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Development of Offloading Oil Products Simulations for Petrol Pump Employees Using Virtual Reality : Offload VR

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Abstract

The "Offloading Oil Products Simulations" project uses VR technology to tackle critical training challenges in the oil and gas industry, a key pillar of global economic stability. Traditional training for high-risk tasks, such as offloading oil from tanker trucks, poses hazards like chemical exposure, physical injuries, and inefficiencies. Developed for the Oculus Quest 3, this innovative application provides a fully immersive, interactive environment where users can safely practice complex procedures. Tailored for petrol pump employees at Ujong Pasir, Melaka, the simulator includes four detailed modules; Dipping, Documentation, HSE Preparation, and Quality Check. By employing TRES-D methodology, the project ensures iterative enhancements, seamless functionality, and user-friendly design, significantly reducing costs and safety risks while improving training outcomes. Usability test conducted on 20 petrol pump employees yielded 69.13 score, indicating that the system is acceptable. This initiative sets new standards for productivity, creativity, and workforce readiness in high-risk industries.

1. Introduction

The oil and gas industry is a cornerstone of global economic prosperity, driving manufacturing, mobility, and daily life [1]. Training a skilled workforce to manage high-risk tasks, such as offloading oil from tanker trucks, is essential but fraught with challenges. Traditional training methods involve physical practice with real equipment, requiring costly facilities, expert trainers, and exposing employees to hazards like chemical exposure, physical injuries, and operational inefficiencies. These risks underscore the need for innovative, safer, and more cost-effective training methods to prepare workers effectively.

Traditional training methods pose significant challenges, including high operational costs, safety risks, and inconsistent training quality. Studies reveal that 94.1% of gas station workers report occupational accidents, with 74.2% involving hazardous fuel contact [2]. There exist the needs to address these gaps by creating a realistic, immersive training solution tailored to improve safety, reduce costs, and prepare employees for certification.

Despite the effectiveness of VR in other industries, its adoption in the oil and gas sector has been slow, particularly for high-risk tasks like fuel offloading. Existing VR solutions primarily target large-scale operations, leaving a gap for focused, task-specific training. Therefore, this project aims to develop a VR-based training application, Offloading Oil Products Simulations, for petrol pump employees at Ujong Pasir, Melaka through a fully immersive simulation for mastering the oil offloading process while enhancing safety and efficiency. Specifically, it focuses on designing interactive VR training modules, guiding users through each step of the process, and performing comprehensive functional and usability testing to ensure the system meets user needs and industry standards.The expected outcomes include a fully immersive application designed for the Oculus Quest 3, featuring four modules: Dipping, Documentation, HSE Preparation, and Quality Check. Users will experience realistic training scenarios with intuitive interfaces and responsive controls, enabling seamless navigation and task execution. This VR application is anticipated to significantly enhance training effectiveness, lower costs by minimizing reliance on physical equipment, and improve safety by providing a risk-free environment for practice, thereby transforming workforce development in the oil and gas industry.

2. Related Work

This section discusses the study domain, the technology used, and the comparative analysis's findings.

2.1 Offloading Process in Oil & Gas Pump Industry

The offloading process in the oil and gas industry is a critical operation requiring meticulous precision, robust safety measures, and strict adherence to established protocols. This process involves transferring petroleum products, such as gasoline, diesel, or crude oil, from transport vehicles like tanker trucks to storage facilities or distribution systems. Any oversight or error during this operation can lead to severe consequences, including environmental hazards, financial losses, and threats to human safety. Studies reveal that over 70% of industrial accidents are attributed to human error, highlighting the urgent need for enhanced training methods to mitigate such risks and improve operational reliability [3].

Traditionally, training methods for offloading operations have relied heavily on theoretical instruction through paid classroom sessions and manual, hands-on demonstrations at actual sites. While these methods provide foundational knowledge, they often fall short of replicating the complexities and unpredictability of real-world challenges. Moreover, such approaches expose trainees to significant risks, including accidental spills, equipment mishandling, or other hazardous incidents. This lack of safe and realistic training environments underscores the need for innovative solutions.

To address these gaps, the "Offloading Oil Products Simulation" project introduces the integration of Virtual Reality (VR) technology into training programs. By leveraging VR, this project provides a controlled, immersive, and interactive environment where employees can practice the offloading process without facing real-world risks. This approach not only enhances the practical understanding of operational procedures but also ensures that trainees are better prepared for emergencies and complex scenarios. VR-based training offers a modern and effective alternative, bridging the gap between theoretical learning and real-world application while prioritizing safety and efficiency [3][4].

2.2 Virtual Reality

The proposed VR simulation leverages cutting-edge technology to deliver a fully immersive training experience. Key components include head-mounted displays (HMDs), motion controllers, and haptic feedback systems. These tools collectively create a virtual environment where users can interact with digital objects in a realistic manner, enabling them to perform tasks such as connecting hoses, climbing ladders, and monitoring equipment [4].

Haptic feedback plays a crucial role in enhancing the sense of realism by simulating tactile sensations, allowing trainees to feel resistance or pressure when interacting with virtual equipment. This not only increases engagement but also ensures that users develop muscle memory for critical tasks. Additionally, the system incorporates real-time feedback mechanisms and adaptive scenarios. These features provide trainees with immediate responses to their actions, helping them learn from mistakes and refine their skills. The adaptive scenarios cater to varying proficiency levels, allowing beginners to focus on fundamental tasks while challenging experienced users with complex, high-pressure situations [5].

The training modules are designed to replicate real-world conditions accurately, including environmental factors, equipment configurations, and safety protocols. This high level of fidelity ensures that trainees are well-prepared to transition from virtual simulations to actual operations with confidence and competence [5].

2.3 Physical, onsite Training Methods in Offloading

Traditional training methods for oil pump employees involve a blend of theoretical instruction, manual practices, and on-the-job observation. These methods typically begin with classroom-based lessons, where employees learn the fundamentals of the offloading process, including safety protocols, equipment functions, and operational steps. While this provides a foundational understanding, the absence of practical application often results in limited retention and preparedness.

On-the-job shadowing is another common component of traditional training. In this approach, trainees observe experienced workers performing tasks such as inspecting hoses and couplings, connecting equipment, and monitoring analog gauges. Although this hands-on exposure introduces employees to real-world conditions, it is inherently risky, as trainees are exposed to hazardous environments without sufficient preparation. Moreover, manual inspections and the reliance on basic tools like analog gauges make the process prone to human error, compromising safety and efficiency.

The lack of immersive and interactive elements in traditional methods leaves significant gaps in the training experience. Employees often struggle to build confidence and competence, particularly in handling complex tasks or emergencies. This underscores the need for more advanced training solutions, such as VR simulations, which offer safe, engaging, and effective learning environments [3].

2.4 Comparative Analysis

Comparative analyses were conducted on three related applications to the proposed system. The three applications are COMOS Walkinside VR[6], VR Familiarization on Oil Platform[7], and PIXO VR - Online Ladder Safety Training [8] as shown in Fig. 1(a), (b), and (c), respectively. Table 1 shows the result of the comparative analysis.

The "Offloading Oil Products Simulation" addresses the specific needs of petrol pump operations, making it a tailored solution compared to general-purpose VR applications like COMOS Walkinside and Paleblue's VR Familiarization. Its fully immersive setup, combined with haptic feedback and real-time adaptive scenarios, ensures a comprehensive training experience that bridges the gap between theoretical knowledge and hands-on expertise. Additionally, by eliminating the risks associated with on-site training, this system provides a safe and efficient alternative, ultimately enhancing employee preparedness and organizational safety standards [3][7], [8].

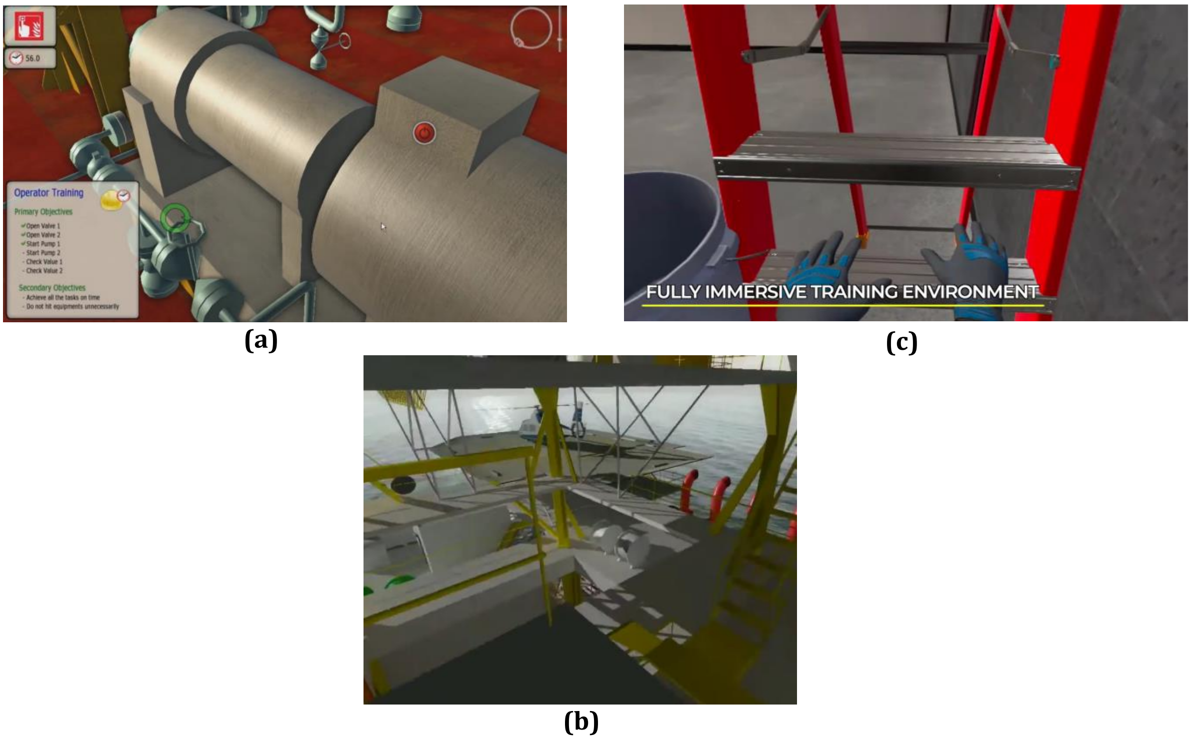


Fig. 1 **(a)** *COMOS Walkinside VR[6];* **(b)** *VR Familiarization on Oil Platform[7];* **(c)***PIXO VR - Online Ladder Safety Training[8].*

Table 1 *Comparative analysis*

	COMOS Walkinside VR[6]	VR Familiarization on Oil Platform[7]	PIXO VR - Online Ladder Safety Training [8]	Off-Loading Simulation VR

Category of VR Technology	Fully-immersive	Fully-immersive	Fully-immersive	Fully-immersive
App Content	User learn the operator training, and emergency training.	User learn about the oil rig environment. (no interaction)	User learn the ladder safety.	Equipment handling and train how to execution of the offloading process
Focus Area	Oil rig	Oil rig	Construction sites	Oil pump station
Hardware	Headset, mouse and keyboard	Headset, mouse and keyboard	Headset and controller	Headset and controller
Learning Module	Provide Emergency protocol learning module	No learning module	Provide ladder safety learning module	Provide 4 learning module : Dipping, Documentation, HSE Preparation, and Quality Check
Interactivity	Operate machine	No interactivity	-Press button to climb	-Tap tablet screen -Draw -Climb ladder

3. Methodology/Framework

The Off-Loading Simulation VR has been developed using the TRES-D methodology, as depicted in Fig. 2. This is so because VR application development is the focus of the TRES-D methodology [9] and for its comprehensive coverage of the development process. The six phases of this methodology are the initial requirement phase, understand requirement phase, concept design phase, iterative design phase, development phase, and testing phase. The iterative design process contains two more subphases, abstract design and presentation design. In this project, deployment and maintenance phase will not be conducted. Some slight modifications have been made to the TRES-D methodology to fit this project. Table 7 in Appendix A provides a summary of the output of the six phases of the TRES-D methodology.

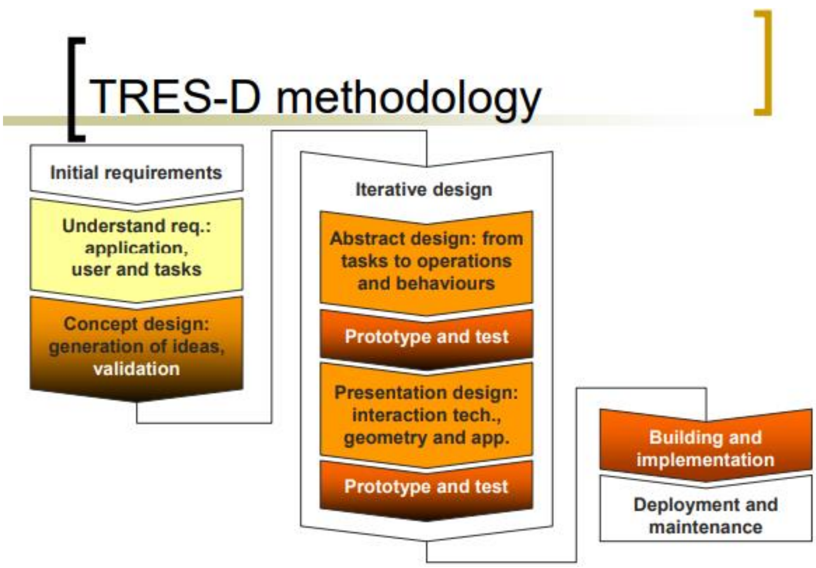


Fig. 2 *TRES-D Model*

3.1 Initial Requirements

In the initial phase of developing the Off-Loading Simulation VR, the required preliminary specifications were identified. This process involved reviewing existing applications, conducting an interview with a Subject Matter Expert (SME) An interview was held with Mrs. Nooredayu binti Yahaya, an experienced oil pump owner at a petrol pump in Melaka, with 20 years of experience in operating all oil pump station. Based on the findings, an initial requirements checklist was compiled, as presented in Table 2. Additionally, Table 3 summarizes the user analysis derived from the interview. The interview transcript and the questionnaire questions are included in Appendix A.

Table 2 *Initial requirement checklist*

Item	Description
Type of application	Training Simulation
Objective	• To design a fully immersive Offloading Oil Products Simulations using virtual reality approach. • To develop the oil offloading simulation that guide users through each step of the oil reception process by implementing fully immersive VR. • To perform functional testing and usability testing on the developed application to the target user.
Target platform	Android-Based
Target device	Oculus meta quest 3
Target user	petrol pump employee
Content	Offloading oil from tanker truck training procedure
Technology used	Virtual Reality (VR)

Table 3 *User analysis*

Stakeholder	Role in product	Design implication	Action needed
Subject Matter Expert (SME) Nooredayu binti Yahaya	Petrol pump owner 20 years experiences	Use action to mimic the real life application.	Make a module where user can climb the truck using ladder.
		Multimedia content	Put audio, music, and images.
		Content, based on Offloading Oil Process	Make 3D Model top replicate real equipment.
		Easy to navigate, user friendly.	Use the start, play, next, previous, and home buttons to navigate the user to relative pages.

3.2 Understand Requirements

The second phase focuses on understanding the requirements essential for developing the project. During this phase, the structure of the application is analyzed in detail. Tables 4 and 5 outline the functional and non-functional requirements of the proposed application. Additionally, the system flowchart, navigation structure diagrams, and content structure for each module of the application are provided in Appendix B through Appendix F.

Table 4 *Functional requirements*

Functional requirement	Module	Description
Autonomous system Activities	Practical Module	The sound and music should play when the users enter the Practical Module
Learning content	Practical Module	The application should allow users to learn four different types of procedures.
User interaction	Main menu	The application should allow users to select the Practical Module, Activity Module, and Setting buttons
	Practical Module	The application should allow users to select four different procedure they want.

Table 5 *Non-functional requirements*

Non-functional requirements	Description
Performance	The applications should be able to perform and load all the modules and pages.
Legal	Users should only be able to view the content of the application and are not able to edit or modify the content.
Usability	Users should be able to access the application everywhere, and anywhere they want if they have the hardware required for the application to run.
Operational	The application should be able to operate on Meta Quest devices with an Android-based platform.

3.3 Concept Design

The third phase of the TRES-D methodology focuses on establishing the concept design for the project. Using the collected data, various solutions are developed to support the project's progression. A key goal of this phase is to define the tasks users can perform within the Off-Loading Simulation, including the specific actions or operations needed to meet their objectives while using the app. These tasks are primarily derived from consultations with subject matter experts (SMEs), including the SME interview and application review conducted for this project. During the concept design stage, several activities related to user interactions were identified and incorporated into the proposed application.

3.4 Iterative Design

The fourth phase of the TRES-D methodology involves iterative design, which consists of two key subphases: abstract design and presentation design. Once these designs are completed, user feedback is collected to identify potential improvements. Based on this feedback, refinements are made to address any identified shortcomings. Detailed discussions of the abstract and presentation design subphases are provided in Sections 3.4.1 and 3.4.2.

This subphase focuses on defining the interactions between the user and the virtual environment. It involves outlining how users will engage with objects, including their responses to various inputs. The design specifies the behaviors of objects, ensuring they react appropriately to user actions. These operations form the foundation for creating a seamless, high-level interaction framework. This framework represents an abstract view of user-object interactions, promoting a clear and intuitive experience. A comprehensive storyboard in Appendix G further illustrates these interactions, while Table 6 offers detailed insights into the interaction design.

Table 6 *Interaction design*

Module	Locomotion System	Interaction
Menu	• Teleport • Snap turn	• Grab interaction • Poke interaction
Dipping	• Continuous movement • Snap turn	• Grab dipping point • Grab dipping stick with rotation limit
Documentation	• Continuous movement • Snap turn	• Draw interaction
HSE Preparation	• Continuous movement • Snap turn	• Grab interaction • Pop ui interaction
Quality Check	• Continuous movement • Snap turn	• Grab interaction • Climb interaction

3.4.1 Abstract Design

This subphase emphasizes the platform-independent aspects of the design. It includes developing plans for the virtual environment, outlining the layout and navigation. The behaviors of objects and their responses to user inputs are defined. Task decomposition identifies specific operations applicable to individual objects, detailing their preconditions, parameters, and outcomes. These operations establish a high-level interaction framework between the user and the objects, representing the abstract perspectives of the items. A comprehensive storyboard is provided in Appendix G.

3.4.2 Presentation Design

This subphase focuses on analyzing the visual and interactive components of the application. It delves into the finer details of user interaction, starting with the selection of interaction styles for each group of operations. The required information for each operation is translated into fundamental interaction tasks, which are then associated with specific interaction techniques. The behavior of these techniques is described based on the actions performed using input devices. The 3D modeling process in Blender starts in this phase where detailed and polished assets are created as shown in Figure 3. Table 7 provides details of the button design.

Table 7 *Button design*

Button	Description	Button	Description
Mula	Takes users to the simulation modules.	"Dipping"	Leads to the dipping module.
Tetapan	Allows users to adjust the volume of background music in settings.	Dokumentasi	Leads to the documentation module.
Mulakan semula	Resets the simulation or process to its starting point.	Penyediaan HSE	Leads to the equipment module.
Audio	Opens the audio settings for controlling sound preferences.	Pemeriksaan kualiti	Leads to the quality check module.
Kawalan	Provides access to the system or simulation controls.	<	Takes the user back or returns to the previous screen.
Tutup	Closes the current window.		

Fig.3 aluminium bucket**(a)**; petrol pump Environment**(b)**; oil finding paste**(c)**; oil truck modal**(d)**

3.5 Building and Implementation

In this phase, the primary objective was to bring the VR application to life by integrating the required tools, models, and functionalities. This involved selecting the appropriate development tools, integrating assets, programming interactions, and continuously testing the system for bugs and usability issues.

3.5.1 Asset Development

In this phase, the main functions of the proposed application were developed. This included creating multimedia assets and integrating them into Unity software. A total of three multimedia elements were developed as application assets, consisting of 2D animation, and audio, as outlined in Table 8.

Table 8 *Application asset development*

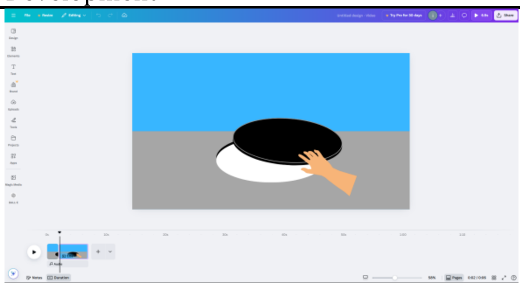
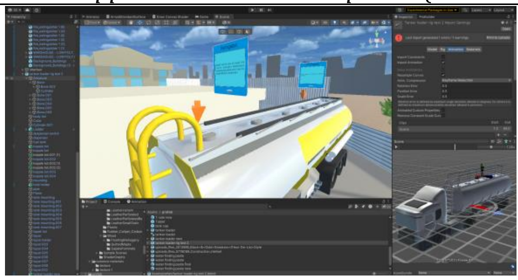
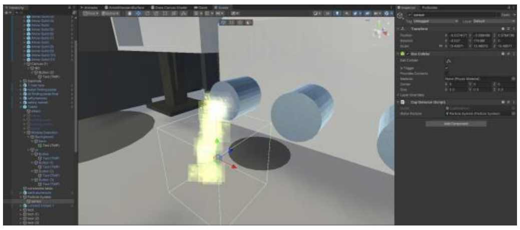
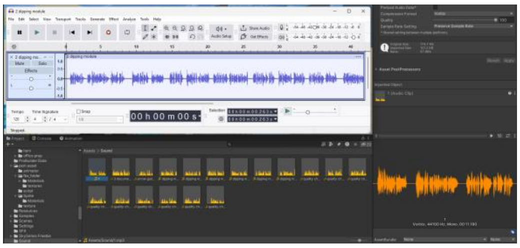
Assets	Development	Description
2D Animation		This 2D educational animation demonstrates the dipping point in the offloading process with smooth, clear transitions set against a professional blue background. Designed to guide users visually without sound, it breaks down each step in an easy-to-follow manner, making it ideal for training and instructional use.

Table 8: *Application asset development (continued)*

3D Animation		This 3D animation simulates a safety procedure where the top railing of a tanker truck rises after the user interacts with the access door near the ladder. Created for training purposes, it visually guides users on proper steps before accessing the top of the tanker.
Particle System		This particle system simulates liquid oil flowing from the side of the tanker truck. It is triggered automatically when an aluminum bucket is placed nearby, visually representing the start of the offloading process.
Audio		The animation includes formal voice narration that guides users step by step through the process, ensuring clear and structured instructions during each part of the simulation.

C# scripting was then used to make sure the application's primary features ran without an issue. According to the integration process in Unity as shown in Table 9, these features include the arrow guide controller system, zone sound trigger, and particle filler stage.

Table 9 *Integration in Unity*

Function	C# script		Description

Arrow Sequence Controller	private void Start()
	{
	foreach (var arrow in arrowSteps)
	{
	arrow.Deactivate();
	}
	if (arrowSteps.Length > 0)
	{
	arrowSteps[0].Activate();
	arrowSteps[0].controller = this;
	}}
		Public void OnArrowStepCompleted(int index)
		{
		if (index != currentArrowIndex) return;
		arrowSteps[currentArrowIndex].Deactivate();
		currentArrowIndex++;
		if (currentArrowIndex < arrowSteps.Length)
		{
		arrowSteps[currentArrowIndex].controller = this;
		arrowSteps[currentArrowIndex].Activate();
		}
		}
			This Unity script manages a sequence of arrow steps, typically for tutorials or guided instructions. At the start, it deactivates all steps and activates the first one. When a step is completed, the OnArrowStepCompleted() method is called to move to the next step, ensuring only one arrow is active at a time.

Table 9: *Integration in Unity* (continued)

Function	C# script		Description

Particle filler stage	void Update()
	{if (isFilling){
	fillTimer += Time.deltaTime;
	if (fillTimer >= timeToFull)
	SetState(2); // Full
	else if (fillTimer >= timeToHalf)
	SetState(1); // Half}}
		public void StartFilling()
		{isFilling = true;}
		public void StopFilling()
		{isFilling = false;}
		private void SetState(int state){
		emptyCup.SetActive(state == 0);
		halfCup.SetActive(state == 1);
		fullCup.SetActive(state == 2);}}
			This Unity script controls a cup filling animation over time. When filling starts, it tracks time in Update() and changes the cup's visual state to half or full. It uses SetState() to switch between empty, half, or full cup objects based on the current fill level.

Zone Sound Trigger	private void
	OnTriggerEnter(Collider other)
	{
	if (other.CompareTag("Player")
	&& !playerInside)
	{
	playerInside = true;
	soundLoopCoroutine =
	StartCoroutine(PlaySoundLoop());
	}}
		private void
		OnTriggerExit(Collider other)
		{
		if (other.CompareTag("Player"))
		{
		playerInside = false;
		if (soundLoopCoroutine != null)
		{
		StopCoroutine(soundLoopCorout
		ine);
		}}}
		private IEnumerator
		PlaySoundLoop()
		{
		while (playerInside)
		{
		audioSource.Play();
		yield return new
		WaitForSeconds(delayBetweenS
		ounds);
			This Unity script plays a looping sound when the player enters a trigger zone. It starts a coroutine to play the sound repeatedly with a delay. When the player exits the zone, the sound loop stops.

3.6 Deploy and maintenance

The testing phase is the final stage and includes functional testing, user acceptance testing, performance testing, and bug fixing. Functional testing focuses on verifying the functionality of the buttons and features within the completed application. Two types of testing was performed: the functional testing and the System Usability Scale (SUS). Any bugs or areas for improvement identified during testing are addressed through bug fixing to ensure smooth operation. Once all issues are resolved and the application performs optimally, user acceptance testing is conducted with the target audience.

Table 10 *Functional testing*

Functional requirement	Module	Description
Autonomous system Activities	Menu	After loading screen, user will hear audio to start training.
		Button on tablet can be press using poke interactor.
Learning content & User interaction	Dipping	User can move using teleport using controller input.
		An audio guild will play after load in the module.
		Audio will play if user step on arrow indicator.
		UI will show if user step on arrow indicator.
		User can grab dipping point using hand.
		User can grab and pull out dipping stick using hand.
		User can use tablet to go to next module.

Table 10 (continued)

	Documentation	User can move using controller input using continuous movement.
		User can grab object using hand
		User can draw using virtual pen on the plane in virtual space.
		User can use tablet to go to next module.
	HSE Preparation	User can grab object to display UI.
		User can see reflection for the wearing safety harness interaction
	Quality Check	User can navigate through the environment using continuous movement.
		Arrow guild will appear during start of training.
		User can step on arrow indicator to play audio for the training guild.
		Audio will looping until user move away from arrow indicator.
		Next arrow will appear after user leave the the previous arrow.
		Audio will play after safety door near ledder is open.
		User can climb using ladder to get on to oil truck.
		User can open the tanker oil cap using hand.
		User can use poke interactor to push button.
		Particle system will play if detect a bucket alluminium.

SUS (System Usability Scale) is a simple and effective instrument to assess usability. It is a 10 item Likert scale to measure the extent to which a system or digital product is user-friendly and easy to use. The final score gives a nice sense about what it was like to use them all. SUS is popular as having flexibility, and give a clear overview of system's usability for a variety of ICT. Result for System Usability Scale outlined in Figure 4.

Responden	Skor Item										Skor Ganjil	Skor Genap	Jumlah Skor
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10			
R01	4	3	4	4	3	2	5	3	4	1	15	12	67.5
R02	4	3	4	4	4	2	4	2	4	4	15	10	62.5
R03	5	5	5	5	5	5	5	5	5	5	20	0	50
R04	5	4	5	5	3	2	5	1	5	4	18	9	67.5
R05	4	3	2	5	4	2	3	1	3	4	11	10	52.5
R06	5	3	5	5	5	3	5	1	5	3	20	10	75
R07	4	4	3	3	3	3	4	2	4	2	13	11	60
R08	3	4	4	2	4	1	5	2	4	2	15	14	72.5
R09	4	2	4	3	5	1	5	1	4	3	17	15	80
R10	4	2	4	5	5	1	5	3	4	3	17	11	70
R11	4	2	4	2	4	2	4	2	4	2	15	15	75
R12	4	4	4	3	2	4	2	5	2	5	9	4	32.5
R13	5	1	5	1	5	1	5	1	5	1	20	20	100
R14	4	2	4	2	5	1	5	1	5	1	18	18	90
R15	4	2	4	2	4	2	4	2	5	1	16	16	80
R16	3	4	3	5	4	2	4	2	4	2	13	10	57.5
R17	5	1	5	2	4	2	5	2	4	2	18	16	85
R18	4	2	4	1	5	2	4	2	5	1	17	17	85
R19	5	2	4	2	5	2	5	4	5	4	19	11	75
R20	2	4	3	3	3	3	4	3	3	4	10	8	45
												Skor Purata	**69.13**

Fig.4 System Usability Scale

4. Result and Discussion

The development and testing of the "Offloading Oil Products Simulations" VR application produced findings that were consistent with the project's goal to enhance training safety, cost efficiency, and procedural rightness for petrol pump employees. The system was tested using the Oculus Quest 3 and included four modules: Dipping, Documentation, HSE Preparation, and Quality Check, each of which corresponded to real-life tasks discovered through talk with industry experts. Functional testing revealed successful implementation of core interactions. Users were able to teleport, climb ladders, manipulate virtual tools, and receive dynamic feedback through audio and arrow indicator. These interactions replicated real-world oil offloading activities while mitigating the associated physical risks. The immersive experience was further enhanced through particle simulations, 3D animations, and responsive C# scripting, aligning with best practices in immersive training development [4][5].

From Figure 4, we can see that there are a total of 10 questions. All these questions are used to evaluate the usability of the proposed application, Offload.For the first question, “Saya fikir saya ingin menggunakan sistem ini dengan kerap,” most respondents selected “strongly agree.” This shows that users found Offload VR useful and engaging. The application's immersive and structured experience made them more inclined to use it regularly to improve their understanding of offloading procedures. In the second question, “Saya mendapati sistem ini terlalu rumit tanpa keperluan,” only a small number of respondents selected “strongly agree,” indicating that most found the app easy to use. This is likely due to its clean interface, step-by-step module guidance, and consistent design that helps users navigate without confusion. The third question, “Saya fikir sistem ini mudah digunakan,” also received a high number of “strongly agree” responses. Users appreciated the responsiveness and logical flow of the application, which made learning tasks smooth and efficient. For the fourth question, “Saya rasa saya memerlukan bantuan daripada individu yang mahir dari segi teknikal untuk menggunakan sistem ini,” the majority answered “neutral.” This could be because many users were first-time VR users and unsure of what support they might need. It may also reflect a learning curve related to interacting with VR hardware for the first time. In the fifth question, “Saya mendapati pelbagai fungsi dalam sistem ini digabungkan dengan baik,” about half of the users selected “strongly agree.” This suggests that they found the modules, such as Dipping, Documentation, HSE Preparation, and Quality Check—functioning smoothly together without disruption.

For the sixth question, “Saya fikir terdapat terlalu banyak ketidakkonsistenan dalam sistem ini,” the majority answered “strongly disagree.” The application maintains a consistent layout, with standardized colors, buttons, and icons across modules, which helps reduce cognitive load and improves usability. The seventh question, “Saya membayangkan kebanyakan orang boleh belajar menggunakan sistem ini dengan cepat,” received mostly “agree” responses. This reflects the application’s intuitive design, which allows users—especially first-time trainees—to pick it up quickly without needing extensive instructions. For the eighth question, “Saya mendapati sistem ini menyusahkan untuk digunakan,” none of the users selected “strongly agree.” This indicates that users found the system efficient, aided by instructional buttons and guided steps that helped them progress without confusion. In the ninth question, “Saya berasa sangat yakin menggunakan sistem ini,” around half of the users answered “strongly agree.” This is likely due to the clear navigation, understandable icons, and well-structured features that helped users feel in control during the simulation. Finally, for the tenth question, “Saya perlu mempelajari banyak perkara sebelum saya dapat menggunakan sistem ini,” responses were evenly split between “agree” and “strongly agree.” This may be due to users' unfamiliarity with VR technology. In addition, since some respondents may be more fluent in Malay, and if the app uses English, this could have contributed to the learning curve.

System Usability Scale (SUS) testing provided a quantifiable assessment of user satisfaction. Most participants rated the application positively, particularly in terms of ease of use, interactivity, and immersiveness. The inclusion of features such as snap turn, grab interaction, and adaptive guidance improved user experience and learning outcomes. Notably, SUS scores indicate that the VR system meets the usability benchmark of 69.13, suggesting average acceptance [9]. In summary, the application met its intended goals by providing a risk-free yet immersive training experience. It stands as a feasible alternative to conventional methods, supporting findings from similar studies that demonstrate VR’s ability to improve safety training in high-risk environments [2][6][8].

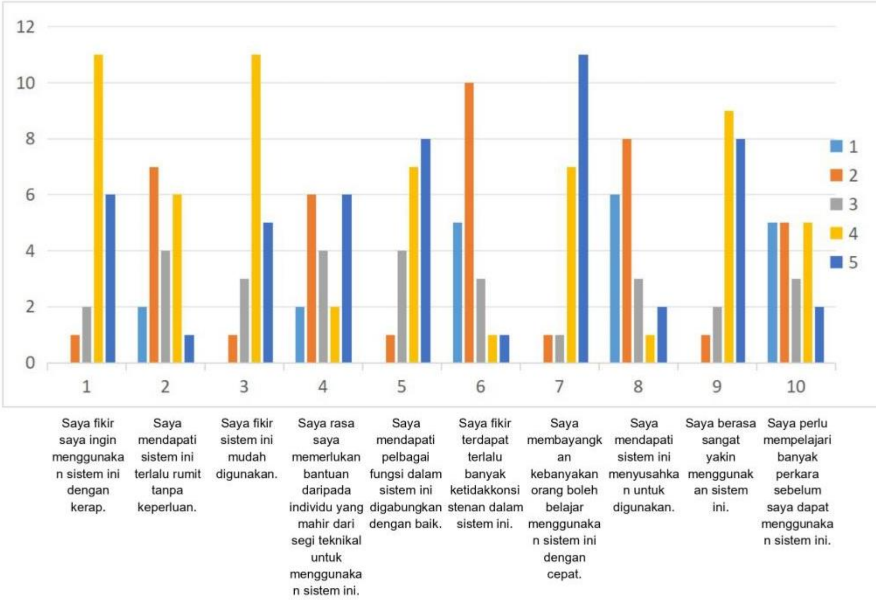


Fig.5 System Usability Scale Results

5. Conclusion

The "Offloading Oil Products Simulations" application successfully addresses critical training challenges in the oil and gas sector by leveraging virtual reality. The application has enhanced safety by eliminating exposure to hazardous environments during training, reduced operational costs associated with physical training setups, and improved training outcomes through interactive and immersive modules. This aligns with findings that highlight VR's potential to enhance workforce training while minimizing risks and costs in high-risk industries [2][3]. This initiative sets a benchmark for integrating advanced technologies into workforce development, offering a safer, more efficient, and cost-effective solution for training high-risk tasks.

To further refine and expand the application, several recommendations are proposed. First, integrating real-time analytics can help track user progress and identify areas needing improvement, supporting research that emphasizes the importance of performance tracking in training applications [4]. Expanding the training modules to include advanced safety protocols and emergency response scenarios would increase the application's comprehensiveness and align with existing VR applications focused on industrial safety [6], [7]. Developing a mobile version of the application could enhance accessibility for users without VR hardware, following trends in extending technology reach [8]. Incorporating AI and machine learning would allow for personalized training paths based on user performance and proficiency levels, as supported by adaptive learning research [5]. Additionally, collaboration with industry stakeholders to validate and refine the training modules ensures alignment with real-world needs and global standards, a practice seen in industry-aligned VR training applications [6], [7]. These enhancements will ensure the application remains innovative and effective, contributing significantly to workforce readiness and safety in high-risk industries.

Acknowledgement

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

References

[1]H. Cai, X. Chen, and H. Ye, "Energy sustainability and workforce development in the oil and gas industry," Energy Journal, 2020.

[2] M. Kamal and N. Syed, "Workplace safety in high-risk industries: A focus on gas station hazards," Journal of Occupational Safety, 2022.

[3] H. Zhang, J. Meng, and H. Tan, "A Method for Identifying the Key Performance Shaping Factors to Prevent Human Errors during Oil Tanker Offloading Work," Journal of Marine Science and Engineering, vol. 10, no. 5, pp. 688–688, May 2022, doi: 10.3390/jmse10050688.

[4] R. Huang et al., "Spatial Computing: Concept, Applications, Challenges, and Future Directions," arXiv preprint arXiv:2402.07912, 2020.

[5] O. Ibrahim and O. Al-Shara, "Impact of Interactive Learning on Knowledge Retention," Lecture Notes in Computer Science, pp. 347–355, Jan. 2007, doi: 10.1007/978-3-540-73354-6_38.

[6] Immersive Operator Training with COMOS Walkinside, YouTube, Nov. 25, 2013. [Online]. Available: https://www.youtube.com/watch?v=19USyVRVW70. [Accessed Nov. 22, 2024].

[7] VR Familiarization on Oil Platform, YouTube, Jun. 10, 2017. [Online]. Available: https://www.youtube.com/watch?v=XA6oO5bDv_0. [Accessed Nov. 22, 2024].

[8] Online Ladder Safety Training - PIXO VR, YouTube, Oct. 6, 2022. [Online]. Available: 1https://www.youtube.com/watch?v=CM4lEZh1qQU. [Accessed Nov. 22, 2024].

[9] Molina, J. P., García, A. S., López-Jaquero, V. and González, P. "Developing VR applications: the TRES-D methodology," 2006.

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Appendix A: Interview Transcribes (Translated from Bahasa Melayu) with SME

Irfan: What are the most common challenges you've encountered in the oil offloading process?
Nooredayu binti Yahaya: During rainy days, the process cannot be done due to lightning, which can create electrostatic charges and potentially cause an explosion. Water can also enter the lorry compartment and contaminate the oil quality, and the work environment becomes slippery.

Irfan: How do you ensure safety and compliance during offloading?
Nooredayu binti Yahaya: We ensure our employees wear harnesses, torches, goggles, gloves, safety boots, and safety helmets during the process. We are very strict about this procedure because failing to follow the rules set by regulatory authorities can result in fines or even the loss of our license. We also have an SOP in place, which includes PPE (Personal Protection Equipment) requirements to ensure employee safety. Additionally, the process is monitored via CCTV, and employees are required to complete a PPM01 checklist.

Irfan: What are the most critical safety protocols or measures in this process?
Nooredayu binti Yahaya: Sampling, using a T-Ruler to ensure the oil is at the correct volume, dipping before and after offloading, and handling only one product at a time are critical. These measures are essential to reduce financial losses and maintain the quality of the oil.

Irfan: Based on your experience, what are the most frequent errors made during offloading operations?
Nooredayu binti Yahaya: The most common errors are employees not wearing full PPE correctly and taking procedures like "dawai pembumi," fire extinguishers, and wheel chocks for granted.

Irfan: What are the potential risks or hazards involved, and how do you mitigate them?
Nooredayu binti Yahaya: Employees are exposed to explosive materials and face the risk of falling from the truck.

Irfan: Can you share an example of an incident or near-miss, and what lessons were learned from it?
Nooredayu binti Yahaya: One common issue is employees opening all the receiving point caps, which can lead to the wrong product entering the wrong underground tank.

Irfan: What tools or equipment are essential for offloading oil safely and efficiently?
Nooredayu binti Yahaya: Essential tools include harnesses, gloves, torches, safety boots, safety helmets, oil-finding paste, water-finding paste, T-Rulers, and aluminum buckets.

Irfan: What skills and knowledge are critical for employees involved in oil offloading?
Nooredayu binti Yahaya: Employees need to be brave enough to climb the truck and knowledgeable about checking oil quality, performing dipping, and determining whether the oil is in good condition.

Irfan: How do you currently train your employees, and what are the limitations of existing training methods?
Nooredayu binti Yahaya: Currently, we require employees to attend training courses conducted by Petronas agencies. These courses come with fees, and there's a possibility that trainees may fail and need to retake the course to obtain their offloader license. Usually, experienced employees teach new hires step-by-step during the oil truck's arrival.

Irfan: What do you think about using VR for training in this field? What areas would benefit most?
Nooredayu binti Yahaya: Using VR can reduce training costs and the manpower needed to train new employees. It also lowers the risk of new employees making mistakes during training.

Irfan: How do you ensure accurate measurements of oil levels during dipping, and what challenges arise in this process?
Nooredayu binti Yahaya: We use oil-finding paste to help employees see the measurements clearly.

Irfan: What documents are crucial in documentation, and what common errors do you observe in record-keeping?
Nooredayu binti Yahaya: The delivery note contains all the information about the product we are receiving, and PPM01 is a checklist to ensure the correct product type from the oil truck enters the appropriate underground tank.

Irfan: What methods or parameters do you use to ensure oil quality standards are met?
Nooredayu binti Yahaya: When employees climb the truck to check the oil volume, we use an "ullage marker" to verify the quantity matches the delivery note. We also use oil-finding paste and water-finding paste to check the oil quality.

Irfan: Do you have any advice for designing an effective training simulation for offloading oil products?
Nooredayu binti Yahaya: Design the simulation to replicate our work environment so that employees can easily adapt and learn.

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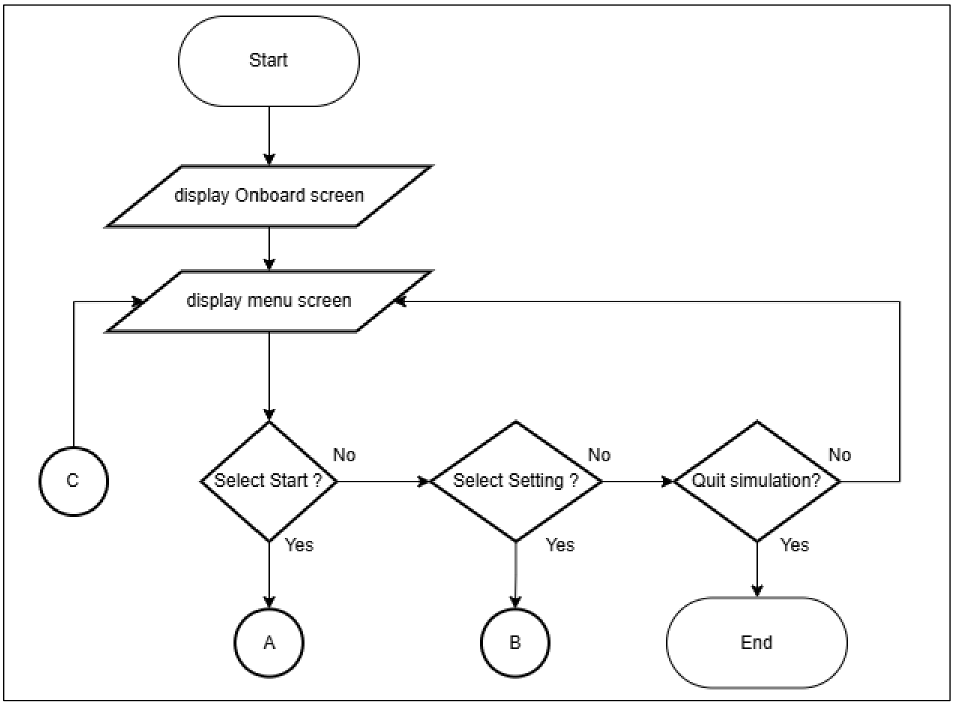
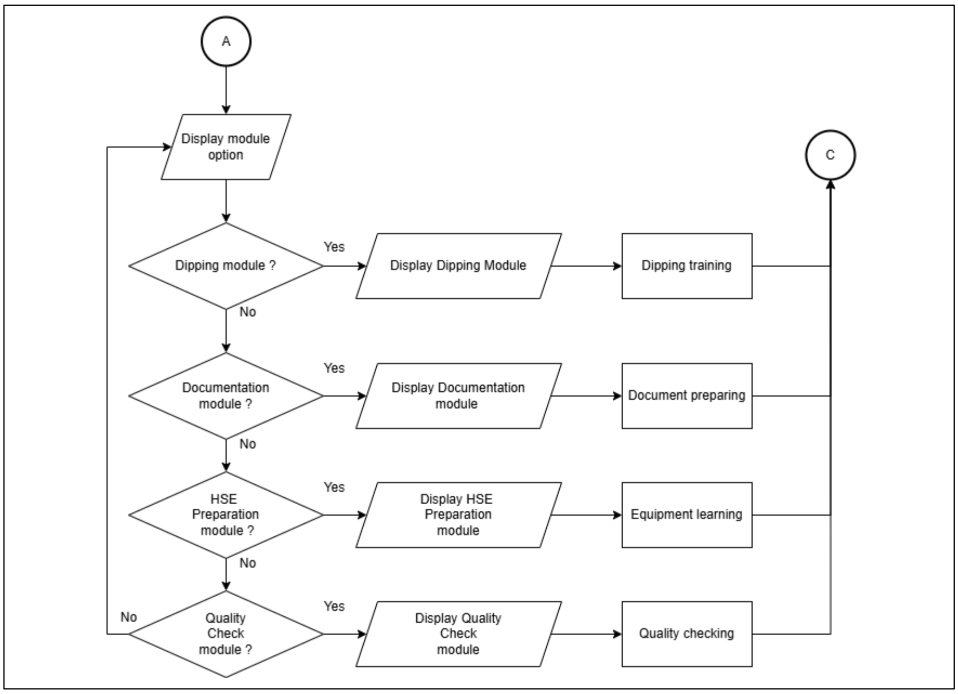
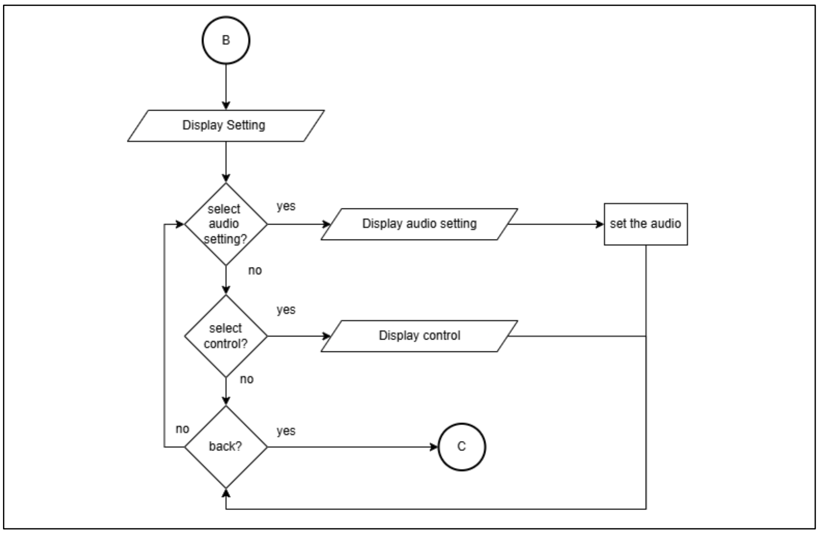
Appendix B: System Flowchart



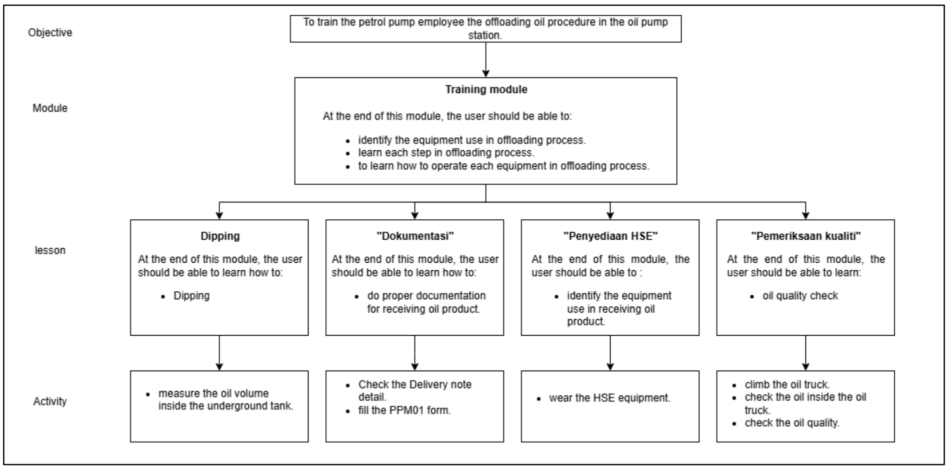
Appendix C: Flowchart of Practical Module



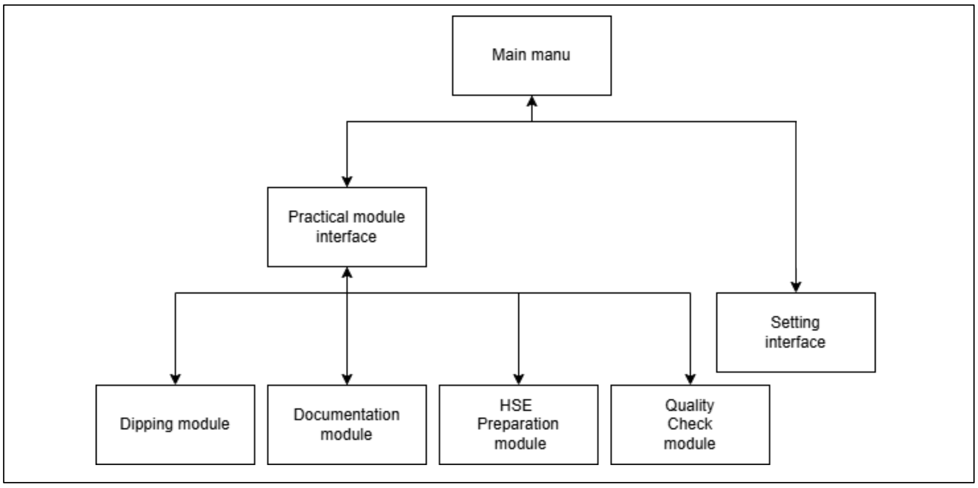
Appendix D: Flowchart of Setting Module



Appendix E: Content Structure



Appendix F: Navigation Structure



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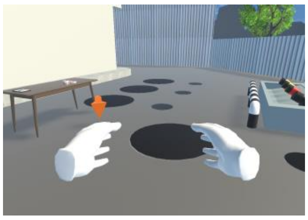
Appendix G: Storyboard

1

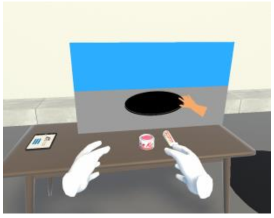
Main menu.There is Start, Setting and Quit button. Start navigate to module selection. Setting navigate to setting page. Quit to close app.

2



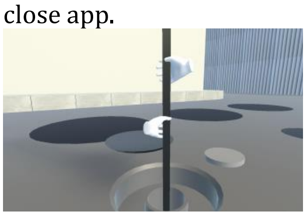
Dipping module as the first learning module. User follow guild arrow. After user step on the arrow an audio will play to guild.

3



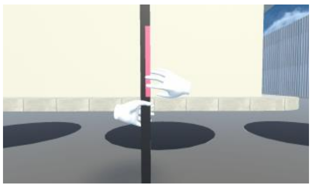
2D animation will play to guild user how to do dipping.
Audio will play to guild user what to do next.

4



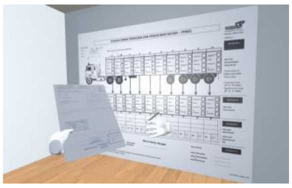
User take out dipping stick to put water finding paste to teflon at the end of dipping stick.

5



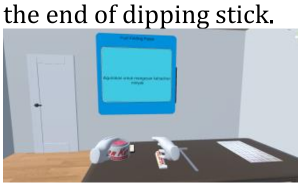
User put oil finding paste on the dipping stick .

6



Next module is documentation module where user must check and fill document.

7



Next module is to interduce user to each equipment that will be use in offlaoding process. UI will be displayed if user grab the object.

8

User is required to follow arrow guild and listen to audio for the instruction.

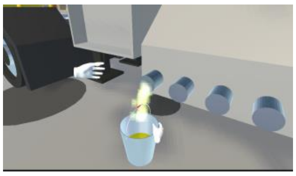
9

User climb the oil truck.

10

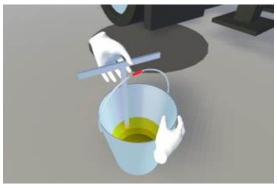
User use t-ruler to measure the oil in oil truck.

11



User take oil sample to check the oil quality using oil and water finding paste.

12



User dip the paste into oil sample to get the testing results.