SILICONMAX ARVR TECHNOLOGY

TEAM KIUTBOIS

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1. Introduction

Author: Lim Hon Sheang, Danny Chan Yi Xiang

Embarking on the frontier of ARVR Immersive Learning Solutions, our project is dedicated to revolutionizing education through immersive learning experiences. Leveraging cutting-edge technologies such as augmented reality (AR), virtual reality (VR), we aim to create dynamic and captivating learning environments. While this innovative approach holds immense promise, it also presents unique challenges that demand our attention and ingenuity. In the realm of ARVR Solutions tailored specifically for immersive learning in the automotive industry, our project sets its sights on enhancing understanding and exploration of critical components such as the car engine, fuel tank, and car battery. With a primary focus on empowering users to delve into intricate details, our ARVR technology offers a transformative approach to education and industry alike.

We are thrilled to collaborate with Siliconmax ARVR, a pioneering company based in Penang, renowned for its expertise in the fields of Augmented Reality (AR) and Virtual Reality (VR) technologies. With Siliconmax ARVR as our partner, we embark on a journey to elevate the realm of AR and VR solutions. In response to the growing demand for innovative learning tools, our client has identified a critical need for effective training resources in automotive engineering. Traditional methods often fall short in conveying the complexities of car engines, leaving learners with theoretical knowledge but lacking in practical application. Recognizing this gap, our project aims to bridge theory and practice by harnessing the power of AR and VR technology.

Our primary objective is to create an unparalleled learning aid that offers users an immersive journey into the heart of a car engine. Through meticulous attention to detail, we will develop a virtual representation that accurately reflects the intricacies of real-world engines, allowing users to interact with and explore its various components. Furthermore, our project seeks to provide a hands-on learning experience that goes beyond passive observation. By simulating real-world scenarios for troubleshooting and diagnostics, we aim to equip learners with the practical skills needed to excel in automotive engineering.

Accessibility remains a key challenge we aim to overcome. By leveraging advanced ARVR technology, users can delve into the complexities of automotive components without the need for expensive specialized equipment or cumbersome VR headsets. (Shanu, 2022) Through the intuitive use of a stylus pen and advanced laptop equipped with eye-tracking sensors, users are empowered to interact with 3D models in a seamless and engaging manner. This approach not only facilitates immersive learning experiences but also enables educators to elucidate intricate concepts with greater clarity and depth. Furthermore, our solution addresses concerns such as motion sickness, ensuring that users can explore automotive components comfortably and without discomfort. (Bermejo, 2023) By providing both first-person and third person viewing perspectives, our technology fosters collaborative learning environments where users can engage with the content together, enriching the educational experience.

In the automotive industry, our ARVR Immersive Learning solution serves as a powerful tool for training and skill development. Whether it's for aspiring mechanics gaining hands-on experience or engineers refining their understanding of complex systems, our technology offers a versatile platform for immersive learning and exploration. (Boboc, 2020) In essence, our project embodies the convergence of cutting-edge technology and educational innovation, paving the way for a more immersive, accessible, and impactful approach to learning about car engine parts and other automotive components.

The focal point of this project is to address the pressing need for innovative learning tools, particularly in the domain of automotive engineering. Our client, discerning the challenges faced by engineering personnel in comprehending complex systems such as car engines, has tasked us with the development of an immersive learning aid. Through the integration of AR and VR technologies, we aim to provide an unparalleled learning experience that fosters deeper understanding and engagement while keeping costs at a minimum.

The essence of our project lies in creating an application that enables users to interact with 3D models and animations of car engines. By leveraging the capabilities of AR and VR, we seek to offer a dynamic platform that allows learners to dissect, analyse, and manipulate virtual representations of engine components in real-time. This hands-on approach not only enhances comprehension but also cultivates practical skills essential for engineering professionals. To realize our vision, we have outlined specific system requirements. A laptop with above-average specifications is imperative to support the seamless operation of the application. This includes robust processing power, ample memory, and high-quality graphics capabilities. By ensuring compatibility with mainstream computing devices, we strive to make our ARVR solution accessible to a wide audience.

In collaboration with Siliconmax ARVR, we are poised to revolutionize the landscape of learning aids through the fusion of cutting-edge technology and educational innovation. Together, we embark on a journey to empower engineering personnel with immersive and cost-effective solutions that redefine the boundaries of learning. At the core of our project lies a commitment to enhancing the educational landscape and fostering a culture of innovation within the automotive industry. By delivering a valuable resource that inspires curiosity and skill development, we strive to empower learners and enthusiasts alike to push the boundaries of automotive knowledge.

2. Project Management

a) Project Planning

Author: Lim Hon Sheang

<u>Pre-sprint plan</u>

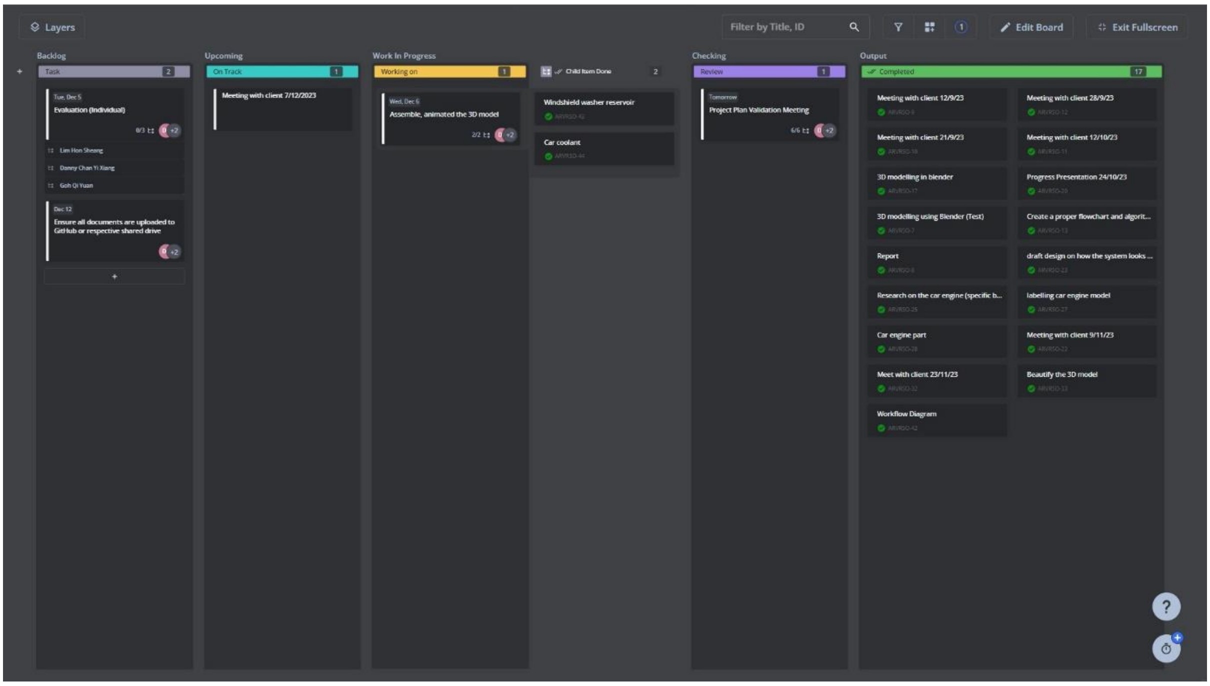


Figure 1.0: Kanban Board from Teamhood

Sprint duration: 3 months

Development Tasks by Team:

i. Model Development:

- **Create 3D Models:** The team will focus on creating detailed 3D models for various car engine components, including the car engine overview, engine, battery, coolant system, and windshield washer reservoir. Each model must accurately represent its corresponding component, capturing all necessary details and features.
- **Ensure Accuracy:** Ensuring the accuracy of each component's representation is crucial. The team will pay attention to detail, ensuring that the size, shape, and appearance of each model align with real-world counterparts.

ii. Animation Development:

- **Develop Assembling and Disassembling Animations:** The team will develop animations depicting the assembly and disassembly processes of car engine components. These animations will provide users with a clear understanding of how each part fits together and functions within the engine.

- **Implement Labelling Functionalities:** Labelling functionalities will be implemented to allow users to interact with the 3D models and view detailed information about each part. When users interact with a specific component, its name and relevant information will be displayed.
- **Create Battery Level Indicator Animation:** An animation demonstrating the functionality of the battery level indicator will be developed. This animation will showcase how the battery level indicator works and its importance in monitoring the battery's status.

What Will Be Developed:

i. 3D Models:
   - **Car Engine Overview:** A comprehensive 3D model showing the layout and main components of the car engine will be developed. This model will provide users with an overview of the engine's structure and organization.
   - **Detailed Component Models:** Detailed 3D models for individual engine components, including the engine itself, battery, coolant system, and windshield washer reservoir, will be created. These models will accurately represent each component's design and functionality.

ii. Animations:
   - **Assemble and Disassemble Animations:** Animated sequences depicting the assembly and disassembly of engine components will be developed. These animations will guide users through the process step-by-step, enhancing their understanding of how the engine works.
   - **Labelling Feature:** A labelling feature will be implemented to highlight and display part names when users interact with the 3D models. This feature will provide additional context and information about each component.
   - **Battery Level Indicator Animation:** An animation illustrating the functionality of the battery level indicator will be created. This animation will demonstrate how the indicator works and its role in monitoring the battery's charge level.

Post-sprint Plan

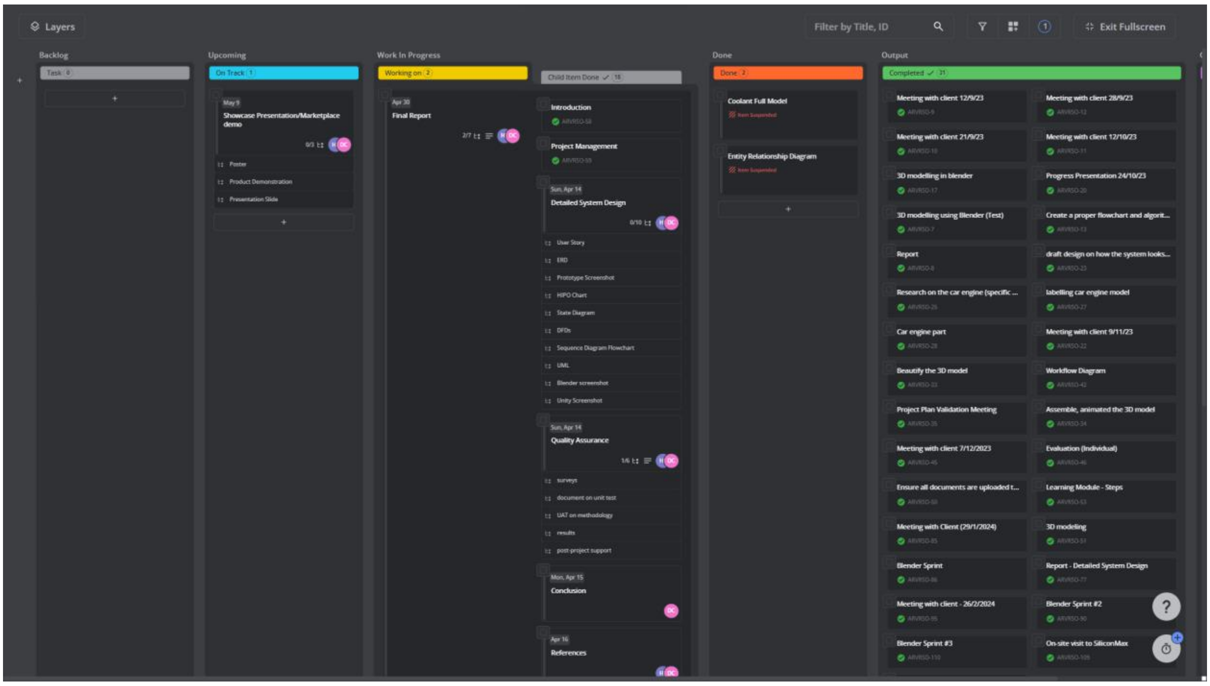


Figure 1.1: Kanban Board from Teamhood

Sprint duration: 3 months

Development Tasks by Team:

i. Model Development:

- **Create 3D Models:** Develop detailed 3D models for the car engine overview, engine, battery, and fuel tank using Blender. Each model should accurately represent its corresponding component, including all relevant details.
- **Ensure Accuracy:** Ensure that each component's representation is accurate and includes appropriate details. Pay attention to factors such as size, shape, and functionality to create realistic models.
- **Implement Labelling Functionalities:** Implement labelling functionalities for each part to provide users with additional information about the components when interacted with.

ii. Animation Development:

- **Develop Assembling and Disassembling Animations:** Create animations illustrating the assembly and disassembly processes of car engine components. Additionally, develop animations to demonstrate the flow of fuel from the fuel tank to the car engine.

What Will Be Developed:

i. 3D Models with Animation:
   - **Car Engine Overview:** Develop a 3D model of the car engine overview showcasing the layout and main components. Create assemble and disassemble animations for the engine components to help users understand their functioning.
   - **Exploded Views:** Provide exploded views for the car engine, battery, and fuel tank. These views will showcase the internal components and their arrangement.
   - **Car Battery and Fuel Tank:** Develop 3D models with exploded views for the car battery and fuel tank, allowing users to explore their internal structures.
   - **Fuel Flow Animation:** Create an animation showing the flow of fuel from the fuel tank to the car engine, illustrating the fuel delivery process.

ii. Unity Implementation:
   - **User Interface Development:** Develop a user interface (UI) for the ARVR feature using Unity. The UI should provide intuitive controls for interacting with the 3D models and accessing additional features.
   - **3D Model Import:** Import 3D models created in Blender into the Unity environment for further integration and interaction.

iii. ARVR Feature:
   - **Drag and Interact Feature:** Implement a drag-and-drop feature that allows users to interact with the 3D components seamlessly. Users should be able to manipulate the components and explore their functionalities in the ARVR environment.

b) Risk Assessment

Author: Danny Chan Yi Xiang

Likelihood impact	High	Moderate	Low
Time consuming		/	
Reputational risk			/
Stakeholder’s risk		/	
Hardware compatibility	/		
Lack of resources	/		

Table 1.0: Risk Assessment

- Time consuming - The complexity of 3D models closely correlates with the time and resources required to create them. Complex models necessitate more intricate effort, such as comprehensive design, rendering, and testing, which can dramatically increase development time. (Dammann, 2023) To prevent delays in development that can affect other project phases and result in missed deadlines, the project timeframe must consider the complexity of the models. To decrease this risk, consider using simpler model designs, strengthening team skills through training, or utilising more efficient software solutions that can handle complicated models more successfully.

- Reputational risks - Meeting project deadlines are critical for project success and the organization's reputation. Delivering the application on time can ensure the organization's image is maintained by undermining its reputation and dependability in the eyes of clients, partners, and the marketplace. This reputational damage might result in missed future chances and diminish stakeholder trust. To mitigate this risk, it is essential to implement effective project management methods such as defining realistic timelines, conducting regular progress reviews, and planning for potential setbacks.

- Stakeholder risks - A project involving student and industry collaboration requires clear and constant communication. Miscommunications can result in misunderstandings about project requirements, goals, and schedules, potentially leading to work that does not match expectations and must be redone. Misalignment can cause project delays and strain on stakeholder relationships. (Fernandes, 2022) To mitigate this risk, developing a clear communication plan that includes regular check-ins, detailed documentation, and agreed-upon communication routes and formats is critical.

- Hardware compatibility - The application's accessibility and usefulness are limited because it requires powerful hardware. It limits the application's user base to people with access to high-end computers, potentially decreasing its market reach and usability in various settings. To address this risk, optimise the programme to lower hardware needs while maintaining functionality. Furthermore, looking into alternative methods, such as cloud computing or designing a less resource-intensive version, could increase the app's accessibility.

- Lack of resources - A shortage of ready-to-use 3D models poses a significant risk to the project, as it may increase the time and effort required to develop these resources from scratch. This situation can delay the project and increase costs. Mitigating this risk could involve sourcing 3D models from online libraries, partnering with other organizations for resource sharing, or adjusting project requirements to align with available resources. Additionally, investing in creating a versatile library of 3D models that can be reused in future projects may provide long-term benefits.

i. Risk Register

Risk Description	Impact Description	Impact level (1-5)	Probability level (1-5)	Priority level
Unable to complete models on-time	Less model than expected to present during presentation	4	2	8
Hardware unable to support the 3D models	Unable to develop the 3D models and render in personal PC	5	3	15
Misunderstanding during communication with company	3D models developed are not met with the requirement	4	1	4
3D models file not saved and lost	Need to redo all the 3D models due to file lost	5	1	5
Lacks 3D models resources	Need to develop our own 3D models	4	3	12

Table 1.1: Risk Register

1) Unable to Complete Models On-Time

- Impact Description: If the project team is unable to complete the 3D models by the deadline, there will be fewer models than expected to present, potentially affecting the project's evaluation or its goals.
- Impact Level: 4 (High)
- Probability Level: 2 (Low)
- Priority Level: 8

This risk is highly impactful because the quality and quantity of deliverables directly influence stakeholders' perceptions and project success. However, its probability is considered low, possibly due to confidence in project management or mitigation plans (like having buffer time). The priority is moderate, suggesting measures should be in place to manage time effectively, perhaps through regular progress checks or agile methodologies.

2) Hardware Unable to Support the 3D Models

- Impact Description: If personal computers or the hardware available to the team cannot support the development or rendering of the 3D models, it may halt or significantly slow down the project.
- Impact Level: 5 (Very High)
- Probability Level: 3 (Moderate)
- Priority Level: 15

This is a critical risk with the highest impact rating because hardware limitations can completely stop progress. The moderate probability suggests there is uncertainty about the hardware capabilities of all team members or variability in the hardware requirements of the models. The high priority level indicates that ensuring hardware compatibility is a crucial preparatory step, potentially requiring hardware assessments or investment in upgrades.

3) Misunderstanding During Communication with Company

- Impact Description: Miscommunications with the company could result in 3D models that do not meet the project requirements, leading to rework or project rejection.
- Impact Level: 4 (High)
- Probability Level: 1 (Very Low)
- Priority Level: 4

Despite its high impact, the risk of miscommunication is deemed very low, possibly because of established communication protocols or previous successful collaborations. However, any misunderstanding can cause significant rework, suggesting the need for clear specifications, regular check-ins, and validation steps with stakeholders.

4) 3D Models File Not Saved and Lost

- Impact Description: Losing 3D model files would necessitate redoing the work, causing delays and extra labour.
- Impact Level: 5 (Very High)
- Probability Level: 1 (Very Low)
- Priority Level: 5

This scenario is a nightmare for any digital endeavour, which explains the tremendous impact. However, the low chance shows trust in modern version control and backup technologies. Nonetheless, it highlights the significance of regular backups, cloud storage, and possibly version control systems in mitigating this risk.

5) Lacks 3D Models Resources

- Impact Description: A shortage of pre-existing 3D models would require the team to develop their models, increasing workload and potentially delaying the project.
- Impact Level: 4 (High)
- Probability Level: 3 (Moderate)
- Priority Level: 12

This risk is critical because creating 3D models from scratch is significantly more resource and time-intensive than modifying existing ones. The moderate probability suggests there's uncertainty about the availability of resources. It's a high priority to address, indicating a need for early resource assessment and perhaps establishing partnerships or sourcing strategies to mitigate this risk.

ii. Risk Mitigation Plan

a. Unable to Complete Models On-Time

Learning from Pixar, implement rigorous version control and backup strategies, ensuring that work is not lost and can be recovered quickly to avoid project delays.

- Implement a system like Git for all projects, ensuring that every change is documented, and a history of modifications is maintained. This allows for easy tracking of changes and the ability to revert to previous versions if necessary.
- Develop a multi-tiered backup approach, including real-time backups for immediate work, daily backups stored both on-site and off-site, and cloud backups. Regular testing of backups should be conducted to ensure they can be restored effectively.
- Train staff on the importance of following the backup and version control policies. Real-life stories, such as the Toy Story 2 incident, can be powerful tools in highlighting the potential consequences of neglecting these practices.

Pixar's Toy Story 2 (1999) faced a near-catastrophic situation when the film's files were almost entirely deleted due to a mistakenly entered command. This incident could have resulted in the loss of years of work and significant project delays. However, quick thinking by an employee with backups of the files at home saved the day. This incident underscored the importance of robust backup strategies for preventing data loss and mitigating project risks. With adequate backups, the consequences of such an error could have been better for the film's production timeline and budget. The incident served as a wake-up call for Pixar and the broader film industry, prompting a revaluation of backup protocols and emphasizing the critical role of redundancy in safeguarding against unforeseen disasters. It also highlighted the value of having knowledgeable and resourceful team members who can act swiftly in crises to prevent irreparable damage. (Cotter, 2022)

b) Hardware Unable to Support the 3D Models

Inspired by the Healthcare.gov experience, conduct stress tests and simulations to ensure the project's infrastructure can handle the required loads, adjusting hardware resources as necessary.

- Conduct a detailed analysis of current hardware capabilities versus project requirements. Upgrade hardware where necessary, considering future growth to ensure scalability.
- Regularly simulate high-load scenarios to understand how the system behaves under stress. Use these findings to make necessary adjustments to hardware and software to avoid real-world failures.
- Implement a robust monitoring system that can provide real-time alerts on hardware performance and stress. Use cloud-based solutions where appropriate for their scalability, allowing resources to be dynamically adjusted based on demand.

Healthcare.gov struggled during its 2013 launch due to numerous faults, including inadequate hardware infrastructure that could not handle the large traffic influx. This deficiency resulted in many technological flaws, system breakdowns, and lengthy wait times for anyone wanting to access the website, leading to widespread condemnation and significant reputational harm to the project. The failure of Healthcare.gov highlighted the critical importance of robust infrastructure planning and scalability testing, especially for high-traffic websites and complex systems. It underscored the need for meticulous preparation and investment in adequate hardware resources to accommodate expected user loads, prevent downtime, and ensure a seamless user experience. (Schlesinger, 2016)

c) Misunderstanding During Communication with Company

Use the Mars Climate Orbiter mishap as a cautionary tale to establish a clear, documented communication protocol that includes regular check-ins, clear documentation, and explicit confirmation of critical data and requirements.

- Develop a set of standardized communication protocols that specify how information is to be documented, shared, and confirmed among teams. This should include a common language or set of terms to prevent misunderstandings.
- Provide ongoing training to all team members on effective communication practices and the tools used by the company to manage projects and tasks. Emphasize the importance of clear, unambiguous communication.
- Implement a double-check system for all critical data and decisions. This could involve a secondary review by a project manager or a cross-functional team to ensure accuracy.

The Mars Climate Orbiter (1999) - The loss of the Mars Climate Orbiter in 1999 was a significant setback for NASA's Mars exploration program. The failure stemmed from a critical oversight: a team discrepancy in unit measurements. While one team used metric units, another used English units, leading to incorrect calculations during the spacecraft's trajectory. This miscommunication resulted in a costly mistake of $327.6

million and the loss of the orbiter. The incident underscored the importance of clear communication and standardization in complex engineering projects, especially those with high stakes and tight margins for error. (Mavroeidakou, 2019)

d) 3D Models File Not Saved and Lost
Emphasize the development and enforcement of a comprehensive backup strategy, including off-site and cloud backups, to prevent any chance of total data loss. The Pixar incident underlines the need for multiple layers of backup.

- In addition to on-site and off-site backups, incorporate real-time or near-real-time backups for active projects. Use cloud services that offer versioning and can recover data to specific points in time.
- Regularly educate and remind employees about the importance of following the established backup procedures. Share stories of past incidents and how rigorous backup strategies can avert disaster.
- Regularly schedule and conduct tests to restore data from backups to ensure that they are not just being created but are also reliable and intact.

Toy Story 2 (1999) is also a perfect example here, showcasing the catastrophic potential of data loss and the importance of backups in preventing a complete disaster.

e) Lacks 3D Models Resources
While the Flappy Bird scenario revolves around ethical considerations, it serves as a reminder of the broader principle that external resources (like 3D models or software components) can become unexpectedly unavailable. Develop in-house capabilities or secure multiple sources for critical components to mitigate this risk.

- Invest in training for staff to create or adapt 3D models in-house, reducing reliance on external resources. This also includes acquiring tools that enable in-house creation and manipulation of 3D assets.
- For components or resources that must be outsourced, establish relationships with multiple suppliers or sources. This diversification can reduce the risk of being caught off-guard by sudden unavailability.
- Be mindful of the ethical considerations and potential impacts of the resources in use. The Flappy Bird example teaches the importance of considering the broader implications of our work, including user welfare and societal impact.

Despite its popularity, the removal of Flappy Bird from app stores in 2014 serves as a reminder of the unpredictable nature of resource availability in the digital realm. The creator's decision to remove the game stemmed from concerns over its addictive nature and its negative impact on players. While not directly related to project management or resource allocation, this situation emphasizes the importance of contingency planning. Just as the sudden unavailability of Flappy Bird surprised and inconvenienced many users, unforeseen events or decisions can disrupt projects and operations. Contingency planning helps mitigate risks by preparing for unexpected scenarios and ensuring that alternative courses of action are available. (Brandão, 2019)

c) Project schedule

Author: Lim Hon Sheang

Project Title: ARVR Solutions for Immersive Learning

Client: Siliconmax ARVR Technology

Project Duration: 27/9/2023 - 30/3/2024

1. **Introduction:**
   Duration: 27/9/2023 – 4/10/2023
   a. **Defining the Problem Statement:**
      To begin, analyse the current status of automotive engineering education and identify any gaps that need to be filled. Highlight areas where standard teaching approaches may need to provide thorough knowledge or hands-on experience, particularly with complicated systems such as vehicle engines. Because of limited hands-on chances and reliance on theoretical lectures, traditional automotive engineering education students frequently require assistance in understanding the inner workings of automobile engines. This gap between theory and practice limits their ability to apply knowledge successfully in real-world situations.

   b. **Establishing Project Objectives:**
      Clearly articulate the goals and objectives of the project, ensuring they are specific, measurable, achievable, relevant, and time-bound (SMART). These objectives should directly address the identified challenges and serve as guiding principles throughout the project.
      i. Create an accurate and detailed virtual representation of a car engine:
         - This goal is to create a high-fidelity 3D car engine model that faithfully depicts its components, including pistons, cylinders, valves, and crankshafts. Use powerful 3D modelling software such as Blender to create and render each automotive engine component carefully, assuring accuracy and realism.
      ii. Facilitate a hands-on learning experience through immersive ARVR technology:
         - This purpose seeks to provide users with an immersive and interactive learning environment to explore automotive engines in virtual reality. It emphasises the value of practical experience in enhancing theoretical understanding. Create an ARVR application that enables users to handle and interact with the virtual automobile engine via motion controllers or gestures, resulting in a haptic and engaging learning experience.
      iii. Provide tools for simulating real-world scenarios:
         - This goal aims to allow users to replicate realistic circumstances relating to automotive engine troubleshooting, diagnostics, and maintenance. It emphasises the application of theoretical knowledge in real-world

settings. Add interactive capabilities to the ARVR application that allow users to run diagnostic tests, detect defective components, and practise repair processes in a simulated environment.

iv. Ensure accessibility and usability across different devices and platforms:
  - This objective emphasises the need to make ARVR learning accessible to a diverse audience by guaranteeing compatibility across devices and platforms. It focuses on inclusivity and usefulness. Optimise the ARVR application for compatibility with various VR headsets, smartphones, tablets, and desktop computers, ensuring a consistent experience independent of device type.

v. Enhance the educational landscape and foster innovation within the automotive industry:
  - This objective highlights the project's more significant impact on automotive education and industry. It aims to motivate learners and experts in the automotive industry to be curious, develop their skills, and innovate. Collaborate with educational institutions, automobile manufacturers, and industry experts to include the ARVR learning application in curriculum and professional training programmes, fostering an environment of continuous learning and innovation.

c. Highlighting the Importance of ARVR Technology:

Emphasize how immersive simulations can enhance engagement, facilitate deeper learning, and bridge the gap between theory and practice.

Advantages of Immersive Learning:

i. Enhanced Engagement:
  - ARVR technology creates a virtual environment that captures learners' attention and encourages active engagement. The participatory nature of immersive simulations fosters engagement and motivation, making learning more pleasurable and exciting. In automotive engineering education, students can virtually disassemble and reassemble vehicle engine components, actively engaging with the content and acquiring a better grasp of how each component works within the system.

ii. Facilitates Deeper Learning:
  - Immersive simulations give learners hands-on experience, allowing them to investigate complicated subjects practically and intuitively. By actively participating in virtual settings, students can better understand theoretical principles and their real-world implications. Students can visualise the inner workings of a car engine in three dimensions using ARVR simulations, allowing them to understand topics like combustion, compression, and torque more clearly and deeply.

iii. **Bridges the Gap Between Theory and Practice:**

- ARVR technology enables learners to apply their knowledge in simulated real-world circumstances, bridging the gap between theory and practice. This experiential learning method improves the memory and comprehension of complicated subjects. In automotive engineering, students can use ARVR simulations to troubleshoot common engine problems, identify faults, and practise repair processes in a safe virtual environment, transforming theoretical knowledge into practical abilities.

iv. **Accessible Hands-on Experience:**

- ARVR simulations provide a cost-effective and accessible alternative to traditional hands-on learning methods. ARVR technology democratises access to practical training opportunities by eliminating the requirement for physical equipment and resources, regardless of location or availability. With ARVR technology, students may access virtual laboratories and workshops from anywhere with an internet connection, allowing them to obtain hands-on experience with vehicle engine components without being limited by physical space or equipment availability.

v. **Personalized and Adaptive Learning:**

- ARVR simulations can be customised to meet individual learning needs and speed. Learners can explore information at their own pace, receive real-time feedback, and access additional resources to aid their learning journey. ARVR applications in automotive engineering can provide adaptive learning experiences tailored to each student's competency level and learning objectives, allowing for personalised guidance and assistance throughout the learning process.

d. Setting Expectations:

i. **Clearly Define Project Scope:**

- Describe the project's primary deliverables, including designing an ARVR learning app, 3D modelling of automobile engine components, user testing, and documentation. The project's scope involves creating a prototype ARVR learning application that allows users to interact with virtual representations of automotive engine components. We will also develop precise 3D models of engine components, conduct user testing sessions to obtain feedback, and produce extensive documentation.

ii. **Establish Timeline and Milestones:**

- Create a project timeline with milestones and deadlines for each development phase. Consider resource availability, task complexity, and project component interdependence. The project timeline is six months long, with milestones such as completing the initial design phase in the first month, developing the prototype application in the third month, conducting user testing and iterations in the fourth and fifth months, and finalising documentation and delivery in the sixth month.

iii. **Allocate Resources:**

- Determine the resources needed to support project activities, including personnel, software tools, hardware equipment. Ensure that resources are allocated appropriately to meet project objectives within the specified timeline. Resource allocation will be managed to optimize productivity and ensure timely delivery."

iv. **Set Realistic Expectations:**

- Acknowledge potential challenges that may arise during the project, such as technical constraints, scope creep, resource limitations, or unforeseen obstacles. Be proactive in identifying and addressing these challenges to mitigate their impact on project success.

e. **Communication and Collaboration:**

- Define communication protocols and channels for regular updates, progress reports, and collaboration among project team members, stakeholders, and the client. Foster open communication and transparency to facilitate efficient decision-making and problem-solving.
- Example, regular project meetings will be held to review progress, address issues, and align on priorities. Additionally, communication channels such as email, project management tools, and video conferences will be utilized to ensure effective collaboration and information sharing among team members and stakeholders.

2. **Project Planning Phase:**
   Duration: 4/10/2023 – 9/10-2023
   - During this phase, meticulous planning is essential to ensure the project's success. The project team defines roles and responsibilities, establishes communication channels, and sets realistic goals and milestones. A detailed project schedule is created to track progress and manage resources effectively.

   a. **Define Roles and Responsibilities:**
      Clearly outline the roles and responsibilities of each team member to ensure accountability and clarity in project execution. Assign tasks based on expertise and capabilities to optimize efficiency.
      - Product owner: The team member is responsible for identifying product features and characteristics, evaluating completed tasks, and determining testing requirements. They take the lead in prioritising the backlog.
      - Scrum master: A team coach manages the team's Scrum implementation, conducting meetings to review progress and plan forthcoming tasks collectively. They take the lead during sprint planning sessions.
      - Technical Lead: The team member in charge of Version Control implementation manages the repository, guarantees correct branch management and commenting, leads the effort to find and communicate appropriate design patterns, and ensures codebase quality.
      - Client Liaison: The team member in charge of arranging client meetings organises the sessions, takes detailed notes, and acts as the principal connection for the client.

   b. **Establish Communication Channels:**
      - Choose appropriate communication tools and platforms for facilitating collaboration and information sharing among team members and stakeholders. Consider options such as email, project management software, video conferencing, and instant messaging.
      - Establish communication protocols, including frequency of updates, meeting schedules, and channels for reporting progress, issues, and concerns. Ensure that communication is clear, transparent, and accessible to all team members.
      - Bi-weekly project meetings are scheduled using video conferencing tools to discuss progress, challenges, and action items. Additionally, a project management platform like Teamhood is utilized for task assignment and tracking.

   c. **Set Realistic Goals and Milestones:**
      - Clearly define the overarching goals and objectives of the project, ensuring they are aligned with stakeholder expectations and project requirements.

- Divide the project into smaller, manageable tasks and subtasks, each with its own specific deliverables and deadlines. Establish milestones to track progress and measure achievement.
- Example: The main objective of the project is to develop an ARVR learning application for automotive engineering education. Milestones include completing the design phase, developing the prototype, conducting user testing, and finalizing documentation.

d. Create a Detailed Project Schedule:

- Map out a detailed project timeline that outlines the sequence of tasks, dependencies, durations, and deadlines. Allocate resources and estimate effort required for each task to ensure realistic scheduling.
- Utilize project management software or tools to create and visualize the project schedule, track progress, and manage resources effectively. Ensure that the schedule is regularly updated and communicated to all stakeholders.
- The project schedule includes tasks such as requirements gathering, design iteration, development sprints, testing phases, and documentation review. Each task is assigned a duration, and dependencies are identified to optimize workflow.

3. Research and Exploration Phase:

Duration: 9/10/2023 – 11/10/2023

- This phase involves conducting thorough research on ARVR technologies, exploring industry trends, and identifying best practices. Market research is conducted to assess available hardware and software options, as well as potential challenges and opportunities.

a. Thorough Research on ARVR Technologies:

- Conduct an extensive study on Augmented Reality (AR) and Virtual Reality (VR) technology, including recent advances, upcoming trends, and innovative applications. Maintain constant awareness of the most recent innovations in hardware, software, and immersive experiences in this dynamic arena, which will be incorporated into the upcoming report.
- Research various ARVR devices such as headsets, motion controllers, and haptic feedback devices. Explore the capabilities of platforms like Unity or Unreal Engine for ARVR development.

b. Identify Industry Trends:

- Examine the use of AR/VR technologies in many industries, including education, healthcare, gaming, and manufacturing. Identify common trends, define critical use cases, and highlight success stories relevant to the project's objectives.

- Analyse case studies of ARVR implementations in automotive engineering education or training programs. Identify best practices and lessons learned from similar projects.

c. Assess Hardware and Software Options:

- Assess the hardware and software options available for ARVR development, considering factors such as compatibility, features, performance, and cost-effectiveness.
- Compare different VR headsets (e.g., Oculus Rift, HTC Vive, or Microsoft HoloLens) in terms of display quality, tracking accuracy, ergonomic design, and price. Evaluate software platforms like Unity or Unreal Engine for creating immersive experiences.
- Goggle-free technology: Though traditional goggles have long been a vital component of immersive experiences, their discomfort and potential adverse effects on eyesight have prompted the exploration of goggle-free AR/VR endeavours.

d. Explore Potential Challenges and Opportunities:

- Anticipate challenges and obstacles that may arise during the project, such as technical constraints, compatibility issues, or resource limitations. Evaluate strategies for overcoming these challenges.

i. Cost and Specialized Equipment:

- Immersive technologies such as Augmented Reality (AR) and Virtual Reality (VR) usually require specialised hardware, such as headsets, controllers, and sensors, which can be costly. This financial commitment may be a significant barrier to entry, particularly for students or educational institutions operating within tight financial constraints.
- Example: High-quality VR headsets like Oculus Rift or HTC Vive can be expensive, making it challenging for schools or individuals with tight budgets to afford them. Additionally, the need for powerful computers to run VR applications further adds to the cost.(Helou, 2022)

ii. Content Development Challenges:

- Developing high-quality immersive content for ARVR experiences requires specialized skills, time, and resources. Designing realistic 3D models, creating interactive environments, and programming complex interactions can be labour-intensive and may require collaboration with experienced developers and designers.
- Example: Building an immersive learning experience for automotive engineering may involve creating detailed 3D models of car engine components, designing interactive simulations for hands-on learning,

and programming realistic physics simulations to mimic real-world behaviours.

iii. **Motion Sickness Concerns:**

- Motion sickness or discomfort in virtual environments is a common issue experienced by some users when using immersive technologies. Factors such as latency, frame rate, field of view, and motion tracking accuracy can contribute to motion sickness symptoms like nausea, dizziness, or eye strain.
- Example: VR experiences can cause motion sickness due to quick movements, abrupt alterations in perspective, or mismatches between visual and vestibular cues. Users sensitive to motion may find it challenging to engage with immersive content for long periods. (Conner, 2022)

Addressing Accessibility Challenges:

a. **Cost Mitigation Measures:**

- Explore options for cost-effective immersive solutions, such as standalone VR headsets or mobile-based AR applications that leverage existing smartphones or tablets.
- Consider alternative approaches such as web-based AR experiences or low-cost VR cardboard viewers that offer basic immersion at a fraction of the cost.

b. **Collaboration and Resource Sharing:**

- Foster collaboration among educational institutions, industry partners, and technology providers to share resources, expertise, and best practices in immersive content development. Establish community-driven initiatives or open-source projects aimed at creating and sharing immersive educational content that is accessible to a wide audience.

c. **User Comfort and Experience Design:**

- Prioritize user comfort and well-being in immersive experience design by optimizing content for comfort, minimizing motion sickness triggers, and providing user-friendly interfaces.
- Incorporate options for adjustable settings, such as field of view adjustments, comfort modes, and motion smoothing techniques, to accommodate users with different comfort levels and preferences.

4. **Collaboration with Siliconmax ARVR:**

Duration: 27/9/2023 – 30/3/2024

- Collaboration with the client, Siliconmax ARVR, is integral to this phase. Through discussions and demonstrations, valuable insights are gained into innovative ARVR applications and best practices. Siliconmax ARVR's expertise guides the development of 3D models and informs the overall project direction.

a. **Establishing Collaboration Framework:**
   - Define the scope and objectives of the collaboration with Siliconmax ARVR, including the goals, expectations, and deliverables to be achieved during this phase. Initiate preliminary negotiations with Siliconmax ARVR to clarify project needs, set timetables, and explore areas for mutual collaboration. Establish clear communication channels and protocols to ensure continuous updates and feedback throughout the collaboration process.

b. **Demonstration and Exploration:**
   - Participate in live demonstrations and exploratory sessions with Siliconmax ARVR to gain direct knowledge of ARVR technology and its potential applications.
   - Example: Visit Siliconmax ARVR's facilities or attend virtual demonstrations where the project team can interact with ARVR hardware and software solutions. Explore immersive experiences and learn how they can be adapted for educational purposes in automotive engineering.

c. **Guidance on 3D Model Development:**
   - Collaborate with Siliconmax ARVR experts to develop high-quality 3D models of car engine components and other relevant assets for the ARVR learning application.
   - Example: Work closely with Siliconmax ARVR's 3D modelling team to create detailed and accurate representations of car engine parts using industry-standard tools and techniques. Incorporate feedback and suggestions from Siliconmax ARVR to ensure the models meet the project requirements and standards.

d. **Informing Project Direction:**
   - Utilize Siliconmax ARVR's expertise and insights to inform the overall direction and strategy of the project, including technology selection, feature prioritization, and user experience design.
   - Example: Consult with Siliconmax ARVR on key decisions related to ARVR platform selection, content development priorities, and implementation strategies. Incorporate recommendations and best practices from Siliconmax ARVR to optimize the project's outcomes and impact.

e. **Regular Collaboration Meetings:**
   - Schedule regular collaboration meetings with Siliconmax ARVR to review progress, discuss challenges, and align on project priorities and next steps.

- Conduct weekly or bi-weekly meetings with Siliconmax ARVR stakeholders to provide updates on project progress, share insights, and address any issues or concerns. Use these meetings as opportunities for collaborative problem-solving and decision-making.

By collaborating closely with Siliconmax ARVR during this phase, the project team can leverage their expertise and resources to accelerate the development of the ARVR learning application for automotive engineering education. This collaboration ensures that the project benefits from industry insights, best practices, and innovative solutions, ultimately enhancing its quality and impact.

5. **Development Phase:**
   Duration: 11/3/2023 – 24/4/2024
   - This phase focuses on translating concepts and ideas into tangible products. The ARVR learning application prototype is developed, incorporating feedback from stakeholders and usability testing. Detailed 3D models of car engine components are designed, ensuring accuracy and realism.

   a. Translating Concepts into Products:
      - Utilize the insights gained from the previous phases, including market research, collaboration with Siliconmax ARVR, and feedback from stakeholders, to inform the development process.
      - Begin by reviewing the project requirements, user stories, and design specifications to ensure alignment with the project objectives and stakeholders' expectations.

   b. ARVR Application Development:
      - Develop the ARVR learning application prototype using appropriate programming languages, frameworks, and development tools. Implement features and functionalities that facilitate immersive learning experiences and user engagement.
      - Developers utilize programming languages such as C#, C++, or JavaScript, along with ARVR development platforms like Unity or Unreal Engine, to build the application. They integrate interactive elements, user interfaces, and 3D assets to create a compelling learning environment.

   c. Iterative Feedback and Testing:
      - Incorporate feedback from stakeholders, including educators, students, and industry professionals, throughout the development process. Conduct usability testing sessions to gather insights into user interactions and preferences. Organize user testing sessions where participants interact with the ARVR application prototype and provide feedback on usability,

navigation, content clarity, and overall user experience. Iteratively refine the application based on feedback and testing results.

d. Designing 3D Models:
   - Create detailed and accurate 3D models of car engine components using 3D modelling software such as Blender. Ensure that the models are realistic, visually appealing, and optimized for performance. Our technical lead collaborates with subject matter experts and refer to technical specifications and reference materials to create 3D models of engine parts. They pay attention to details such as dimensions, textures, and material properties to enhance realism.

e. Integration and Optimization:
   - Integrate the 3D models of car engine components into the ARVR application, ensuring seamless interaction and visualization. Optimize the performance of the application to ensure smooth rendering and responsiveness across different devices.
   - Technical lead imports the 3D models into the ARVR development environment and implement mechanisms for user interaction, such as object manipulation, zooming, and highlighting.

f. Quality Assurance and Bug Fixing:
   - Conduct thorough quality assurance testing to identify and address any bugs, glitches, or usability issues in the ARVR application. Ensure that the application meets quality standards and performance requirements.
   - Testers perform functional testing, compatibility testing, and performance testing to validate the application's functionality, compatibility with different devices, and performance under various conditions. They document and prioritize identified issues for resolution by the development team.

By meticulously executing the Development Phase, the project team brings the ARVR learning application prototype to life, incorporating immersive experiences and accurate 3D models of car engine components. This phase lays the foundation for the subsequent testing, refinement, and deployment stages of the project.

6. **Documentation and Reporting:**

Duration: 1/4/2024 – 15/4/2024

During the Documentation and Reporting phase, the project team focuses on documenting the project's journey, outcomes, and deliverables in a comprehensive manner.

a. Prepare Project Report:
   - Compile a detailed project report that summarizes key findings, insights, achievements, and lessons learned throughout the project lifecycle. Include information on project objectives, methodologies, results, and conclusions.

b. Document Achievements and Deliverables:
   - Describe the project's achievements, including the development of the ARVR learning application prototype, creation of 3D models, successful collaboration with stakeholders, and any innovative solutions implemented.
   - Provide an overview of the ARVR application's features, functionalities, and user interface design. Showcase screenshots, videos, or demonstrations to illustrate the application's capabilities and impact.

c. Create User Manuals and Technical Documentation:
   - Create user manuals and technical documentation to guide users on how to use the ARVR learning application effectively. Provide step-by-step instructions, tips, and troubleshooting guidance.
   - Example: Prepare user manuals that explain how to navigate the ARVR application, interact with 3D models, access educational content, and customize settings. Include screenshots, diagrams, or illustrations to enhance clarity and comprehension.

d. Ensure Compliance and Accessibility:
   - Ensure that the documentation complies with relevant standards, guidelines, and regulations, including accessibility requirements. Make the documentation accessible to all users by following industry best practices for documentation design and accessibility, such as using clear language, consistent formatting, and descriptive alt text for images.

e. Review and Finalize Documentation:
   - Conduct thorough reviews of the documentation to ensure accuracy, completeness, and consistency. Incorporate feedback from stakeholders, subject matter experts, and project team members. Organize review sessions where stakeholders and project team members can provide feedback on the documentation. Address any identified issues, clarify ambiguities, and make necessary revisions before finalizing the documentation.

d) Client Management

Author: Lim Hon Sheang, Danny Chan Yi Xiang

Effective client management relies on clear and efficient communication strategies to ensure alignment, transparency, and collaboration throughout the project.

1. Communication Channels:
   a. Internal Team Communication:
      - Utilize Whatsapp as a central communication platform for project updates, queries, and informal discussions among team members. Create dedicated channels for different project aspects or teams to streamline communication.

   b. **Project Updates and Announcements:**
      - While email remains the primary channel for formal project updates and announcements, WhatsApp can complement this by providing a more immediate and informal communication channel.
      - We create dedicated WhatsApp groups for project updates and announcements, where team members can receive timely notifications about milestone achievements, deadline reminders, or changes to project scope.
      - It is to ensure that project updates shared on WhatsApp are concise, relevant, and aligned with the content shared via email. This helps maintain consistency in communication across different channels and ensures that all team members stay informed of progress and changes in direction.

   c. **Informal Discussions and Brainstorming:**
      - WhatsApp groups can serve as virtual meeting rooms for informal discussions and brainstorming sessions that don't require immediate attention or real-time collaboration. It could encourage team members to share ideas, insights, and suggestions through WhatsApp threads, allowing for asynchronous collaboration and input from all team members. Also, foster a collaborative and inclusive environment where team members feel comfortable expressing their thoughts and contributing to discussions, regardless of their location or time zone.

   d. **Regular WhatsApp Updates:**
      - Schedule regular WhatsApp updates or announcements to recap project progress, highlight achievements, and share important reminders or announcements. Keep these updates brief and focused to ensure that they are read and absorbed by team members amidst their busy schedules.
      - Leverage multimedia elements such as images, videos, or voice messages to make updates more engaging and visually appealing but ensure that they are relevant and add value to the communication.

e. **Document Sharing and Collaboration:**
   - WhatsApp also supports document sharing and collaboration, allowing team members to share files, documents, or links related to the project.
   - Encourage team members to use WhatsApp and OneDrive to share relevant project documents, reports, or resources, ensuring that everyone has access to the latest information and materials.
   - Establish guidelines for document sharing on WhatsApp to maintain data security and confidentiality, especially when sharing sensitive or proprietary information.

2. Weekly Team Meetings:
   - Conduct weekly team meetings to discuss project progress, challenges, and action items. Use video conferencing tools like Zoom or Microsoft Teams for virtual meetings or gather in-person for face-to-face discussions when feasible. Weekly team meetings serve as an opportunity for the entire team to come together, discuss project progress, share updates, and address any challenges or blockers. These meetings foster team cohesion, alignment, and accountability. Whether conducted virtually or in person, they provide a forum for open dialogue, brainstorming, and problem-solving.

   a. **Alignment and Cohesion**:
      - Weekly team meetings serve as a regular touchpoint for all team members to come together and align on project objectives, priorities, and timelines. This helps ensure that everyone is on the same page and working towards common goals. By fostering a sense of cohesion and unity, these meetings strengthen team bonds and promote a shared understanding of the project's purpose and direction.

   b. **Project Progress Updates**:
      - During these meetings, team members could provide updates on their individual tasks, share progress made since the last meeting, and discuss any challenges encountered. This enables the team to track overall project progress, identify areas where additional support may be needed, and make informed decisions to keep the project on track.

   c. **Problem-Solving and Decision-Making**:
      - Weekly team meetings provide a dedicated forum for problem-solving and decision-making. Team members can brainstorm solutions to challenges, discuss different perspectives, and collectively address issues that may arise. By leveraging the diverse expertise and experiences of team members, these meetings facilitate the generation of creative solutions and help overcome obstacles more effectively.

d. **Accountability and Responsibility**:
   - Regular team meetings help reinforce a culture of accountability and responsibility within the team. By openly discussing progress and challenges, team members take ownership of their tasks and commitments. This promotes a sense of accountability towards the team's collective goals and encourages individuals to meet their deadlines and deliverables consistently.

e. **Virtual vs. In-Person Meetings**:
   - In today's increasingly remote work environment, the choice between virtual and in-person meetings depends on factors such as team location, accessibility, and preferences. Virtual meetings conducted via platforms like Zoom or Microsoft Teams offer flexibility and convenience, allowing team members to participate from anywhere with an internet connection. In-person meetings, when feasible and safe, provide opportunities for more personal interaction, relationship-building, and non-verbal communication cues that can enhance team dynamics.

3. Stakeholder Updates:
   Bi-weekly Project Progress Updates: Schedule bi-weekly project progress updates for stakeholders through online video conferences or physical meetings. Provide detailed reports on project milestones, achievements, risks, and upcoming activities to keep stakeholders informed and engaged. Bi-weekly project progress updates are essential for keeping stakeholders informed and engaged in the project. These updates can be delivered through online video conferences or physical meetings, depending on stakeholders' preferences and availability. Presenting comprehensive reports that highlight key milestones achieved, risks identified, and upcoming activities helps maintain transparency and manage stakeholders' expectations effectively.

a. **Scheduling and Frequency**:
   - Bi-weekly project progress updates scheduled at regular intervals to provide stakeholders with consistent updates on the project's status. These updates ensure that stakeholders remain informed without overwhelming them with too frequent communications. Also, must determine the most suitable timing for these updates based on stakeholders' availability and preferences by considering factors such as time zones, work schedules, and other commitments to maximize attendance and participation.

b. **Communication Medium**:
   - We choose a communication medium that accommodates stakeholders' preferences and facilitates effective engagement. Options include online video conferences, conference calls, or physical meetings, depending on

stakeholders' availability and the nature of the project. Online video conferences offer the flexibility to engage stakeholders remotely, allowing for real-time interaction and visual presentations while physical meetings provide opportunities for face-to-face communication and relationship-building, and most of the time is about the training that client gave us on the project.

c. **Content of Updates**:
   - Generate detailed reports on project milestones, achievements, risks, and forthcoming activities to present stakeholders with an overview of progress. Highlight significant accomplishments and milestones from the previous report, exhibiting actual progress and outcomes. Identify any emerging risks or obstacles and develop mitigation methods or contingency plans. To manage stakeholder expectations and ensure alignment, provide updates on anticipated activities, deliverables, and milestones for the next reporting period.

d. **Maintaining Transparency and Engagement**:
   - Transparency is essential in stakeholder updates to build trust and confidence in the project's progress. It ensures that the information shared is accurate, relevant, and easily understandable for stakeholders. Moreover, encourage active participation and engagement from stakeholders by inviting questions, feedback, and suggestions during the update sessions. Also, to create a supportive environment where stakeholders feel comfortable sharing their insights and concerns with us and our project.

e. **Documentation and Follow-Up**:
   - Document the key points discussed, and decisions made during the stakeholder updates for reference and follow-up. Distribute meeting minutes or summary reports to stakeholders right after every meeting through email to ensure alignment and accountability. While we will follow up on any action items or outstanding issues raised during the update session, assigning responsibilities, and setting deadlines as needed and keep stakeholders informed of progress on these items in subsequent updates.

4. Document Sharing and Collaboration:

a. **OneDrive for Document Sharing**:
   - OneDrive serves as a centralized repository for storing, organizing, and sharing project documents, ensuring easy access and collaboration among team members.

- Using the OneDrive's document management capabilities to create structured folders and libraries for storing project documents, 3D models, animations, and other relevant materials.
- Implement version control mechanisms to track changes and revisions to documents, ensuring that team members always have access to the latest versions.
- Apply access permissions and security settings to control who can view, edit, or modify documents, safeguarding sensitive information and maintaining data integrity.

b. **Teamhood for Progress Tracking**:

- Teamhood offers a comprehensive project management solution for tracking project progress, managing tasks, and visualizing workflow. We use Teamhood's Kanban boards to visualize tasks and workflows, allowing team members to track progress, prioritize work, and identify bottlenecks or blockers. It could employ Gantt charts to create project timelines, set milestones, and monitor task dependencies, providing a visual representation of project progress and deadlines. We can customize dashboards and reporting features to provide stakeholders with real-time insights into project metrics, performance indicators, and resource allocation.

5. Feedback Mechanisms:
   Open Communication Channels:
   Maintain open communication channels, such as email, to encourage continuous feedback and suggestions from both team members and stakeholders. Actively solicit input on project deliverables, processes, and improvements to foster a culture of collaboration and continuous improvement. By fostering a culture of constructive feedback and collaboration, teams can identify opportunities for improvement, address issues proactively, and continuously enhance project outcomes.

   a. Dedicated Feedback Channels:

   - Establish dedicated communication channels, such as email threads, specifically designated for sharing feedback, suggestions, and concerns related to the project. These channels provide a structured platform for team members and stakeholders to communicate their thoughts in an organized manner.

   b. Encouraging Participation:

   - Actively encourage participation from all team members and stakeholders in providing feedback. Emphasize the importance of their input in shaping the project's direction and improving outcomes. Create a supportive environment where individuals feel empowered to share their perspectives without fear of judgment or reprisal.

c. Prompt Response:
   - Ensure timely responses to feedback received, acknowledging receipt and expressing appreciation for contributions. This demonstrates respect for individuals' input and reinforces the importance of their feedback in driving project success.

d. Transparency and Accountability:
   - Maintain transparency in the feedback process by openly addressing feedback received, discussing potential actions or resolutions, and providing updates on outcomes or decisions taken. Hold accountable individuals responsible for implementing changes or addressing concerns raised through feedback.

e. Regular Feedback Cycles:
   - Establish regular feedback cycles throughout the project lifecycle, ensuring that opportunities for feedback are not limited to specific phases or milestones. Solicit feedback at key junctures, such as after the completion of deliverables, milestone achievements, or project meetings.

3. Detailed System Design

a) Prototype Screenshot

Author: Lim Hon Sheang

Link to the demo video: https://youtu.be/qu3N-huEaFM

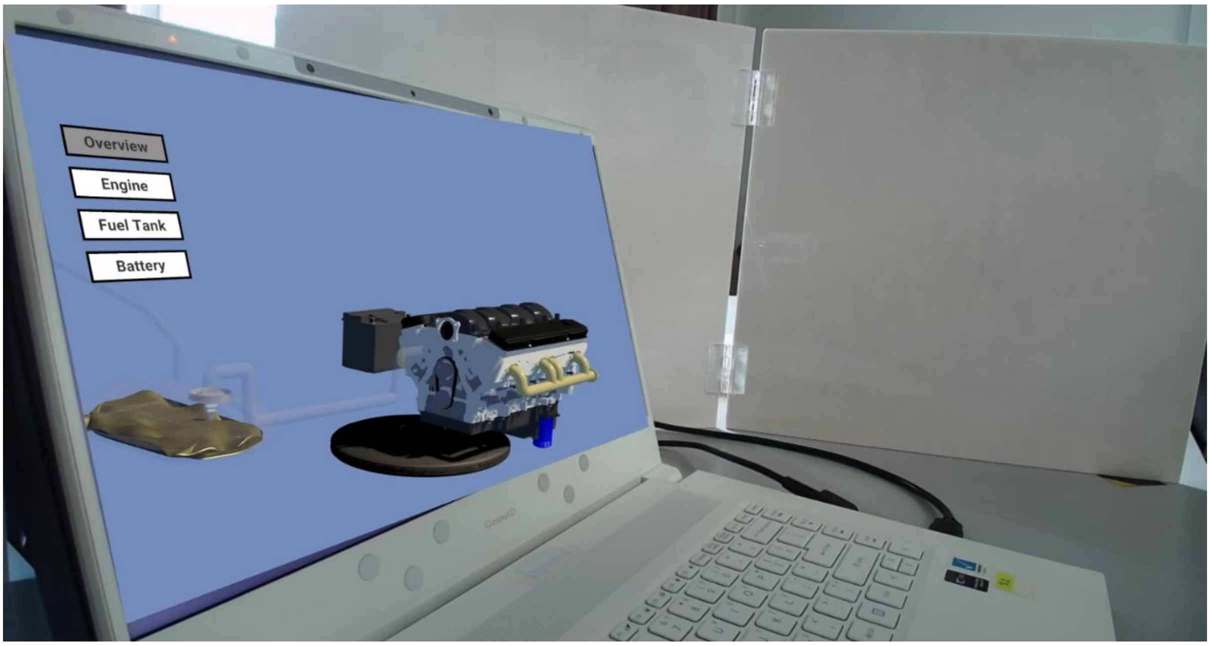


Figure 2.0: Overview model

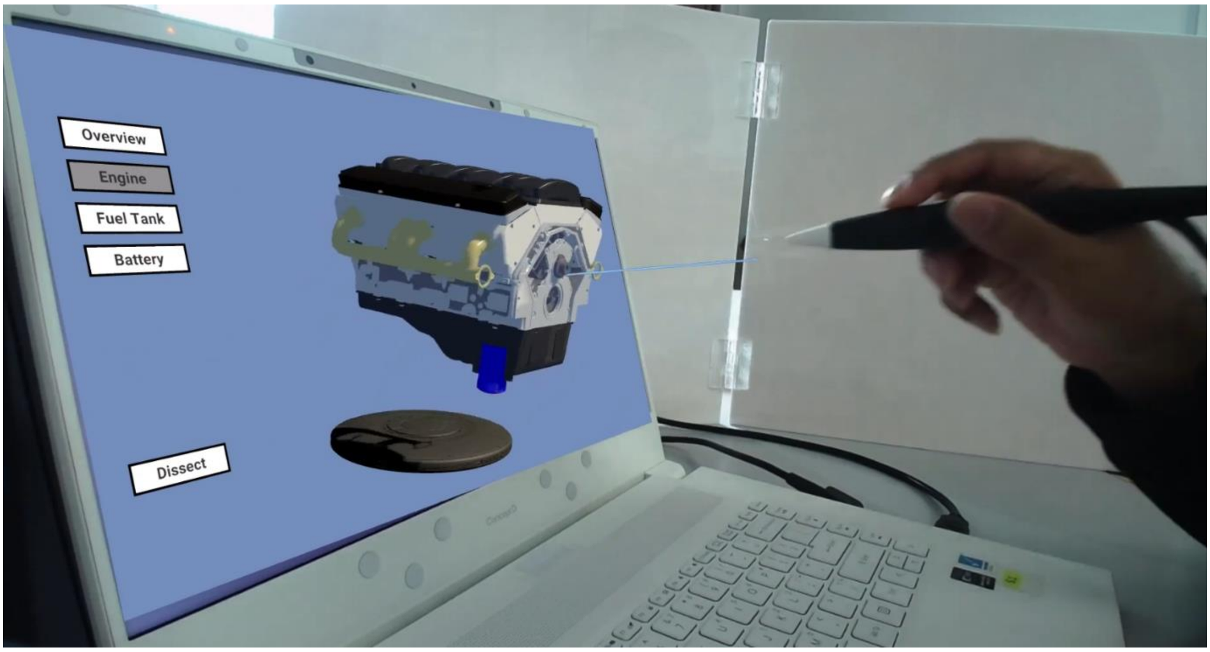


Figure 2.1: Engine model

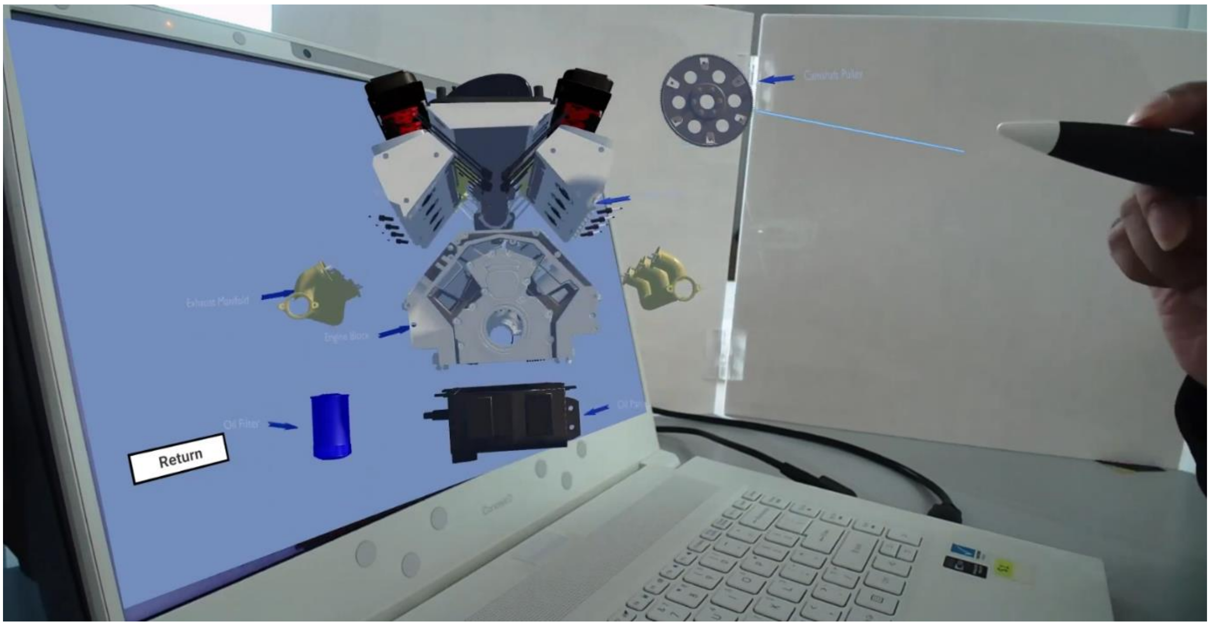


Figure 2.2: Dismantle view of car engine

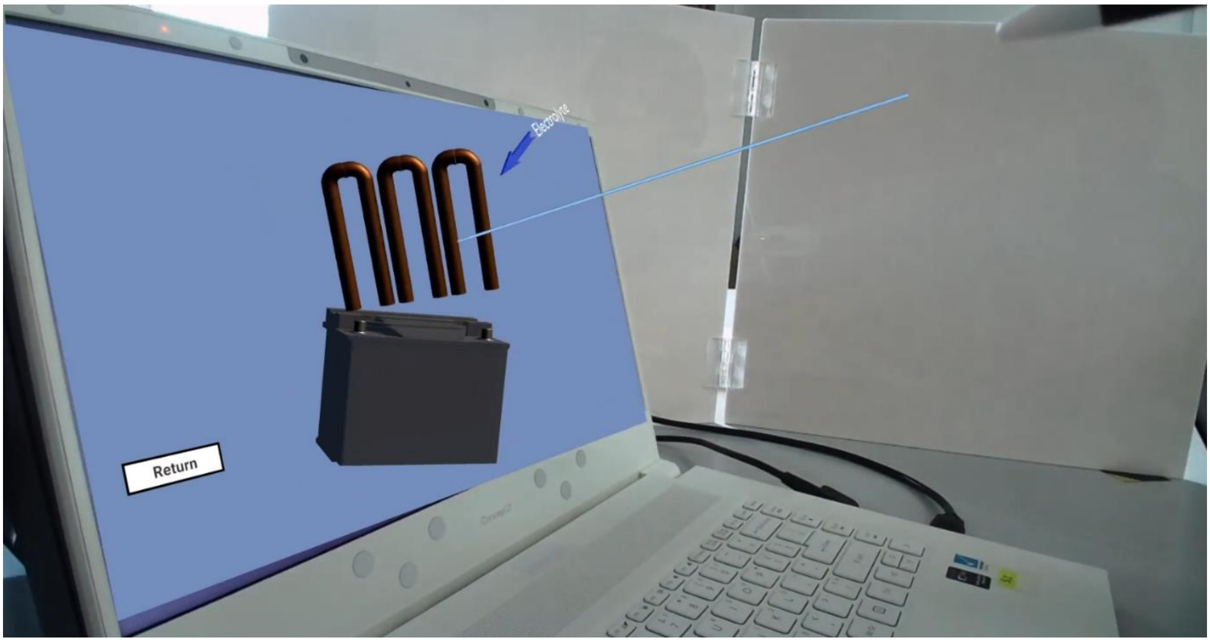


Figure 2.3: Battery view (Dismantle)

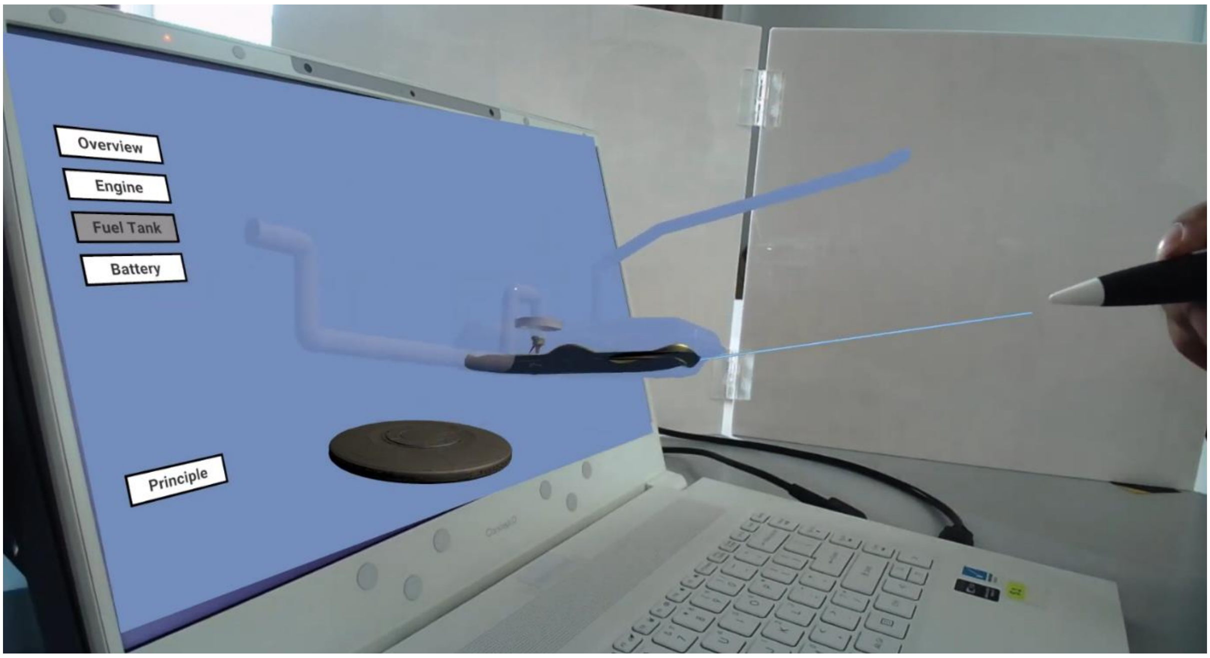


Figure 2.4: Fuel model

b) User Story

Author: Danny Chan Yi Xiang

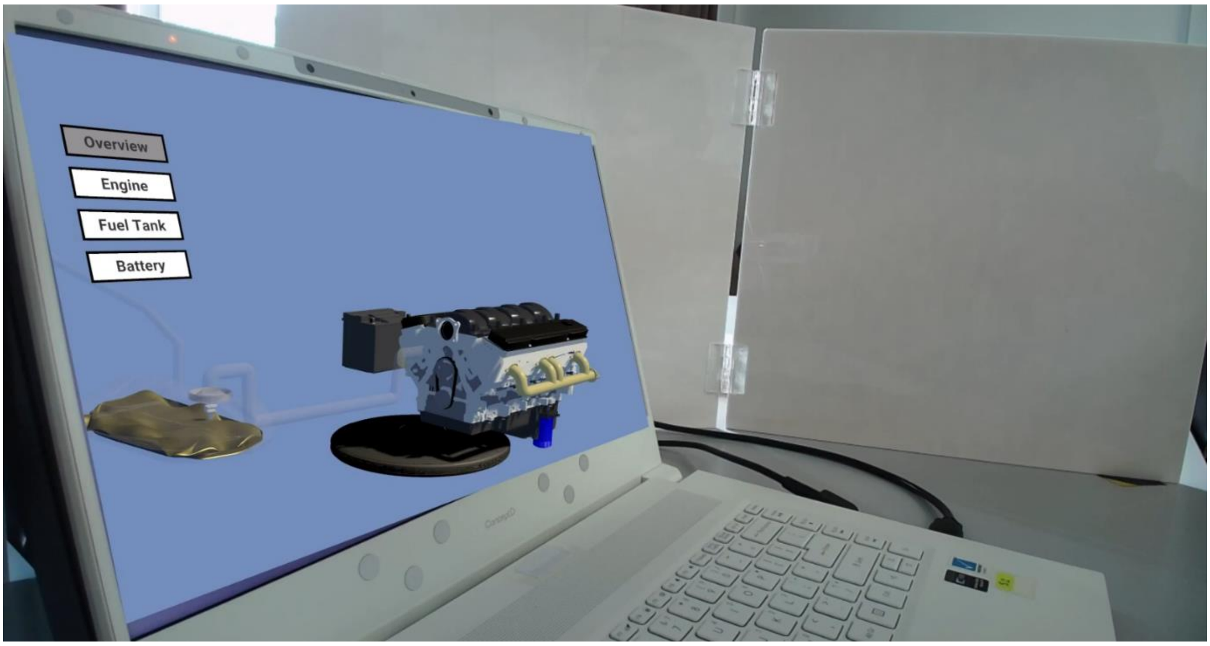


Figure 3.0: Overview model

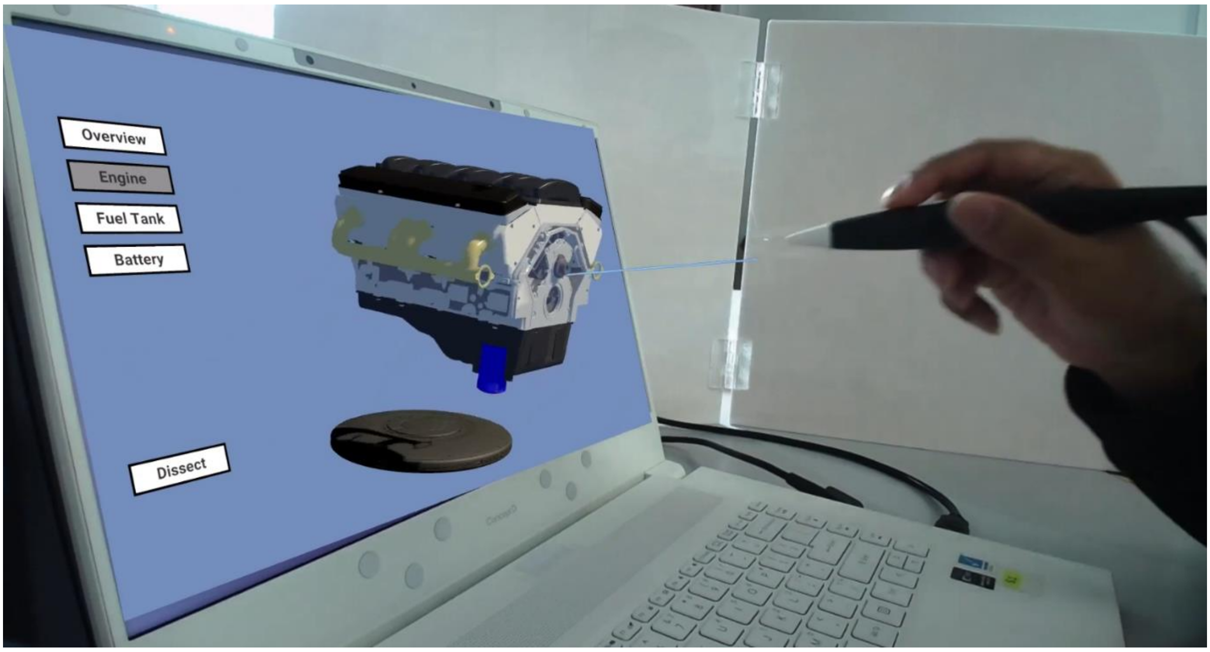


Figure 3.1: Car engine model

The final product of our AR/VR prototype project is depicted in Figure 3.0 and Figure 3.1. These images showcase models presented via a camera, enabling users to observe them in a 3D view. Users can interact with the models by dragging and editing them using a stylus pen, enhancing the immersive experience. The diagram above illustrates the primary layout of our application, encompassing components such as the engine, fuel tank, and battery. Users can examine the entire model layout before selecting specific parts for closer inspection. The diagrams demonstrate a user selecting the engine model specifically, with the user seen dragging the engine model from the screen in our perspective. Users can rotate and manipulate the model according to their preferences within this interface, facilitating a customizable viewing experience.

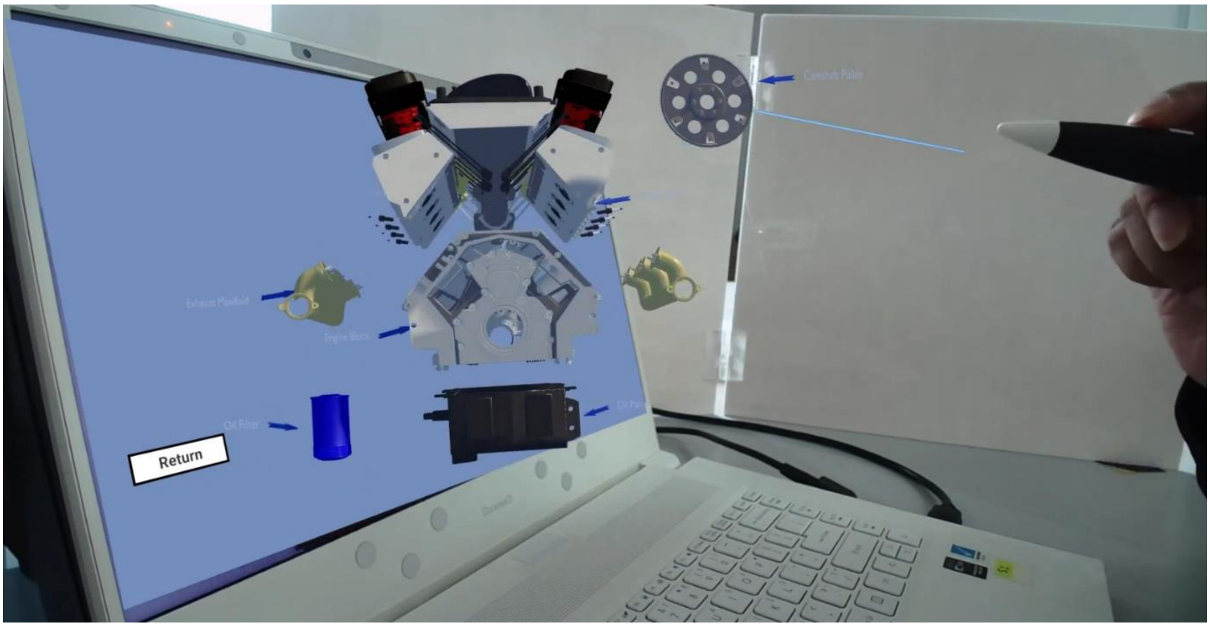


Figure 3.2: Car engine model (Dissect)

In Figure 3.2, users can gain deeper insights into the engine by selecting the "dissect" button. This action enables users to dissect parts of the engine, with each component labelled to facilitate a comprehensive understanding of its functionality. Users can then drag specific parts of the engine from the dissected view and position them anywhere on the screen according to their preferences.

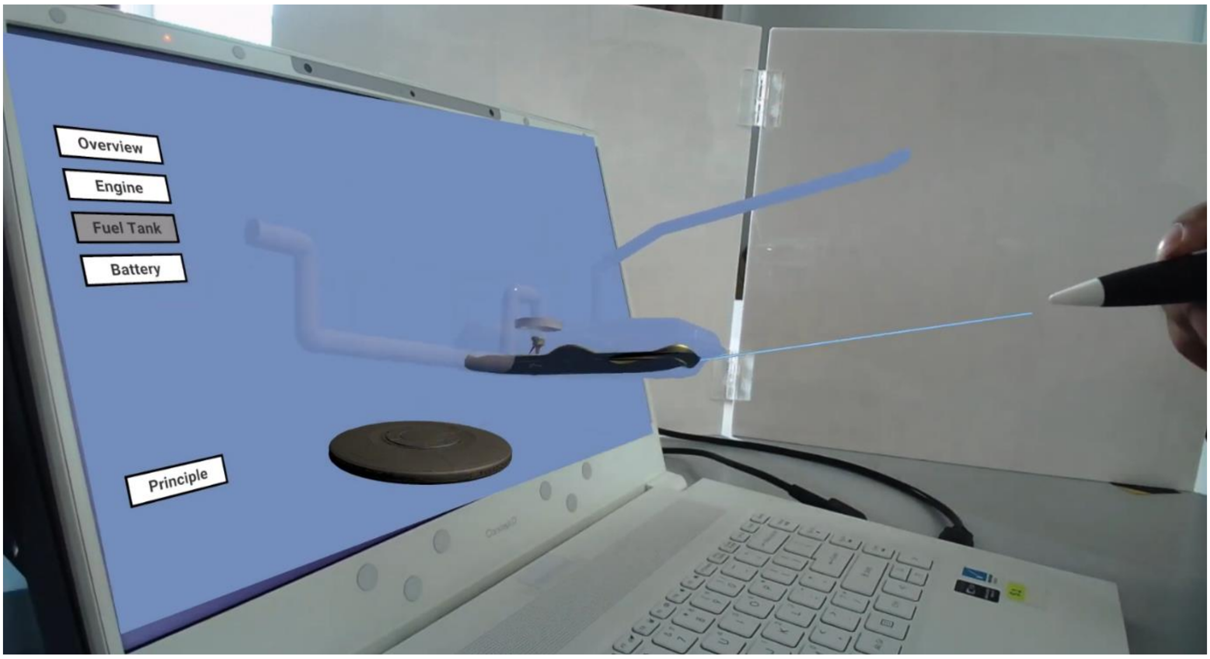


Figure 3.3: Fuel tank model

Figure 3.3 showcases the Fuel tank view, where users can access the complete model of the fuel tank. This model can be manipulated, moved, and rotated to provide users with a clearer view, particularly for educational purposes.

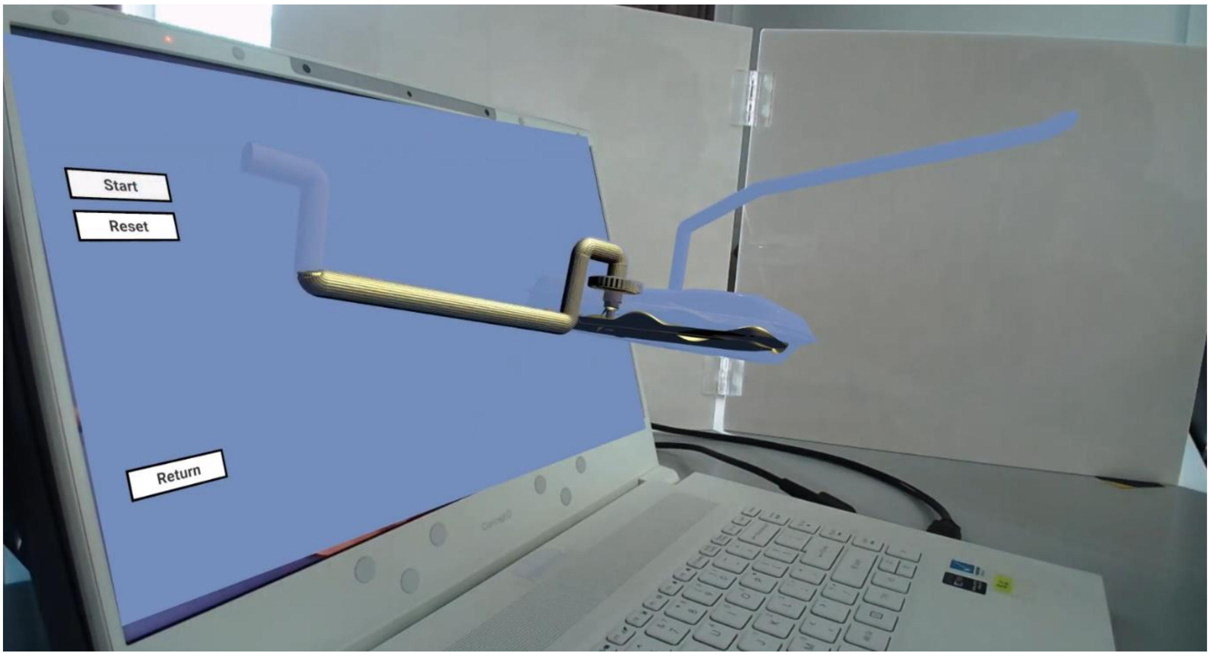


Figure 3.4: Fuel tank (animated)

Figure 3.4 depicts the fuel tank view. Upon clicking on the “principal” option, users are presented with a visual representation of the fuel flow process from the pipe to the engine. This interactive feature allows users to observe the motion of the liquid clearly, providing a detailed insight into the fuel transfer process.

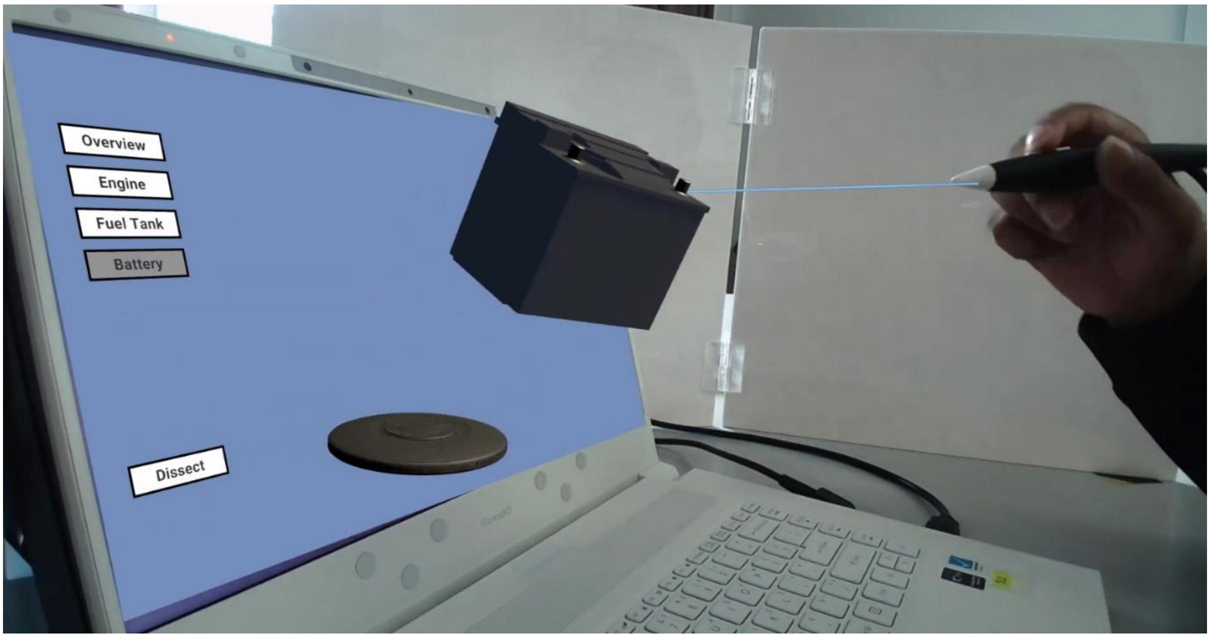


Figure 3.5: Battery model

In Figure 3.5, the battery view offers users a detailed battery layout. Users can drag the battery out for rotation, allowing for a closer examination of its components and structure.

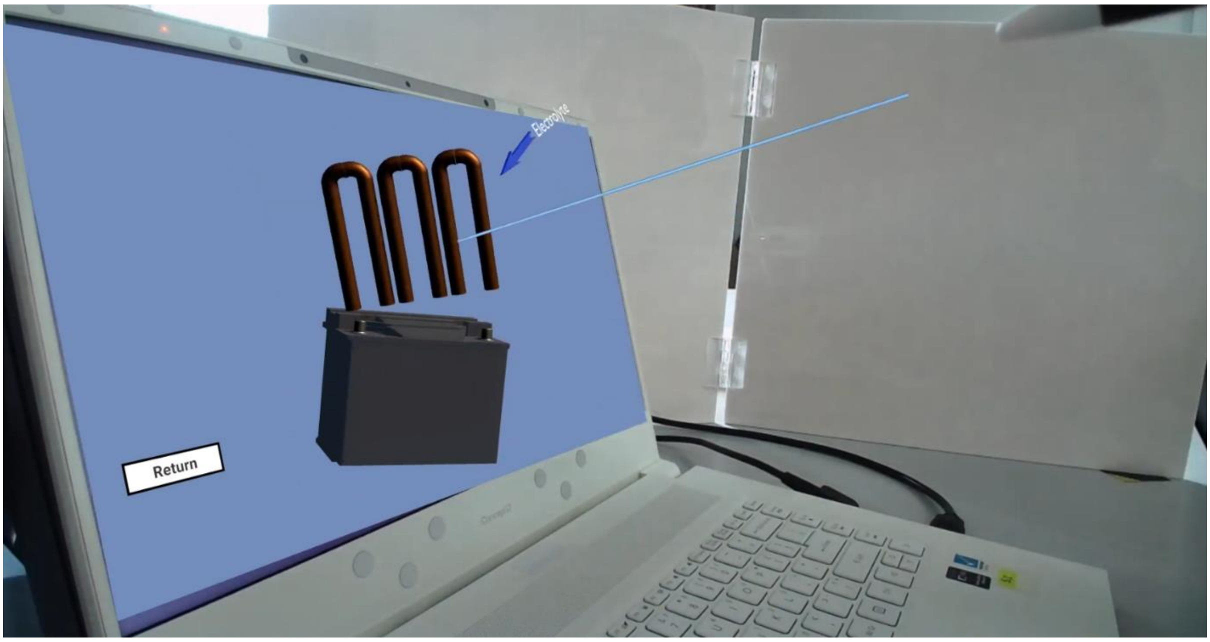


Figure 3.6: Battery model (Dissect)

In Figure 3.6, the Battery model is presented in an animated format. Upon clicking the dissect button, users are presented with the electrolyte of the battery separating from the main body of the battery. Users can interact with the electrolyte using a stylus pen, enabling rotation and dragging for closer examination and exploration.

c) Use Case Diagram

Author: Danny Chan Yi Xiang

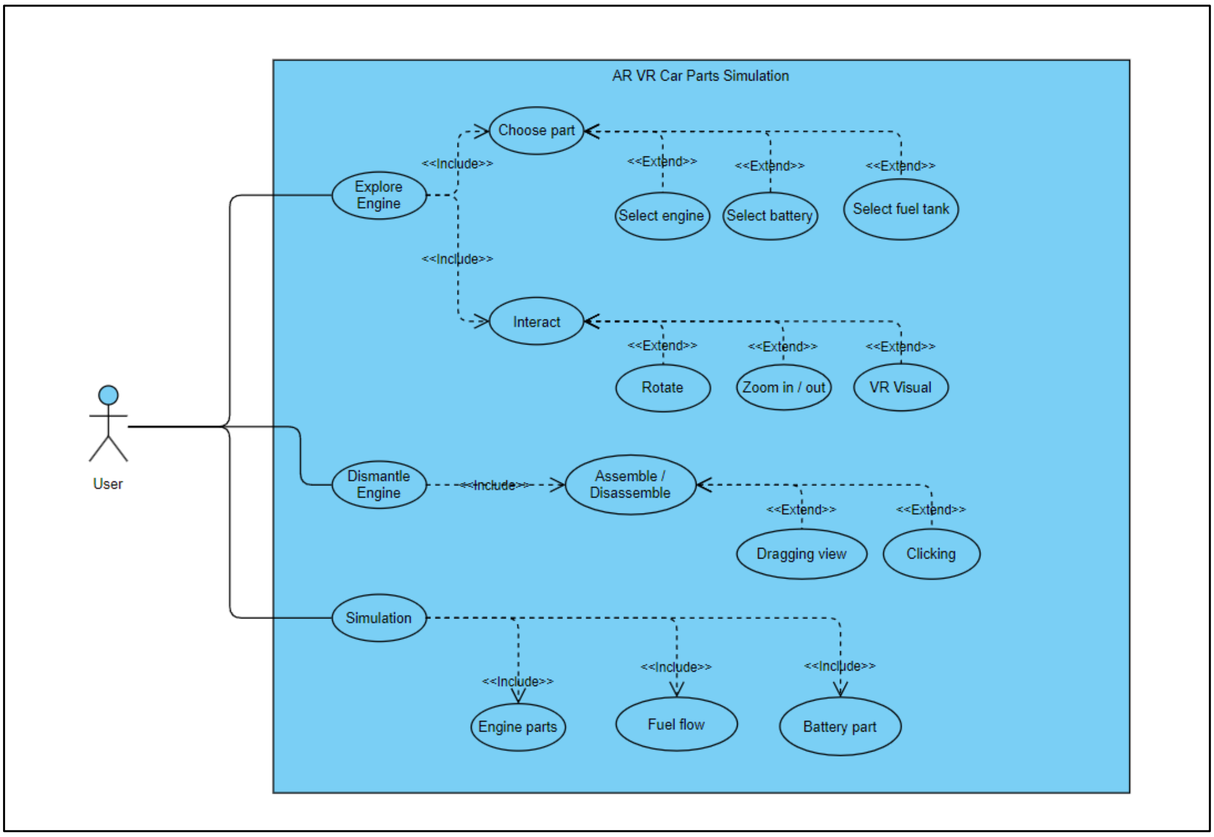


Figure 4.0: Use Case Diagram

In Figure 4.0, the use case diagram illustrates how users can interact with the system. When users explore the engine, they can select a specific part of interest, such as the engine itself, battery, or fuel tank, for closer examination. Following this selection, users can interact with the 3D models by rotating and zooming in or out to gain a better understanding.

Should users desire to dismantle the models for a more detailed view, they can click on the dissect button, prompting the parts of the models to be separated for more precise observation. All parts are draggable and clickable, facilitating interaction via a stylus pen.

For simulation purposes, users can click on the principal button to experience simulations such as fuel flow from the tank to the engine and the assembly of engine components, providing an immersive learning experience.

d) HIPO Chart

Author: Lim Hon Sheang

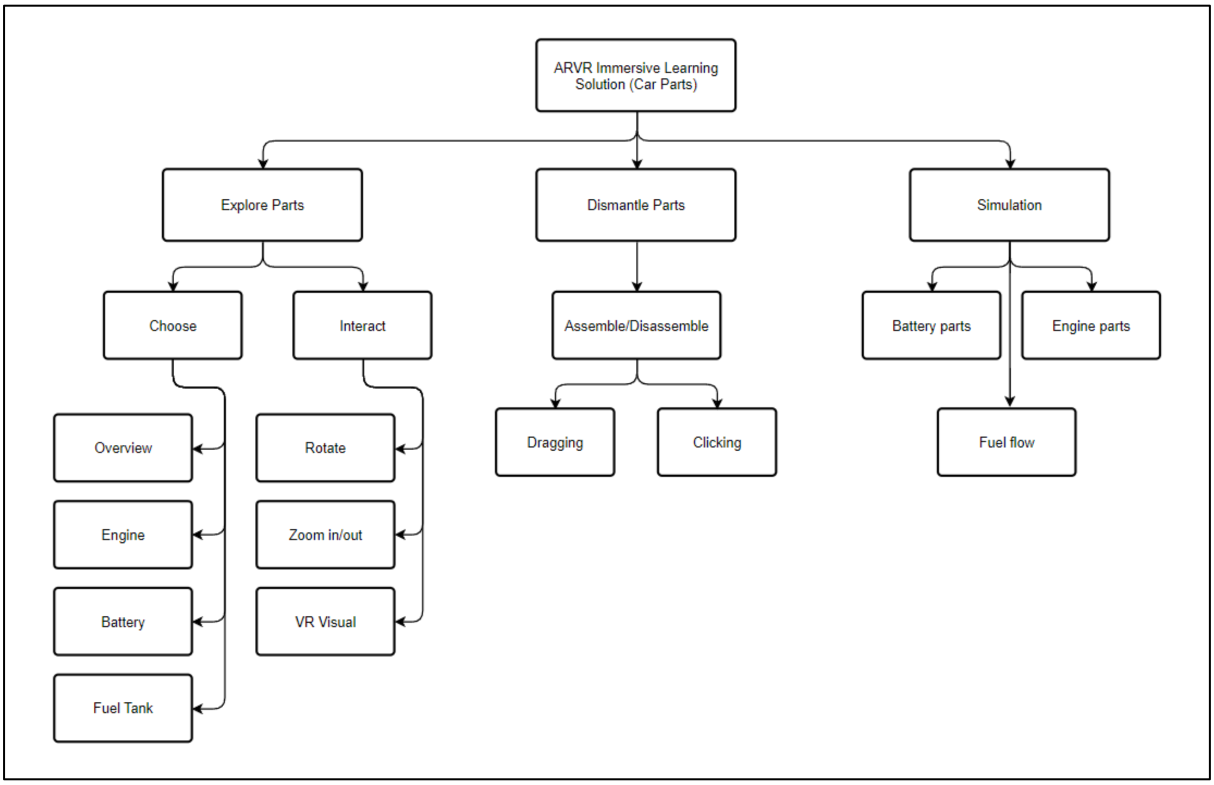


Figure 4.1: HIPO Chart

The HIPO chart provided outlines the structure of an "ARVR Immersive Learning Solution (Car Parts)."

Explore Parts:

- **Choose:** Select between an overview or specific parts like the engine, battery, or fuel tank.
    - **Overview:** Displays all car parts.
    - **Engine:** Focuses on the engine.
    - **Battery:** Focuses on the battery.
    - **Fuel Tank:** Focuses on the fuel tank.
- **Interact:** Engage with car parts by rotating, zooming, or using VR mode.
    - **Rotate:** View parts from different angles.
    - **Zoom:** Adjust the view for closer inspection or wider perspective.
    - **VR Visual:** Experience parts in virtual reality.

Dismantle Parts:

- Assemble or disassemble parts by dragging or clicking.
    - **Dragging:** Move elements to assemble or disassemble.
    - **Clicking:** Use clicks to assemble or disassemble.

Simulation:

- Simulate the functionality of battery parts, engine parts, and fuel flow, each representing different aspects of these components in a simulated environment.

The chart provides a clear sequence for users to navigate the simulation, with labelled arrows indicating the flow and options at each step. It serves as a visual guide for the interactive process within the AR/VR simulation.

e) State Diagram

Author: Lim Hon Sheang

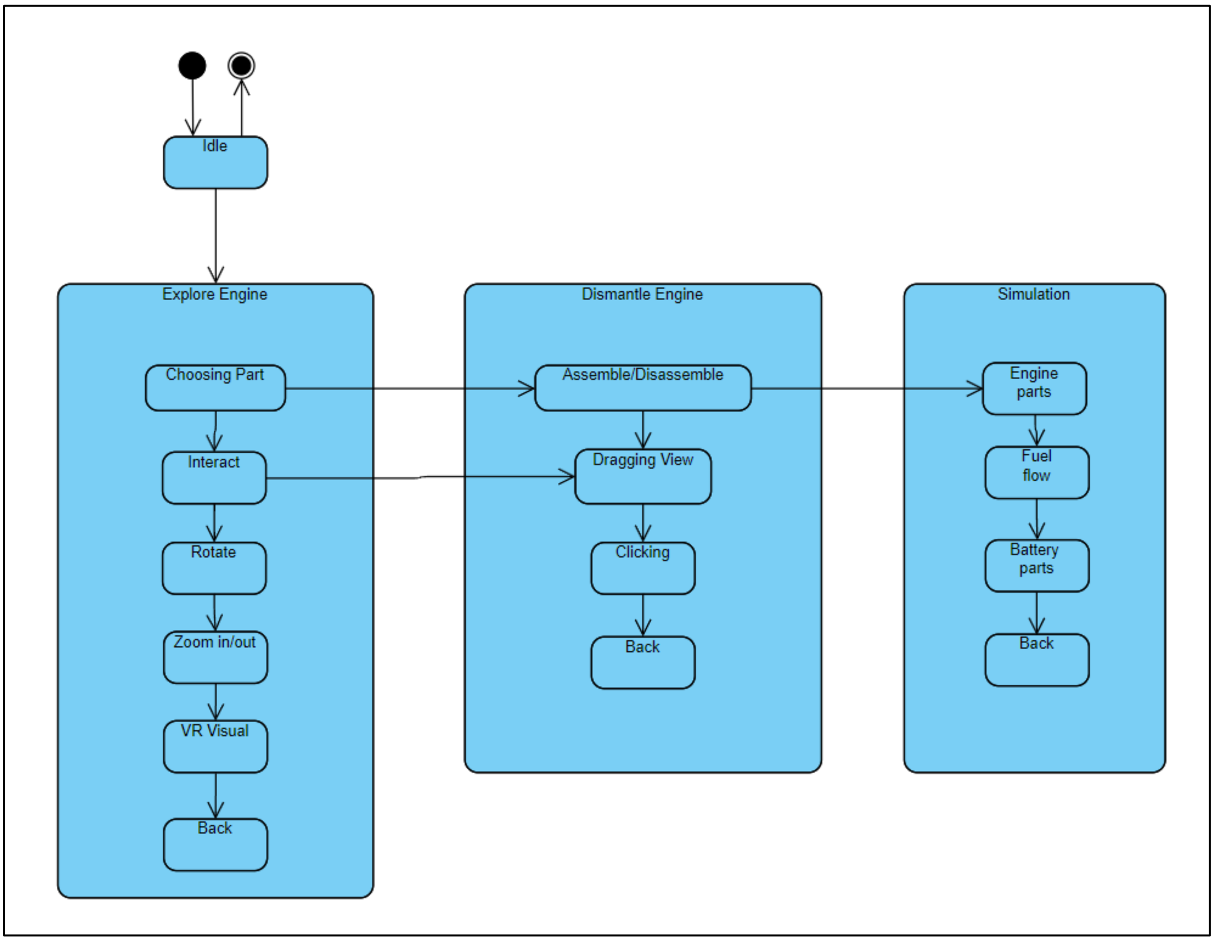


Figure 4.2: State Diagram

Figure 4.2 State Diagram illustrates the interactive process of exploring, dismantling, and simulating engine parts within a virtual environment, emblematic of an AR/VR immersive learning solution for automotive components. By harnessing augmented and virtual reality technologies, users can partake in a hands-on learning journey, navigating through intricate engine components sans the need for physical models. This interactive methodology enriches understanding and retention by furnishing immersive visualizations and simulations, enabling users to grasp intricate concepts more effectively. Furthermore, the solution fosters active participation and exploration, allowing users to engage with virtual objects and witness dynamic animations elucidating the functionality of various engine parts. Ultimately, this solution epitomizes a state-of-the-art educational instrument bridging the chasm between theoretical knowledge and practical application within automotive engineering.

f) Sequence Diagram Flowchart

Author: Danny Chan Yi Xiang

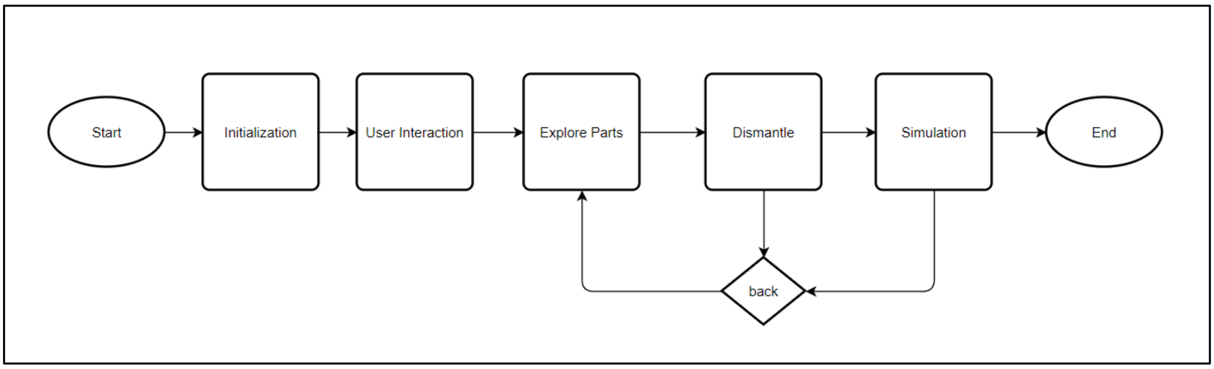


Figure 4.3: Sequence Diagram Flowchart

1. System Startup:
    - The user initiates the system by starting it up. This could involve powering on a device, launching an application, or activating a specific mode.
    - Once the system is up and running, the user gains access to its features and functionalities.
2. Exploring 3D Models:
    - After startup, the user can delve into the 3D models available within the system.
    - These models might represent various objects, structures, or concepts. Users can choose which ones they want to explore further.
3. Interacting with Models:
    - Users have the freedom to interact with the 3D models in different ways:
        - **Dismantling**: Users can virtually disassemble the models, examining individual components or parts. This feature is particularly useful for educational purposes or understanding how things work.
        - **Simulation Button**: Some models may include interactive simulations. By pressing the principal button, users trigger animations or dynamic behaviour within the model. For instance, a mechanical assembly might demonstrate movement, or a biological model could simulate processes.
4. Model Selection and Navigation:
    - If the user wants to explore a different 3D model, they can easily navigate back to the selection screen.
    - By clicking the **Back** button, users return to the model menu, where they can choose other parts of the 3D models.
    - This flexibility allows users to explore various models at their own pace and according to their interests.

g) Blender screenshot

Author: Lim Hon Sheang

Figure 5.0: Overview engine model (Blender)

Figure 5.0 provides a comprehensive view of the entire car engine assembly, including the battery and fuel tank, positioned accurately within the engine compartment. The scene is meticulously crafted to showcase the intricate details of each component while maintaining spatial coherence and realism.

In the centre of the image, the car engine serves as the focal point, showcasing its various parts, such as cylinders, pistons, crankshaft, and camshaft. The engine's layout is visible, allowing viewers to understand the spatial relationships between different components and their functions within the engine system.

Adjacent to the engine, the car battery is positioned in its designated location within the engine compartment. The battery's size, shape, and placement are accurately depicted, providing viewers with a clear understanding of its role in the vehicle's electrical system.

On the opposite side of the engine, the fuel tank is situated in its appropriate position, completing the overview of the engine assembly. The fuel tank's placement is strategically chosen to reflect its connection to the engine and fuel delivery system, enhancing the overall realism and coherence of the scene.

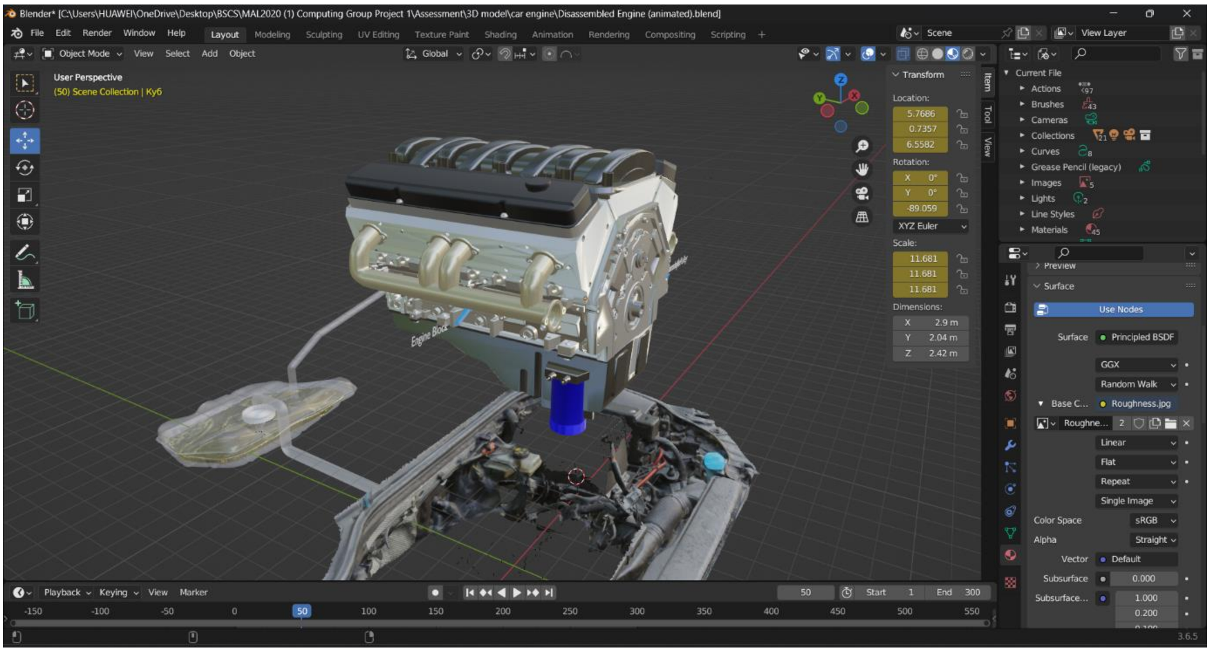


Figure 5.1: Car engine model (Blender)

Figure 5.1 showcases a meticulously crafted representation of a car engine model created in Blender, providing a detailed and lifelike depiction of its internal components.

a) **Engine Components**: The screenshot centres on the car engine, exhibiting various intricately modelled parts, including cylinders, pistons, crankshaft, camshaft, valves, and connecting rods. Each component is meticulously designed to portray its real-world counterpart accurately.

b) **Texturing and Materials:** The engine components feature textures and shading to emulate metal, rubber, and plastic materials. These textures convey surface details like scratches, rust, and mechanical markings, enhancing the model's authenticity.

c) **Detailing**: The engine model is enriched with meticulous detailing, incorporating features such as bolt heads, nuts, screws, and wiring harnesses to enhance its realism further.

d) **Assembly**: The screenshot may depict the engine in various stages of assembly, offering viewers insights into how different components interconnect to form the complete engine unit. This can include exploded views highlighting individual parts or fully assembled configurations for a comprehensive understanding.

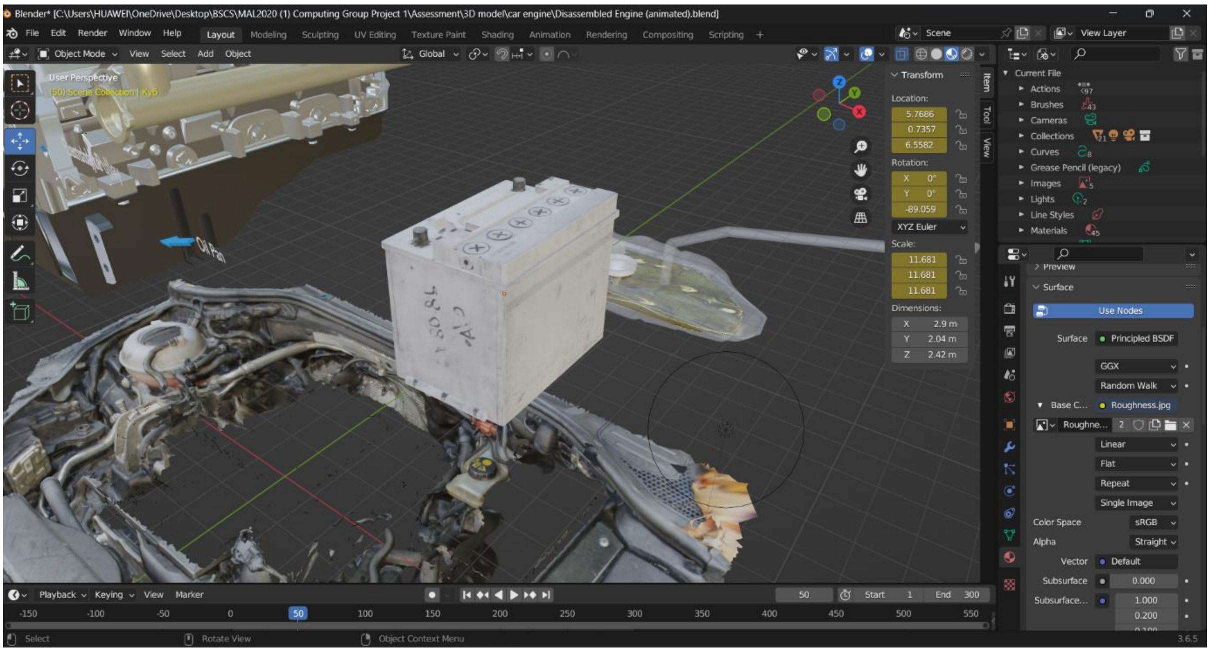


Figure 5.2: Car battery model (Blender)

Figure 5.2 shows a comprehensive 3D model of a standard vehicle battery. It uses realistic textures and materials to depict the battery's outer casing, terminals, labels, and internal components. Lighting effects improve the model's three-dimensional appearance, giving spectators a clear and realistic representation of this vital vehicle component.

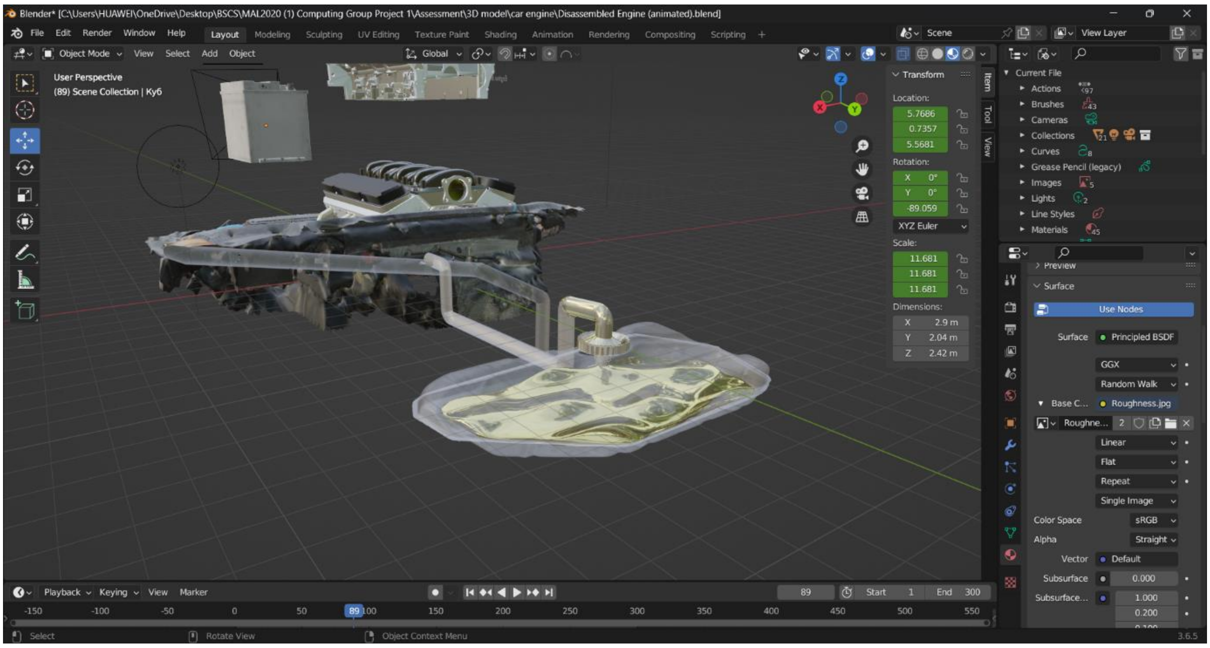


Figure 5.3: Car fuel tank model (Blender)

Figure 5.3 depicts a meticulously constructed 3D model of a conventional automobile fuel tank. The model includes precise elements such as fuel inlet/outlet ports, mounting brackets, and structural components, which capture the character of a real-world fuel tank. Connections between the gasoline tank and the engine are visible, suggesting that it supplies fuel to the vehicle's propulsion system. Realistic textures and shading improve the model's visual quality, resulting in an appealing representation of this critical vehicle component.

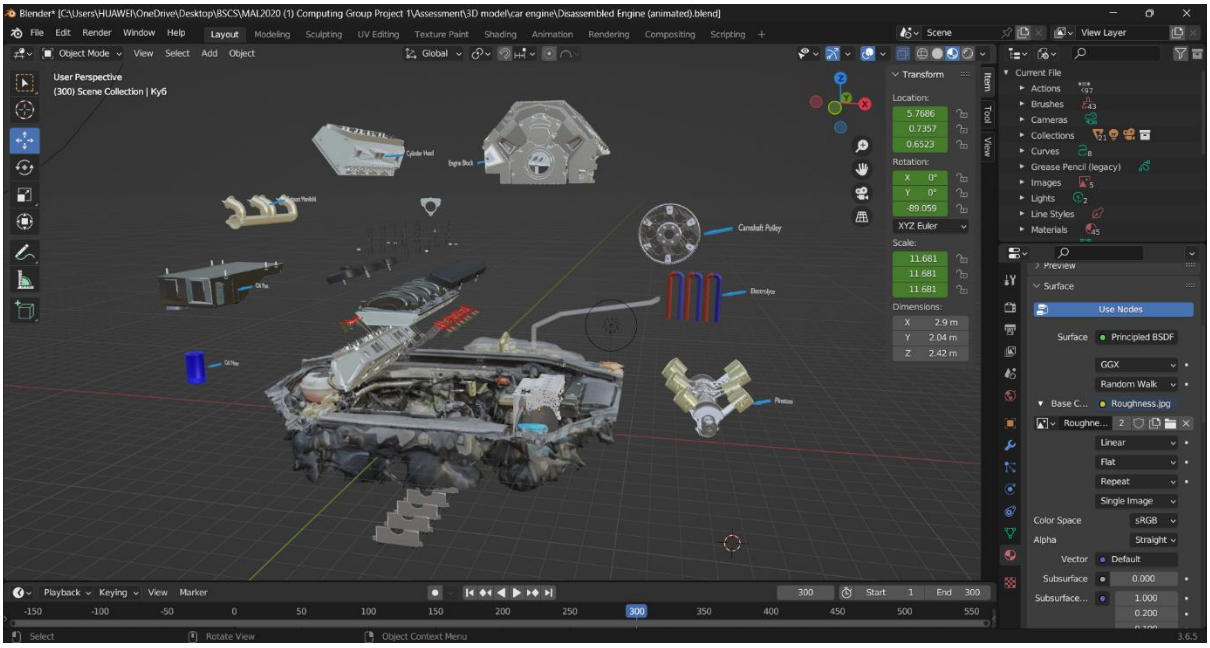


Figure 5.4: Car engine model in exploded view (Blender)

Figure 5.4 shows a screenshot of the automobile engine model in an exploded view in Blender, displaying the engine's numerous components that have been methodically organised and visually segregated. Each component, including pistons, cylinders, camshafts, and crankshafts, is easily identifiable and carefully placed to demonstrate their different responsibilities within the engine assembly. The exploded view provides a thorough picture of the engine's complicated internal structure, allowing for deep investigation and analysis of its component elements. Labels or annotations may accompany each component, adding context and information about their distinct functions. This visualisation is used for educational reasons, namely, to teach automotive engineering students about the anatomy and functions of an automobile engine.

h) Unity Screenshot

Author: Danny Chan Yi Xiang

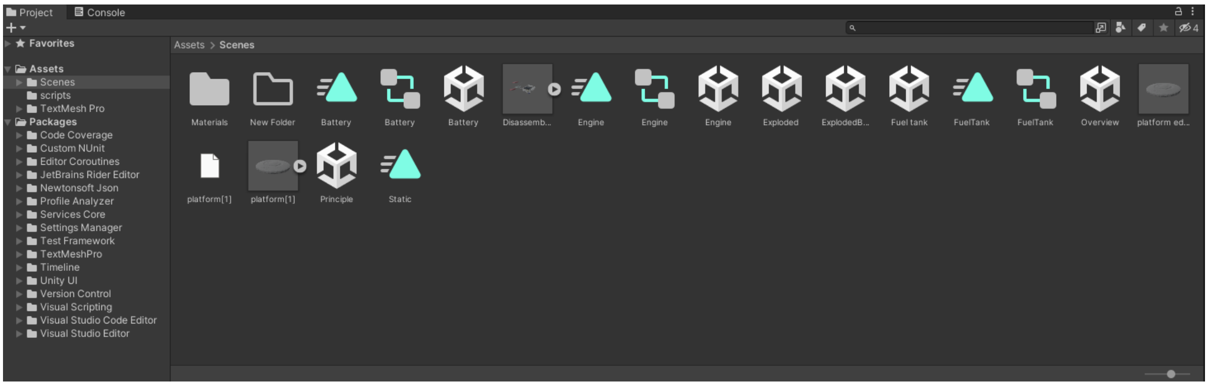


Figure 6.0: Asset Scene (Unity)

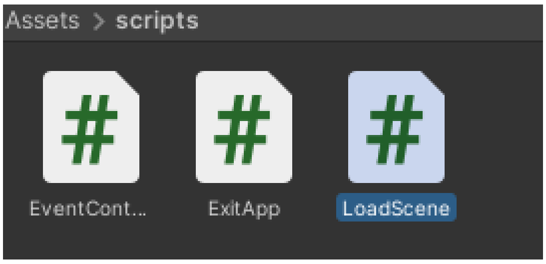


Figure 6.1: Assets Script (Unity)

Inside the Assets folder, it included everything we need to build our models and animations. The Assets package includes:

- Materials - Materials include all the colours and texture needed for every model to be applied on them for displaying purposes
- Scripts - Scripting exists to instruct how the models should behave. In this project, we have used 3 scripts, which are EventControl, ExitApp and LoadScene. The scripts are created with the help of Visual Studio.
- Scenes - Scenes are created for each model which each model can have their own specific environment and features embedded to their scenes.
- Animation & Engine controller - Animation and engine controller helps to animate the object for transition for the model and controls the logic of an animated 3D models.
- Platform - Platform is added to decorate all the environments and display the models in a much more professional method.

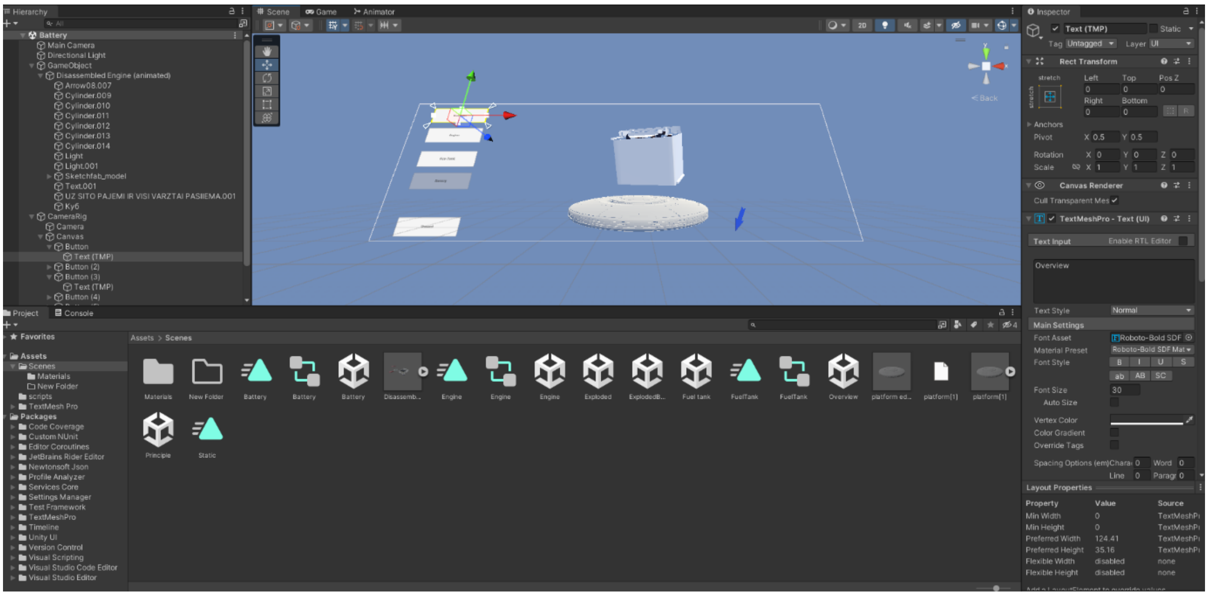


Figure 6.2: Process of editing clickable button (Unity)

Figure 6.2 illustrates the process of editing a clickable button through scripting. The screenshot depicts the Inspector on the right side of the control bar, where users can modify various attributes of the button displayed on the screen. Users can adjust parameters such as font, size, and location to customize the appearance and functionality of the button. In this instance, Roboto-Bold SDF with a font size 30 is utilized for each button, as specified in the Inspector.

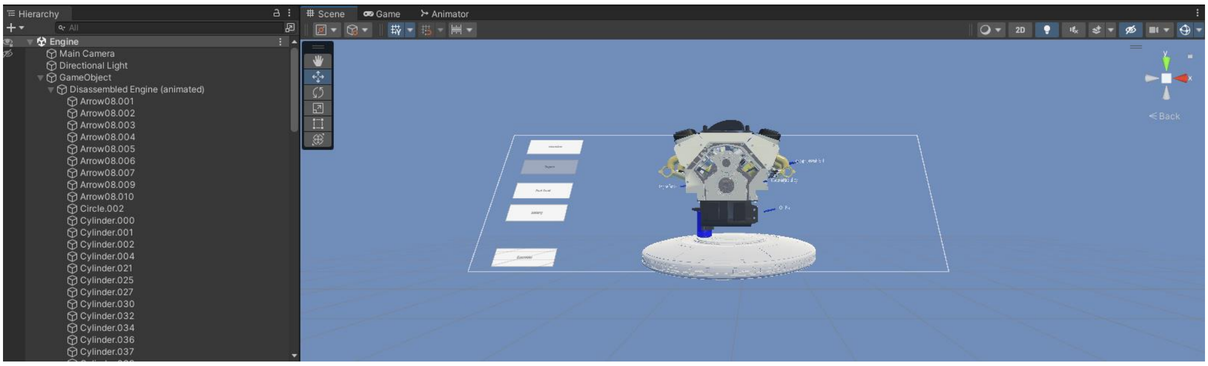


Figure 6.3: Positioning models (Unity)

Figure 6.3, positioning of the models are also crucial for tidiness. Models can be viewed from different perspective using the X, Y and Z axis on the top right corner. After that, we could use the tool bar on the left for scaling rotation and moving purposes. Separating every component in the model is also important when we first import the 3D models inside the Unity Hub. By separating the components as children, we can edit specific items without affecting other components.

Scripting

a. EventControl

```csharp
using System.Collections;
using System.Collections.Generic;
using UnityEngine;

public class EventControl : MonoBehaviour
{
    private Animator animator;
    // Start is called before the first frame update
    void Start()
    {
        animator = GetComponent<Animator>();
        animator.enabled = true;
    }

    // Update is called once per frame
    void Update()
    {
        if (animator.GetCurrentAnimatorStateInfo(0).normalizedTime >= 1.0f)
        {
            animator.enabled = false;
        }
    }
}
```

Figure 6.4: EventControl script

Figure 6.4 shows that this script primarily turns off an animation after it has finished playing. It is a common requirement in games where an animation should only play once or needs to be controlled programmatically based on game logic. This script provides a simple example of achieving this in Unity using the `Animator` component and scripting.

b. ExitApp

Miscellaneous Files

```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;

public class ExitApp : MonoBehaviour
{
    // Start is called before the first frame update

    // Update is called once per frame
    void Update()
    {
        if (Input.GetKey("escape"))
        {
            Application.Quit();
        }
    }
}
```

Figure 6.5: ExitApp script

Figure 6.5 presents the `ExitApp` script, a simple method to incorporate a standard application exit functionality into your Unity project. This script lets users quit the game or application by pressing the Escape key. Such functionality is precious for desktop applications, where exiting via key commands is customary. However, it is worth noting that within the Unity Editor environment, pressing Escape will not cause the application to quit due to the constraints of `Application.Quit()`. Considering this limitation is important when testing the Unity Editor's functionality.

c. Load Scene

LoadScene.cs

Miscellaneous Files

```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;
using UnityEngine.SceneManagement;

public class LoadScene : MonoBehaviour
{
    public void SceneLoader(string sceneName)
    {
        SceneManager.LoadScene(sceneName);
    }
}
```

Figure 6.6: LoadScene script

Figure 6.6 depicts a script that facilitates Unity's flexible and straightforward scene transitions. This script offers a versatile solution for various scenarios, including game-level loading and UI navigation within applications.

5. Quality Assurance

a) Surveys & Questionnaire

Author: Lim Hon Sheang, Danny Chan Yi Xiang

Link to survey form: https://docs.google.com/forms/d/1zaSSx3Yv-vMe9vEnuEFsjmRKLAksY0Fq3J2HRrz4b5o/edit

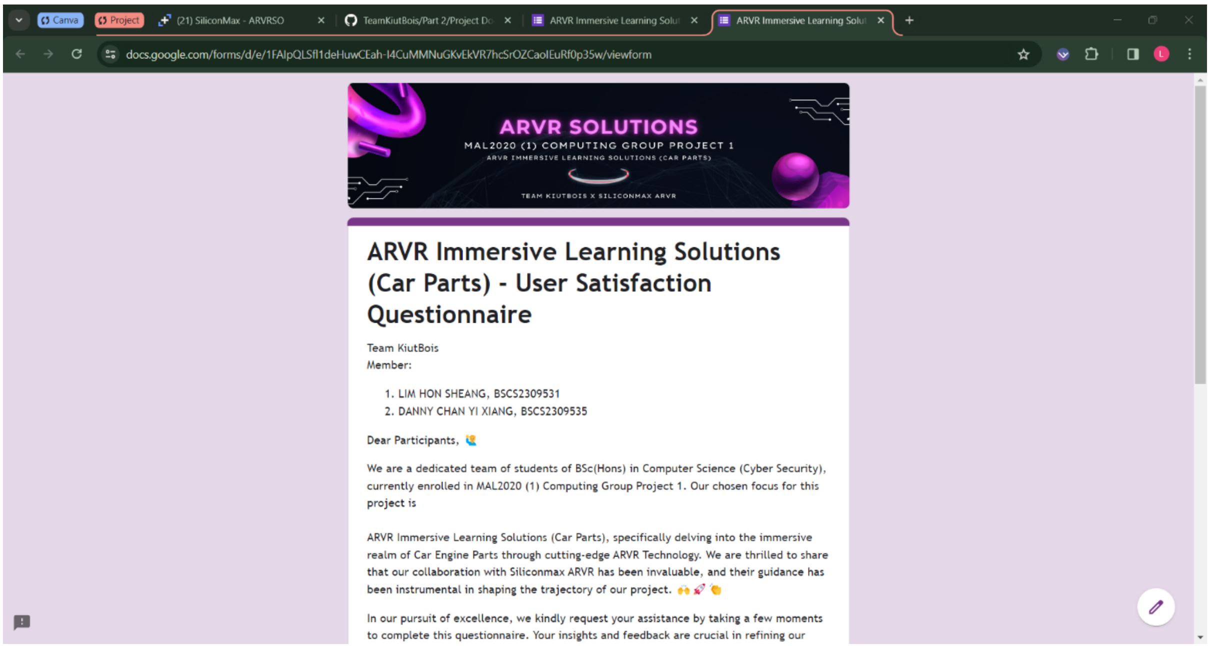


Figure 7.0: Survey & Questionnaire form

i. Feedback from the survey and questionnaire form

Section 1: User Feedback

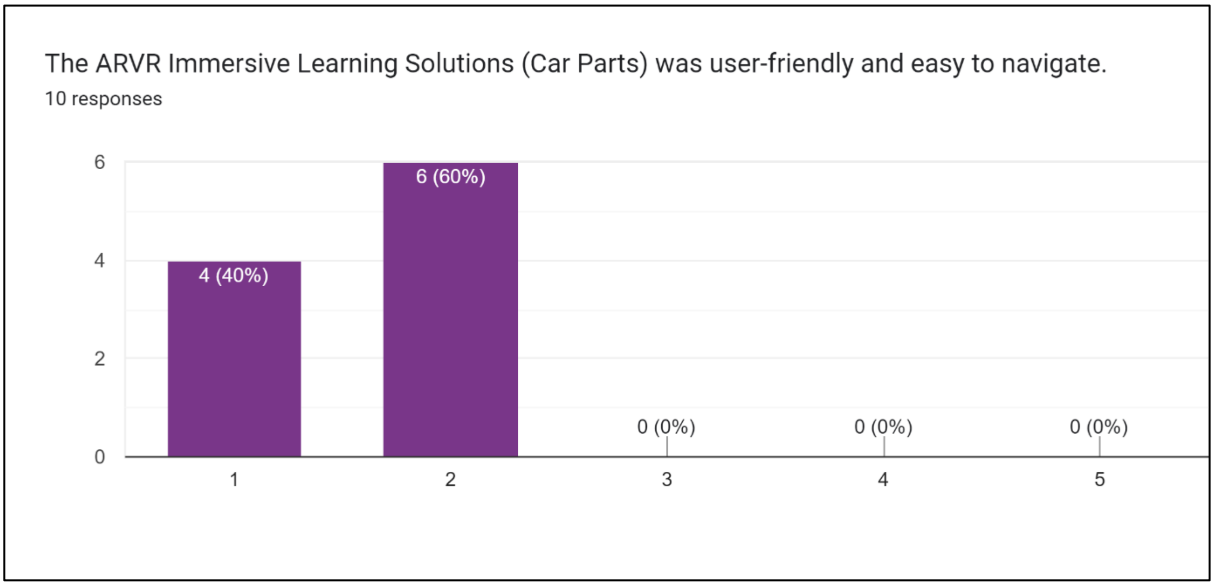


Figure: 7.1: Section 1 Question 1

Based on the survey responses for Section 1 Question 1 regarding the user-friendliness and navigation of the ARVR Immersive Learning Solution (Car Parts), it is evident that most respondents found the solution user-friendly and easy to navigate. Six of the ten respondents (60%) indicated agreement (voted for 2), suggesting they found the interface intuitive and accessible. However, four respondents (40%) selected strongly agree (voted for 1), indicating that they perceived the solution as exceptionally user-friendly.

Overall, these responses suggest a positive sentiment towards the usability and navigation of the ARVR solution, with a slight preference towards agreement rather than solid agreement. This feedback indicates that while most users found the solution easy to navigate, there may still be room for improvement to address the needs of those who did not strongly disagree with the statement.

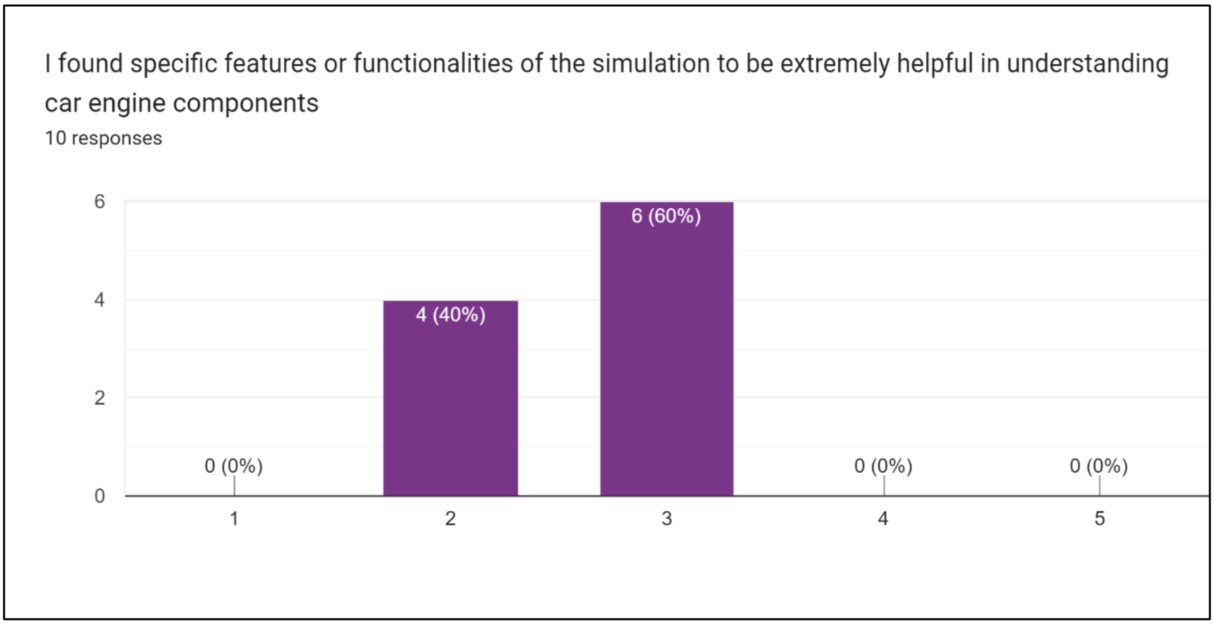


Figure: 7.2: Section 1 Question 2

Based on the survey responses for Section 1 Question 2 regarding the helpfulness of specific features or functionalities in understanding car engine components, it appears that opinions are more evenly distributed compared to the previous question.

Six of the ten respondents (60%) indicated a neutral stance (voted for 3), suggesting they neither strongly agreed nor disagreed with the statement. This indicates a mixed perception regarding the effectiveness of specific features or functionalities in aiding understanding.

On the other hand, four respondents (40%) voted for 2, indicating agreement with the statement. This suggests that these respondents found certain features or functionalities to help understand car engine components.

Overall, the responses suggest a more nuanced perspective on the effectiveness of specific features or functionalities. While some users found them helpful, others remained neutral, indicating that there may be variability in the perceived usefulness of different aspects of the simulation. Further investigation and feedback could help identify the most beneficial features that may require improvement.

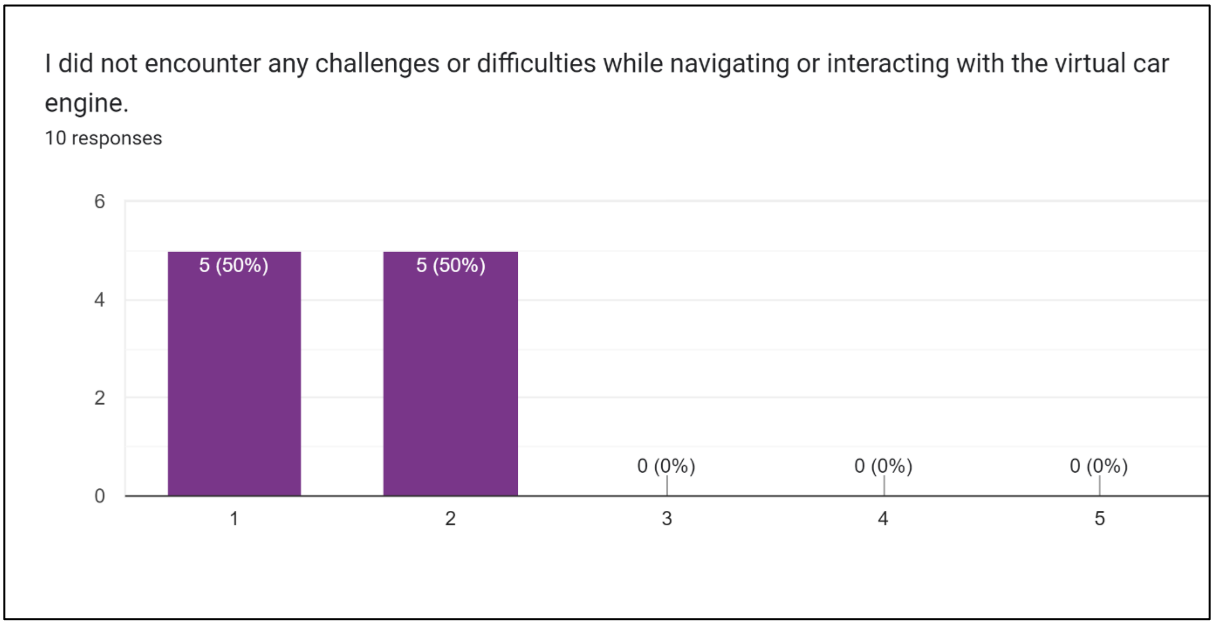


Figure: 7.3: Section 1 Question 3

Based on the survey responses for Section 1 Question 3 regarding the ease of navigation and interaction with the virtual car engine, the results are evenly split between the two options.

Five of the ten respondents (50%) indicated a strong agreement (voted for 1), suggesting they did not encounter any challenges or difficulties while navigating or interacting with the virtual car engine.

Similarly, the other five respondents (50%) voted for 2, indicating agreement with the statement but not as strongly as those who voted for option 1. This suggests that while they may have encountered minor challenges or difficulties, overall, the navigation and interaction with the virtual car engine were relatively smooth.

Overall, the responses indicate that many users did not face significant obstacles while using the virtual car engine. However, there may still be areas for improvement to address any minor difficulties some users encounter.

Section 2: Educational Impact

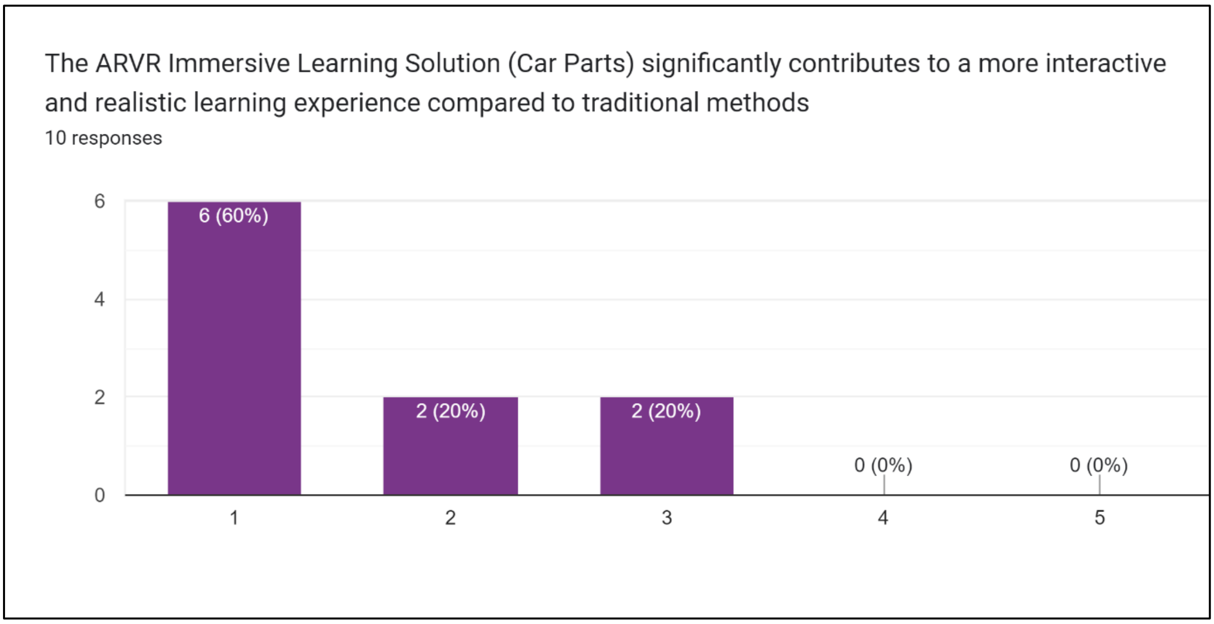


Figure: 7.4: Section 2 Question 1

In Section 2 Question 1, focusing on the educational impact of the ARVR Immersive Learning Solution (Car Parts), the responses indicate a strong positive sentiment regarding its effectiveness compared to traditional methods.

Six out of the ten respondents (60%) strongly agreed (voted for 1) that the ARVR solution significantly contributes to a more interactive and realistic learning experience than traditional methods. This indicates a high level of satisfaction and endorsement of the immersive learning approach facilitated by the ARVR solution.

Two respondents (20%) voted for option 2, indicating agreement but not as strongly as those who chose option 1. Another two respondents (20%) voted for option 3, suggesting a neutral stance on the statement.

Most respondents recognize the ARVR Immersive Learning Solution (Car Parts) as a valuable tool for enhancing the learning experience, attributing it to its interactive and realistic nature. However, a few respondents may have reservations or are undecided about its superiority over traditional methods, highlighting the need for further exploration or clarification on its educational impact.

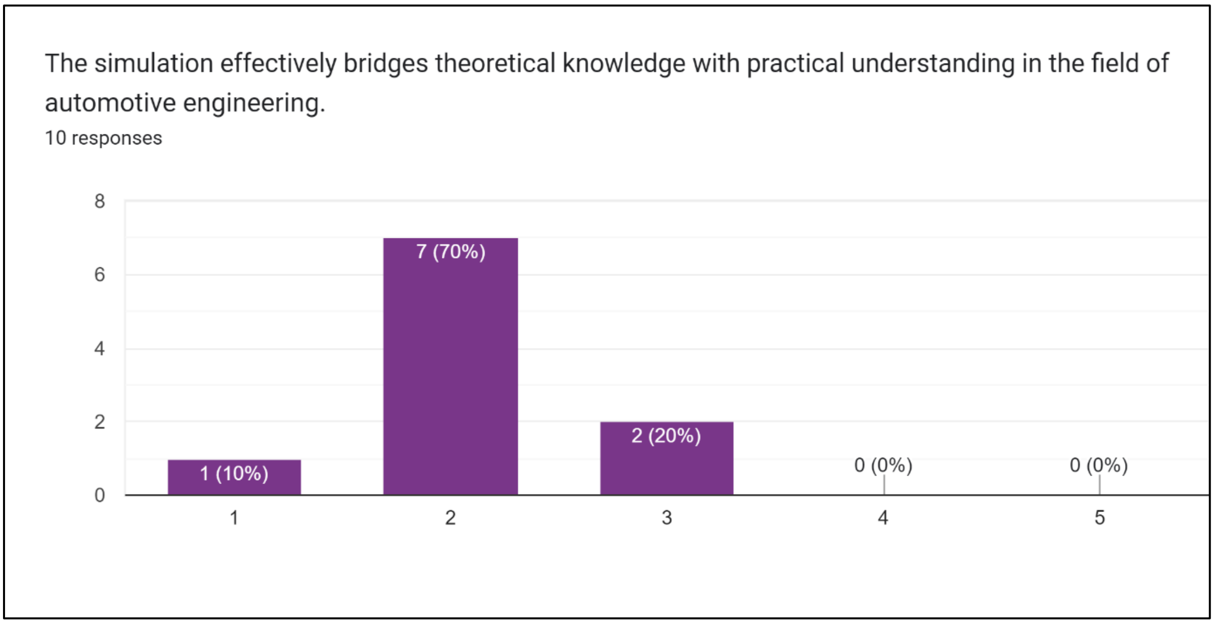


Figure: 7.5: Section 2 Question 2

In Section 2 Question 2, regarding the educational impact of the ARVR Immersive Learning Solution (Car Parts), the responses suggest a positive perception of its ability to bridge theoretical knowledge with practical understanding in automotive engineering.

One respondent (10%) strongly agreed (voted for 1) that the simulation effectively bridges theoretical knowledge with practical understanding, indicating a high confidence level in the solution's educational effectiveness.

Seven respondents (70%) voted for option 2, agreeing with the statement. This majority suggests that the simulation is perceived as effective in connecting theoretical concepts with practical application, albeit more emphatically than those who chose option 1.

Two respondents (20%) voted for option 3, expressing a neutral stance on the statement. This suggests that while they may not entirely disagree, they also do not strongly agree with the effectiveness of the simulation in bridging theoretical and practical knowledge.

Overall, the responses indicate a generally positive perception of the ARVR Immersive Learning Solution (Car Parts) as a tool for integrating theoretical learning with practical application in automotive engineering. However, a minority of respondents remain neutral, emphasizing the importance of further evaluation or clarification regarding the solution's educational impact.

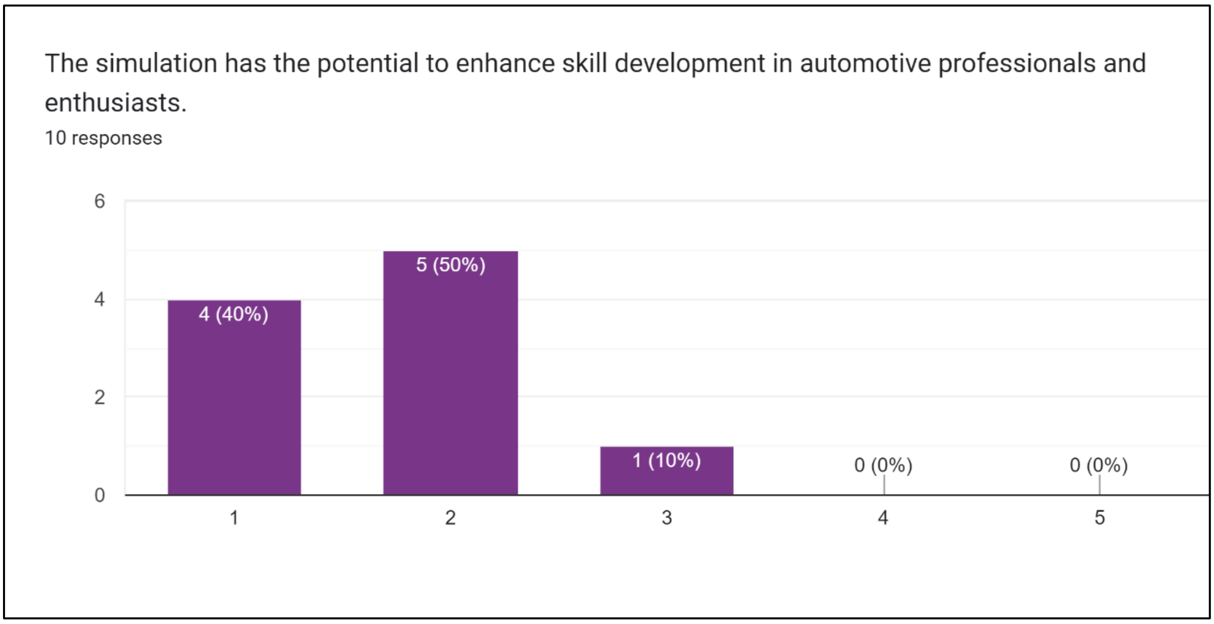


Figure: 7.6: Section 2 Question 3

In Section 2 Question 3, regarding the potential educational impact of the ARVR Immersive Learning Solution (Car Parts) on skill development in automotive professionals and enthusiasts, the responses indicate a generally positive outlook.

Four respondents (40%) strongly agreed (voted for 1) that the simulation can enhance skill development, showing high confidence in its effectiveness in this aspect.

Five respondents (50%) voted for option 2, agreeing with the statement. This suggests that the majority acknowledges the potential of the simulation to contribute to skill development, although more emphatically than those who chose option 1.

One respondent (10%) voted for option 3, expressing a neutral stance. This suggests a slight reservation or uncertainty regarding how much the simulation can enhance skill development in automotive professionals and enthusiasts.

Overall, the responses suggest a positive perception of the ARVR Immersive Learning Solution (Car Parts) as a tool to enhance skill development in its target audience. However, there is a diversity of opinions, with some respondents expressing more substantial confidence in its effectiveness than others.

Section 3: Technical Performance

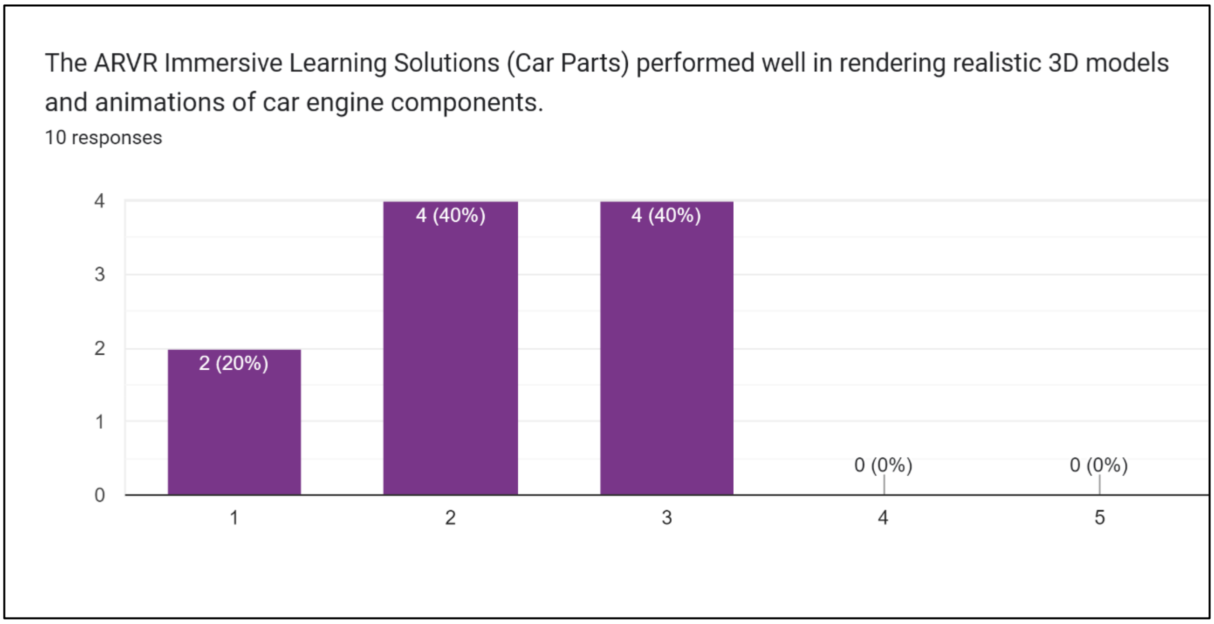


Figure: 7.7: Section 3 Question 1

In Section 3 Question 1, which assesses the technical performance of the ARVR Immersive Learning Solution (Car Parts) in rendering realistic 3D models and animations of car engine components, the responses reflect a mixed perception.

Two respondents (20%) strongly agreed (voted for 1) that the solution performed well in this aspect, indicating high satisfaction with the realism of the 3D models and animations.

Four respondents (40%) voted for option 2, agreeing with the statement. This suggests that a significant portion of the respondents found the performance satisfactory, although not to the extent of solid agreement.

Four respondents (40%) voted for option 3, expressing a neutral stance on the statement. This indicates that another significant portion of respondents neither agreed nor disagreed with the statement, suggesting a degree of uncertainty or reservation regarding the technical performance of the solution.

Overall, the responses suggest a varied perception of the solution's technical performance in rendering realistic 3D models and animations. While some respondents expressed satisfaction with its performance, others were more neutral or reserved in their assessment. This diversity of opinions highlights the need for further evaluation and potential improvements in this aspect of the ARVR solution.

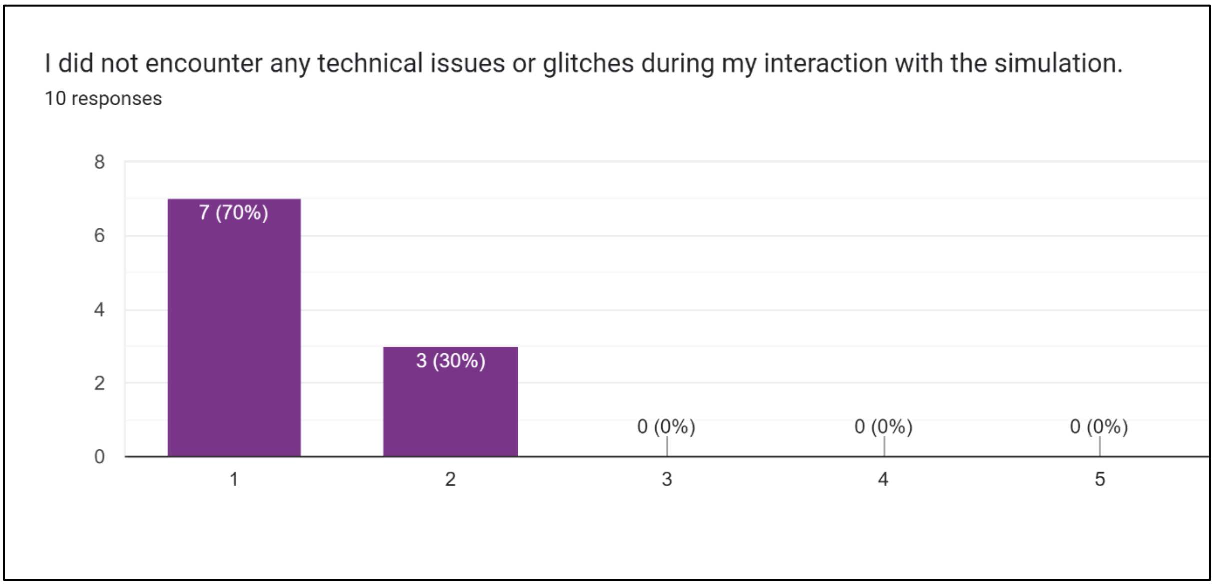


Figure: 7.8: Section 3 Question 2

In Section 3 Question 2, concerning the technical performance of the ARVR Immersive Learning Solution (Car Parts) and the occurrence of technical issues or glitches during interaction with the simulation, the responses indicate a generally positive experience among most respondents.

Seven respondents (70%) strongly agreed (voted for 1) that they did not encounter any technical issues or glitches. This suggests a high level of satisfaction with the stability and performance of the simulation, as they did not experience any disruptions during their interaction.

Three respondents (30%) voted for option 2, agreeing with the statement. While they did not strongly agree, these respondents still acknowledged that they did not encounter significant technical issues or glitches, reflecting a generally smooth user experience.

Overall, the responses suggest that the ARVR solution performed well regarding technical stability, with most respondents reporting a lack of technical issues or glitches during their interaction. This indicates a positive perception of the solution's technical performance and reliability among the surveyed users.

Section 4: Global Accessibility

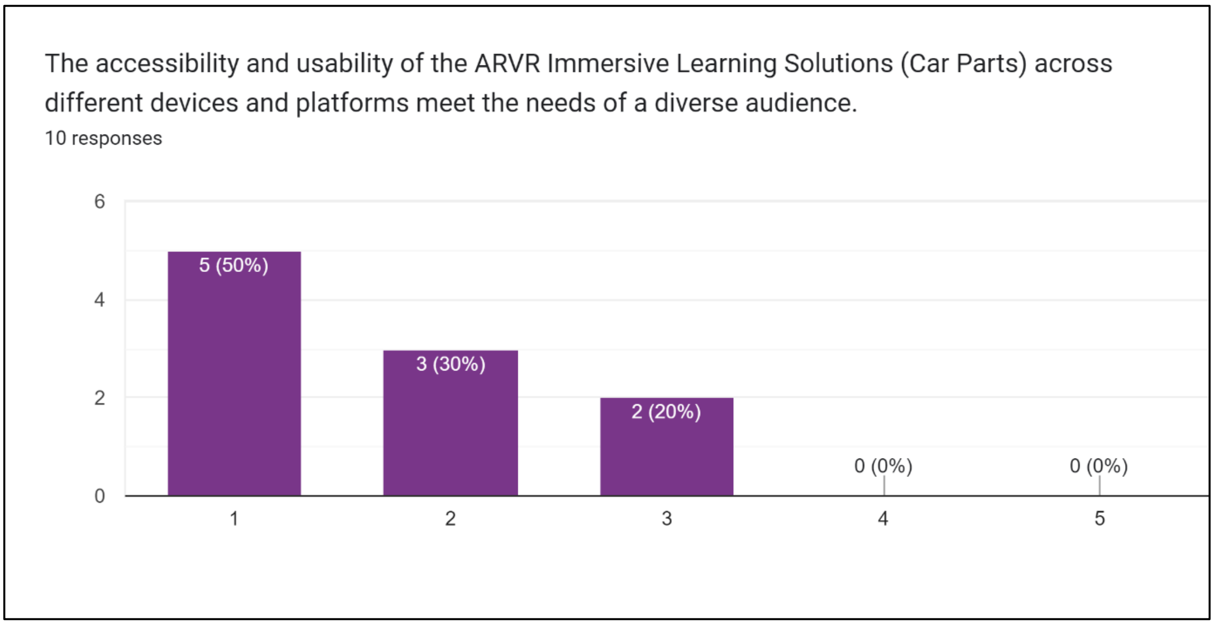


Figure: 7.9: Section 4 Question 1

In Section 4 Question 1, which addresses the global accessibility of the ARVR Immersive Learning Solution (Car Parts) across various devices and platforms, the responses suggest a mixed perception among the respondents.

Five respondents (50%) strongly agreed (voted for 1) that the accessibility and usability of the solution meet the needs of a diverse audience. This indicates high satisfaction with the solution's adaptability to different devices and platforms, suggesting that it effectively caters to the needs of users with varied technological preferences and accessibility requirements.

Three respondents (30%) voted for option 2, agreeing with the statement. While not strongly agreeing, these respondents still acknowledged that the solution's accessibility and usability across different devices and platforms generally meet the needs of a diverse audience.

Two respondents (20%) voted for option 3, indicating a neutral stance. These respondents neither strongly agreed nor disagreed with the statement, suggesting a degree of uncertainty or lack of strong opinion regarding the solution's global accessibility.

Overall, the responses indicate a generally positive perception of the solution's accessibility and usability across different devices and platforms, with most respondents expressing satisfaction with its adaptability to diverse user needs. However, some respondents may have reservations or uncertainties, as reflected by the neutral responses.

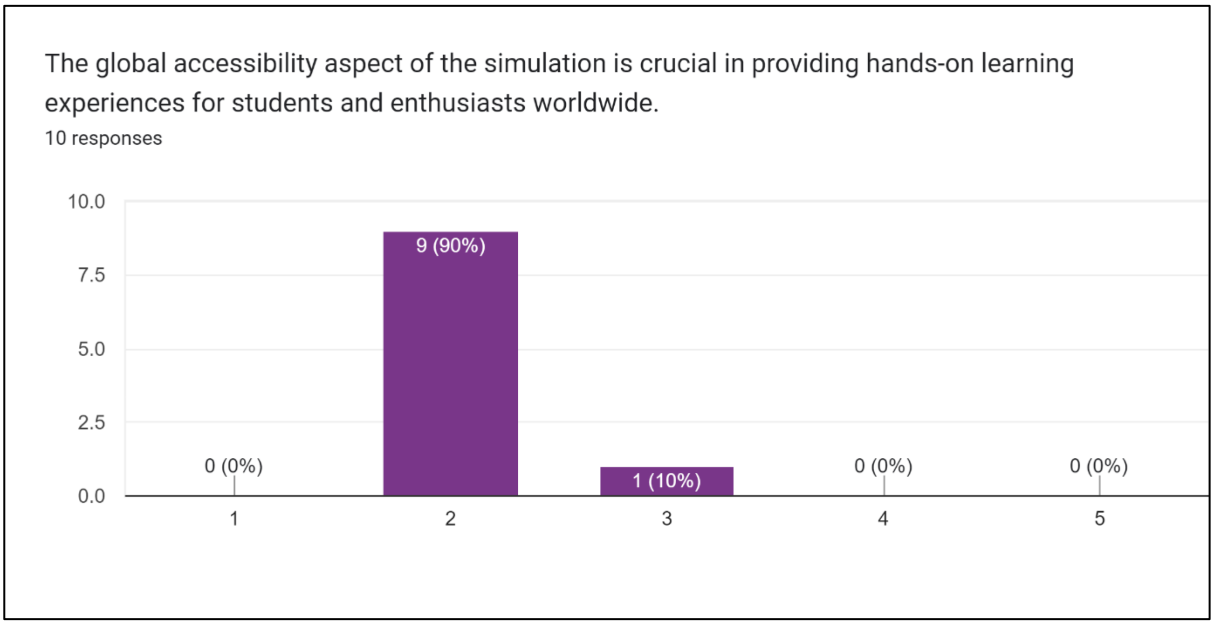


Figure: 7.10: Section 4 Question 2

In Section 4 Question 2, which addresses the global accessibility aspect of the simulation, the responses suggest a predominant agreement among the respondents regarding its importance in providing hands-on learning experiences for students and enthusiasts worldwide.

Nine respondents (90%) voted for option 2, agreeing with the statement. These respondents recognize the significance of global accessibility in facilitating hands-on learning experiences for a broad audience, including students and enthusiasts from different geographical locations and backgrounds. This suggests a consensus among most respondents regarding ensuring that the simulation is accessible to users worldwide.

One respondent (10%) voted for option 3, indicating a neutral stance. This respondent neither agreed nor disagreed with the statement, suggesting a degree of uncertainty or lack of strong opinion regarding the crucial role of global accessibility in providing hands-on learning experiences.

Overall, the responses highlight a strong acknowledgement among the respondents of the importance of global accessibility in making the simulation accessible to a diverse audience worldwide, enhancing its educational impact and reach.

Section 5: Learning Objectives

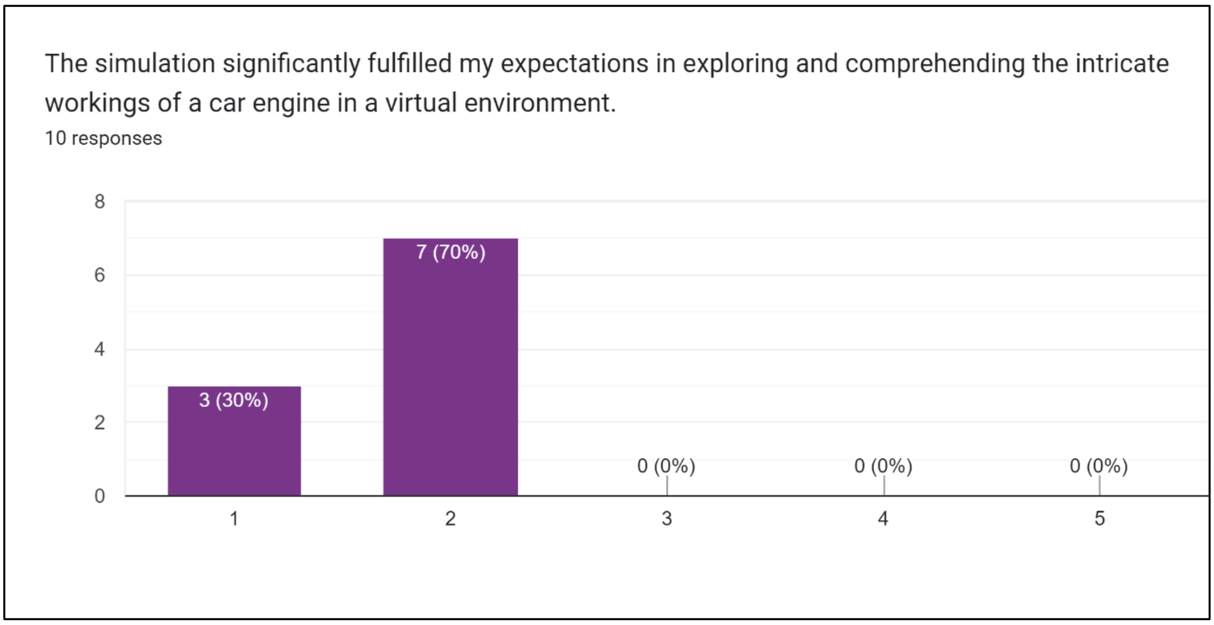


Figure: 7.11: Section 5 Question 1

In Section 5 Question 1, which evaluates the extent to which the simulation fulfilled the respondents' expectations in exploring and comprehending the intricate workings of a car engine in a virtual environment, the responses indicate a generally positive perception.

Seven respondents (70%) voted for option 2, agreeing with the statement. These respondents expressed satisfaction with the simulation, suggesting that it met their expectations in providing a comprehensive understanding of car engine operations within a virtual environment. Their positive feedback underscores the effectiveness of the simulation in delivering on its intended learning objectives and providing an immersive learning experience.

Three respondents (30%) voted for option 1, indicating a slightly lower level of agreement. While these respondents acknowledged that the simulation somewhat fulfilled their expectations, they might have perceived certain areas where improvements could enhance the learning experience. Their responses suggest a nuanced view, acknowledging the simulation's effectiveness while recognizing potential areas for enhancement.

Overall, most respondents expressed satisfaction with how the simulation fulfilled their expectations in exploring and comprehending the intricate workings of a car engine in a virtual environment, indicating a positive perception of its educational value and effectiveness.

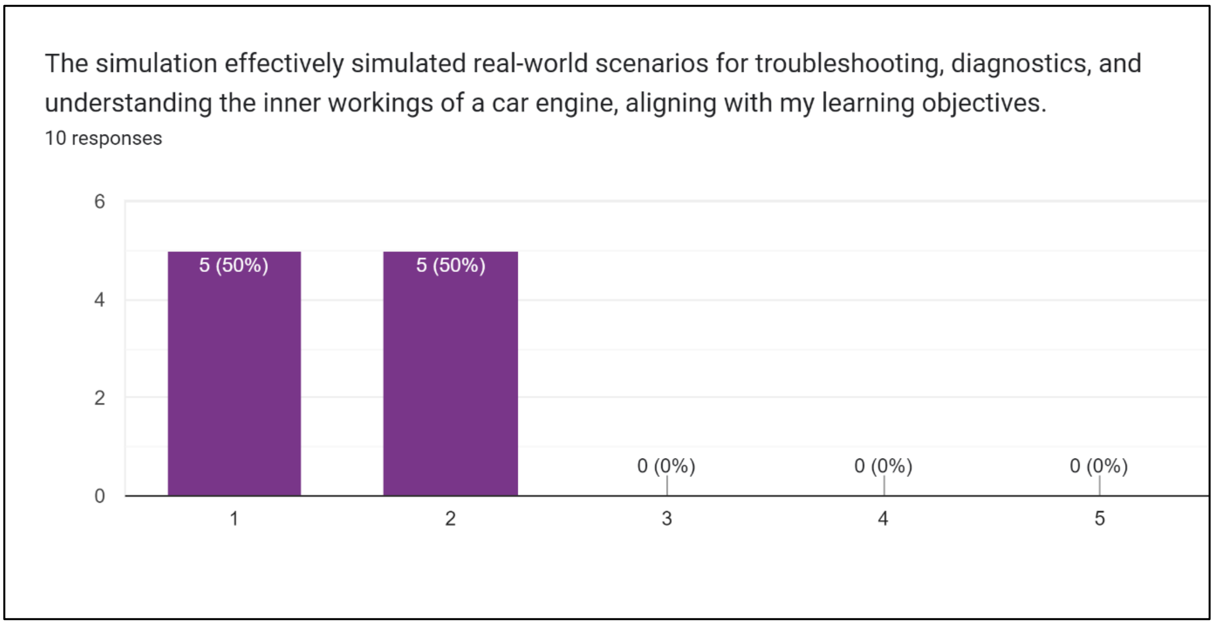


Figure: 7.12: Section 5 Question 2

In Section 5 Question 2, respondents were asked to evaluate the simulation's effectiveness in simulating real-world scenarios for troubleshooting, diagnostics, and understanding the inner workings of a car engine, aligning with their learning objectives. The responses indicate a balanced perspective, with equal numbers of respondents voting for options one and two.

Five respondents (50%) voted for option 1, indicating substantial agreement with the statement. These respondents found the simulation highly effective in simulating real-world scenarios, providing valuable opportunities for troubleshooting, diagnostics, and gaining a deeper understanding of car engine operations. Their feedback suggests that the simulation aligned with their learning objectives and provided a realistic and immersive experience.

Similarly, five respondents (50%) voted for option 2, agreeing with the statement. While these respondents might not have strongly agreed that the simulation effectively simulated real-world scenarios, they still acknowledged its effectiveness in aligning with their learning objectives. Their feedback suggests that while the simulation might have been beneficial, there could be some areas for improvement or refinement to simulate real-world scenarios better.

Overall, the responses in this section indicate that the simulation generally aligned with respondents' learning objectives and provided valuable opportunities for hands-on learning and understanding of car engine operations. However, there might be room for enhancement further to improve its realism and effectiveness in simulating real-world scenarios.

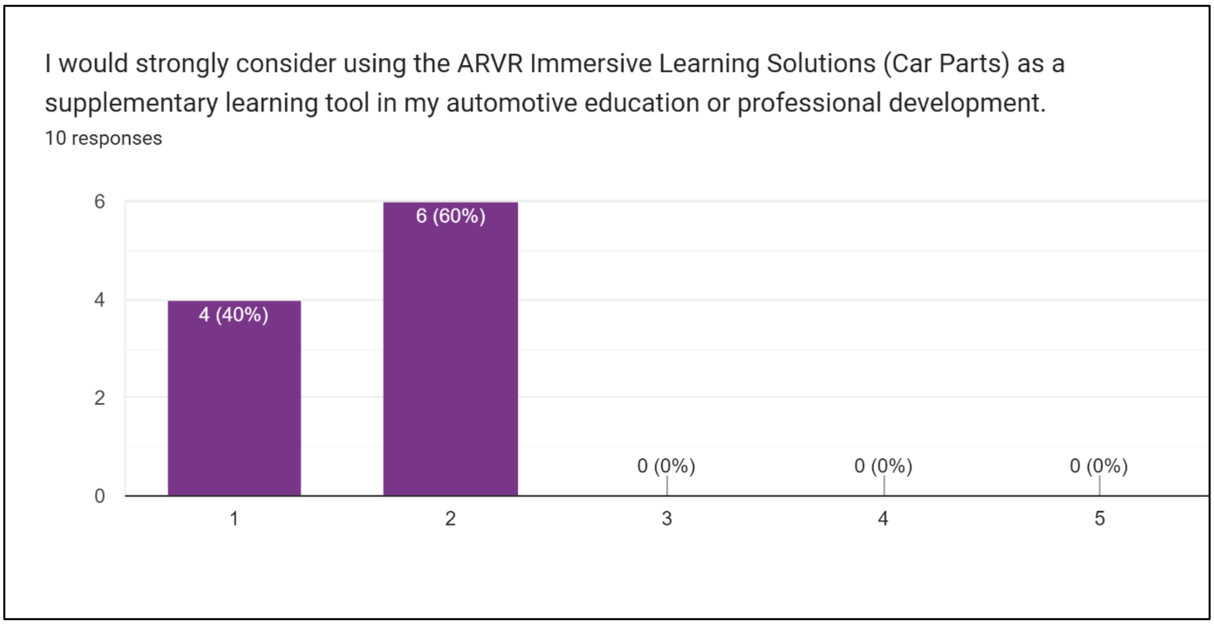


Figure: 7.13: Section 5 Question 3

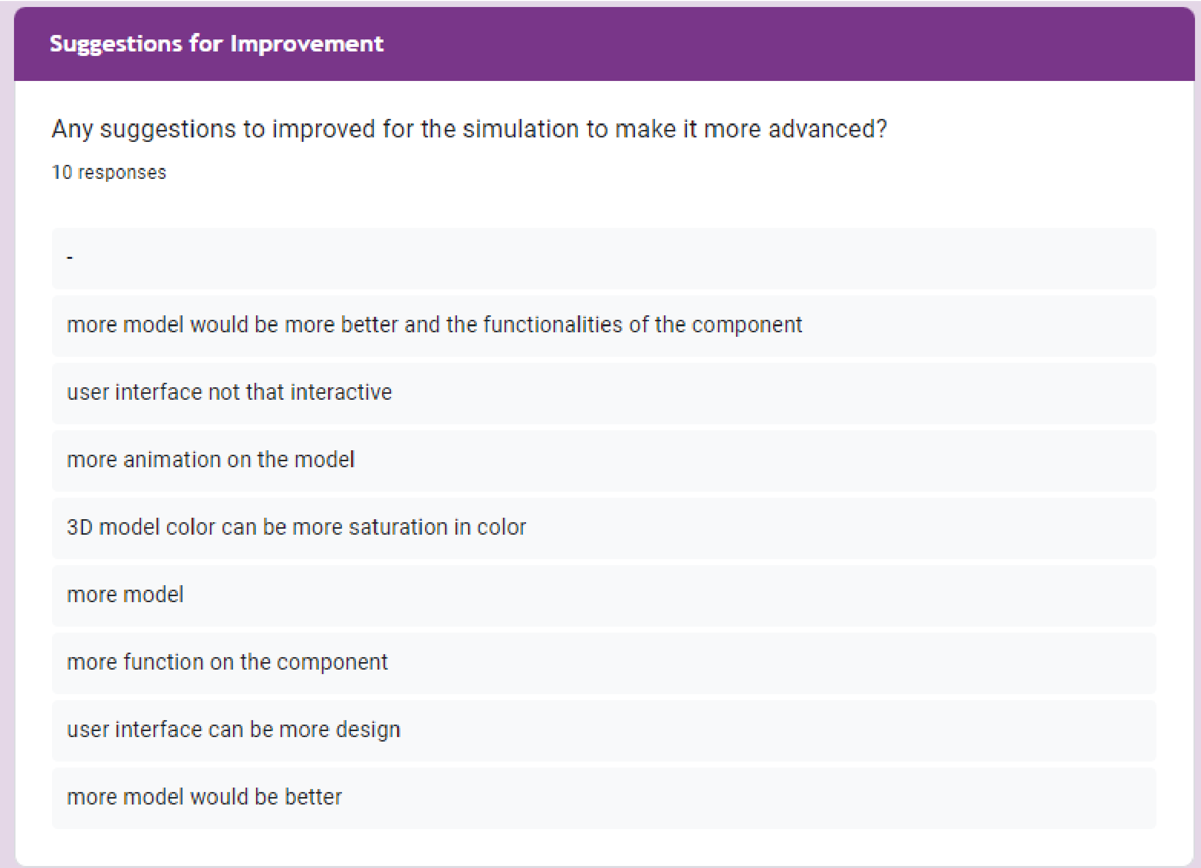
In Section 5 Question 3, respondents were asked to assess their likelihood of using the ARVR Immersive Learning Solutions (Car Parts) as a supplementary learning tool in their automotive education or professional development. The responses indicate a favourable inclination towards utilizing the solution, with most respondents expressing a willingness to consider its use.

Four respondents (40%) voted for option 1, indicating a solid inclination to use the ARVR solution as a supplementary learning tool. These respondents expressed a high level of confidence in the effectiveness and relevance of the solution to their educational or professional development needs. Their feedback suggests a strong endorsement of the solution's potential to enhance learning experiences and knowledge acquisition in automotive education.

On the other hand, six respondents (60%) voted for option 2, indicating a cheerful disposition towards using the ARVR solution but perhaps with some reservations or considerations. While these respondents may have yet to firmly commit to using the solution, they are still willing to consider it a supplementary learning tool. Their feedback suggests an openness to exploring new educational technologies and methodologies to augment their automotive education or professional development.

Overall, the responses in this section highlight a favourable perception of the ARVR Immersive Learning Solutions (Car Parts) as a valuable supplementary learning tool in automotive education and professional development. Most respondents were willing to consider its use, reflecting its perceived potential to enhance learning outcomes and provide immersive learning experiences in the automotive domain.

Section 6: Suggestion for Improvement


Suggestions for Improvement

Any suggestions to improved for the simulation to make it more advanced?

10 responses

-

more model would be more better and the functionalities of the component

user interface not that interactive

more animation on the model

3D model color can be more saturation in color

more model

more function on the component

user interface can be more design

more model would be better

Figure: 7.14: Suggestion for improvement

In Section 6, respondents suggested improving the ARVR Immersive Learning Solutions (Car Parts) to make it more advanced. The responses indicate several areas where enhancements could be made to enrich the learning experience and usability of the simulation.

1. **Increased Variety of Models and Functionalities**: Respondents emphasized the importance of adding more models and enhancing the functionalities of the components within the simulation. This suggestion indicates a desire for greater diversity and depth in the content available for exploration and interaction.
2. **Improvement of User Interface (UI)**: Some respondents noted that the user interface could be more interactive and visually appealing. They suggested redesigning the UI to enhance usability and engagement by incorporating more intuitive navigation features or interactive elements.
3. **Incorporation of More Animation**: Several respondents recommended adding more animations to the models within the simulation. This enhancement would likely increase the dynamic nature of the learning experience and provide users with a more immersive understanding of the car engine components' functions and interactions.
4. **Enhancement of 3D Model Colours**: One respondent suggested increasing the saturation of colours in the 3D models to improve visibility and clarity. This adjustment could help users distinguish between different components and details within the simulation, contributing to a more effective learning experience.
5. **Reiteration on the Need for More Models and Functions**: Multiple respondents reiterated the importance of adding more models and functions to the simulation. This

feedback underscores the significance of expanding the content and features available within the simulation to cater to diverse learning preferences and educational objectives.

Overall, the suggestions provided by respondents in this section highlight opportunities for advancing the ARVR Immersive Learning Solutions (Car Parts) to meet users' needs and expectations better. By incorporating additional models, enhancing functionalities, improving the user interface, adding animations, and refining 3D model colours, the simulation can offer a more comprehensive and engaging learning experience in the automotive field.

b) Documentation on Unit Test

Author: Lim Hon Sheang

Test Case TC-001

Test Case TC-001 evaluated the performance of the eye-tracking sensor in the ARVR interface. Testers found the sensor highly responsive and accurate, effectively tracking users' eye movements in real time within the virtual environment. They encountered no difficulties during testing, indicating the reliable functionality of the sensor. Users expressed satisfaction with its precision and ease of use. Feedback emphasized the added value of the eye-tracking feature, noting its accurate detection and seamless integration with the interface. No significant areas for improvement were identified, demonstrating that the sensor met or exceeded expectations in performance and usability. Overall, Test Case TC-001 demonstrated the effectiveness and reliability of the eye-tracking technology integrated into the ARVR solution.

Test Case TC-002

Test Case TC-002 evaluated the functionality of the stylus pen for drag-and-drop actions and button clicks within the ARVR interface. Testers confirmed that the system correctly recognized the stylus pen, indicating its readiness for interaction. Users successfully performed drag-and-drop actions, demonstrating the stylus pen's capability to interact with virtual components effectively. This functionality allows users to engage with learning content in a hands-on manner. Testers also verified that the stylus pen accurately clicked on buttons within the interface, prompting expected actions. Overall, Test Case TC-002 demonstrated that the stylus pen functionality aligns with specified requirements, serving as an effective tool for user interaction and contributing to an immersive learning experience.

Test Case TC-003

Test Case TC-003 focused on evaluating the functionality of the overview button within the ARVR interface. Testers successfully navigated to the overview section, indicating intuitive navigation. Upon clicking the overview button, testers observed a prompt display of the model overview, allowing users to grasp the model's layout and components quickly. The clear presentation enhanced user comprehension and engagement with the learning content. Test Case TC-003 passed, confirming that the overview button met specified requirements and contributed to an enhanced ARVR learning experience.

Test Case TC-004

Test Case TC-004 evaluated the effectiveness of the car engine button within the ARVR interface and its associated functionalities. Testers successfully navigated to the car engine section, indicating intuitive navigation. Upon clicking the car engine button, the model appeared promptly, providing immediate visual feedback to users. Testers verified the presence of the dissect button, enabling in-depth exploration of internal components. Clicking the dissect button initiated the animation without issues, enhancing the educational experience. Overall, Test Case TC-004 demonstrated that the car engine button met specified requirements, facilitating an immersive learning experience in automotive engineering.

Test Case TC-005

Test Case TC-005 evaluated the functionality of the car battery button within the ARVR interface. The user successfully navigated to the car battery section, confirming intuitive navigation. Clicking the car battery button promptly displayed the model, allowing users to inspect and explore it visually. The presence and functionality of the dissect button were verified, enabling detailed examinations of internal structures. Initiating the dissection animation proceeded seamlessly, providing insights into the battery's construction and operation. Test Case TC-005 ensured a comprehensive and engaging learning experience, facilitating users' understanding of car battery components.

Test Case TC-006

Test Case TC-006 assessed the functionality of the fuel button and flow animation feature within the ARVR interface. The user seamlessly navigated to the fuel section, demonstrating intuitive navigation. Clicking on the fuel button triggered the display of the 3D fuel model, allowing a visual examination of its details. Verifying the start button's presence ensured easy access to initiate the flow animation. Clicking the start button initiated the animation, visually representing fuel flow dynamics. Overall, Test Case TC-006 affirmed the proper functionality of the fuel button and flow animation feature, enhancing the ARVR learning experience for car parts.

c) UAT on Methodology

Author: Lim Hon Sheang, Danny Chan Yi Xiang

The User Acceptance Testing (UAT) methodology for the ARVR Immersive Learning Solution (Car Parts) is designed to ensure a thorough evaluation of the application's effectiveness and usability in delivering an engaging learning experience.

1. Scope and Objectives:
    - The UAT aims to assess several critical aspects of the ARVR Immersive Learning Solution, including its ability to facilitate interactive learning experiences, accurately represent car engine components, and seamlessly integrate 3D models and ARVR features. The primary objectives include evaluating usability, catering to diverse learning styles, and validating educational effectiveness. Success is measured by how well the application fulfils these objectives and contributes to the field of automotive education.

2. Testing Team:
    - The testing team comprises a UAT Coordinator (Lim Hon Sheang) and a Test Designer/Executor (Danny Chan Yi Xiang). Lim Hon Sheang oversees coordination, communication, and documentation, while Danny Chan Yi Xiang is responsible for designing comprehensive test cases and executing tests. This division of responsibilities ensures effective coordination, comprehensive test coverage, and meticulous reporting throughout the UAT process.

3. Milestones and Deliverables:
    - The UAT process is divided into stages, including staging environment setup, training, UAT execution, and reporting. Each stage is meticulously planned to facilitate thorough testing, feedback collection, and analysis. Deliverables include a staging environment mirroring the production setup, structured training sessions for testers, execution of predefined test cases, and a comprehensive UAT report summarizing findings and recommendations.

4. Staging Environment:
    - A staging environment closely replicating the production environment is established to ensure realistic testing conditions. Testers are provided with access to authentic data sets and scenarios for accurate evaluation. This environment helps minimize risks associated with testing in live production systems and allows for controlled experimentation and validation of the application's functionality.

5. Training:
    - Structured training sessions are conducted to familiarize testers with the ARVR solution's features, navigation guidelines, and testing procedures.

Training ensures that testers are equipped with the necessary knowledge and skills to execute test cases effectively, thereby maximizing the quality and accuracy of test results.

6. UAT Execution:
   - Testers execute predefined test cases covering various aspects of the ARVR solution, including functionality, usability, and integration. We meticulously document their observations and report any issues encountered during testing, ensuring that all aspects of the application are thoroughly evaluated.

7. Reporting and Data Analysis:
   - Testers' feedback, bug reports, and test results are compiled and analysed to identify trends, patterns, and areas for improvement. A comprehensive UAT report is prepared, summarizing findings, recommendations, and action plans derived from the testing process. This report serves as a valuable resource for informing decision-making and driving improvements to the application.

8. Environmental Requirements:
   - Minimal and recommended hardware specifications are outlined to ensure optimal performance and user experience during testing. Adhering to these requirements helps maintain consistency and reliability across testing environments, enabling testers to accurately evaluate the application's performance under realistic conditions.

9. Features to be Tested:
   - Test cases are planned to verify specific functionalities of the ARVR solution, such as eye tracking, stylus pen interaction, button functionalities, and model displays. Each test case is prioritized based on its relevance and impact on the application's usability and effectiveness, ensuring that critical aspects of the application are thoroughly evaluated.

d) Result

Author: Danny Chan Yi Xiang

Based on the detailed descriptions provided for each test case, all were executed successfully without encountering significant issues or failures. The ARVR Immersive Learning Solutions (Car Parts) platform demonstrated robust functionality and responsiveness, including eye-tracking, stylus pen interaction, model display, and animation features.

Here is a summary of the overall results for each test case:

1. Test Case TC-001: The eye-tracking sensor functionality was highly responsive and accurate, contributing to a smooth user experience. No difficulties or issues were reported during testing, and feedback from testers was overwhelmingly positive.

2. Test Case TC-002: The stylus pen functionality for drag-and-drop actions and button clicks was thoroughly evaluated and found to align with specified requirements. Testers successfully performed interactions with the stylus pen without encountering any issues.
3. Test Case TC-003: The overview button functionality within the ARVR interface was evaluated and found to meet specified requirements. Testers were able to access and display the model overview without any difficulties.
4. Test Case TC-004: The car engine button functionality, including the car engine model's display and the dissection animation's initiation, was successfully executed without any issues.
5. Test Case TC-005: The car battery button functionality, including the model display and initiation of dissection animations, was verified to meet specified requirements without encountering any failures.
6. Test Case TC-006: The fuel button functionality, including model display and flow animation initiation, was executed successfully, demonstrating the platform's capability to deliver an immersive learning experience.

Overall, based on the successful execution of all test cases and the absence of significant issues or failures, the testing results indicate that the ARVR Immersive Learning Solutions (Car Parts) platform meets or exceeds specified requirements and is ready for deployment to users.

e) Post-project support

Author: Lim Hon Sheang

1. User Assistance and Training Materials:

   - Develop comprehensive user manuals and guides that outline the features, functionalities, and navigation instructions for the ARVR learning solution. These materials should be accessible online and regularly updated to reflect any changes or enhancements to the platform.
   - Create a library of video tutorials covering various aspects of the ARVR solution, including primary navigation, advanced features, and troubleshooting tips. These tutorials can be hosted on the platform's website or integrated directly into the application for easy access.
   - Offer live training sessions experienced instructors conduct to educate users on effectively utilizing the ARVR learning solution. These sessions can be delivered in person or virtually and tailored to different user groups, such as educators, students, and professionals.

2. Technical Support:

   - Establish a dedicated technical support team to respond to user queries, troubleshoot technical issues, and provide timely assistance. Ensure that support staff are well-trained and equipped with the resources to address user concerns effectively.
   - Offer multiple channels for users to reach out for support, including email, phone, live chat, and an online ticketing system. Provide clear instructions on contacting support and set reasonable response times for addressing user inquiries.

3. Bug Fixing and Updates:

- Implement systems to continuously monitor the ARVR learning solution for bugs, glitches, or performance issues. Utilize automated testing tools, user feedback, and internal testing procedures to identify and prioritize issues for resolution.
- Release regular updates and patches to address identified issues, improve performance, and introduce new features or content. Communicate update schedules and release notes to users to keep them informed of changes to the platform.

4. Content Expansion:

- Establish a structured content development pipeline to continuously expand the library of car parts models, interactive simulations, and educational modules. Engage subject matter experts and instructional designers to create high-quality content that aligns with curriculum standards and industry best practices.
- Solicit feedback from users, educators, and industry professionals to identify content gaps and prioritize new content development initiatives. Regularly review usage analytics and user feedback to inform content expansion decisions.

5. Feedback Collection and Analysis:

- Regular surveys and feedback forms will be conducted to collect input from users regarding their experience with the ARVR learning solution. Ask questions about usability, content relevance, and overall satisfaction to gather actionable insights.
- Utilize data analytics tools to analyse feedback data, identify trends, and uncover areas for improvement. Look for patterns in user feedback and prioritize enhancements based on the user community's most pressing needs and preferences.

6. Partnership and Collaboration Opportunities:

- Forge partnerships with educational institutions, automotive companies, and industry associations to promote the adoption of the ARVR learning solution. Collaborate on joint projects, research initiatives, and outreach activities to expand the reach and impact of the platform.
- Explore opportunities to syndicate content from reputable sources within the automotive industry, such as manufacturers, suppliers, and training organizations. Partnering with industry experts can enhance the credibility and relevance of the platform's content offerings.

6. Conclusion

Author: Lim Hon Sheang, Danny Chan Yi Xiang

In conclusion, the ARVR Immersive Learning (Car Parts) project has been outstanding, representing innovation and educational growth. This initiative has transformed how automotive engineering ideas are taught and comprehended by seamlessly integrating augmented and virtual reality technologies. By offering users rich, engaging experiences, the initiative has successfully bridged the gap between academic knowledge and actual application.

Throughout the project lifecycle, rigorous planning, diligent testing, and ongoing feedback have been critical in delivering a high-quality learning solution. The devotion and experience of the project team, which included developers, testers, and designers, were critical in attaining the project's goals.

The project's impact extends beyond traditional schooling by providing students a dynamic platform for exploring and comprehending complex automotive parts and systems. Its user-friendly interface, realistic 3D models, and engaging simulations have received excellent user comments, demonstrating its efficacy in improving learning outcomes.

Looking ahead, the success of the ARVR Immersive Learning (Car Parts) project serves as a model for future educational technology innovation. As technology advances, there is tremendous potential for additional developments in immersive learning experiences, ultimately allowing learners and educators to pursue knowledge and skill development in automotive engineering and beyond.

7. Reference

Author: Lim Hon Sheang, Danny Chan Yi Xiang

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8. Appendix

Author: Lim Hon Sheang, Danny Chan Yi Xiang

(attach the 1000 word CW Submission Evidence and Evaluation file for each member as appendix.)

Member 1: BSCS2309531

Member 2: BSCS2309535

UAT Test Plan for ARVR Immersive Learning Solution (Car Parts)

Team KiutBois

1. **Scope**
   a) **Objectives and business requirements**
      Goals:

      - The primary goal of this UAT is to assess the effectiveness and usability of the ARVR Immersive Learning Solution (Car Parts) (Car Parts). This entails evaluating how well the application fulfils its intended purpose of providing an Immersive and engaging Learning experience for automotive engineering students and professionals. Testers will gauge the application's ability to effectively convey complex concepts related to car engine components through interactive simulations and visual representations.
      - Another crucial objective is to ensure that the application meets the educational needs of its target audience. This includes catering to the diverse Learning styles and preferences of automotive engineering students and professionals. The UAT will focus on verifying whether the application provides sufficient depth of understanding, fosters critical thinking skills, and supports practical skill development in the field of automotive engineering.
      - Success in this UAT will be measured by the application's ability to fulfil specific criteria:
        - **Facilitation of Interactive Learning Experiences:** Testers will assess the degree to which the application engages users in interactive Learning experiences. This includes evaluating the interactivity of 3D models, animations, and other ARVR features.
        - **Accurate Representation of Car Engine Components:** The accuracy and fidelity of 3D models representing car engine components will be scrutinized to ensure they align with real-world counterparts.
        - **Seamless Integration of 3D Models and ARVR Features:** The integration between 3D models and ARVR features should be seamless, allowing users to navigate, interact with, and manipulate virtual objects effortlessly.

      These goals collectively serve to ascertain the ARVR Immersive Learning Solution (Car Parts)'s efficacy in enhancing Learning outcomes, providing a valuable educational resource, and addressing the educational requirements of automotive engineering students and professionals. The UAT aims to validate the application's ability to meet these objectives and contribute positively to the field of automotive education and training.

   b) **Pain Point**
      - The existing methods of learning about car engine components lack interactivity and engagement, hindering effective comprehension and practical skill development. Traditional educational approaches often rely on static textbooks or lectures, which fail to provide hands-on experiences or visualizations of complex

concepts. As a result, learners may struggle to grasp key principles and apply them in real-world scenarios.

c) **What We Are Testing**

i. **Functionality, Usability, and Integration Aspects:** The scope of testing encompasses various aspects of the ARVR Immersive Learning Solution (Car Parts). This includes evaluating its functionality, usability, and integration capabilities to ensure a seamless user experience.

ii. **Accuracy of 3D Models:** Testers will verify the accuracy and fidelity of 3D models representing car engine components. These models should closely resemble their real-world counterparts to facilitate effective Learning and comprehension.

iii. **Effectiveness of Animations:** The effectiveness of animations depicting assembly and disassembly processes will be assessed. These animations play a crucial role in elucidating complex concepts and procedures, enhancing understanding and retention.

iv. **Implementation of Interactive Features:** The implementation of interactive features such as drag-and-drop functionality and labelling will be evaluated. These features aim to engage users actively in the learning process, promoting exploration and experimentation.

v. **Unity Implementation:** The integration between Blender-created 3D models and ARVR features implemented in Unity will undergo testing to ensure seamless functionality and interaction.

vi. **User Experience:** User experience aspects including navigation, interface design, and responsiveness will be scrutinized. A user-friendly interface and intuitive navigation pathways are essential for maximizing user engagement and satisfaction.

d) **What We Are Not Testing**

i. **Hardware Compatibility and Performance:** Testing of hardware compatibility or performance limitations of VR headsets or devices falls outside the scope of this UAT. The focus remains on evaluating the application's functionality and usability rather than the underlying hardware infrastructure.

ii. **Administrative Features and Team Management Functionalities:** Administrative features such as user management or team collaboration functionalities are not within the purview of this UAT. The emphasis is on assessing the core educational features and functionality of the ARVR Immersive Learning Solution (Car Parts).

iii. **Data Overview Aspects:** Detailed data analytics or reporting features are excluded from testing in this stage. While data collection and analysis may be relevant for future iterations, they are not priorities for the current UAT phase.

By defining the scope clearly, we ensure that the UAT focuses on validating essential aspects of the ARVR Immersive Learning Solution (Car Parts) while aligning with business goals and requirements. This approach helps prioritize testing efforts and ensures that the application meets the desired objectives effectively.

2. Testing team

Name	Responsibility
Lim Hon Sheang	As the UAT Coordinator, Lim Hon Sheang plays a pivotal role in ensuring effective communication between end users and the Quality Assurance (QA) team. They serve as the central point of contact, facilitating discussions, gathering feedback, and conveying it to the QA team for action. Additionally, Lim Hon Sheang is responsible for setting up staging environments and developing usability test cases tailored to the end users' requirements. They meticulously document test results, analyse findings, and compile comprehensive reports summarizing the UAT outcomes. Their role is crucial in ensuring that the UAT process runs smoothly and that any issues or concerns raised by end users are addressed promptly and effectively.
Danny Chan Yi Xiang	Danny Chan Yi Xiang is primarily responsible for designing test cases that comprehensively cover the UAT objectives. Drawing upon their expertise in testing methodologies, Danny meticulously plans and structures test scenarios to validate the functionality, usability, and integration aspects of the ARVR Immersive Learning Solution (Car Parts) (Car Parts). In addition to designing test cases, Danny is tasked with creating test data sets that accurately represent real-world usage scenarios. They meticulously execute test cases, recording observations and findings, and collaborate with the QA team to ensure thorough testing coverage. Furthermore, Danny takes charge of writing detailed UAT reports, documenting test results, analysing trends, and providing actionable insights for further improvements. Their contributions are instrumental in ensuring the quality and effectiveness of the UAT process.

3. Milestones and deliverables

a) Design & Wireframes

- Link to designs:
  The designs for the ARVR Immersive Learning Solution (Car Parts), including 3D models, animations, and user interface elements, will be shared through this link. These designs serve as visual references to ensure that the QA team understands the intended functionality and user experience.

- Link to wireframes:
  Wireframes outlining the layout and structure of the application's screens and interactions will be provided via this link. Wireframes offer a simplified representation of the application's design, focusing on layout and content organization.

Testing Stages

1. **Staging Environment Setup:**
    - The staging environment, orchestrated by Lim Hon Sheang, will replicate the production environment to the closest extent possible. This environment ensures that testing occurs in a controlled setting that mirrors real-world conditions. To achieve this, a snapshot of the production database will be captured and utilized within the staging environment, providing testers with access to authentic data for testing purposes.

2. **Training:**
    - Training sessions led by Danny Chan Yi Xiang will be conducted to prepare UAT testers for their roles and responsibilities. These sessions will cover various aspects, including an overview of the ARVR application's features, navigation guidelines, and testing procedures. Through comprehensive training, testers will gain the necessary knowledge and skills to effectively execute test cases and provide valuable feedback during UAT.

3. **UAT Execution:**
    - During the UAT execution phase, testers will execute predefined test cases to evaluate the application's performance and functionality. Test cases will encompass scenarios related to 3D model accuracy, animation functionality, interactive features, and user experience. Testers will meticulously document their observations, noting any discrepancies, bugs, or usability issues encountered during testing. The execution of test cases will adhere to a structured approach, ensuring thorough coverage of all relevant aspects of the ARVR application.

4. **Reporting:**
   - Following the completion of UAT execution, a comprehensive data analysis will be conducted to review the test results. This analysis involves bug triage, where identified issues are prioritized based on severity and impact on the application's usability and functionality. A collaborative meeting will be convened to discuss the outcomes of the UAT, review the bug triage results, and strategize on necessary actions to address identified issues. The UAT report, compiled by Lim Hon Sheang, will document the findings, recommendations, and action plans derived from the UAT process.

b) Staging environment

The staging environment for the ARVR Immersive Learning Solution (Car Parts) will be designed to closely replicate the production environment while providing a controlled setting for UAT testing. The following requirements outline the setup and accessibility of the staging environment:

- **Data Replication:** To simulate real-world conditions, a copy of the production database will be utilized within the staging environment. This ensures that testers have access to authentic data sets and can perform testing activities with realistic scenarios. The process of copying the production database to the staging environment will be overseen by the system administrator or designated personnel to maintain data integrity and security.
- **User Onboarding:** Testers will be onboarded to the staging environment using our existing user profiles or credentials. This approach ensures consistency and familiarity for testers, allowing them to access the staging environment with the same user permissions and privileges as in the production environment.
- **Precautionary Measures:** Clear guidelines will be provided to testers to prevent accidental modifications or disruptions to live production systems. Additionally, measures will be in place to monitor and mitigate any potential risks or issues that may arise during UAT testing to safeguard the integrity of production systems.

By adhering to these requirements, the staging environment will serve as a reliable and secure platform for conducting UAT testing of the ARVR Immersive Learning Solution (Car Parts). Testers will have access to realistic data model and scenarios, allowing them to evaluate the application's functionality, usability, and performance effectively.

c) Training

For the training of beta testers participating in the User Acceptance Testing (UAT) of the ARVR Immersive Learning Solution (Car Parts), a structured approach will be adopted to ensure testers are equipped with the necessary knowledge and skills to effectively carry out their testing responsibilities. The training sessions will be conducted over a series of meetings held during the UAT period. The following outline delineates the training schedule and content:

Training Schedule

1. First Meeting (Week 1):
   - Duration: 30 minutes
   - Agenda:
     Presentation of New Feature & Business Objectives:
     - An overview of the ARVR Immersive Learning Solution (Car Parts) will be presented, highlighting its key features, functionalities, and intended objectives.
     - The business objectives driving the development of the ARVR Solution will be discussed to provide context for testers.

2. Second Meeting (Week 2):
   - Duration: 1 hour
   - Agenda:
     Logging into Staging Environment:
     - Detailed instructions will be provided on how to access the staging environment for UAT testing.
     - Enabling and Best Practices on the New Feature:
     - Testers will be guided on how to enable the ARVR feature within the staging environment and navigate through its functionalities.
     - Best practices for utilizing the ARVR Immersive Learning Solution (Car Parts) effectively will be shared, including tips for optimal user experience and engagement.

3. Third Meeting (Week 3):
   - Duration: 1 hour
   - Agenda:
     Reporting on Test Cases:
     - Testers will be trained on how to report their findings, observations, and test results using predefined test cases or reporting templates.
     - Guidelines on documenting issues, bugs, or usability concerns encountered during testing will be provided.

     Q&A Session:

- An opportunity for testers to ask questions, seek clarification on any aspects of the ARVR Solution or testing process, and discuss any challenges or concerns.

Training Facilitator:

- Danny Chan Yi Xiang will oversee the organization and facilitation of the training sessions.
- As the designated UAT Coordinator, Lim Hon Sheang will ensure that testers receive comprehensive training and support throughout the UAT process.

By conducting structured training sessions, testers will gain a thorough understanding of the ARVR Immersive Learning Solution (Car Parts), its features, and functionalities. This enables testers to execute their testing tasks effectively, provide valuable feedback, and contribute to the success of the UAT initiative.

d) UAT Execution

The UAT execution for the ARVR Immersive Learning Solution (Car Parts) will span over a designated period to allow testers to thoroughly evaluate the application's functionality, usability, and performance.

Timeline:

- UAT Execution Period: [1/4/2024] to [3/4/2024]
- Deadline for UAT Execution: [5/4/2024]

Steps:

1. **Onboarding:**
    - Each UAT tester will be individually onboarded to the staging environment.
    - Assistance will be provided to help testers access the ARVR Immersive Learning Solution (Car Parts).
    - Testers will be briefed on the testing objectives, expectations, and guidelines, which were also covered during the training sessions.
2. **Test Case Execution:**
    - Testers will be assigned specific test cases tailored to evaluate different aspects of the ARVR Solution.
    - Testers will execute the assigned test cases, interacting with the application's features and functionalities as per the defined scenarios.
    - Testers will report any bugs, issues, or feedback encountered during test case execution using the designated reporting mechanism (feedback form).

3. **Feedback Collection:**
    - Upon completion of test case execution, a quick meeting will be scheduled with each tester to gather feedback on their overall experience.
    - Testers will have the opportunity to provide insights, suggestions, and comments regarding the application's usability, effectiveness, and any areas for improvement.
    - Feedback collected during these sessions will be documented and compiled for further analysis and review.
4. **Deadline for UAT Execution:**
    - The UAT execution must be completed by the specified deadline to ensure timely evaluation and subsequent actions based on the feedback received.

Reporting and Analysis:

- Testers' feedback, bug reports, and test case results will be compiled and analysed to identify patterns, trends, and areas requiring attention.
- A comprehensive UAT report will be prepared, summarizing the findings, observations, and recommendations gathered during the testing phase.
- The UAT report will serve as a valuable resource for informing decision-making, prioritizing enhancements, and driving improvements to the ARVR Immersive Learning Solution (Car Parts).

By following these steps and adhering to the designated timeline, the UAT execution will proceed systematically, enabling testers to provide valuable insights and feedback essential for refining and optimizing the ARVR Solution before its final deployment.

e) Reporting & data analysis

Test Case TC-001

During the execution of Test Case TC-001, testers found the eye-tracking sensor to be highly responsive and accurate in detecting the user's eye movements. The sensor effectively tracked the user's gaze as they interacted with the ARVR interface, reflecting the movement of their eyes in real-time within the virtual environment. This seamless integration of eye-tracking technology with the ARVR interface contributed to a smooth and intuitive user experience.

- Testers reported no difficulties or issues encountered while performing the test cases, indicating the reliable functionality of the eye-tracking sensor. Users expressed satisfaction with the ease of use and precision of the eye-tracking feature, highlighting its effectiveness in enhancing user interaction within the ARVR environment.

- Feedback from testers was overwhelmingly positive, emphasizing the added value brought by the eye-tracking sensor to the overall ARVR experience. The accurate detection of eye movements and seamless integration with the interface were noted as particularly impressive features.
- No significant areas of improvement were identified during the testing process, indicating that the eye-tracking sensor met or exceeded expectations in terms of performance and usability.

Overall, the successful execution of Test Case TC-001 demonstrates the effectiveness and reliability of the eye-tracking technology integrated into the ARVR solution.

Test Case TC-002

During the execution of Test Case TC-002, the functionality of the stylus pen for drag and drop actions and button clicks was thoroughly evaluated to ensure its effectiveness in facilitating user interaction within the ARVR interface.

- Testers confirmed that the stylus pen was detected and ready for use, indicating that the device was properly recognized by the system. This initial observation reassured testers that the stylus pen was available for interaction within the ARVR environment, setting the stage for further testing.
- Users successfully performed drag and drop actions using the stylus pen, demonstrating its capability to interact with components within the ARVR interface. This functionality enables users to manipulate virtual objects effectively, allowing them to engage with the learning content in a hands-on manner. The successful execution of drag and drop actions signifies the responsiveness and accuracy of the stylus pen, essential for an immersive learning experience.
- Testers verified that the stylus pen accurately clicked on buttons within the ARVR interface, prompting the expected actions. This precise control and responsiveness enable users to navigate through the interface seamlessly, accessing various features and functionalities with ease. The ability to trigger actions through stylus pen clicks enhances user interaction and facilitates intuitive exploration of the ARVR environment.

Overall, the successful execution of Test Case TC-002 demonstrates that the stylus pen functionality for drag and drop actions and button clicks aligns with the specified requirements. The stylus pen serves as an effective tool for user interaction within the ARVR environment, contributing to an immersive and engaging learning experience for users.

Test Case TC-003

During the execution of Test Case TC-003, the functionality of the overview button within the ARVR interface was thoroughly evaluated to ensure its effectiveness in providing users with an overview of the model.

- Testers successfully navigated to the overview section within the ARVR interface, indicating that the navigation system was intuitive and user-friendly. This seamless navigation experience ensures that users can easily access relevant sections of the interface without encountering any obstacles or confusion.
- Upon clicking the overview button using the stylus pen, testers observed that the overview of the model was promptly displayed as expected. This functionality allows users to gain a quick understanding of the model's layout and main components, providing valuable context for further exploration and learning. The clear and concise presentation of the model overview enhances users' comprehension and facilitates their engagement with the learning content.

Overall, Test Case TC-003 yielded a pass result, indicating that the functionality of the overview button successfully met the specified requirements. The ability to access and display the model overview enhances the ARVR learning experience by providing users with essential information in a convenient and accessible manner.

Test Case TC-004

In the analysis of Test Case TC-004, the focus was on evaluating the effectiveness of the car engine button within the ARVR interface and its associated functionalities.

- The initial step involved testers navigating to the car engine section within the ARVR interface. The successful completion of this step indicates that the interface's navigation system is intuitive and user-friendly. This aspect is crucial for ensuring that users can seamlessly access different sections of the application without encountering any obstacles or confusion.
- Upon clicking the car engine button using the stylus pen, testers confirmed that the car engine model appeared promptly on the screen. This observation verifies that the button's functionality to display the corresponding model works as intended. The prompt display of the car engine model is essential for providing users with immediate visual feedback and engaging them in the learning process effectively.
- Testers verified that the dissect button, which allows users to initiate the dissection animation for the car engine model, was correctly displayed. This verification ensures that users have access to all relevant functionalities within the ARVR interface. The presence of the dissect button enhances the application's interactive nature, enabling users to explore the internal components of the car engine in-depth.
- Upon clicking the dissect button, testers confirmed that the dissection animation commenced without any issues. This observation indicates that the animation feature is seamlessly integrated into the application and responds promptly to user interactions. The initiation of the dissection animation

enhances the educational experience by providing users with a dynamic visualization of the car engine's internal structure and operation.

In summary, the analysis of Test Case TC-004 demonstrates that the car engine button's functionality within the ARVR interface meets the specified requirements effectively. The successful display of the car engine model and initiation of the dissection animation contribute to an immersive and informative learning experience for users. These observations affirm the application's capability to engage users and facilitate their understanding of complex concepts in automotive engineering.

Test Case TC-005

During Test Case TC-005, it demonstrates the car battery model and the button’s functionality within the ARVR interface.

- The initial step involves the user navigating to the car battery section within the ARVR interface. This step aims to verify the ease and effectiveness of the interface's navigation system in accessing specific sections. Upon execution, the user successfully reaches the car battery section without encountering any navigational issues. This confirms that the navigation within the interface is intuitive and user-friendly, ensuring seamless exploration of different components.
- After reaching the car battery section, the user proceeds to click the car battery button using the stylus pen. The expected outcome is the display of the car battery model on the screen. Upon execution, the car battery model is promptly displayed, indicating that the button's functionality to showcase the corresponding model operates as intended. This ensures that users can visually inspect and explore the car battery component within the ARVR environment.
- Following the display of the car battery model, the user verifies the presence of the dissect button associated with the car battery. This step aims to ensure that users have access to additional functionalities, such as initiating dissection animations, for further exploration. Upon verification, the dissect button is visible and correctly displayed for the car battery model, confirming that users can engage in detailed examinations of the component's internal structure.
- In the final step, the user clicks the dissect button to trigger the dissection animation for the car battery model. The expected outcome is the seamless initiation of the animation, allowing users to explore the internal components of the battery. Upon execution, the dissection animation starts as expected, indicating successful integration and functionality of the animation feature within the ARVR interface. This enables users to gain insights into the intricate details of the car battery's construction and operation.

In summary, Test Case TC-005 verifies the functionality of the car battery button within the ARVR interface, including the display of the corresponding model and the initiation of dissection animations. The successful execution of each step ensures a comprehensive and engaging learning experience for users, facilitating their understanding of car battery components and functionalities.

Test Case TC-006

During Test Case TC-006, the user successfully navigated to the designated fuel section within the ARVR interface without encountering any issues. This initial step ensured that the user could access the specific area intended for exploring the fuel component.

- Upon reaching the fuel section, the user utilized the stylus pen to interact with the interface, specifically clicking on the fuel button. This action triggered the display of the 3D model representing the fuel system, allowing the user to visually examine the component's details and structure. The successful rendering of the fuel model indicated that the interface responded appropriately to the user's input, ensuring a seamless transition to the fuel exploration mode.
- Following the display of the fuel model, the user proceeded to verify the presence of the start button, which is essential for initiating the flow animation. Confirming the visibility of the start button ensured that users could easily access the functionality required to commence the animation sequence.
- Once satisfied with the verification, the user clicked on the start button using the stylus pen. This action initiated the flow animation, simulating the process of fuel moving from the fuel tank to the engine within the ARVR environment. The animation sequence played smoothly, providing users with a realistic representation of the fuel flow dynamics.

Throughout the test case execution, the ARVR interface exhibited robust functionality, accurately responding to user interactions and effectively delivering the intended learning experience. The successful completion of Test Case TC-006 confirms the proper functionality of the fuel button and flow animation feature, contributing to the overall effectiveness of the ARVR immersive learning solution for car parts.

4. Environmental requirements

a) Hardware requirements

The ARVR immersive learning solution for car parts may have specific hardware requirements to ensure optimal performance and user experience. These requirements should be verified by the QA team to ensure compatibility with testers' machines. The following outlines the minimal and recommended hardware specifications that we will be using

- **CPU**: 11th Gen Intel® Core™ i5-11400H processor
- **GPU**: NVIDIA® GeForce RTX™ 3060 with 6GB GDDR6 VRAM

- **Memory**: Dual-channel 16GB DDR4 SDRAM
- **Additional Requirements**:
    - Stylus Pen: A compatible stylus pen for interaction with the ARVR interface.

Meeting the recommended specifications will enhance performance and overall user experience.

5. Features to be tested

a) Test Case Plan

Test Case ID	Description	Test Priority	Pre-Requisite	Post-Requisite
TC-001	Track user's eyes in the laptop	High	Laptop setup with eye-tracking sensor	Successful detection of user's eyes by sensor
TC-002	Verify stylus pen functionality for drag and drop	High	Stylus pen available	Stylus pen successfully drags and drops components
TC-003	Verify functionality of overview button	High	ARVR interface loaded with overview model	Overview of the model is displayed upon clicking the button
TC-004	Verify functionality of car engine button	High	ARVR interface loaded with car engine model	Car engine model is displayed upon clicking the button Dissect button is displayed for car engine
TC-005	Verify functionality of car battery button	High	ARVR interface loaded with car battery model	Car battery model is displayed upon clicking the button Dissect button is displayed for car battery
TC-006	Verify functionality of fuel button	High	ARVR interface loaded with fuel model	Fuel model is displayed upon clicking the button

				Start button is displayed for fuel model

b) Test Case

i. Eye tracking sensor

Test Scenario ID	TS-001	Test Case ID			TC-001
Description	User interaction with eye-tracking sensor	Test Priority			High
Pre-Requisite	Laptop setup with eye-tracking sensor	Post-Requisite			Successful detection of user's eyes by sensor
Test Execution Steps					
Step	Action	Inputs	Output	Test Result	Test Comments
1	User sits in front of the laptop	None	Proper visualization of ARVR interface	Pass	User's presence is detected by the eye-tracking sensor.
2	User moves eyes while looking at the screen	None	Movement of eyes reflected in the ARVR interface	Pass	Eye-tracking sensor accurately tracks user's eye movements.
3	User looks away from the screen briefly	None	Pause or stop in eye movement detection	Pass	Eye-tracking sensor pauses detection when user looks away.

ii. Stylus pen functionality

Test Scenario ID	TS-001	Test Case ID	TC-002
Description	Verify stylus pen functionality for drag and drop and click	Test Priority	High
Pre-Requisite	Stylus pen available	Post-Requisite	Stylus pen successfully drags and drops components and clicks buttons
Test Execution Steps			

Step	Action	Inputs	Output	Test Result	Test Comments
1	User picks up the stylus pen	None	Proper functionality of stylus pen observed	Pass	Stylus pen is detected and ready for use.
2	User attempts to drag and drop a component in the ARVR interface	Stylus pen	Component is successfully dragged and dropped	Pass	Stylus pen successfully performs drag and drop action..
3	User attempts to click on a button using the stylus pen	Stylus pen	Button is clicked and action is triggered	Pass	Stylus pen successfully clicks buttons in the ARVR interface.

iii. Overview model

Test Scenario ID	TS-001	Test Case ID	TC-003
Description	Verify functionality of overview button	Test Priority	High

Pre-Requisite	ARVR interface loaded with overview model	Post-Requisite	Overview of the model is displayed upon clicking the button
Test Execution Steps			

Step	Action	Inputs	Output	Test Result	Test Comments
1	User navigates to the overview section in the ARVR interface	None	User navigates to the overview section in the ARVR interface	Pass	User reaches the overview section without issues.
2	User locates and clicks the overview button using the stylus pen	Stylus pen	Overview of the model is displayed	Pass	Overview of the model is successfully displayed upon clicking the button.

iv. Car engine

Test Scenario ID	TS-001	Test Case ID	TC-004
Description	Verify functionality of car engine button	Test Priority	High
Pre-Requisite	ARVR interface loaded with car engine model	Post-Requisite	Car engine model is displayed upon clicking the button, and the dissect button is displayed for car engine
Test Execution Steps			

Step	Action	Inputs	Output	Test Result	Test Comments
1	User navigates to the car engine section	None	Navigation to the car engine	Pass	User reaches the car engine

	in the ARVR interface		section successful		section without issues.
2	User locates and clicks the car engine button using the stylus pen	Stylus pen	Car engine model is displayed	Pass	Car engine model is successfully displayed upon clicking the button.
3	User verifies the dissect button is displayed for car engine	Stylus pen	Dissect button is visible	Pass	Dissect button is correctly displayed for the car engine model.
4	User clicks the dissect button	Stylus pen	Dissection animation starts	Pass	Dissection animation starts as expected upon clicking the dissect button.

v. Car battery

Test Scenario ID	TS-001	Test Case ID			TC-005
Description	Verify functionality of car battery button	Test Priority			High
Pre-Requisite	ARVR interface loaded with car battery model	Post-Requisite			Car battery model is displayed upon clicking the button, and the dissect button is displayed for the car battery
Test Execution Steps					
Step	Action	Inputs	Output	Test Result	Test Comments
1	User navigates to the car	None	Navigation to the car battery	Pass	User reaches the car battery

	battery section in the ARVR interface		section successful		section without issues.
2	User locates and clicks the car battery button using the stylus pen	Stylus pen	Car battery model is displayed	Pass	Car battery model is successfully displayed upon clicking the button.
3	User verifies the dissect button is displayed for car battery model	Stylus pen	Dissect button is visible	Pass	Dissect button is correctly displayed for the car battery model.
4	User clicks the dissect button	Stylus pen	Dissection animation starts	Pass	Dissection animation starts as expected upon clicking the dissect button.

vi. Car fuel

Test Scenario ID	TS-001	Test Case ID	TC-006		
Description	Verify functionality of fuel button and flow animation	Test Priority	High		
Pre-Requisite	ARVR interface loaded with fuel model and start button visible	Post-Requisite	Animation for fuel flow from fuel tank to engine starts upon clicking the start button		
Test Execution Steps					
Step	Action	Inputs	Output	Test Result	Test Comments

1	User navigates to the fuel section in the ARVR interface	None	Navigation to the fuel section successful	Pass	User reaches the fuel section without issues.
2	User locates and clicks the fuel button using the stylus pen	Stylus pen	Fuel model is displayed.	Pass	Fuel model is successfully displayed upon clicking the button.
3	User verifies the start button is visible for the fuel model	Stylus pen	Start button is visible.	Pass	Start button is correctly displayed for the fuel model.
4	User clicks the start button	Stylus pen	Flow animation starts	Pass	Flow animation starts as expected upon clicking the start button.