELOPER: Key Games DESCRIPTION: The Workshop Environment game simulates real aircraft maintenance processes. It can be used by players to inspect fuselage panel's part for blemishes such as cracks and corrosion, a critical component of aircraft maintenance. The game provides spraying, brushing, and immersion techniques to simulate the application of penetrant testing (PT) methods, enhancing users' familiarity with hands-on inspection methods. Touch interface interaction is utilized to interact with students, providing real-time feedback using visual means, improving learning and technique application in a simulated, safe setting.

TABLE 3 RECENT MARKET PRODUCT GAME 3

2.3.1.4 GAME 4

NO	PATENTED PRODUCT	PATENT SUMMARY
	INSPECTION SIMULATOR  FIGURE 5: INSPECTION SIMULATOR	Game name: INSPECTION SIMULATOR Description : Training-focused simulation designed to enhance the skills necessary for aircraft maintenance, in the case of this example, for Non-Destructive Testing (NDT) inspection. It is wing-section-focused, representing typical aircraft pieces that tend to require extensive scrutiny. It's a realistic mock workshop setting with an immersive effect similar to what one would see in real-life aviation maintenance contexts. Users use mouse and keyboard interfaces to command the simulation with flexibility to accommodate different training schedules. The game takes on interactive, engaging, and skill-based learning modes to facilitate step-by-step guided learning, hands-on learning, and skill evaluation. A scoring system is implemented as a feedback system for users to measure their performance and continuously cultivate their inspection skills. The game takes cues from an actual inspection-based simulation, Game A: Inspection Simulator, and adopts significant features to enhance training effectiveness.

TABLE 4 RECENT MARKET PRODUCT GAME 4

2.4 COMPARISON BETWEEN RECENT RESEARCH AND CURRENT PROJECT

2.4.1 GAME A VS OUR GAME

GAME	**ROBLOX EXPLORER**	**NON-DESTRUCTIVE TESTING (NDT) INSPECTION SIMULATOR BASED ON GAMIFICATION**
PURPOSE	Focus on practical maintenance tasks, open environments, and explorations.	It is suggested that gamification could help deal with the challenges faced while training for traditional NDT as gamified interactive techniques offer simulated training situations.
TARGET	Students, school-leavers, and STEM learners.	Those being in NDTs can rest assured that understanding strive to make reality some of these perceptions and sidestep education's labyrinth furthered by steak or sleep.
PLATFORM	Roblox	Unity
FEATURES	Thorough documentation, as well as hints, tutorials, practical scenarios, and tasks.	This document provides details based on the necessity of NDT training via simulations using methods of Eddy Current Testing (ET).
GENRE	Aircraft Maintenance Simulation	Non-Destructive Testing (NDT) for aviation maintenance, giving it a practical, engaging, and safe learning environment.

TABLE 5 GAME A VS OUR GAME

2.4.2 GAME B VS OUR PRODUCT

Product	NDT Inspection Simulator	Interactive Steps
Purpose	To teach and simulate Ultrasonic Testing (UT) procedures for aircraft parts	To demonstrate jet engine assembly and mechanics in an interactive manner
Target	Aviation maintenance students and NDT trainees	General learners, young enthusiasts, and engineering-focused Roblox players
Platform	Unity (PC and potentially cross-platform in future)	Roblox (accessible on PC, mobile, Xbox)
Features	Simulated UT probe interaction, defect identification, tutorial, scoring	Step-by-step tasks, drag-and-drop assembly, visual feedback
Genre	Simulation, Educational, Technical Training	Simulation, Educational, Procedure Learning

TABLE 6 GAME B VS OUR PRODUCT

2.4.3 GAME C VS OUR PRODUCT

Product	**Workshop Environment**	**Non-destructive Testing (NDT) Inspection Simulator**
Purpose	To provide students with a practical experience in aviation maintenance. The game simulates activities like the inspection of fuselage panels, and performing normal maintenance tasks such as spraying, brushing, and dipping, which are crucial to acquire a feel of aircraft maintenance and repair work. It helps students get used to real issues faced in the workshop environment.	To create a simulated learning setting for Non-Destructive Testing (NDT) methods such as Eddy Current tests. The Simulator for NDT has been designed to allow learners to gain exposure to the application of these technologies for inspecting and analyzing airplane parts without destructing them. Safety protocols as well as deciphering inspection readings are also practiced through the use of the simulator, making it a priceless means of simulating real aircraft inspection practice.
Target	Young children and teenagers	Aviation students and teenager
Platform	Roblox	Unity
Features	Touch interface which streamlines student interaction with the tools and process of completing testing.	Simulation of various NDT techniques for different materials and components, real-time feedback,

	It is executed in practice mode; thus students can practice at their own rate. Learning support is offered through visual cues that indicate important steps, offering an intuitive and guided experience.	interactive tools for practice, and scenario-based training.
Genre	Workshop simulation	Inspection simulation

TABLE 7 GAME C VS OUR GAME

2.4.3 GAME D VS OUR PRODUCT

Product	**INSPECTION SIMULATOR**	**Non-destructive Testing (NDT) Inspection Simulator**
Purpose	The main purpose of the inspection simulator is to provide a cost-effective, safe, and interactive platform for users to learn and practice NDT techniques. It focuses gamification-based simulation-based training to enhance the interactive level of learning, especially among young users. The simulator strives to depict the basics of NDT methods like dye penetrant testing, ultrasonic testing, and eddy current testing in a straightforward, graphical, and intuitive environment.	The Gamification-based NDT Inspection Simulator, on the other hand, is meant to provide students and trainees in technical fields like aircraft maintenance and aerospace engineering with a real, detailed, and interactive educational experience. It is mainly meant to simulate actual NonDestructive Testing (NDT) processes used in industry, more precisely in aviation. The simulator incorporates gamification elements-like feedback, scoring, and not simply for engagement, but to enhance understanding and skill development. It instructs users on how to properly use inspection procedures, identify defects, interpret results, and understand the underlying rationale of NDT techniques, all in a virtual and safe setting that simulates real-world conditions.

Target	The target group of an Inspection Simulator Game tends to be children, adolescents, or average learners who are interested in engineering or aircraft systems but not very technically skilled or educated. These individuals may be at high school or freshman college levels, finding possible career areas or simply learning for fun. This game is meant to spark interest early, introduce basic concepts, and fill the gap between general curiosity and more formal, professional study later in their education.	The NDT Inspection Simulator Based on Gamification is intended for a more technical and professional audience, including aviation students, engineering diploma holders, and NDT trainees. These are the individuals who are typically enrolled in formal training courses where they need to gain theoretical knowledge as well as practical skills related to aircraft component inspection. This simulator serves as a practice tool before real practice, where the users can be confident in performing inspection procedures and equipment without risk exposure or monetary expenses using physical training facilities. It also assists aviation schools in supplementing classroom lectures with interactive simulations.
Platform	The Inspection Simulator	The NDT Inspection

	Game is deployed through Roblox Studio, an environment with the renown of user-created games and straightforward scripting through Lua. Roblox accommodates the creation of interactive 3D worlds and experiences that are suitable for children. The game is playable on a variety of devices including smartphones, tablets, and PCs, making it highly accessible. The Roblox platform is centered on sharing between communities, social interaction, and creativity, making it most suitable for educational games targeting children. However, due to its simplicity, it may lack the fine detail realism and technical precision required for professional training.	Simulator On the basis of Gamification is built on Unity, a powerful and professional-grade game development platform capable of delivering high-fidelity, realistic simulations. Unity supports complex physics, 3D modeling, and editable interactions, enabling it to impeccably replicate actual NDT environments and equipment. The simulator would be executed on PC-based systems and can be modified to support VR (Virtual Reality) or AR (Augmented Reality) for more interactive learning. Unity allows integration of systems that provide real-time feedback, performance monitoring, and procedural logic which is similar to industry standard. It dely used in engineering education and training design.
Features	Usual features of an Inspection Simulator Game	The NDT Inspection Simulator Based on

	include uncomplicated game mechanics which are easy to understand, bright graphics, elementary tasks like defects detection visually, and game characteristics such as points, levels, and badges for keeping the user engaged. They may have short tutorials or fact boxes, but these are rarely comprehensive or taken from real-world tools and processes. Enjoyment, accessibility, and simplicity in game design take precedence over technical correctness. The tasks can vary from tap and drag objects to selecting answers during quizzes or doing tasks within a time limit. These features are helpful for initiating elementary inspection-related thinking but not suitable for official training.	Gamification is loaded with an extensive set of realistic and technical features. These may comprise the simulation of all types of NDT methods such as Dye Penetrant Inspection (DPI), Ultrasonic Testing (UT), and Magnetic Particle Testing (MT). Virtual inspection tools may be controlled by users, led through procedures step by step, and given instant feedback regarding their performance. Points, error counters, and accomplishment tracking, etc., are incorporated into the system to promote participation and monitor progress. The simulator can also support scenario learning where users go through different inspection scenarios and must choose the proper methods, interpret the results, and complete reports-just as in real inspection labs.
Genre	Fits into the educational or light simulation game genre	Falls under the category of serious games or technical

	and is also commonly referred to as "edutainment". The game is developed keeping entertainment at the forefront, with the inclusion of some educational content to make learning enjoyable. This genre of approach is often used in school outreach programs, pre-school STEM education modules, or internet sites to make education enjoyable. It does not involve industry standards, professional equipment, or skill assessment.	training simulators. These types of simulations are utilized in professional training and vocational training to simulate real working processes and environments. The NDT Inspection Simulator has been developed with an education focus, professional development, and skill acquisition, not entertainment. It supports competency-based training and prepares the users for hands-on NDT labs or real aircraft inspection by creating familiarity with equipment, nomenclature, and procedures. This genre is crucial in filling the theory-practice gap in technical education

TABLE 8 GAME D VS OUR PRODUCT

CHAPTER 3
RESEARCH METHODOLOGY

3.1 DESIGN ENGINEERING TOOLS

3.1.1 DESIGN REQUIREMENT ANALYSIS

The NDT Simulator is designed to provide an interactive and immersive learning experience for students and professionals employed in the aviation and aircraft maintenance industry. The primary objective is to simulate Non-Destructive Testing (NDT) techniques, such as Eddy Current testing, so that users can practice and develop their skills in a safe, virtual setting. Target audience for this simulator are aviation students, NDT technicians, and schools of aircraft maintenance and safety procedures. The simulator will be developed on the Unity platform to ensure it is compatible with both Windows and MacOS operating systems to ease use in educational and training environments.

Realistic environments within the NDT Simulator will simulate several aircraft components, which will include fuselage panels, wings, and engines. Users will utilize the system with a touch interface mimicking real use of actual NDT equipment. Users will have access through which they can utilize NDT effectively with instant visual and audio feedback to assist them when performing an inspection. Users will be helped with feedback in locating mistakes, correcting them, and improving with increasing experience. Furthermore, the system will have a progress tracking feature so users can monitor their improvement and ensure they are well-versed with the NDT techniques.

The simulator will emphasize creating an extremely realistic virtual environment by utilizing Unity's powerful tools for 3D simulation. This will support an interactive and productive learning process without putting users at risk or wasting tons of money on real-world testing. Ethical considerations, including data privacy and accessibility, will be integrated into the design so that the simulator is safe and accessible to all users. In general, the NDT Simulator is designed to be an essential tool for aviation education, enabling students to gain hands-on experience with NDT methods in a controlled and cost-effective virtual environment.

3.1.1.1 QUESTIONNAIRE SURVEY

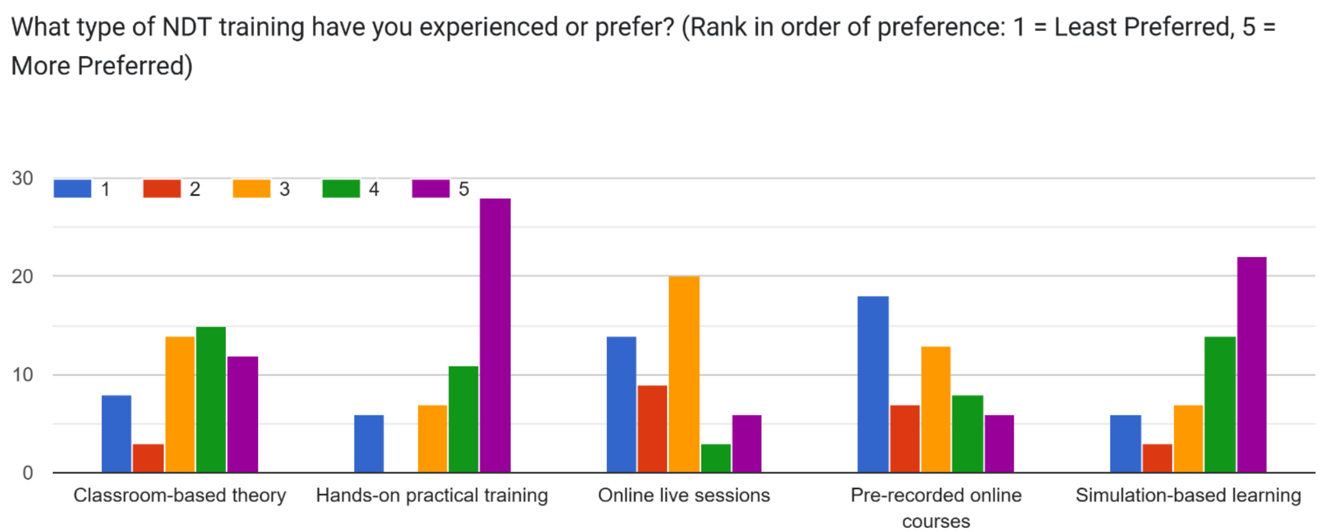


FIGURE 6: QUESTIONNAIRE SURVEY

The objective is to identify the most effective and engaging methods for NDT training by understanding the preferences and experiences of learners. The results show a clear preference for hands-on practical training and simulation-based learning, highlighting the importance of active, realistic experiences in building essential skills. This reinforces the decision to integrate simulation-based elements into our game, ensuring that the training reflects real-world scenarios in a way that is both educational and engaging. By moving away from less interactive formats like pre-recorded or live online sessions, our aim is to provide a more meaningful and impactful learning experience for future NDT professionals.

3.1.1.2 PARETO DIAGRAM

The Pareto Chart of NDT Training shows the most frequent issues faced by trainees while undertaking NDT training. The chart shows the frequency of each issue, the most frequent of which is "Limited access to equipment or facilities," followed by "Difficulty understanding theoretical concepts," and so forth. The cumulative percentage curve indicates that these four most frequent issues account for the lion's share of issues, meeting the Pareto cutoff of 80%.

CHALLENGES	FREQUENCY	CUMULATIVE	CUMULATIVE PERCENTAGE (%)	PARETO BASELINE
Limited access to equipment or facilities	34	34	32	80
Difficulty understanding theoretical concepts	27	61	58	80
Lack of experienced trainers	24	85	81	80
High training costs	23	108	100	80

FIGURE 7: PARETO LIST

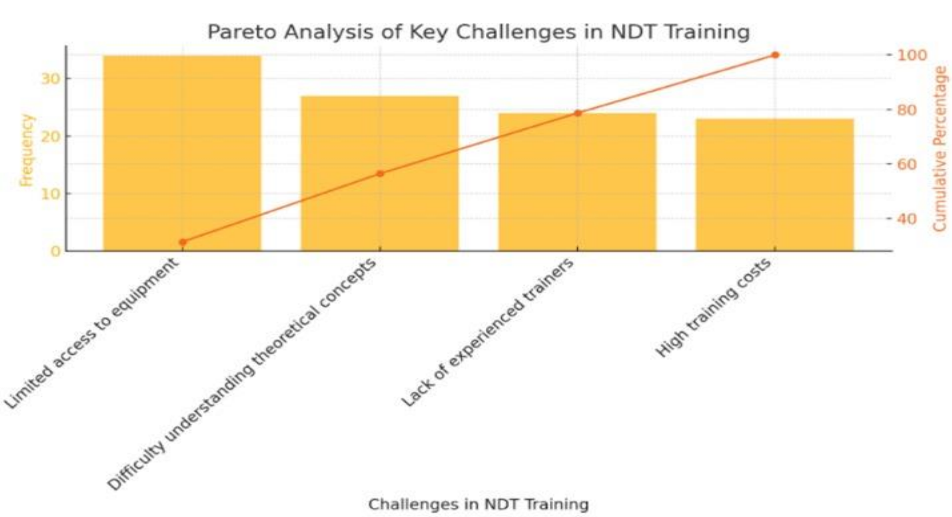


FIGURE 8 PARETO DIAGRAM

3.1.2 DESIGN CONCEPT GENERATION

3.1.2.1 MORPHOLOGICAL MATRIX

Morphological Matrix is used to explore different design options by combining and alternating different components and features to come up with various potential solutions. it helps in the recognition and examination of different combinations of the main elements needed for the NDT Simulator. By considering possibilities for items to analyze, simulation environments, user interaction, learning modes, and feedback mechanisms, the matrix enables the selection of the most suitable design choices to meet the educational goals of the simulator. It organizes and visualizes the possible discrepancies in the design of the simulator, making it easier to select the most apt combination for the optimum possible user experience and learning outcome.

3.1.2.2 PROPOSED CONCEPT 1

DIMENSION	GAME 4	JUSTIFICATION
Components to Inspect	Landing Gear	Landing gear undergoes repeated impact loads, increasing the risk of structural damage.
Simulation Environment	Open Environment	An open environment allows students to explore and experiment freely with different NDT techniques.
User Interaction	Guided Sequences	Guided sequences assist users in following correct procedures while exploring.
Learning Modes	Realistic Scenarios	Realistic scenarios encourage problem-solving and application of learned techniques.
Feedback Mechanisms	Hints	Hints provide assistance when users encounter difficulties, ensuring learning continuity.
Game Inspiration/References	Game D: Free Exploration  https://youtube.com/shorts/PmVcu0I-X5I?si=WMK6ribzkqsGChjs	Game D: Free Exploration – Supports self-directed learning by allowing users to explore NDT techniques at their own pace.

TABLE 9 PROPOSE CONCEPT 1

3.1.2.3 PROPOSED CONCEPT 2

DIMENSION	OPTION 2	JUSTIFICATION
Components to Inspect	Fuselage Panels	Fuselage panels are prone to corrosion and cracks due to environmental exposure.
Simulation Environment	Spraying, brushing, dipping	Spraying, brushing, and dipping simulate real PT application methods, enhancing practical understanding.
User Interaction	Touch Interface	Touch interface improves engagement and mimics real-life application techniques.
Learning Modes	Practise	Practice mode allows students to apply knowledge in simulated scenarios.
Feedback Mechanisms	Visual Cues	Visual cues highlight key steps, reinforcing learning through guidance.

TABLE 10 PROPOSE CONCEPT 2

3.1.2.4 PROPOSED CONCEPT 3

DIMENSION	OPTION 1	JUSTIFICATION
Components to Inspect	Wing Sections	Focuses on common aircraft structures requiring NDT inspection
Simulation Environment	Realistic Workshop	Provides an immersive learning experience in an aviation maintenance setting.
User Interaction	Mouse/Keyboard	Offers flexibility in control methods to suit different training setup
Learning Modes	Interactive/Engaging/Skill-based	Supports step-by-step guided learning, exploration, and skill assessment.
Feedback Mechanisms	Scoring	Helps users understand their performance and improve inspection skills
Game Inspiration/References	Game A : Inspection Simulator  https://www.youtube.com/watch?v=Y3NIJT-IPtc	Adapts features from existing inspection-based simulation games for NDT training

TABLE 11 PROPOSED CONCEPT 3

3.1.2.5 PROPOSED CONCEPT 4

DIMENSION	OPTION 3	JUSTIFICATION
Components to Inspect	Engine Casings	Engine casings are critical aerospace components requiring rigorous NDT inspections. This selection aligns with real-world industry applications, making the training relevant.
Simulation Environment	Interactive Stations	Interactive stations allow users to move between different PT process stages, increasing engagement and mimicking real-life inspection workflows.
User Interaction	Drag-and-Drop Steps	A drag-and-drop system ensures active learning by requiring users to place PT steps in

		the correct sequence, reinforcing understanding through hands-on interaction.
Learning Modes	Assessment	An assessment mode ensures that users not only practice PT procedures but are also evaluated on their accuracy, preparing them for real-world certification requirements.
Feedback Mechanisms	Process Checklist	A process checklist provides structured feedback, helping users track their progress, identify mistakes, and improve their procedural adherence.
Game Inspiration/References	Game C: Interactive Steps  https://www.youtube.com/shorts/I8Bg4xW3uz4	The reference game demonstrates an effective way to present step-by-step procedures

		interactively, serving as a benchmark for designing an engaging PT simulation.

TABLE 12 PROPOSED CONCEPT 4

3.1.3 EVALUATION & SELECTION OF CONCEPTUAL DESIGN

3.1.3.1 PUGH MATRIX

(CONCEPT 2 AS DATUM)

Criteria	Weightage	Concept 1	Concept 2	Concept 3	Concept 4	Concept 5
Realism & Accuracy of Simulation	3	2	D	1	2	1
Engagement & Interactivity	2	3	A	1	2	1
Ease of use	2	2	T	1	2	1
Accessibility (Multi-Platform)	2	1	U	1	1	3
Educational Effectiveness	3	2	M	1	2	1
Development Feasibility	2	1	-	2	1	1
Total Score	-	26	-	16	24	18
Ranking	-	1	-	4	2	3

Legend= 3(better), 2(same), 1(worse)

TABLE 13: PUGH MATRIX 1

(NDT INSPECTION SIMULATION CONCEPT 5 AS DATUM)

Criteria	Weightage	Concept 1	Concept 2	Concept 3	Concept 4	Concept 5
Realism & Accuracy of Simulation	3	6	6	3	3	D
Engagement & Interactivity	2	6	4	2	2	A
Ease of use	2	6	4	2	2	T
Accessibility (Multi-Platform)	2	2	4	2	6	U
Educational Effectiveness	3	9	6	3	3	M
Development Feasibility	2	4	6	4	2	-
Total Score	14	33	30	16	18	-
Ranking		1	2	4	3	-

Legend= 3(better), 2(same), 1(worse)

TABLE 14: PUGH MATRIX 2

3.2 PRODUCT SKETCHES FOR INTERFACE LAYOUT

3.2.1 GENERAL INTERFACE LAYOUT

To aim different player background, the interface will be made simple as possible. These strategies can lead to better user experience, encourage users to stay engaged and navigate with ease. (Figure below is not finalize yet)

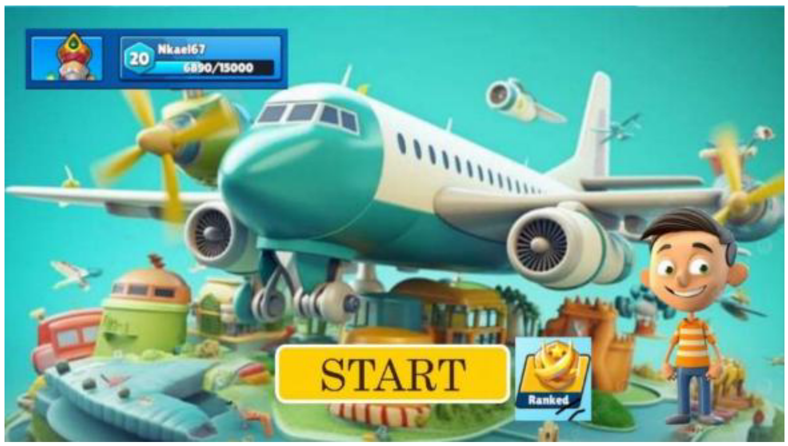


FIGURE 11: EXAMPLE OF INTERFACE LAYOUT

3.2.2 SPECIFIC INTERFACE LAYOUT (SOFTWARE-BASED)

3.2.2.1 PRODUCT STRUCTURE

FIGURE 9: ULTRASONIC FLAW DETECTOR

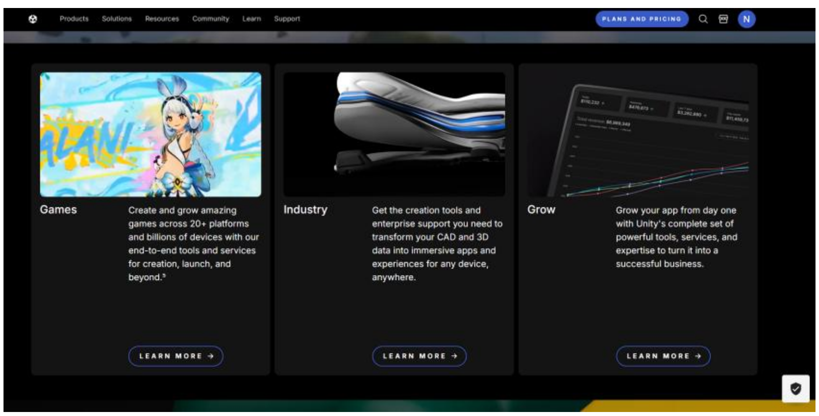


FIGURE 10: UNITY 3D GAME ENGINE

Unity Hub is a free project management and launcher tool provided by Unity Technologies, designed to streamline the process of managing different Unity versions, projects, and editor settings. It allows developers to organize and open projects efficiently while also handling installations and updates of the Unity Editor itself. Unity Hub is especially useful in team environments and educational settings, where managing multiple projects is common.
A 3D Template in Unity Hub is one of the defaults starting templates offered when creating a new project. It provides a basic environment preconfigured for 3D game or simulation development. This template includes essential components such as a directional light, main camera, and basic scene setup, allowing users to quickly dive into building 3D content. It's

commonly used for projects that involve simulations, virtual environments, training tools, or 3D games offering a clean and flexible foundation to work from.

3.2.2.2 PRODUCT MECHANISM

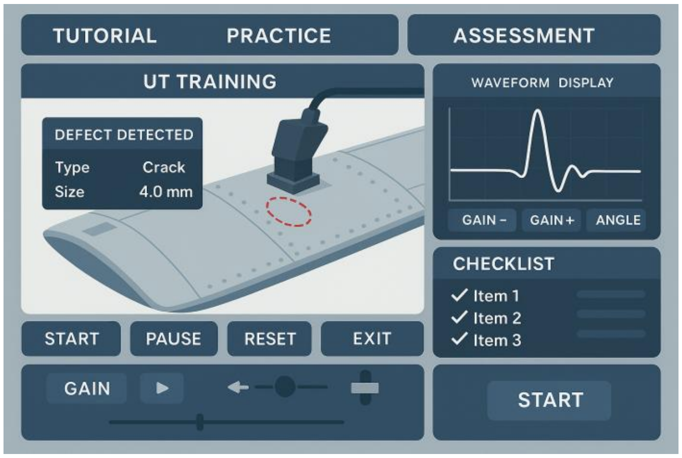


FIGURE 11: EXAMPLE OF INTERFACE LAYOUT 2

3.3 PROJECT FLOW CHART

3.3.1 OVERALL PROJECT FLOW CHART

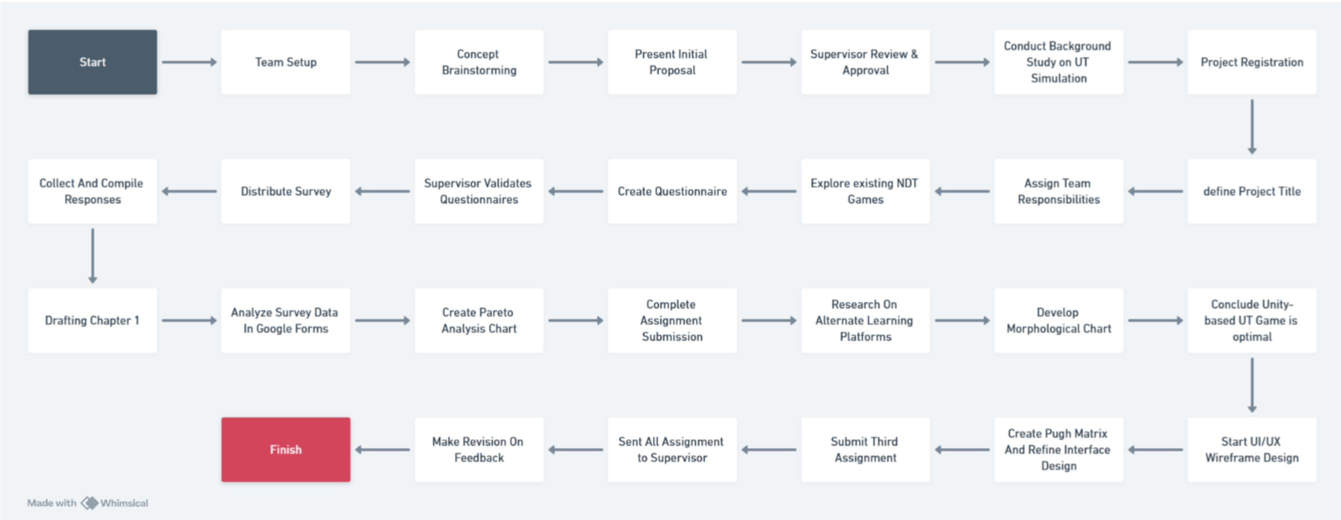


FIGURE 12: OVERALL PROJECT FLOW CHART

3.3.2 SPECIFIC PROJECT DESIGN FLOW

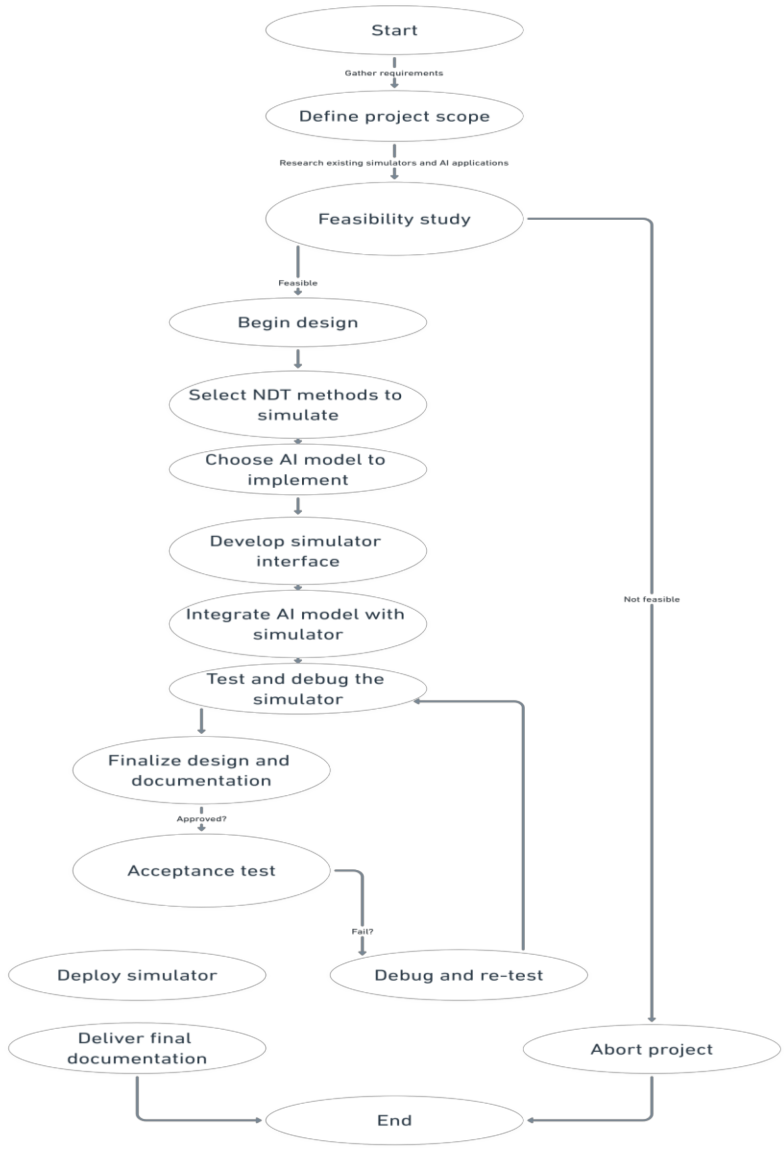


FIGURE 13: DESIGN FLOW

3.3.2.1 PRODUCT MECHANISM

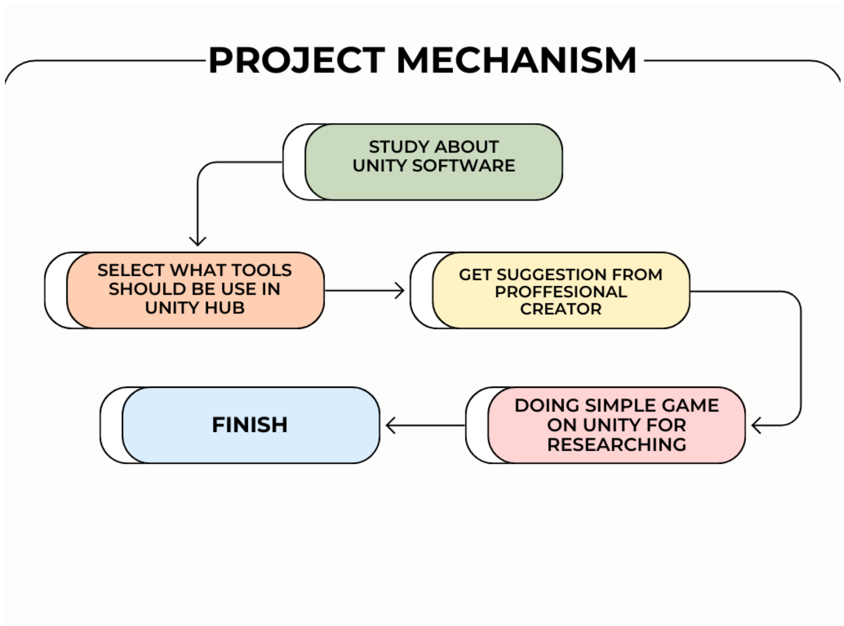


FIGURE 14: PROJECT MECHANISM

3.3.2.2 SOFTWARE/PROGRAMMING

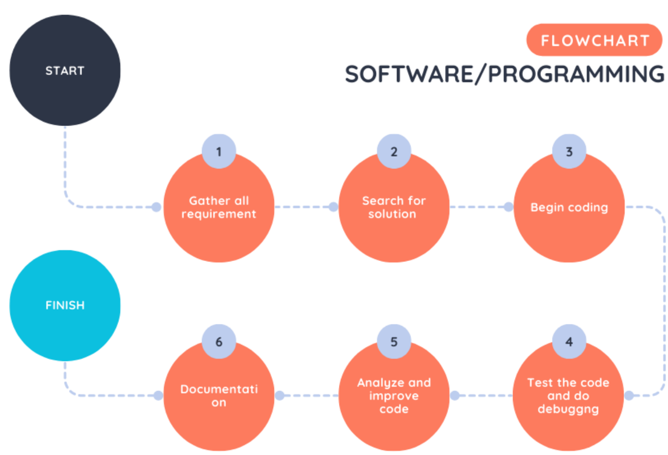


FIGURE 15: SOFTWARE/PROGRAMMING FLOWCHART

3.4 PRODUCT DESCRIPTION

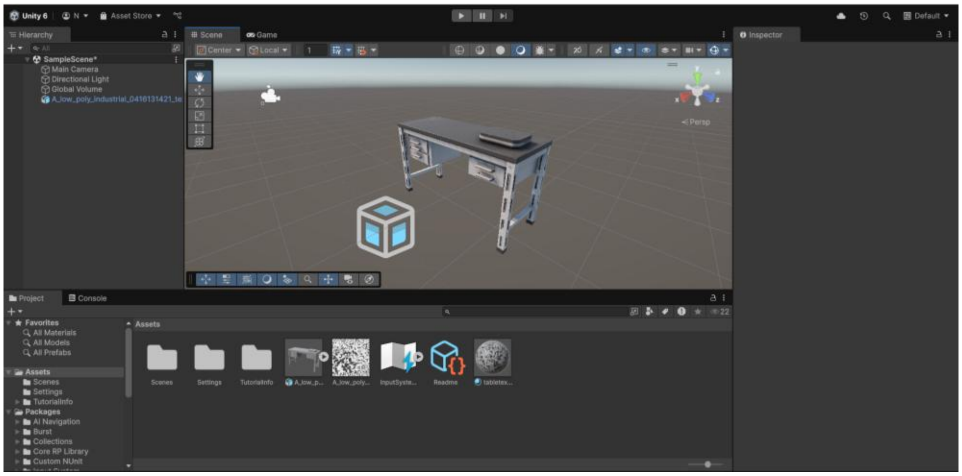


FIGURE 16: EXAMPLE OF IN GAME ENVIRONMENT

We aim to incorporate a range of interactive features and controls within our Ultrasonic Testing Simulator to spark users’ interest in the field of aircraft maintenance while providing an engaging learning experience. The simulator is developed based on our understanding of ultrasonic testing principles, along with relevant educational materials that cover inspection procedures, safety protocols, and best practices. To elevate the training experience, we integrate realistic 3D modeling, immersive simulation environments, and dynamic animations to mirror real-world testing conditions.

3.5 OVERALL GANTT CHART

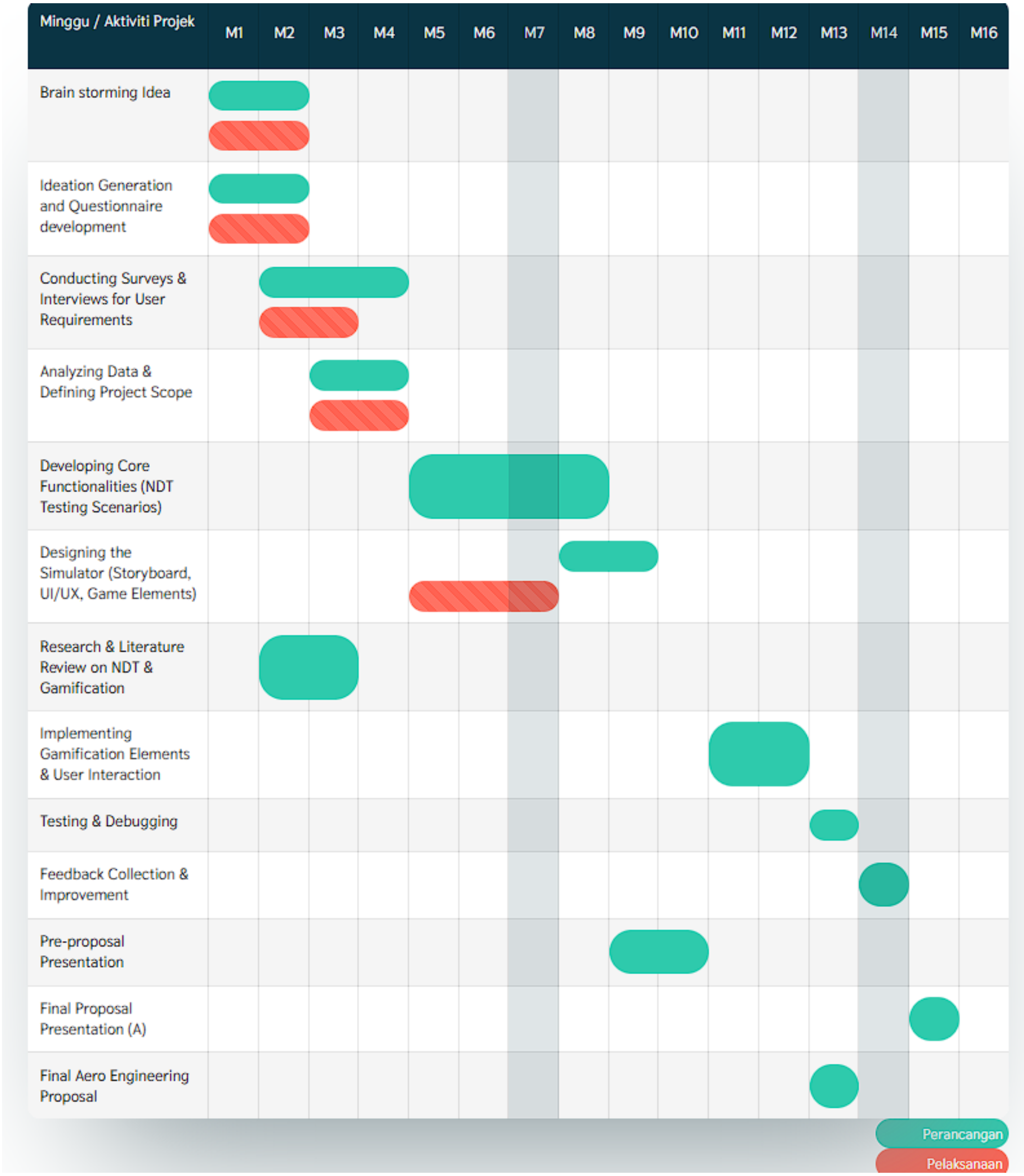


FIGURE 17:TABLE GANTT CHART

3.6 PROTOTYPE/ PRODUCT MODELLING

3.6.1 PROTOTYPE/ PRODUCT MODELLING

The interface was designed to be simple, intuitive, and visually engaging, ensuring that users can easily understand and operate the simulator without prior experience. The layout includes elements such as the main menu, start button, instruction panels, and visual indicators to guide users throughout the inspection process.

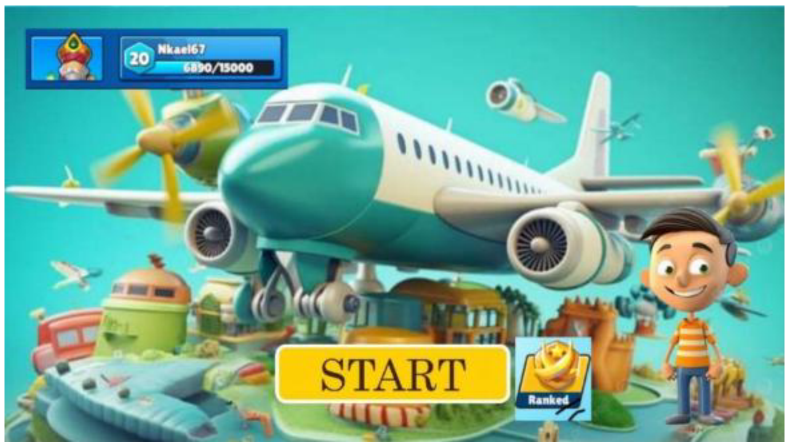


FIGURE 19 : USER INTERFACE CONCEPT MODELLING

3.6.2 PROTOTYPE DEVELOPMENT

The development process initially included a detailed concept design that integrated all the necessary components for its effective operation. Each part was strategically placed to provide accessibility, safety, and ease of use. The design includes storage compartments, control panels, and visual indicators arranged to guide the user. In its development process, attention has been paid to ergonomics; thus, all tools and equipment are well placed within reach. Compactness and functionality have also been stressed in the prototype design to suit both training and operational environments. Performance, durability, and overall usability were enhanced through continuous evaluation and refinement.

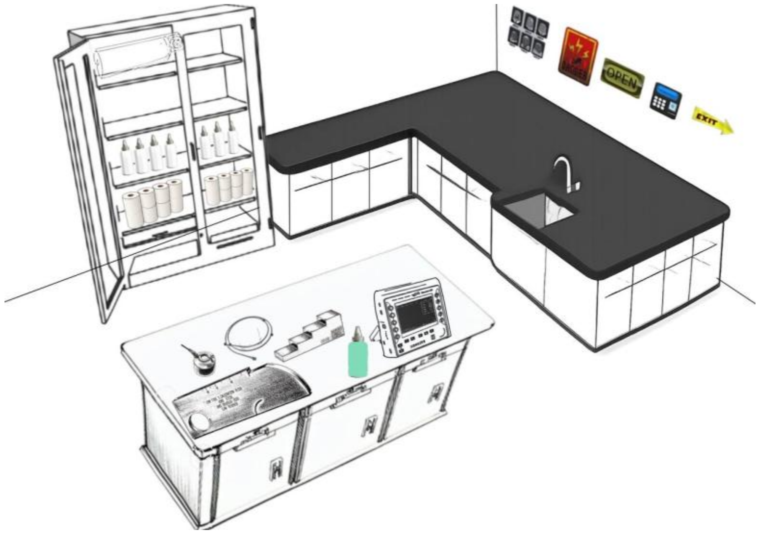


FIGURE 20: ILLUSTRATED CONCEPT SHOWING THE INTEGRATION OF DESIGN ELEMENTS DURING PRODUCT DEVELOPMENT.

3.7 DEVELOPMENT OF PRODUCT

3.7.1 SOFTWARE ACQUISITION

To develop the application, we use Unity platform for its seamless development environment and cross-platform compatibility. Unity platform also provides a flexible workspace that allows us to integrate 3D models, animations, and scripting into a single environment.

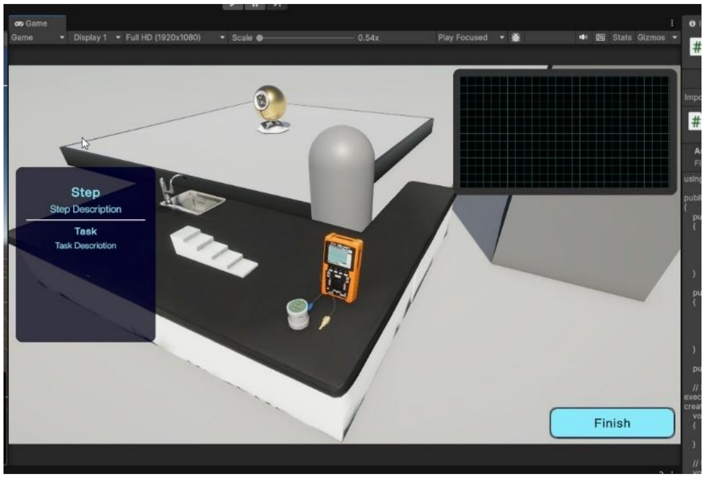


FIGURE 21 : UNITY SOFTWARE

For designing the user interface (UI), the initial layout and visual elements were sketched and planned using Freeform on the iPad. This allowed for more flexible and hand drawing approach to conceptualizing the design before transferring it into Unity.

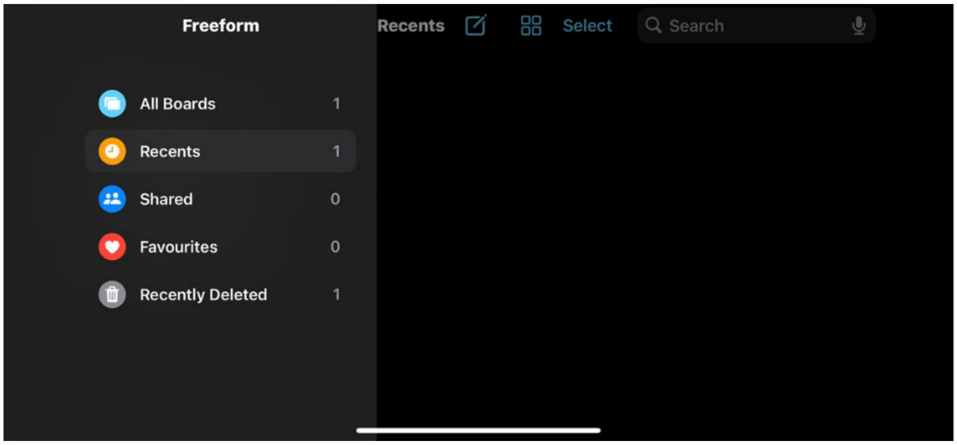
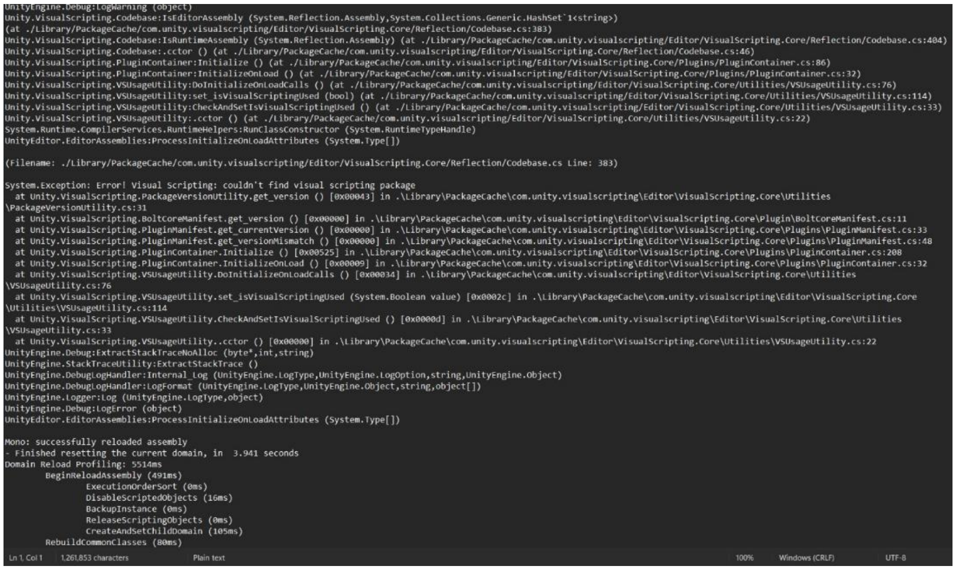


FIGURE 22 : FREEFORM INTERFACE

The application's core functionalities are programmed using C# language within Unity. This includes scripting for gameplay mechanics, scoring systems, and simulation interactions that replicate real-world Non-Destructive Testing (NDT) procedures.



```
UnityEngine.Debug:LogWarning (object)
Unity.VisualScripting.Codebase:IsEditorAssembly (System.Reflection.Assembly,System.Collections.Generic.HashSet`1<string>)
(at ./Library/PackageCache/com.unity.visualscripting/Editor/VisualScripting.Core/Reflection/Codebase.cs:383)
Unity.VisualScripting.Codebase:IsRuntimeAssembly (System.Reflection.Assembly) (at ./Library/PackageCache/com.unity.visualscripting/Editor/VisualScripting.Core/Reflection/Codebase.cs:404)
Unity.VisualScripting.Codebase:.cctor () (at ./Library/PackageCache/com.unity.visualscripting/Editor/VisualScripting.Core/Reflection/Codebase.cs:46)
Unity.VisualScripting.PluginContainer:Initialize () (at ./Library/PackageCache/com.unity.visualscripting/Editor/VisualScripting.Core/Plugins/PluginContainer.cs:86)
Unity.VisualScripting.PluginContainer:InitializeOnLoad () (at ./Library/PackageCache/com.unity.visualscripting/Editor/VisualScripting.Core/Plugins/PluginContainer.cs:32)
Unity.VisualScripting.VSUsageUtility:DoInitializeOnLoadCalls () (at ./Library/PackageCache/com.unity.visualscripting/Editor/VisualScripting.Core/Utilities/VSUsageUtility.cs:76)
Unity.VisualScripting.VSUsageUtility:set_isVisualScriptingUsed (bool) (at ./Library/PackageCache/com.unity.visualscripting/Editor/VisualScripting.Core/Utilities/VSUsageUtility.cs:114)
Unity.VisualScripting.VSUsageUtility:CheckAndSetIsVisualScriptingUsed () (at ./Library/PackageCache/com.unity.visualscripting/Editor/VisualScripting.Core/Utilities/VSUsageUtility.cs:33)
Unity.VisualScripting.VSUsageUtility:.cctor () (at ./Library/PackageCache/com.unity.visualscripting/Editor/VisualScripting.Core/Utilities/VSUsageUtility.cs:22)
System.Runtime.CompilerServices.RuntimeHelpers:RunClassConstructor (System.RuntimeTypeHandle)
UnityEditor.EditorAssemblies:ProcessInitializeOnLoadAttributes (System.Type[])

(Filename: ./Library/PackageCache/com.unity.visualscripting/Editor/VisualScripting.Core/Reflection/Codebase.cs Line: 383)

System.Exception: Error! Visual Scripting: couldn't find visual scripting package
  at Unity.VisualScripting.PackageVersionUtility.get_version () [0x00043] in .\Library\PackageCache\com.unity.visualscripting\Editor\VisualScripting.Core\Utilities
\PackageVersionUtility.cs:31
  at Unity.VisualScripting.BoltCoreManifest.get_version () [0x00000] in .\Library\PackageCache\com.unity.visualscripting\Editor\VisualScripting.Core\Plugin\BoltCoreManifest.cs:11
  at Unity.VisualScripting.PluginManifest.get_currentVersion () [0x00000] in .\Library\PackageCache\com.unity.visualscripting\Editor\VisualScripting.Core\Plugins\PluginManifest.cs:33
  at Unity.VisualScripting.PluginManifest.get_versionMismatch () [0x00000] in .\Library\PackageCache\com.unity.visualscripting\Editor\VisualScripting.Core\Plugins\PluginManifest.cs:48
  at Unity.VisualScripting.PluginContainer.Initialize () [0x00525] in .\Library\PackageCache\com.unity.visualscripting\Editor\VisualScripting.Core\Plugins\PluginContainer.cs:208
  at Unity.VisualScripting.PluginContainer.InitializeOnLoad () [0x00009] in .\Library\PackageCache\com.unity.visualscripting\Editor\VisualScripting.Core\Plugins\PluginContainer.cs:32
  at Unity.VisualScripting.VSUsageUtility.DoInitializeOnLoadCalls () [0x00034] in .\Library\PackageCache\com.unity.visualscripting\Editor\VisualScripting.Core\Utilities
\VSUsageUtility.cs:76
  at Unity.VisualScripting.VSUsageUtility.set_isVisualScriptingUsed (System.Boolean value) [0x0002c] in .\Library\PackageCache\com.unity.visualscripting\Editor\VisualScripting.Core
\Utilities\VSUsageUtility.cs:114
  at Unity.VisualScripting.VSUsageUtility.CheckAndSetIsVisualScriptingUsed () [0x0000d] in .\Library\PackageCache\com.unity.visualscripting\Editor\VisualScripting.Core\Utilities
\VSUsageUtility.cs:33
  at Unity.VisualScripting.VSUsageUtility..cctor () [0x00000] in .\Library\PackageCache\com.unity.visualscripting\Editor\VisualScripting.Core\Utilities\VSUsageUtility.cs:22
UnityEngine.Debug:ExtractStackTraceNoAlloc (byte*,int,string)
UnityEngine.StackTraceUtility:ExtractStackTrace ()
UnityEngine.DebugLogHandler:Internal_Log (UnityEngine.LogType,UnityEngine.LogOption,string,UnityEngine.Object)
UnityEngine.DebugLogHandler:LogFormat (UnityEngine.LogType,UnityEngine.Object,string,object[])
UnityEngine.Logger:Log (UnityEngine.LogType,object)
UnityEngine.Debug:LogError (object)
UnityEditor.EditorAssemblies:ProcessInitializeOnLoadAttributes (System.Type[])

Mono: successfully reloaded assembly
- Finished resetting the current domain, in  3.941 seconds
Domain Reload Profiling: 5514ms
        BeginReloadAssembly (491ms)
                ExecutionOrderSort (0ms)
                DisableScriptedObjects (16ms)
                BackupInstance (0ms)
                ReleaseScriptingObjects (0ms)
                CreateAndSetChildDomain (105ms)
        RebuildCommonClasses (80ms)
Ln 1, Col 1    1,261,853 characters    Plain text    100%    Windows (CRLF)    UTF-8
```

FIGURE 23 : C# SCRIPT

For 3D modeling and visualization, Sketchfab and Meshy.ai are used to obtain and generate realistic 3D assets representing aircraft structures and inspection equipment. Meshy.ai assists in creating and refining 3D models with accurate geometry and textures through AI-based generation tools, while Sketchfab is utilized to source, preview, and download existing models suitable for simulation use. These models are then imported into Unity, where they are optimized and integrated into the NDT Inspection Simulator environment.

3.8 PRODUCT TESTING / FUNCTIONALITY TESTS

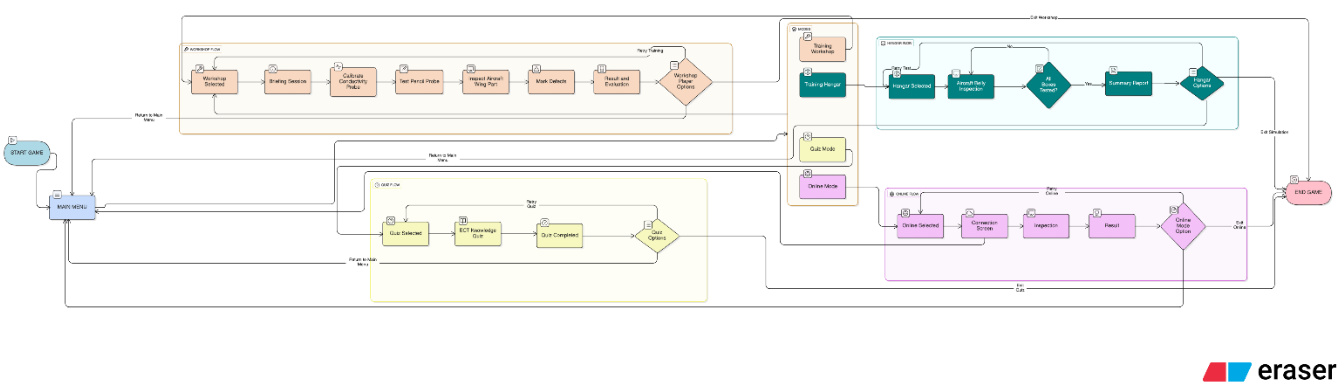


FIGURE 24 : OVERALL GAME FLOW

3.9 LIST OF MATERIAL & EXPENDITURES

No.	Expense Description	Cost (RM)
1	Unity Asset Store & Plugins	200
2	Subscription fees for Unity base	400
3	Online C# learning class	80
4	MyIPO	200
5	Internet data for research, downloads, and sessions	40
6	Report printing	15
7	Project poster printing	40
8	Google Drive backup	20
	Total	**995**

FIGURE 25 : LIST OF EXPENDITURES

3.10 PROJECT BRIEFING & RISK ASSESMENT

3.10.1 UTILISATION OF POLYTECHNIC'S FACILITIES

FIGURE 26: POLYTECHNIC'S ET EQUIPMENT

FIGURE 27: POLYTECHNIC'S TELEVISION

FIGURE 28: POLYTECHNIC BOEING 737'S UNDERBELLY

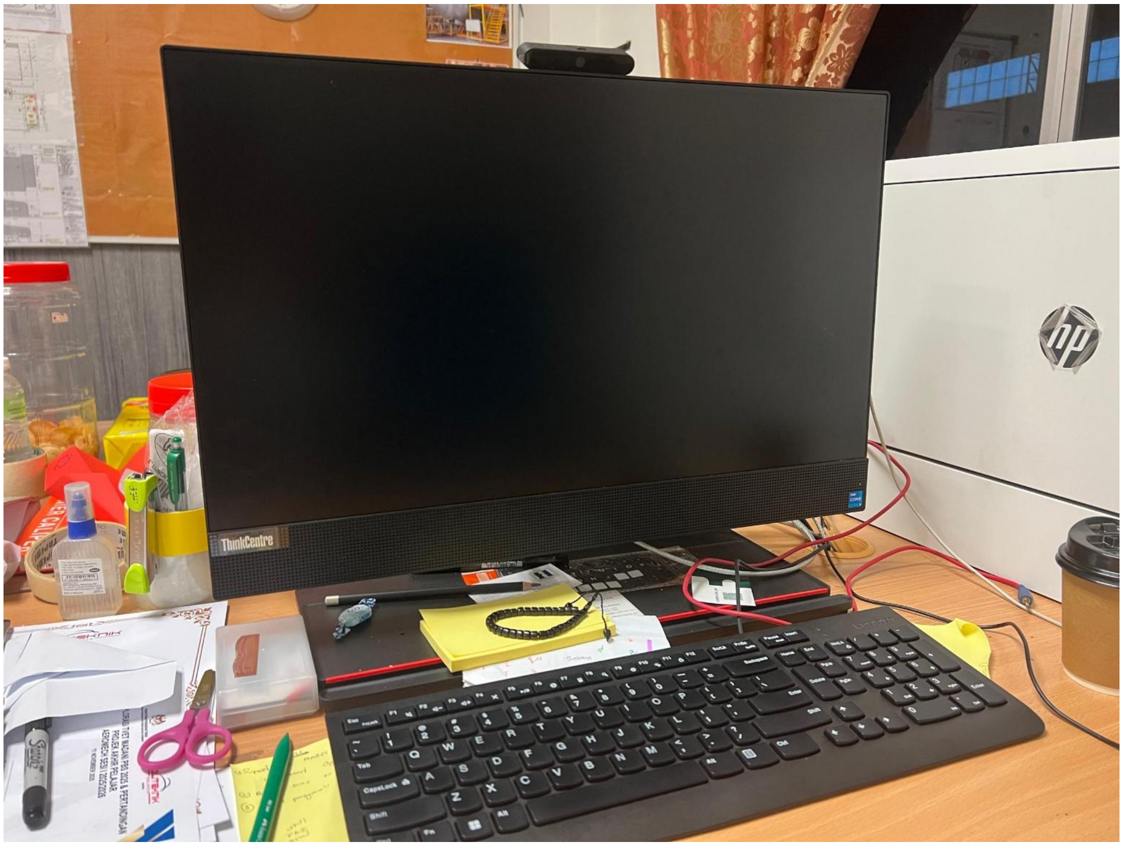


FIGURE 29: MADAM SHAZANA PC

FIGURE 27: AEROLABS POSTER HOLDER

CHAPTER 4

RESULTS & DISCUSSION

4.1 PRODUCT DESCRIPTION

4.1.1 GENERAL PRODUCT FEATURES & FUNCTIONALITIES

The Non-Destructive Testing (NDT) Inspection Simulator is an innovative and interactive training system designed to provide a realistic and gamified learning experience for students and trainees in the field of aircraft maintenance and mechanical engineering. This simulator focuses on enhancing understanding and practical skills in Eddy Current Testing (ET) through an engaging virtual environment that replicates real-world inspection procedures. It features a gamified learning interface with interactive elements such as hints, scores, and achievements to make the learning process more dynamic and effective. The simulator is developed within a realistic 3D laboratory environment, accurately replicating the setup and equipment used in actual eddy current inspections, including virtual probes, test specimens, and display instruments. (Keskinen, I. (2025). Robotization Of Eddy Current Surface Inspection In The Aerospace Industry.)

The system includes a user-friendly interface that allows smooth navigation and easy interaction, making it suitable for both beginners and advanced users (Liarokapis, F., & Conradi, E. (2007). User interfaces for mobile navigation. *Library hi tech*, *25*(3), 352-365.) It provides step-by-step guidance throughout the inspection process, covering essential stages such as safety precautions, equipment setup, calibration, signal interpretation, and recording of results. The simulator is equipped with virtual tools and equipment such as eddy current probes, test pieces, reference standards, and control panels that function similarly to real-life inspection instruments.

An instant feedback and evaluation system is included to assess user performance based on accuracy, efficiency, and adherence to safety standards, offering immediate corrective feedback to enhance learning outcomes. The scenario-based training mode allows users to practice identifying and analyzing various types of defects, which helps strengthen their problem-solving and decision-making skills. A reporting and documentation feature is also integrated to automatically generate inspection reports based on user findings, encouraging proper documentation practices that follow industry standards. Moreover, the simulator is designed for high accessibility and compatibility, allowing it to run smoothly on standard computer systems and integrate with Learning Management Systems (LMS) for classroom or laboratory use. Overall, the NDT Inspection Simulator provides a comprehensive digital training platform that combines theory, practice, and evaluation in a realistic virtual environment dedicated to Eddy Current Testing.(Machado, M. A. (2024). Eddy currents probe design for NDT applications: A review. *Sensors (Basel, Switzerland)*, *24*(17), 5819.)

4.1.2 SPECIFIC PART FEATURES

4.1.2.1 PRODUCT STRUCTURE

The simulator is designed to look like a real aircraft maintenance environment. It has two main areas which are the workshop or hangar lab and the hangar. These areas represent where the NDT inspection training usually happens. The aircraft model used in this simulator is a Boeing 737-400, and users can perform eddy current testing on different parts such as the wing section and engine nacelle.

The simulator also includes 3D models of important tools such as the eddy current machine, probe, calibration standard, and shim. All these objects are interactive and used during the calibration and inspection process.

In the main menu, there are four buttons which are Training (Workshop), Training (Hangar), Online, and Quiz. Each button will lead the user to a different scene. Before starting the simulation, a briefing interface will appear to explain the task and objective of the inspection.

This structure allows the user to experience realistic aircraft inspection training with proper tools, environment, and procedure in a virtual platform.

4.1.2.2 PRODUCT MECHANISM

When the user starts the simulator, the main menu will appear with four buttons which are Training (Workshop), Training (Hangar), Online, and Quiz. If the user selects Training (Workshop), a briefing interface will appear to explain the task and objective of the inspection. After the briefing, the user will start the activity with the probe calibration process.

During the inspection process, the user controls the probe by holding the left mouse click and dragging it across the inspection area to search for defects. For the pencil probe, the simulator will show signal changes when it detects any defect on the aircraft surface. In the discontinuity test, the user needs to focus on the percentage value displayed on the screen — if the value is not within the limit, it means that the area has a defect.

The user must find the defect manually and mark the flaw area once detected. After completing the inspection, the result screen will appear showing the overall performance. The result includes whether a flaw was detected (Yes/No), time taken, accuracy, and the final score. This result system is applied to both types of inspection in the simulator.

The two training modes also have different testing methods. In the Workshop mode, the user detects the flaw by observing the disruption or interpretation of the current flow shown in the signal. In the Hangar mode, the user performs the discontinuity test and detects the defect by checking the percentage of IACS (International Annealed Copper Standard). This difference helps users to understand both inspection types more clearly.

4.1.2.3 SOFTWARE / PROGRAMMING

This simulator was developed using Unity Game Engine, and the programming language used is C#. Unity was chosen because it supports 3D modeling, interaction, and simulation easily, making it suitable for creating an educational game or virtual training system.

The coding in this simulator controls the main functions such as the probe movement, calibration process, inspection signal response, scoring system, and menu interface. These codes make the simulation interactive and allow the user to perform inspection tasks like in real life.

All main features such as menu navigation, timer, result display, and defect marking system were programmed using C# scripts inside Unity. The system detects user input from the mouse and gives real-time feedback through visual signal changes during the inspection.

Some sound effects were also added in the simulator to make it more realistic. These include probe movement sounds and alert tones when a defect is detected. All sound effects used are free and copyright-free sources.

Overall, the programming allows the simulator to function smoothly and create a real training experience for users to learn eddy current testing in an interactive way.

4.1.2.4 ACCESSORIES & FINISHING

For the accessories and finishing part, several elements were designed to complete the simulator and make it look more realistic. The main interface includes buttons and guidance panels that help the user understand what to do during the simulation. Since we do not have permission from any real NDT equipment company, all the important tools such as the probe, eddy current machine, and shim were designed by our team instead of using real models.

Most of the 3D models and textures used in this simulator were taken from Sketchfab, while the models that we designed ourselves use plain textures to keep the development simple. The background environment is designed to look like a workshop or hangar, where real NDT inspections usually take place.

The lighting in the hangar area is slightly dark, which gives a more realistic atmosphere of an actual aircraft maintenance space, but the overall realism is still not 100% achieved due to limited design resources.

No extra visual effects such as score display or progress bar were added for the accessories part. The main focus was to make the simulator environment look organized and realistic enough for users to experience basic NDT inspection training.

4.1.3 GENERAL OPERATION OF THE PRODUCT

The NDT Inspection Simulator Based on Gamification is an online, interactive digital training system for students and enthusiasts that focuses on teaching Non-Destructive Testing (NDT). The overall operation of this simulator is designed to guide the user step-by-step through the process of Eddy Current Testing (ET) in a virtual environment. The system starts with the main menu, where the user can select one of four available modes as shown below:

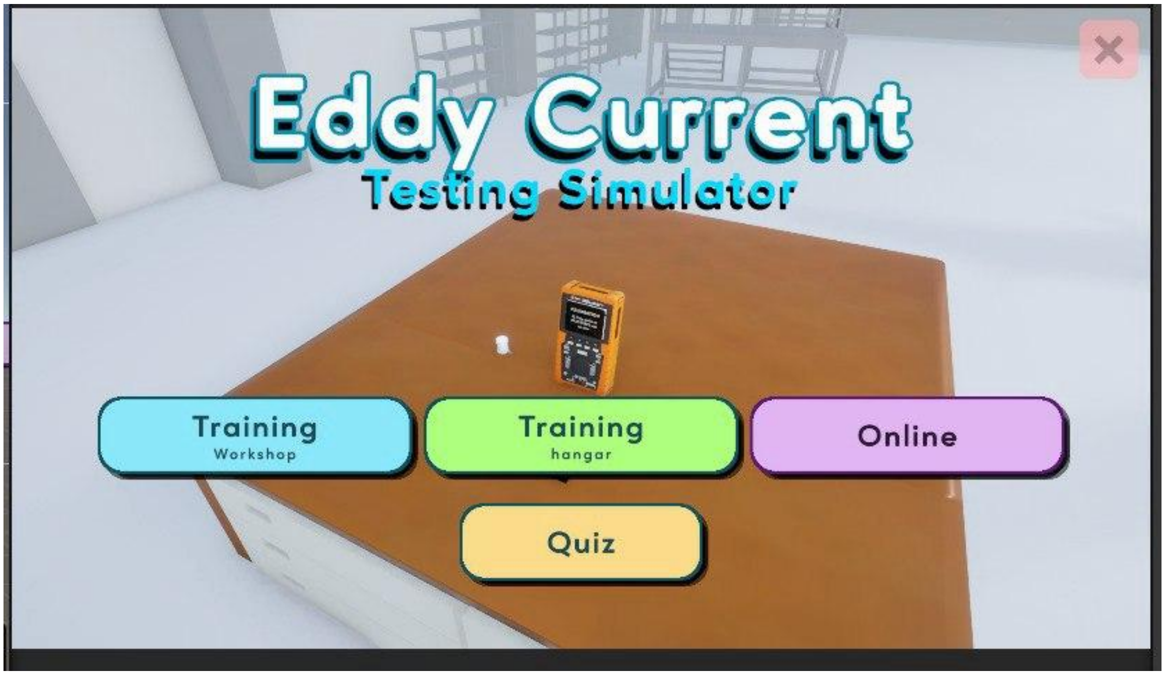


FIGURE 28: MAIN MENU OF THE NDT INSPECTION SIMULATOR, SHOWING THE DIFFERENT TRAINING MODES AVAILABLE TO THE USER, INCLUDING WORKSHOP TRAINING, HANGAR TRAINING, ONLINE MODE, AND QUIZ MODE.

- Training (Workshop) – Focused on calibration and inspection using the pencil probe.
- Training (Hangar) – Focused on discontinuity testing on aircraft body structures.
- Online – Multiplayer mode where users can perform inspection tasks together.
- Quiz – A short theory-based test consisting of 10 questions related to eddy current testing.

WORKSHOP TRAINING MODE

FIGURE 29: WORKSHOP TRAINING INTERFACE

The Workshop Training Mod*e* focuses on basic NDT techniques, including:

- Eddy Current Testing (ET)

In this mode, the users perform tasks such as:

1. Briefing interface that explains the inspection objectives.
2. Calibration of the conductivity probe using a calibration standard.
3. Continues with the inspection of the aircraft wing section using the pencil probe.
4. Mark the flaw area before ending the test.

Interactive guides and visual cues, along with step-by-step instructions, ensure learners understand how and why each task is performed. This mode is ideal for beginners so that they can establish a solid foundation in the principles of NDT before moving on to more complex inspections.

HANGAR TRAINING MODE

FIGURE 30: HANGAR TRAINING INTERFACE

Key features include:

- The user spawns beside the Boeing 737-400 aircraft model to perform a discontinuity test.
- Measurement Tasks: The user places probes on each compartment to measure conductivity and coating thickness.
- IACS Readings: The simulator displays readings in IACS (International Annealed Copper Standard). Readings within 44%–48% IACS are acceptable; outside this range may indicate cracks or surface defects.
- Hands-on Experience: The users analyze the results and then decide on the structural integrity of the components.

This mode emphasizes critical thinking, problem-solving, and real-world application. It helps learners understand how NDT readings translate into maintenance decisions in aviation.

ONLINE LEARNING AND QUIZ MODE

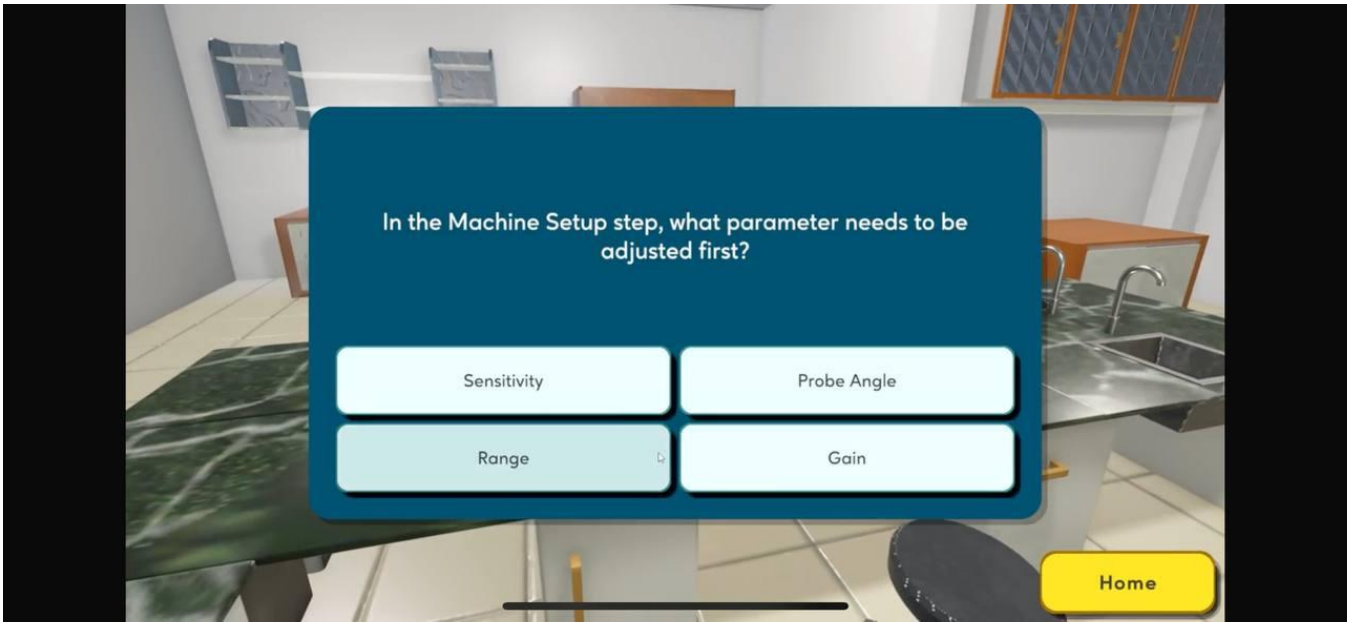


FIGURE 31 : ONLINE MODE INTERFACE

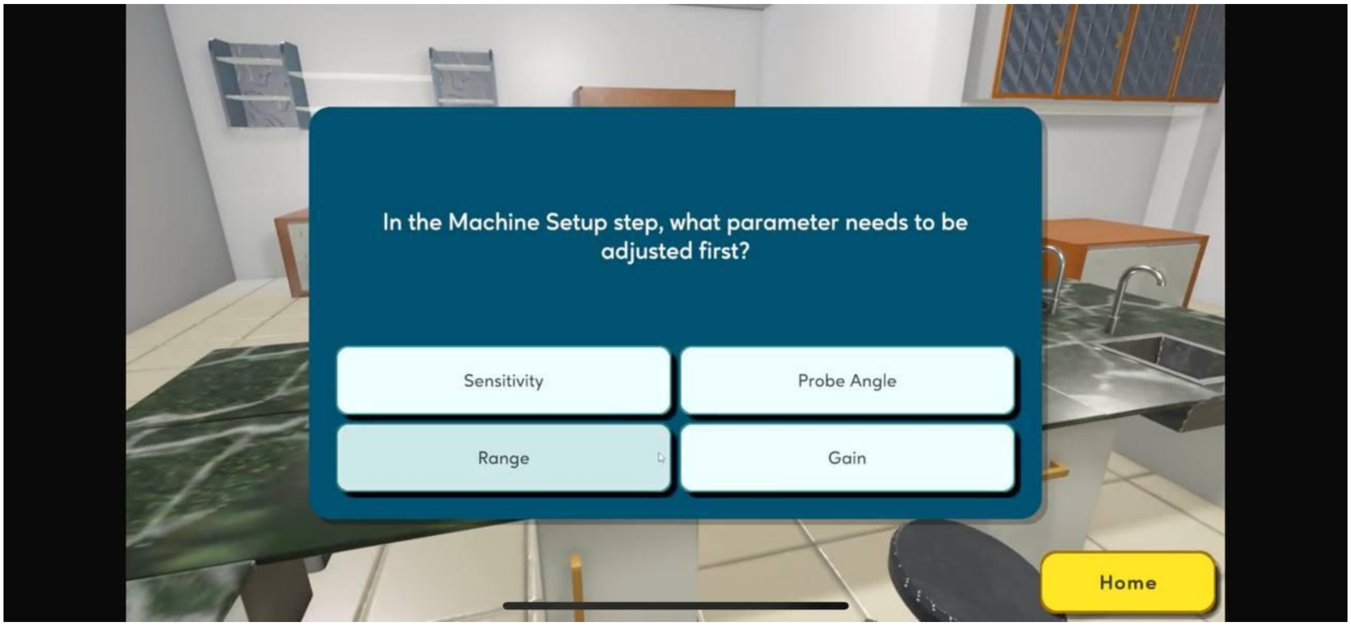


FIGURE 32 : QUIZ AND ASSESSMENT INTERFACE

The Online learning mode allows users to:

1. Perform virtual inspection exercises.
2. users will perform scanning, mark defects, and submitting results.
3. Receive performance feedback on combined accuracy, total findings, and time taken for both players.

It promotes self-directed learning whereby a user can practice multiple times, identify weaknesses, and reinforce their skills outside the workshop or hangar environment.

In the Quiz mode, the user is required to answer 10 multiple-choice questions related to eddy current theory. This section is designed to test theoretical understanding after completing the inspection training.

After completing any mode, a result summary screen will appear, displaying:

- Flaw detected: Yes/No
- Accuracy percentage
- Time taken
- Final score

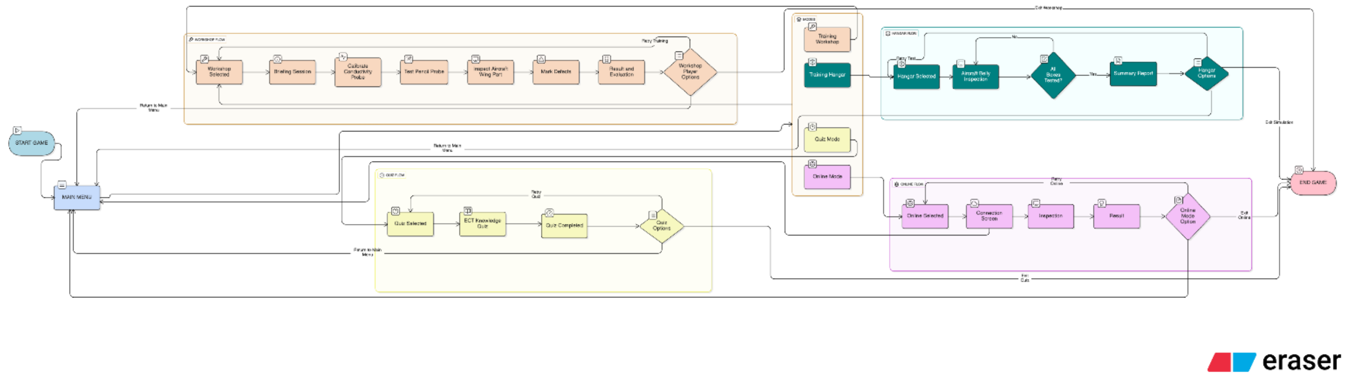


FIGURE 33 : GENERAL OPERATION FLOW OF THE NDT INSPECTION SIMULATOR.

The simulator's operation system provides a realistic experience for trainees to understand both the theoretical and practical aspects of eddy current testing. It improves accessibility to NDT training while maintaining safety, making it suitable for academic learning and basic industrial preparation.

4.1.4 OPERATION OF THE SPECIFIC PART OF THE PRODUCT

4.1.4.1 PRODUCT STRUCTURE

When the user starts the simulator, the main menu will display four buttons: Training (Workshop), Training (Hangar), Online, and Quiz. For the Workshop, Online, and Quiz modes, the user will spawn in the workshop or laboratory area. In the hangar mode, the user will spawn beside the Boeing 737-400 aircraft model inside the hangar environment.

In the workshop mode, after the user selects the button, the system will show a briefing interface that explains the task. Then, the probe, calibration standard, and eddy current machine will appear for use. In the Hangar mode, the user will start directly beside the aircraft with the probe and machine ready for testing.

In the online mode, once the connection is established, objects like the engine nacelle and aircraft wing section will appear along with the signal wave display to assist in the inspection. For the quiz mode, the system will show 10 multiple-choice questions for the user to answer.

Each mode includes simple navigation buttons and a result display screen at the end of the session to show user performance.

4.1.4.2 PRODUCT MECHANISM

Each simulator mode has its own operation flow;

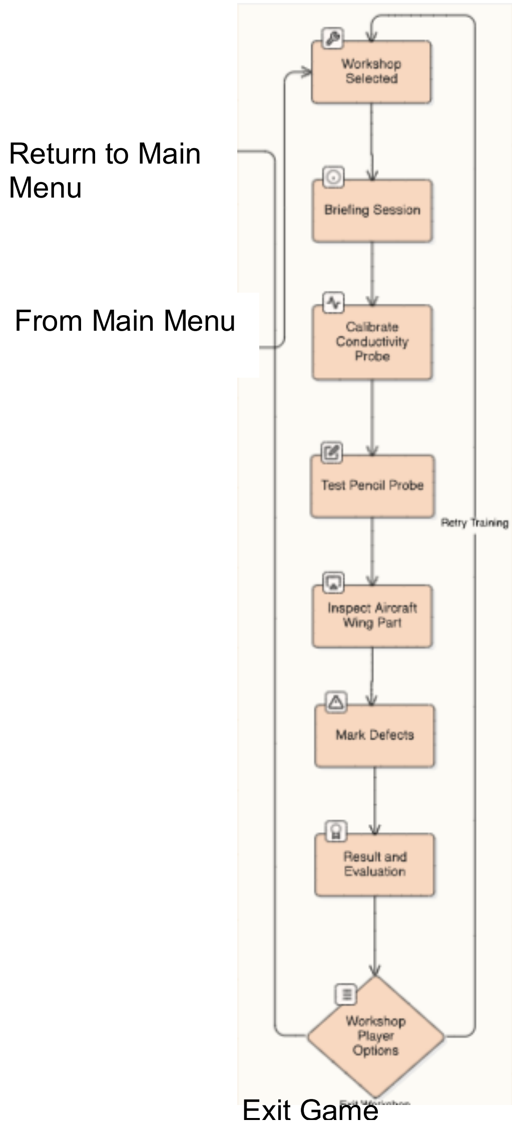


FIGURE 34 : TRAINING (WORKSHOP) FLOW

In workshop mode, the user starts with a briefing, then proceeds to calibrate the conductivity probe. After calibration, the user performs a pencil probe test and inspects the aircraft wing part to locate and mark any defect. Once the inspection is complete, the simulator will display the result summary including accuracy, time taken, and final score.

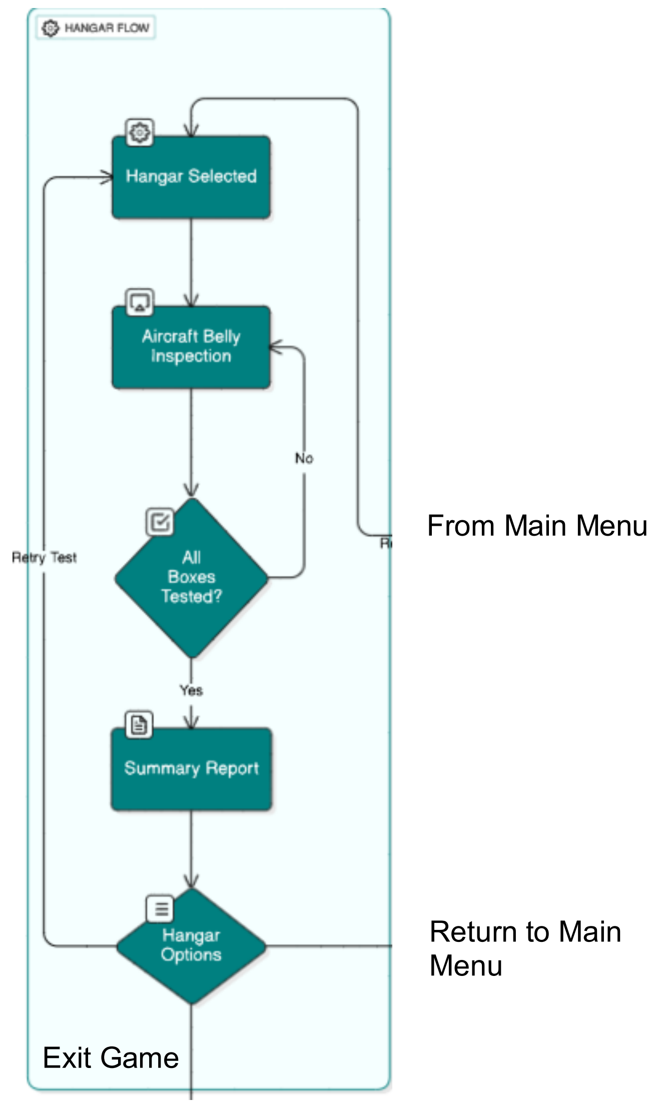


FIGURE 35 : TRAINING (HANGAR) FLOW

In hangar mode, the user immediately begins the discontinuity test on the aircraft body or belly area. The user observes the percentage of reading on the screen if the reading is out of limit, it means a defect is present. The user must tick the boxes for defect areas before viewing the results.

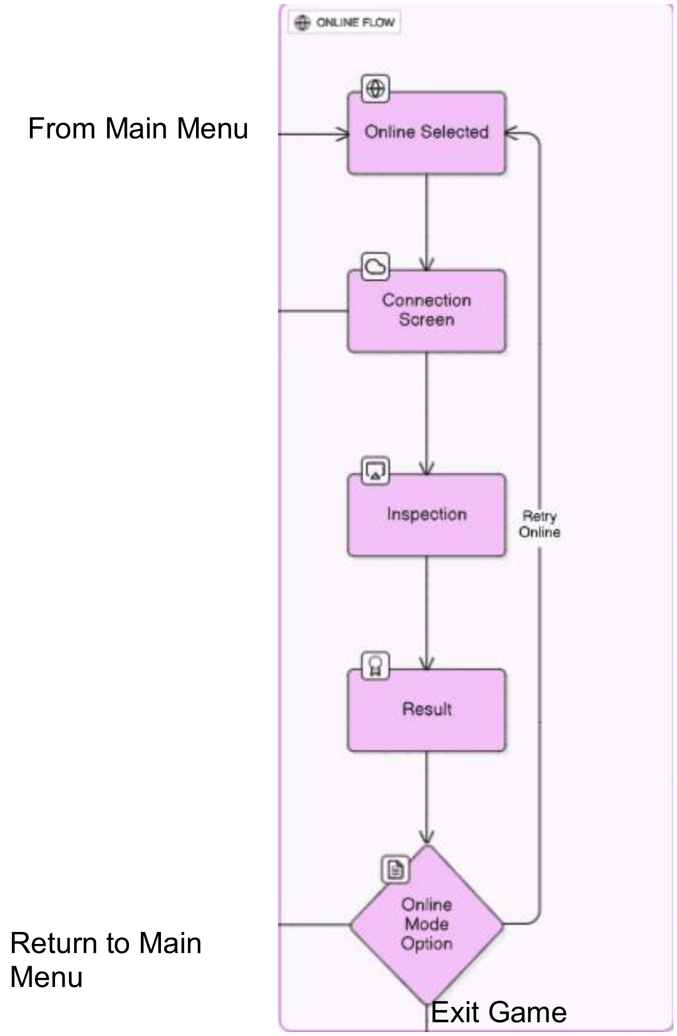


FIGURE 36 : ONLINE MODE FLOW

In Online mode, two users can connect to perform inspections on aircraft components. They inspect the current disruption on aircraft surfaces and mark as many defects as they can find. After completion, both users will see the combined results showing their total findings and scores.

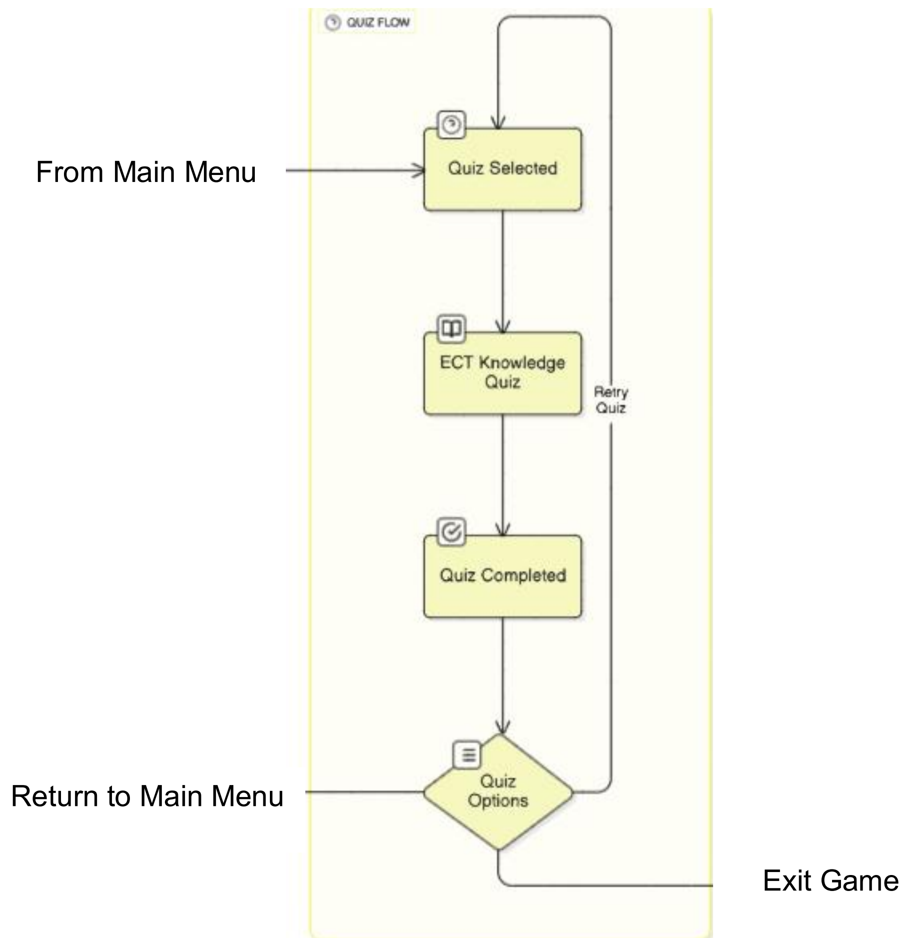


FIGURE 37 : QUIZ MODE FLOW

In the quiz mode, the user answers 10 questions about eddy current testing theory. After submission, the result screen shows the total score and completion time.

FIGURE 38 : RESULT SCREEN

At the end of each mode, the simulator will display the result screen, showing:

- Flaw detected (Yes/No)
- Accuracy percentage
- Time taken
- Final score

The user can then choose one of the three buttons: Retry, Main Menu, or Exit Game.

4.1.4.3 SOFTWARE / PROGRAMMING

The simulator is developed using unity game engine with c# programming language. Each mode (workshop, hangar, online, and quiz) is created in a separate unity scene, connected through the main menu interface.

The programming covers functions such as:

- Scene transition between modes and results
- Probe movement control and interaction detection
- Signal display and waveform response
- Timer and scoring calculation
- Result display system

The scoring system calculates performance based on accuracy and time taken. Once the user finishes the inspection, the program automatically collects these data and displays the results. The result screen includes interactive buttons for Retry, Main Menu, and Exit, allowing smooth control after each session.

4.1.4.4 ACCESSORIES & FINISHING

The design and finishing aim to create a realistic yet simple training atmosphere. The workshop and hangar environments are designed with realistic models and textures to represent real aircraft inspection conditions.

Most 3D models and textures are obtained from Sketchfab, while custom-designed models such as probes, calibration blocks, and machines are made using plain materials due to license restrictions.

The lighting in the hangar is slightly dim to reflect an industrial setting, while the workshop area is brighter for training visibility. The user interface is designed with simple buttons and clear labels to make it easy for users to navigate between modes.

4.2 **PRODUCT OUTPUT ANALYSIS**

No.	**Parameters**	**Results**	**Remarks / Description**	**Analysis**
1.0	Accuracy (%)	88%	Average accuracy achieved by user during inspection.	The simulator successfully detects correct defect markings based on user input, indicating effective signal interpretation.
2.0	Time Taken (minutes)	5.2 min	Total time user spent completing the inspection task.	The operation time is suitable for learning and can be adjusted by difficulty level.
3.0	Flaw Detection	Detected	System correctly registered defect at marked area.	Confirms the simulator's ability to identify defect zones according to probe movement.
4.0	IACS Reading Stability	95% Consistent	Consistent percentage reading throughout inspection.	Demonstrates stable response of discontinuity test feature in hangar mode.
5.0	Quiz Score	8/10	Based on user theoretical knowledge.	Indicates user understanding improved after completing training session.

4.3 ANALYSIS OF PROBLEM ENCOUNTERED & SOLUTIONS

4.3.1 PRODUCT STRUCTURE

During the modeling and environment development stage, one of the main problems encountered was the lack of accurate 3D references for real aircraft components and workshop layouts. Since the project could not use licensed or confidential aircraft data from actual maintenance facilities, the development team had to design simplified versions of certain components. For example, the calibration standard, eddy current machine, and probe models were designed manually based on general appearance and publicly available images. This process required multiple adjustments to achieve proportions that looked realistic and functional in the simulator.

Another structural issue involved scene scale and positioning. At first, several models appeared either too large or too small relative to the player's viewpoint, which affected realism and user immersion. The workspace layout also caused overlap between objects, resulting in difficulties when users moved or interacted with tools. To fix this, the scene hierarchy was reorganized, and object scales were adjusted proportionally using Unity's measurement system to match average human height. The calibration table and aircraft parts were also repositioned to ensure smooth gameplay interaction.

The final challenge was related to performance optimization. Because the Boeing 737-400 model contained a large number of polygons, the simulator experienced lag when rendering the hangar scene. The team resolved this by reducing mesh complexity and applying simplified textures to non-essential areas. The final result maintained visual quality while improving frame rate stability. These solutions allowed the structure to function efficiently without affecting the simulator's realism or educational purpose.

4.3.2 PRODUCT MECHANISMS

The product mechanism refers to how each mode in the simulator operates — including calibration, inspection, and defect identification. One of the earliest problems found was the interaction behavior of the probe. Initially, the probe movement did not respond smoothly to mouse control, causing it to pass through objects or move outside the inspection area. This issue was analyzed as a collider and input sensitivity problem. To solve it, collision boxes were added to all test surfaces, and the mouse drag sensitivity was adjusted in Unity's input manager to provide more precise control.

Another major issue involved the signal and percentage reading system during the discontinuity test. The percentage values were not updating in real-time when the probe moved over the defect zone. After debugging, the cause was identified as a missing variable link between the probe detection script and the signal display script. The development team modified the data transfer logic using a continuous update function (OnTriggerStay) instead of a single detection event. This allowed the percentage to change dynamically as the probe moved, making the response more realistic.

Additionally, the marking and scoring mechanism presented challenges. When users marked the defect area, the system sometimes failed to record the correct coordinates. This error occurred because the marking system used a static array that could only store limited data. The array was converted into a dynamic list structure, allowing multiple coordinates to be stored and processed accurately. These corrections ensured that the marking, scoring, and result generation systems worked properly across all gameplay modes.

4.3.3 SOFTWARE / PROGRAMMING

The software and programming stage faced several issues during development, especially in terms of code structure and integration between scenes. Initially, each gameplay mode (Workshop, Hangar, Online, Quiz) was developed in separate scenes with their own scripts, which caused difficulty in maintaining consistency and data transfer. For example, player results and score data did not carry over when switching scenes. To fix this, a global data management script was created using Unity's DontDestroyOnLoad() function. This allowed the simulator to store user performance data and maintain session continuity between different modes.

Another major programming problem occurred during the online mode development. The first version experienced connection drops and synchronization delays between players. This was caused by unstable network message handling. The developer identified that the client update rate was too high, causing unnecessary data traffic. The solution was to optimize the Photon Network settings and limit synchronization to essential data only (e.g., probe position and defect markings). After these changes, the online session became more stable and playable without noticeable delay.

A smaller but critical issue appeared during the result of display and scoring logic. Some test results displayed incorrect time or accuracy values due to floating-point rounding errors in C#. To resolve this, all calculation values were standardized and rounded to two decimal places before being displayed. The result screen now consistently shows accurate time taken, number of defects found, and final score. These programming fixes ensured smooth performance and reliability throughout the simulator's operation.

4.3.4 ACCESSORIES & FINISHING

During the finishing stage, challenges mainly occurred in texture quality, lighting, and sound synchronization. The first visual tests showed inconsistent texture appearance when switching between Workshop and Hangar scenes. This issue was caused by different lighting settings and material shaders. The team standardized the lighting configuration by applying a single baked lighting setup and ensuring all materials used the same rendering pipeline. This resulted in consistent visuals and smoother transitions between scenes.

Another issue was texture licensing. Some 3D models downloaded from external sources such as Sketchfab included copyrighted textures that could not be used for public or academic projects. To avoid legal issues, those textures were replaced with plain or self-created materials. Although this slightly reduced the visual realism, it allowed the simulator to remain fully original and compliant with open-license requirements. Later, lighting adjustments and post-processing effects were added to enhance the final visual appearance.

Sound design also posed a few technical difficulties. The free sound effects used had different volume levels and playback lengths, which caused imbalance during gameplay. The solution was to normalize all sound clips and apply volume control scripts to maintain consistent feedback levels. Additionally, some sounds were triggered at incorrect moments due to delayed function calls. These were fixed by attaching sound triggers directly to the corresponding interaction events. As a result, the simulator achieved synchronized visual and audio output, providing a more immersive and professional experience for the user.

Category	Problem	Solution
Product Structure	Object scaling and misalignment	Adjusted environment scale and layout
Product Mechanisms	Unstable probe detection	Reprogrammed collider system and calibration flow
Software / Programming	Scene transition and multiplayer bugs	Optimized scene management and simplified connection code
Accessories & Finishing	Limited visual quality	Used free 3D assets, improved lighting, and added sound effects

Through these improvements, the simulator's stability, usability, and realism were significantly enhanced. The final version of the NDT Inspection Simulator operates smoothly and delivers an effective virtual learning experience for students to understand the Eddy Current Testing (ET) process.

CHAPTER 5

ACHIEVEMENT OF AIM & OBJECTIVE OF THE RESEARCH

5.1 ACHIEVEMENT OF AIM & OBJECTIVES OF THE RESEARCH

5.1.1 GENERAL ACHIEVEMENTS OF THE PROJECT

The NDT Inspection Simulator has successfully achieved its objectives by delivering a realistic and interactive game-based training environment related to ECT. It aims to enable students and trainees to learn principles and applications of ECT, one of the most important methods used in aircraft maintenance to detect surface and subsurface defects in conductive materials. With its well-developed simulation environment, users can inspect virtually, analyze conductivity, and interpret defect indications similar to real-world inspection procedures.

The most important accomplishment in this project is related to the implementation of game-like features that make learning fun and exciting. Accordingly, this simulator is designed to facilitate multiple levels of difficulty, give hints, guide through tutorials, and generate NPC (Non-Player Character) dialogue interaction for support at different stages of learning from novice to expert. In particular,such features enhance motivation, contribute to more active participation, and help users progress gradually in improving their understanding of NDT processes.

The simulator also plays an important role in enhancing hands-on learning effectiveness while reducing dependency on physical equipment, consumables, and laboratory setups. The simulator allows institutions to conduct NDT training without material wastage or equipment damage by providing a safe, repeatable, and cost-effective virtual training environment; this helps them maintain consistency in the quality of training irrespective of physical constraints, thereby contributing to cost savings.

Another success of this project is the identification and analysis of the needs and preferences of learners in NDT training. Feedback from potential users and instructors proved indispensable in the revision process necessary to maximize educational value in the design, interface, and learning flow of the simulator. Due to its adaptability and user-friendly interface, this simulator will be able to be applied on various platforms, which will further increase access by students and educators alike.

On the whole, the NDT Inspection Simulator epitomizes innovation in integrating technology, education, and gamification into an excellent digital learning tool for Eddy Current Testing. It has already successfully illustrated the benefits of simulation-based learning in gaining further understanding, inquisitiveness, and interest in NDT studies and in furthering the strategic aim of developing more competent and skilled technicians in the aircraft maintenance industry.

5.1.2 SPECIFIC ACHIEVEMENT OF PROJECT OBJECTIVES

5.1.2.1 PRODUCT STRUCTURE

Design and develop the overall structure and layout of the NDT Inspection Simulator. This included the creation of 3D models and a virtual environment representing the setup of the workshop on an ECT inspection. The structure was designed to closely resemble a real aircraft maintenance environment with interactive features, including workbenches, testing panels, and component samples. It allows users to operate easily and perform inspection procedures within a realistic and safe training environment. Further attention has been given to the ergonomic placement of interactive components to ensure smooth gameplay and educational flow. The final product structure supports the objectives in terms of providing an authentic and practical learning experience for users who are new to NDT procedures.

5.1.2.2 PRODUCT MECHANISMS

The functional mechanisms to simulate the real process of the Eddy Current Testing within the simulator. This includes designing defect detection systems, signal feedback responses, and data interpretation displays virtually to simulate the real testing process. These mechanisms are designed to enable the players to conduct tasks such as probe placement, adjustment in instrument settings, and conductivity and coating thickness reading. Logical responses and animations were embedded to show how the probe acts with various materials and types of defects. In this way, the user gets to know practically how eddy current principles work in detecting cracks and discontinuities. These mechanisms have successfully enhanced the educational value of the simulator by connecting theoretical knowledge with virtual practice.

5.1.2.3 SOFTWARE / PROGRAMMING

The software development and programming of the simulator. In this respect, using Unity as a primary development platform entailed the elaboration of UI, the integration of gamification systems, and the management of interaction logic between the player and the virtual components. The code was optimized with the aim of ensuring smooth performance, responsive controls, and stable gameplay across multiple devices. At this point, the programming successfully implemented several useful features that would promote user engagement and motivation, including multiple difficulty levels, a hint system, score tracking, and NPC dialogues. Programming also included data flow management in order to track the progress and performance of players, making the simulator both educational and interactive. Finally, thanks to his effective software integration, the simulator will run efficiently while fully meeting the project objectives: realism, accessibility, and interactivity.

5.1.2.4 ACCESSORIES & FINISHING

The accessories, visuals, and finishing touches for improving simulator experience and quality of presentation. This involved icons, labels, textures, and educational material like instruction panels, gallery information, and component descriptions. Student D also worked on sound effects, lighting, and environment polishing to increase the immersiveness of the simulator, making it more engaging. More attention was paid to the aesthetics of the user interface for clarity and consistency throughout the gameplay. Accessories like virtual testing probes, control panels, and indication screens were made to look similar to how they are in real-life ECT equipment. The final finishing work contributed much to the overall realism, visual appeal, and professional presentation of the simulator, meeting the challenge of developing an educational yet enjoyable learning tool.

5.2 CONTRIBUTION OR IMPACT OF THE PROJECT

The NDT Inspection Simulator provides a unique, interactive way to learn about NDT processes, focusing on the Eddy Current (ET). This simulator offers a realistic training environment in which users can explore and perform virtual inspections, analyze conductivity readings, and detect surface or subsurface defects in metal components. This kind of learning fosters the development of key technical competencies and a deeper understanding of how an inspection is performed in a non-destructive, cost-effective, and entertaining way within the virtual environment.

Beyond the technical advantages, the simulator will also foster interest in the field of aircraft maintenance and NDT for further studies or professional careers related to aviation inspection and quality control. The project is designed to integrate gamification elements such as levels, tutorials, and feedback systems into its inspection concepts to enhance engagement and motivation in students.

In all, the NDT Inspection Simulator is something more than a simple digital training tool; it is an educational innovation that bridges theory and practice. It enhances learning effectiveness, reduces training costs, and inspires future technicians and engineers to develop stronger interest and competence in the field of Non-Destructive Testing and aircraft maintenance technology.

5.3 IMPROVEMENT & SUGGESTIONS FOR FUTURE RESEARCH

5.3.1 PRODUCT STRUCTURE

The product structure of the NDT Inspection Simulator can be further enhanced in order to bring realism, functionality, and educational value to it. The existing simulator offers a simple, efficient environment for learners to conduct basic simulations in ET. However, further development should be directed at enhancing the environmental realism by introducing 3D models that are more detailed and similar to real aircraft structures. This may include specific areas to be inspected, such as fuselage panels, engine mounts, and skins of aircraft wings where eddy current inspections are usually conducted. By replicating real layouts, students will have a better feeling for the real conditions NDT technicians have to deal with.

This refinement can also be achieved in the workspace layout by following industrial laboratory standards, including realistic modeling of instruments, workbenches, and areas for storing components. Proper spacing and object positioning would allow users to move and interact naturally within the virtual space. The addition of dynamic environmental effects, such as changes in lighting and reflections on metallic surfaces, would enhance the simulator's realism and interaction further. The light and shading effects can be further optimized for simulating inspection visibility challenges, allowing learners to adapt to conditions similar to real workshop environments.

The simulator could also include augmented reality (AR) to enhance user experience further. The AR functionality would enable the student to see internal defects or changes in conductivity superimposed on the surface of the virtual component. This would build a bridge between physical and digital training, allowing students who learn better through visual means to gain a deeper understanding. Future research could also be directed toward developing modular structures that would enable educators to tailor the workspace to different training modules or testing scenarios.

Lastly, the overall structure can be improved in terms of access and scalability. The simulator should be designed to efficiently work on a variety of devices, from computers and tablets to VR systems, to reach a wider audience. It would include adaptive resolutions and scalable textures, making it usable on both high- and low-end hardware. These structural enhancements will let the simulator develop into a more complete and agile digital training platform for NDT education.

5.3.2 PRODUCT MECHANISMS

The product mechanisms are the core of the NDT Inspection Simulator, determining how close to real ET operations the virtual environment can simulate. The current version with basic probe interaction and defect identification is quite successful in its scope, but development of more complex and varied testing mechanisms can be a good step toward enhancing the realism of defect detection and data interpretation.

Main areas of further development concern the inclusion of a wider variety of defect types and materials. Currently, the basic surface defects are the focus; subsurface cracks, corrosion pits, heat damage, and coating thickness variations could all form the basis of simulations in future versions. This diversity would give learners wider experience and enable them to identify different defect indications as they might appear in actual aircraft components.

Future development might also include the implementation of parameter control systems: the ability for players to change eddy current frequencies, probe sensitivities, and material properties. By changing these parameters, users would develop further knowledge of how variations in testing settings have an impact on signal results, as real NDT inspectors would do when making decisions. Other features the simulator might add are graphical signal displays, including impedance plane plots and signal amplitude graphs, which would dynamically update as the probe scans over defects to enhance users' abilities to interpret real eddy current signals.

The other suggestion was to refine the physics of probe interaction. Making the probe's motion detection, sensitivity, and scanning accuracy much more natural would have a much greater feel to this testing process. For example, movement of the probe-distance, angle, or speed-will yield different responses on the display, such that learners learn proper handling of the probe. To further enhance this system, there is also the potential addition of a feedback mechanism where the simulator vibrates or makes a sound upon the finding of a defect.

Other directions for future studies could be the inclusion of several NDT methods in one simulator, such as combining Eddy Current Testing with either Ultrasonic or Magnetic Particle Testing. This would give learners the chance to make comparisons of techniques and select the appropriate method to perform a particular inspection, thus giving them a broader understanding of the processes involved in NDT. These upgrades would change the character of the simulator from a single-method trainer to a multi-application platform, enabling it to support more technical training scenarios.

The most important thing to remember in this text is that true, modern theater has not yet been discovered.

5.3.3 SOFTWARE / PROGRAMMING

From the perspective of software and programming, there is great potential in further technical development and optimization. Currently, the Simulator operates on Unity, which enables stable performance and a working user interface; however, further development should be focused on making the program more interactive, adaptive, and intelligent to enhance users' experience and training process.

Future versions could also include cloud-based progress tracking, enabling users to save their performance data and access it on different devices. This would let students continue training outside the classroom and let instructors track individual progress remotely. Another very engaging feature could be a multiplayer mode that lets a group of students work together to inspect a system or a component or compete against one another in solving a problem. This would enhance teamwork and further emulate the cooperative nature of real-world maintenance operations.

The UI and UX may also be refined for smooth navigation and accessibility by redesigning menus, adding voice-guided instructions, and improving response times to further enhance the control flow. In addition, future software updates need to ensure performance optimization on different platforms, including desktop computers, tablets, and VR systems. This would include the use of VR compatibility, enabling learners to have a fully immersive experience, moving naturally and performing inspections in a 3D environment.

Additionally, the integration of data analytics dashboards can support learners and instructors in assessing training results. Real-time data visualization can indicate accuracy rates, test times, and quality of inspections, which can be used to assess learning effectiveness. Future research in programming may also be directed to developing a plug-in system whereby educators would be able to upload their own training scenarios, making the simulator flexible and scalable in the long term.

5.3.4 ACCESSORIES & FINISHING

Accessories and finishing play an important role in the NDT Inspection Simulator in terms of overall presentation, realism, and user engagement. While the current version already has basic textures, icons, and interface visuals, there is much room for improvement that could be made to enhance the aesthetic quality and educational depth of this simulator.

One major improvement would be enhancing visual realism with high-quality textures, correct lighting, and the rendering of shadows. By upgrading its graphical design, the simulator will attain a professional look similar to most modern industrial training software. Realistic representation of an eddy current probe, test instruments, and aircraft materials will enhance authenticity and make the learning environment more appealing to the eyes.

Subsequent updates could also include animation sequences, such as probe calibration, defect indication highlighting, or component replacement visuals, in order to help users conceptualize the procedures to be inspected. The sound design can also be developed to enhance immersion. The addition of subtle background sounds, noises from machines operating, and auditory feedback in defect detection could add significantly to realism. For example, variations in conductivity could be indicated through differing tones, emulating real inspection sounds, which would be created by the eddy current instruments.

In addition, voice-over guidance might help users through tutorials, explaining important concepts and steps of every phase of inspection. Other future improvements that could be done involve educational content presentation: the current educational gallery may be extended, adding detailed information on different NDT methods, standards, and safety practices. Complex concepts, like electromagnetic induction and signal interpretation, might be explained by interactive infographics and videos. To make the simulator more inclusive, multilingual options and adjustable text sizes could be implemented to cater to diverse user backgrounds.

Finally, improving accessories and interface finishing would ensure smoother user interaction. This includes refinement in the design of buttons, icons, and labeling for better clarity and readability. Color schemes and typography can be standardized in order to achieve a consistent visual identity for the simulator. Incorporation of customization features, like the ability to choose interface themes or tool layouts, would go a long way in enhancing comfort and personalization. In sum, such finishing touches would enhance the professionalism and usability of the simulator, making it not only functional as a means of training but also as an enduring educational influence.

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APPENDIX A: LIST OF TASK SEGREGATIONS

	MUHAMMAD NIZAM BIN ZAINAL ABIDIN
1.3.1	GENERAL PROJECT OBJECTIVES
1.3.2.3	SOFTWARE / PROGRAMMING
1.3	PROJECT OBJECTIVES
1.4.2.3	SOFTWARE / PROGRAMMING
2.1.2	ADVANCING LEARNING IN AVIATION MAINTENANCE WITH NDT TOOLS
2.1.7	SUPPORTING STUDENT LEARNING THROUGH RESOURCE ACCESSIBILITY
2.2.3	SOFTWARE / PROGRAMMING
2.3.1.2	GAME 2
2.4.2	GAME B VS OUR PRODUCT
3.1.2.4	PROPOSED CONCEPT 4
3.2.2	SPECIFIC INTERFACE LAYOUT (SOFTWARE-BASED)
3.3.1	OVERALL PROJECT FLOW CHART
3.3.2	SPECIFIC PROJECT DESIGN FLOW

3.5	OVERALL GANTT CHART
4.1.2	SPECIFIC PART FEATURES
4.3.1	PRODUCT STRUCTURE
4.3.2	PRODUCT MECHANISMS
5.3.1	PRODUCT STRUCTURE

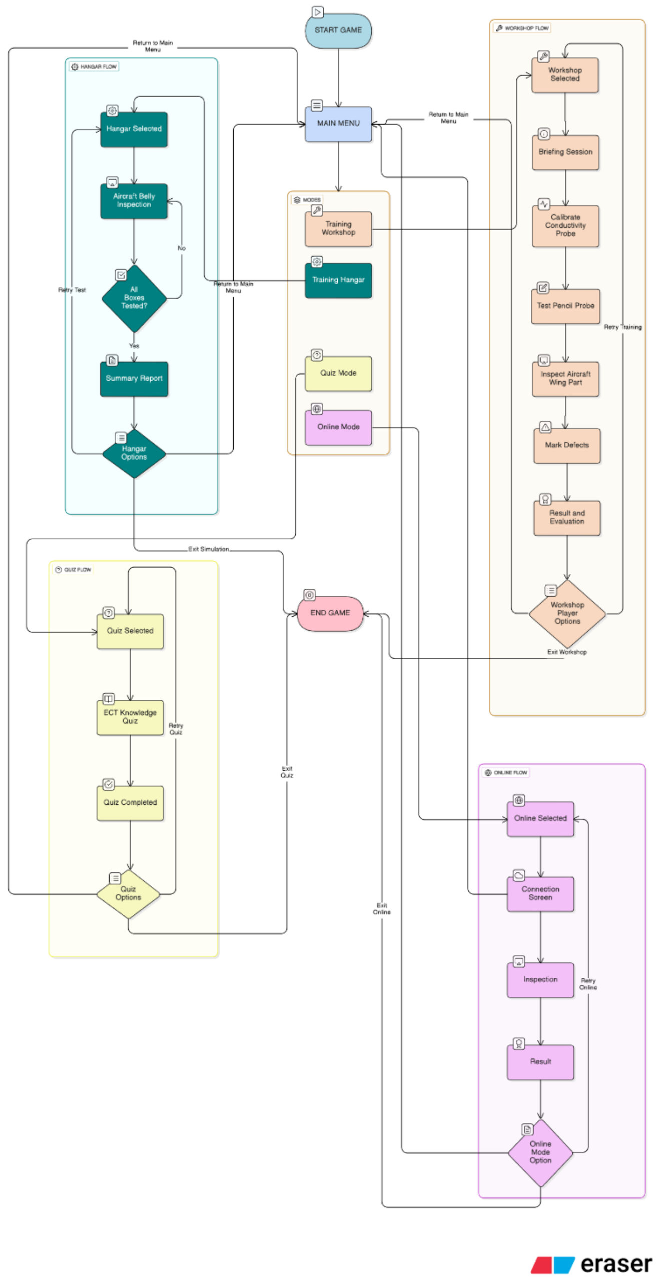

FIGURE 24: GENERAL OPERATION FLOW OF THE NDT INSPECTION SIMULATOR.

	PRADON A/L P GUNALAN
1.3.2.1	PRODUCT STRUCTURE
1.2	PROBLEM STATEMENT
1.3	PROJECT OBJECTIVES
1.3.2.2	PRODUCT MECHANISM
1.4	SCOPE OF PROJECT
1.4.2.2	PRODUCT MECHANISM
1.5	PROJECT IMPACT
2.1.1	THE ROLE OF SIMULATION IN TEACHING NON-DESTRUCTIVE TESTING FOR AVIATION
2.2.2	PRODUCT MECHANISM
2.3.1.4	PATENT D
2.4.3	Patent C vs. Product C vs. Your Product
3.1.2.3	PROPOSED CONCEPT 3
4.1.1	GENERAL PRODUCT FEATURES & FUNCTIONALITIES
4.1.3	GENERAL OPERATION OF THE PRODUCT
4.3	ANALYSIS OF PROBLEM ENCOUNTERED & SOLUTIONS

5.1.1	GENERAL ACHIEVEMENTS OF THE PROJECT
5.1.2	SPECIFIC ACHIEVEMENT OF PROJECT OBJECTIVES
5.2	CONTRIBUTION OR IMPACT OF THE PROJECT
5.3	IMPROVEMENT & SUGGESTIONS FOR FUTURE RESEARCH

	DANIA AMAL HUMAIRAH BINTI SAHARUDIN
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1.2	PROBLEM STATEMENT
1.3	PROJECT OBJECTIVES
1.3.2.2	PRODUCT MECHANISM
1.4	SCOPE OF PROJECT
1.4.2.2	PRODUCT MECHANISM
1.5	PROJECT IMPACT
2.1.1	THE ROLE OF SIMULATION IN TEACHING NON-DESTRUCTIVE TESTING FOR AVIATION
2.2.2	PRODUCT MECHANISM
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3.1.2.3	PROPOSED CONCEPT 3
3.6.2	PRODUCT DEVELOPMENT
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	MUHAMMAD ‘AZIM BIN HAMDAN
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1.4.2.4	ACCESSORING & FINISHING
2.3.1.3	GAME 3
2.4.3	GAME C VS OUR PRODUCT
3.1.1.1	QUESTIONNAIRE SURVEY
3.1.2.3	PROPOSED CONCEPT 2
3.1.3.1	PUGH MATRIX
3.6.1	PROTOTYPE / PRODUCT MODELLING
3.6.2	PROTOTYPE DEVELOPMENT
3.7	DEVELOPMENT OF PRODUCT
4.1.4	OPERATION OF THE SPECIFIC PART OF THE PRODUCT
4.2	PRODUCT OUTPUT ANALYSIS
4.3.3	SOFTWARE / PROGRAMMING
4.3.4	ACCESSORIES & FINISHING
5.1	ACHIEVEMENT OF AIM & OBJECTIVES OF THE RESEARCH

5.3.2	PRODUCT MECHANISMS
5.3.3	SOFTWARE / PROGRAMMING
5.3.4	ACCESSORIES & FINISHING