DEVELOPMENT OF A PROTOTYPE VIRTUAL REALITY TEACHING PLATFORM FOR VOCATIONAL TRAINING CENTERS IN UGANDA : A CASE STUDY OF AUTOMOTIVE ENGINEERING AT ST SIMON PETERS VTI HOIMA

RONALD STEVE MWANJE

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A DISSERTATION SUBMITTED TO THE FACULTY OF ENGINEERING, DESIGN AND TECHNOLOGY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF THE MASTER OF INFORMATION TECHNOLOGY OF UGANDA CHRISTIAN UNIVERSITY

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UGANDA CHRISTIAN UNIVERSITY

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Declaration

I, Mwanje Ronald Steve, do hear by declare that this research report is my original work and has not been submitted to any other institution of higher learning for the award of a degree or any other qualification. Where the work of others has been used or referenced, full acknowledgement has been made in accordance with academic and ethical standards.

I also affirm that this study was conducted with strict adherence to research ethics, including informed consent, confidentiality, and academic integrity.

Signature…………………………………

19TH SEPTEMBER 2025

Date………………………………………

Approval

This is to certify that this research report titled:

"**Development of A Prototype Virtual Reality Teaching Platform for Vocational Training Centers In Uganda – A Case Study of Automotive Engineering at St Simon Peters VTI Hoima**"

has been written under my guidance and supervision. The work presented is original, worthy and ready for submission in partial fulfillment of the requirements for the award of Master of Information Technology of Uganda Christian University.

Signature Date

2/10/2025

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Dr. Francis Otto, PhD

(Academic Supervisor)

Dedication

This research report is dedicated with deepest love and gratitude to my mother, whose unwavering support, prayers, and encouragement have been the foundation of my journey.

Her sacrifices, wisdom, and belief in my potential have inspired me to persevere and achieve this milestone.

This accomplishment is as much hers as it is mine.

Acknowledgment

First and foremost, I thank the Almighty God through my Lord Jesus Christ for granting me the strength, wisdom, and perseverance to successfully complete this research.

I extend my heartfelt gratitude to my supervisor, Dr. Francis Otto, for his invaluable guidance, constructive feedback, and continuous support throughout the development of this work. His mentorship has been instrumental in shaping both the direction and quality of this study.

Special thanks go to the administration, instructors, and students of St. Simon Peter's Vocational Training Centre, Hoima, for their cooperation and participation in the evaluation of the VR-based teaching platform. Their contributions provided the practical insights that enriched this research.

I am equally grateful to my colleagues and friends who offered encouragement, shared ideas, and supported me in various ways during the course of this study.

Finally, my deepest appreciation goes to my family, especially my mother, for her prayers, sacrifices, and unwavering support that have made this achievement possible.

ABSTRACT

Vocational education plays a critical role in Uganda's socio-economic development by equipping learners with practical skills for employability. However, many vocational training institutions, particularly in mechanical disciplines such as motor vehicle mechanics, face persistent challenges including limited workshop tools, outdated equipment, and overcrowded training environments. This study explores the development, implementation, and evaluation of a Virtual Reality (VR)-based teaching platform designed to address these challenges by simulating automotive procedures in an immersive, interactive environment.

Guided by the Design Science Research (DSR) methodology and grounded in Experiential Learning Theory (ELT) and the Technology Acceptance Model (TAM), the research involved designing a VR prototype using 3D Studio Max and Unreal Engine. The system was piloted at St. Simon Peter's Vocational Training Centre in Hoima, Uganda. To evaluate the prototype, data were collected from 30 participants including trainees, instructors, and support staff through questionnaires, focus group discussions, and observations.

Findings revealed that over 90% of students found the VR system engaging and educationally useful, while instructors noted improved learner attentiveness and performance. Despite challenges such as limited VR hardware and initial staff resistance, the platform demonstrated significant potential to enhance vocational training. The study concludes that VR can be a scalable and cost-effective tool to supplement hands-on training in resource-constrained environments. Recommendations include integrating VR into national TVET curricula, enhancing instructor capacity, and localizing VR content to fit Uganda's automotive training needs.

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CHAPTER ONE: GENERAL INTRODUCTION

1.1 Introduction

Vocational education in Uganda is an essential pillar for equipping learners with hands-on skills in technical fields like automotive mechanics (Education Uganda, 2020) . However, numerous challenges, including inadequate training tools, limited workshop space, and outdated equipment, hinder the effectiveness of practical training (NPA Uganda, 2020) . This research explores the development and pilot implementation of a Virtual Reality (VR) teaching platform to address these challenges. The VR solution simulates automotive tasks such as engine oil changes and change of car brakes in an immersive environment, thereby improving engagement, accessibility, and practical competency among learners (Radianti et al., 2020a). Specifically, the study focuses on the development and evaluation of a VR-based teaching platform aimed at enhancing vocational training at St. Simon Peter's Vocational Training Centre in Hoima. It responds to the persistent lack of hands-on learning opportunities by offering a scalable, interactive, and cost-effective alternative that replicates real-world automotive procedures within a virtual setting.

1.2 Background to the Study

Vocational training plays a pivotal role in Uganda's socio-economic development, particularly in addressing youth unemployment and bridging the gap between education and industry needs. The government has prioritized skills development through frameworks such as the Business, Technical, and Vocational Education and Training (BTVET) Strategic Plan and the Skilling Uganda initiative, which aim to produce a skilled, employable workforce to support Uganda's Vision 2040 (Ministry of Education and Sports, 2019a). Despite these policy efforts, vocational institutions continue to face significant infrastructural deficits, particularly in practical-oriented disciplines like mechanical engineering. According to (UNESCO-UNEVOC, 2021a) , many training centers in Uganda lack essential tools, vehicles, and equipment necessary for effective hands-on learning.

As a result, students in motor vehicle mechanics often rely heavily on theoretical instruction, with limited opportunities to engage in actual mechanical assembly, diagnostics, and repair procedures. The National Planning Authority (NPA, 2020) noted that over 70% of vocational learners graduate without adequate exposure to the tools or vehicles they are expected to work with in the field. This mismatch between curriculum goals and instructional resources not only undermines skill acquisition but also diminishes the employability of graduates.

The emergence of immersive technologies such as Virtual Reality (VR) presents a transformative opportunity to bridge this skills gap. VR enables the creation of highly interactive and realistic simulations that replicate complex real-world environments. In contexts where physical resources are constrained, VR allows students to practice technical procedures in a risk-free, cost-effective digital space. Recent studies in Uganda have begun to explore this potential, such as (Buyego et al., 2022a) , who reported successful use of VR in healthcare training and highlighted its adaptability for other technical disciplines.

This study builds on that foundation by exploring the application of VR in motor vehicle mechanics training. It seeks to understand how immersive learning environments can be used to simulate essential automotive tasks such as engine oil change and change of car brakes in a virtual setting that promotes experiential learning. By leveraging VR, institutions can overcome infrastructural challenges, enhance student engagement, and align vocational training with the demands of modern workplaces.

1.3 Problem Statement

In Uganda, over 70% of vocational institutions face significant challenges in delivering quality practical training for automotive education due to chronic underfunding, limited workshop space, and inadequate access to modern training equipment (Ministry of Education and Sports, 2019b; NPA Uganda, 2020). Many institutions rely on outdated, non-functional vehicle parts or theory-based instruction to teach hands-on mechanical procedures. This situation has led to a widening skills gap, where trainees graduate with limited practical competence, making it difficult for them to meet industry expectations or compete in the job market (UNESCO-UNEVOC, 2021b).

Observational reports from institutions such as St Simon Peters Vocation Training Centre in Hoima highlight that learners rarely get to physically interact with complete vehicle systems during training. Tasks like changing engine oil, replacing brake pads, or using diagnostic tools are often demonstrated by instructors using improvised materials, without direct student involvement. As a result, many learners complete their programs without ever performing key automotive tasks themselves, compromising skill acquisition and workplace readiness (Buyego et al., 2022b).

To address these limitations, this study seeks to mitigate these issues with the development and evaluation of an interactive Virtual Reality (VR) teaching platform. The VR system simulates real-world automotive procedures such as engine oil changes and car brake replacements in an immersive, guided, and repeatable environment. By allowing trainees to visualize and virtually perform tasks, VR offers a safe, cost-effective, and scalable solution to bridge the gap between theory and practice. Its integration into vocational training holds great potential to enhance student engagement, reinforce procedural knowledge, and build competence, particularly in resource-constrained settings like Uganda (Radianti et al., 2020b; Rafiq et al., 2022).

1.4 Objectives of the Study

Main Objective:

To develop a prototype VR-based teaching platform for motor vehicle mechanics in vocational institutions in Uganda: A Case Study of St. Simon Peter's VTI Hoima

Specific Objectives:

1. To identify the technical and pedagogical requirements for a VR teaching platform in motor vehicle mechanics through stakeholder consultations and curriculum analysis.
2. To design a VR environment with interactive automotive modules (, that is: engine oil change, brake replacement) using 3D Studio Max and Unreal Engine.
3. To test the VR prototype with at least 30 participants (students, instructors, and support staff) at St. Simon Peter's VTC Hoima during the pilot phase.
4. To evaluate the VR system's effectiveness using the Technology Acceptance Model (TAM) framework; Assessing perceived usefulness, ease of use, behavioral intention, and actual usage

1.5 Research Questions

1. What challenges currently hinder practical training in motor vehicle mechanics at vocational centers in Uganda?
2. How can VR technology be effectively applied to simulate automotive repair and maintenance training?
3. What is the impact of VR-based learning on student engagement and skill acquisition?
4. What are users' perceptions regarding the ease of use and usefulness of the developed VR platform?

1.6 Justification of the Study

The study is justified by the urgent need for affordable, scalable, and effective alternatives to conventional training tools in vocational education. VR offers the ability to simulate real-world mechanics training without physical limitations, thereby reducing costs, risks, and space requirements (Buyego et al., 2022a) . This study fills a critical gap in applied educational technology for vocational training in Uganda, particularly where resource limitations hinder effective instruction.

1.7 Significance of the Study

This research contributes to the modernization of vocational training by offering evidence-based insight into the application of VR in practical education. It benefits students, educators, curriculum developers, and policymakers by demonstrating a model for integrating immersive technology into technical skills development. The findings support national efforts to align vocational training with industry standards and global technological trends (UNESCO, 2022).

1.8 Scope of the Study

Geographically, the study is based in Hoima District, Uganda, with implementation at St. Simon Peter's VTC. Thematically, it focuses on VR applications in motor vehicle mechanics training. The study covers system development, user testing, and impact evaluation but excludes long-term tracking or national policy integration.

1.9 Theoretical Framework

This study integrates three theoretical models: Experiential Learning Theory (ELT), Design Science Research (DSR), and the Technology Acceptance Model (TAM). ELT by Kolb (1984) informed the development of VR simulations by emphasizing learning through experience enabling students to engage in a cycle of doing, reflecting, conceptualizing, and reapplying skills. DSR by Hevner et al. (2004) structured the research process through six stages, ensuring systematic development and testing of the VR platform within a real-world vocational setting. TAM (Davis (1989b) guided the evaluation by measuring perceived usefulness and ease of use, which helped predict user acceptance and actual adoption. Together, these models provided a comprehensive framework to design, implement, and assess the VR teaching solution in a Ugandan vocational context.

1.10 Summary of Chapters

Chapter One presents the introduction, outlining the research problem, objectives, and rationale for the study. Chapter Two reviews related theoretical and empirical literature that informs the context and foundation of the research. Chapter Three outlines the research methodology and the process used to develop the Virtual Reality teaching platform. Chapter Four analyzes and interprets the data collected during the evaluation of the prototype. Chapter Five discusses the findings in relation to existing literature and theoretical frameworks. Finally, Chapter Six concludes the study and offers recommendations based on the results and insights gathered.

1.11 Conclusion

This chapter has introduced the background, research problem, rationale, and purpose of the study. It has defined the research questions and laid out the theoretical framework and scope. The following chapters build upon this foundation to explore the implementation and impact of VR in vocational education.

CHAPTER TWO: LITERATURE REVIEW

2.1 Literature Review

This literature review explores both theoretical and empirical perspectives that depict the development and use of Virtual Reality (VR) in vocational education. The review emphasizes how VR enhances experiential learning, its theoretical foundations, empirical applications, and the gaps this study addresses in the Ugandan context.

2.1.1 Theoretical Literature Review

This study is grounded in three theoretical frameworks that is; Experiential Learning Theory (ELT) by Kolb , Design Science Research (DSR) by Hevner et al , and the Technology Acceptance Model (TAM) by Davis . These frameworks collectively support the development, deployment, and evaluation of the Virtual Reality (VR) teaching platform, aligning with the study's four specific objectives.

Experiential Learning Theory (ELT):

To address the objective of identifying technical and pedagogical requirements for a VR teaching platform, the study draws on Experiential Learning Theory (ELT). According to Kolb , ELT emphasizes that effective learning is a cyclical process involving four sequential stages: concrete experience, reflective observation, abstract conceptualization, and active experimentation.

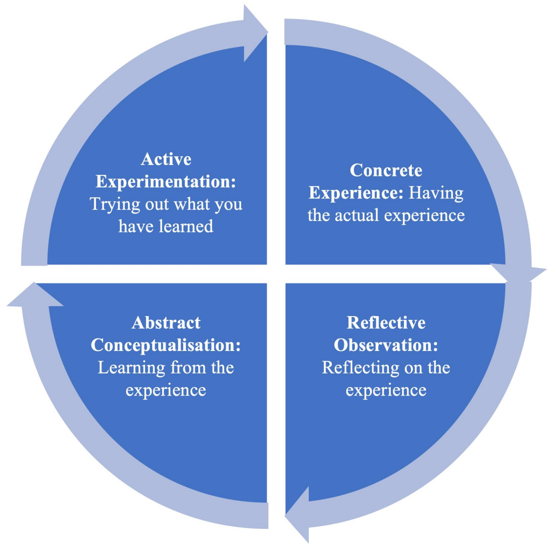


Figure 1: Demonstration of the Experimental Learning Theory

In the context of vocational training, these stages guide the identification of instructional design requirements for immersive learning. For instance, the concrete experience stage emphasizes the need for realistic simulations that mirror real-world scenarios such as engine oil changes or brake pad replacements. Reflective observation requires the system to facilitate critical thinking and feedback loops, prompting users to evaluate their actions and outcomes. Abstract conceptualization highlights that learners need clear instructions and theory inside the VR system to help them understand the reason behind what they are doing. Then, active experimentation allows students to try out what they've learned in different virtual situations, helping them master the steps through practice. In this way, Kolb's Experiential Learning Theory (ELT) guides both what to include in the VR platform and how learning should happen inside it it (Kolb & Kolb, 2012).

The Design Science Research (DSR):

To support the design, development, and evaluation of a Virtual Reality (VR) teaching platform for motor vehicle mechanics training, the study adopted the Design Science Research (DSR) methodology. This approach, as conceptualized by Hevner et al. . (2004a) , offers a systematic structure for creating, deploying, and assessing innovative technological solutions in real-world environments. The process consists of six sequential stages: Problem Identification & Motivation, Define Objectives, Design & Development, Demonstration, Evaluation, and Communication as illustrated in the chart.

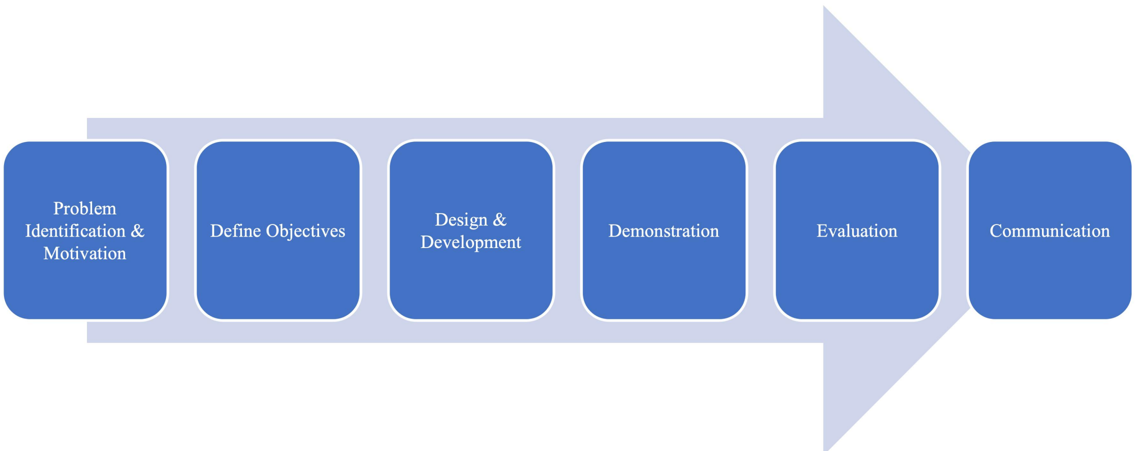


Figure 2: The DSR process

The study began with Problem Identification & Motivation, where infrastructural and pedagogical challenges in vocational training were identified, particularly at St. Simon Peter's Vocational Training Centre in Hoima. Trainees faced limited access to physical automotive parts, diagnostic tools, and fully equipped workshops highlighting the need for an immersive, low-risk, and repeatable training solution.

From these insights, the next step was to Define Objectives, which included designing a VR platform that could simulate essential mechanical procedures (e.g., engine oil changes and brake system assembly) in an engaging and pedagogically meaningful way. This set a clear direction for the project, ensuring that both technical and educational goals would be aligned.

The Design & Development phase saw the actual creation of the VR prototype using 3D Studio Max for modeling vehicle components and Unreal Engine for programming immersive simulations. Key features such as object manipulation, step-by-step guidance, and interactive feedback were embedded to foster learner engagement and procedural accuracy.

In the Demonstration phase, the VR system was installed in the Computer Hub at St. Simon Peter's VTC, and a pilot test was conducted with selected instructors and students. This phase allowed the artifact to be exposed to real users in a realistic institutional setting.

The platform was then subjected to Evaluation, wherein usability, perceived usefulness, and skill acquisition were assessed using structured questionnaires, focus group discussions, and observational checklists.

Finally, the results, insights, and learning from this research were documented and Communicated through this academic report. This final stage ensures that the knowledge generated both theoretical and practical is shared with a wider audience, contributing to the advancement of digital innovation in vocational education.

In essence, DSR provided a robust methodological foundation that allowed the research to not only build a functioning VR system but to iteratively validate its educational relevance and adaptability within a Ugandan vocational training context. This approach is especially valuable for developing localized edtech solutions where cost, infrastructure, and digital literacy remain major constraints (Peffers et al. (2007).

Technology Acceptance Model (TAM):

To evaluate the usefulness, usability, and user perception of the VR system; This is anchored in the Technology Acceptance Model (TAM) by Davis (1989) . TAM provides a predictive framework for understanding users' behavioral intention to adopt and continue using new technologies. The model centers around two primary constructs: Perceived Usefulness (PU) and Perceived Ease of Use (PEOU).

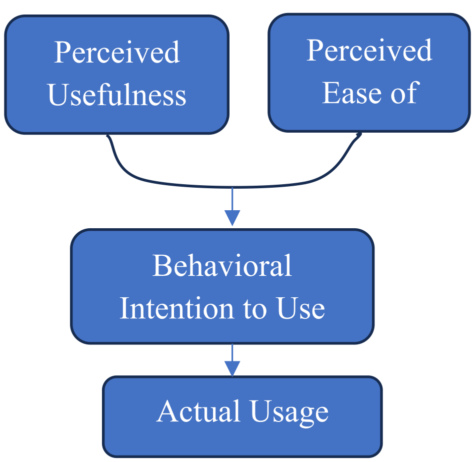


Figure 3: The Technology Acceptance Model cycle

In the context of this study, PU refers to whether learners and instructors believe that the VR platform enhances their practical skills and knowledge retention, particularly for complex automotive tasks. PEOU assesses how intuitive and accessible the platform is, especially for users with limited prior exposure to immersive technologies. Both constructs were measured through structured questionnaires and observation checklists during the evaluation phase. According to TAM, if users perceive the system as both useful and easy to use, they are more likely to develop a Behavioral Intention to Use, which correlates with Actual Usage of the technology in instructional settings Venkatesh & Davis (2000). This model is crucial for gauging the long-term sustainability and scalability of the VR solution, particularly in low-resource vocational institutions.

In conclusion, ELT supports the identification of pedagogical requirements and instructional flow; DSR ensures a rigorous development and implementation strategy; and TAM offers a robust model for evaluating user acceptance and potential for adoption. While each theory plays a distinct role corresponding to specific objectives, their synergy provides a comprehensive theoretical foundation for the research. Although these frameworks have been extensively applied in global studies, their integration in vocational training contexts in Uganda remains limited. This study contributes by demonstrating how these models can be applied in tandem to design, implement, and assess a VR-based learning solution tailored for resource-constrained environments.

2.1.2 Empirical Literature Review

Empirical studies from diverse educational settings have increasingly underscored the potential of Virtual Reality (VR) as a transformative tool in vocational and technical education. Globally, researchers have explored how immersive learning environments can overcome traditional instructional limitations, improve learner engagement, and enhance skill acquisition (Chen et al., 2023; Conrad et al., 2024). These studies often employ rigorous methodologies such as control-group experiments, pre-and post-intervention testing, observational protocols, and self-report surveys to substantiate their findings.

A study by Zahabi & Abdul Razak (2020b) conducted a systematic review of VR applications in automotive training. They concluded that learners who engaged with VR-based simulations demonstrated higher comprehension and task accuracy compared to those in conventional training setups. The study emphasized that learners developed a stronger procedural memory due to repeated, safe interaction with simulated tools and environments. VR's capacity to replicate hazardous or costly real-world scenarios (e.g., engine diagnostics or fuel system repairs) in a virtual space significantly reduced the risk and cost associated with traditional hands-on training.

Similarly, Radianti et al. (2020a) found that immersive learning environments boosted student engagement by over 30% relative to non-immersive, traditional methods. Their meta-analysis of VR applications in higher education illustrated that the multisensory feedback and high interactivity inherent in VR settings encouraged deeper cognitive involvement, task persistence, and better learning outcomes. These outcomes were especially significant in STEM and skill-based disciplines, where spatial awareness and procedural precision are critical.

The growing body of empirical work from developed contexts provides compelling evidence that VR can supplement or even substitute physical laboratories in constrained environments. However, these studies are largely situated in technologically advanced countries, and their results cannot be fully generalized to low-resource settings without careful contextual adaptation.

In Uganda, the application of VR in education remains limited but evolving. Some of the spotted pilot interventions have occurred in the healthcare and tourism sectors. For instance, (Buyego et al., 2022a) evaluated the impact of VR simulations during COVID-19 emergency response training for healthcare workers. Their findings indicated that participants appreciated the ability to rehearse complex, high-stakes procedures in a low-risk virtual environment, leading to improved preparedness and reduced anxiety. While this success showcases VR's promise in professional training, similar evidence from vocational education especially at the diploma and certificate levels is scarce.

Existing vocational institutions in Uganda continue to face structural challenges such as underfunding, equipment scarcity, and large trainee-to-instructor ratios, which hamper effective practical instruction (UNESCO, 2022) . Most empirical studies that touch on educational technology in Uganda either focus on general ICT skills or e-learning platforms, neglecting the immersive technologies that are now gaining traction globally. The few studies that touch on VR often involve higher education institutions or urban-based projects with relatively better infrastructure. This leaves a significant research gap regarding how the rural vocational trainees who often have limited digital literacy interact with and benefit from VR learning systems.

This study contributes to addressing this empirical gap by evaluating a purpose-built VR training prototype for motor vehicle mechanics at St. Simon Peter's Vocational Training Centre in Hoima, a rural-based Ugandan institution. The research not only captures pre-and post-training learner feedback but also integrates instructor insights and observational data. By situating the evaluation within a real vocational setting, the study offers context-specific evidence on the feasibility, effectiveness, and acceptance of immersive technology in under-resourced educational environments.

CHAPTER THREE: RESEARCH METHODOLOGY

This chapter outlines the methodology employed to develop, pilot, and evaluate a Virtual Reality (VR)-based teaching platform for vocational training in automotive mechanics. It adopts a structured approach incorporating both design and evaluation phases to validate the educational value and user acceptance of the prototype.

3.1 Research Design

This study employed a Design Science Research (DSR) methodology, complemented by a descriptive case study approach, to develop and evaluate a Virtual Reality (VR)-based teaching platform for motor vehicle mechanics. DSR offered a structured, iterative process for designing and refining the VR prototype, while the case study method allowed for in-depth, context-specific analysis of the platform's real-world application at St. Simon Peter's Vocational Training Centre (VTC) in Hoima, Uganda. The integration of these methods ensured both technological innovation and practical relevance.

3.1.1 Design Science Research (DSR) Approach

Design Science Research (DSR) is a research paradigm that emphasizes the systematic creation and evaluation of artifacts to solve clearly defined problems, particularly within technological and organizational contexts. As described by Hevner et al. (2004a), DSR is distinguished by its focus on producing innovative solutions while simultaneously contributing to theoretical knowledge. It balances rigor and relevance, making it especially appropriate for fields such as information systems and educational technology, where practical tools must meet both technical and pedagogical standards.

In this study, DSR was applied to address the problem of limited hands-on training opportunities in vocational automotive education in Uganda. The research began with the identification of this gap as a major obstacle to effective skills development. The study then defined the objective: to develop a VR-based teaching platform capable of simulating realistic engine maintenance procedures in a digital environment. The artifact comprising immersive simulations was developed using 3D modeling and game engine tools.

Following the development phase, the platform was demonstrated through a controlled pilot at St. Simon Peter's Vocational Training Centre. This stage involved training students and instructors to use the VR system and observing their interactions with the simulation. The evaluation phase involved collecting data through structured surveys, focus group discussions, and classroom observations to assess the platform's usability, effectiveness, and reception among end-users. The findings from this evaluation were then systematically documented and shared, completing the communication phase of the DSR cycle.

The strength of DSR lies in its capacity to bridge theory and practice. By producing a working prototype and validating it within a real educational environment, this study ensured that the artifact was not only theoretically sound but also practically valuable. This methodology was particularly appropriate for the research, as it allowed the design and iterative refinement of a VR platform that addressed the specific contextual needs of vocational education in Uganda.

3.1.2 Development Tools: 3D Studio Max and Unreal Engine

The development of the VR-based teaching platform leveraged two industry-standard tools: 3D Studio Max and Unreal Engine. These tools were selected for their capabilities in producing realistic, interactive environments suitable for vocational training simulations.

3D Studio Max, developed by Autodesk, is a professional-grade 3D modeling and animation software widely used in engineering, game design, and film production. In the context of this study, it was used to design and model automotive components such as engine blocks, gears, and essential workshop tools. The precision of 3D Studio Max enabled the creation of detailed representations of mechanical systems, which were critical for delivering a high-fidelity simulation. By accurately rendering textures, dimensions, and spatial relations of parts, the tool ensured that students experienced realistic visual cues that mirror actual workshop setups. These immersive and contextually accurate models formed the visual backbone of the VR experience (Autodesk, 2023).

Unreal Engine, developed by Epic Games, functioned as the real-time simulation platform for deploying the 3D assets. Known for its powerful rendering engine, built-in physics systems, and robust scripting capabilities through Blueprints and C++, Unreal Engine allowed for the integration of interactivity and feedback mechanisms within the virtual training environment. Importantly, its compatibility with Meta Quest headsets made it suitable for standalone VR deployment, allowing learners to engage with the simulation without high-end PCs. The engine also enabled the scripting of tasks such as virtual engine oil changes, part identification, and tool handling, enhancing procedural understanding and engagement (Games, 2023).

The combination of 3D Studio Max and Unreal Engine was critical to achieving both visual realism and interactive depth in the VR platform. While 3D Studio Max provided the structural and visual content, Unreal Engine brought these models to life within a responsive virtual environment. This integration ensured that the prototype was not only visually compelling but also pedagogically effective, as learners could manipulate virtual objects, follow step-by-step instructions, and receive real-time feedback in a simulated workshop that reflected real-life conditions. AI was added to ease instruction flow as well examine, check and validate each step before allowing progression, ensuring procedural accuracy and reducing error rates.This addressed the challenge of digital illiteracy and limited supervision capacity, making the VR system more self-directed while maintaining instructional quality.

Figure 4: The simulation design using unreal engine

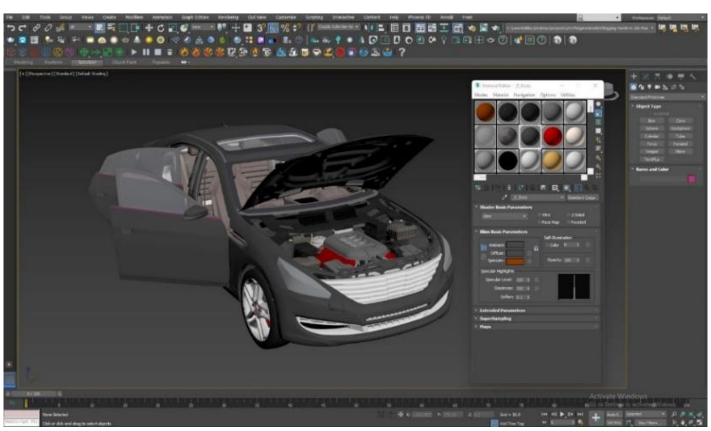


Figure 5: 3D modeling and animation using 3d Studio

3.1.3 Instantiation of Design Science at St. Simon Peter's VTC

The instantiation of the Design Science Research (DSR) methodology occurred through the real-world deployment and evaluation of the VR-based teaching platform at the Computer Hub of St. Simon Peter's Vocational Training Centre (VTC) in Hoima, Uganda. This institution was deliberately chosen as the pilot site due to its active motor vehicle mechanics department and its persistent challenges in delivering practical, hands-on training. These challenges included limited access to real vehicle components, inadequate workshop space, and outdated training tools, the conditions that made the centre an ideal setting to evaluate the effectiveness of a digital alternative such as VR.

The deployment process began with the installation of the VR modules onto Meta Quest VR headsets within the institution's Computer Hub which allowed learners to navigate and engage with the simulation in a hands-free, spatially aware manner. Following the installation and configuration, both instructors and students participated in orientation sessions aimed at familiarizing them with the interface, features, and intended use of the VR platform. These introductory sessions were crucial for easing the transition from traditional instruction methods to immersive digital learning, especially in a context where digital literacy levels vary.

Once familiarized, the participants engaged in practical sessions where they used the VR platform to simulate engine oil change procedures and basic automotive diagnostics like change of car brakes. This hands-on interaction with virtual mechanical environments allowed students to follow step-by-step procedures, make guided decisions, and receive real-time feedback all without the risks, costs, or spatial constraints typically associated with physical equipment. Instructors supervised these sessions and contributed to the observational evaluation by noting student behaviors, challenges encountered, and instructional possibilities offered by the platform.

To assess the outcomes of the deployment, data was collected using structured questionnaires, focus group discussions, and direct observation. Students and instructors provided feedback on the platform's usability, relevance to the curriculum, and impact on understanding technical procedures. These responses were used to evaluate both the pedagogical effectiveness and technical performance of the VR system.

This structured process starting from identifying the problem and developing a prototype, to implementing and evaluating it in an authentic educational context demonstrated a full instantiation of the DSR methodology. It reinforced the value of using DSR to develop context-specific educational technologies, particularly in resource-constrained environments where traditional solutions are insufficient. The iterative evaluation and feedback loop also provided insights into how such innovations can be improved and scaled across similar vocational institutions.

3.2 Area of Study

The research was carried out in Hoima District, specifically at St. Simon Peter's VTC a recognized institution offering motor vehicle mechanics training. The area was selected due to its relevance, accessibility, and the institution's interest in enhancing digital innovation in practical instruction.

3.3 Sources of Information

The data sources employed in this study align closely with the Experiential Learning Theory (ELT) by Kolb , which conceptualizes learning as a continuous process involving four stages: Concrete Experience, Reflective Observation, Abstract Conceptualization, and Active Experimentation. To ensure that each of these stages was effectively captured and analyzed, the study adopted both primary and secondary sources of information, fostering a holistic understanding of how VR enhances vocational training.

Concrete Experience

Primary data collection began with providing students and instructors at St. Simon Peter's Vocational Training Centre with direct, immersive exposure to the VR platform. As participants engaged with the simulated automotive tasks such as engine oil changes and brake assembly, their experiences constituted the concrete experience stage of ELT. To document this, utilization of direct observation, closely monitoring user interactions, behavioral engagement, and learning patterns during simulation sessions were implemented.

Reflective Observation

Following the VR simulations, focus group discussions were conducted to facilitate reflective observation. These sessions encouraged participants to articulate their experiences, identify challenges, and share feedback about the system's realism, interactivity, and pedagogical value. This stage allowed the researchers to capture learners' reflections on how the VR training compared with traditional methods, as well as their perceptions of its practical applicability in the mechanical workshop context.

Abstract Conceptualization

To understand how participants internalized and mentally processed their experiences, structured Google Forms-based questionnaires were administered. These instruments gathered both quantitative and qualitative data regarding user satisfaction, perceived usefulness, and system usability. Closed-ended questions (e.g., Likert scales) allowed for statistical analysis, while open-ended items invited abstract conceptualizations from learners how the VR modules reinforced theoretical knowledge or enabled new perspectives on motor vehicle systems.

Active Experimentation

Finally, the study analyzed how participants applied their learning in subsequent tasks both within the VR environment and during regular training sessions. Observational checklists tracked whether learners revisited simulations, adjusted techniques, or collaborated more confidently with peers, indicating active experimentation. These behavioral cues offered insight into how learners implemented new knowledge and skills gained through immersive practice.

Secondary Sources and ELT Alignment

In support of the ELT framework, secondary sources such as curricular documents, institutional reports, and empirical literature helped align the VR simulation content with Uganda's vocational education standards. These documents provided the conceptual grounding necessary for meaningful experiential learning, ensuring that each module contributed to competency-based outcomes and aligned with national educational objectives.

By embedding data collection within the ELT cycle, the study did more than gather information, it modeled how learners experience, reflect on, conceptualize, and reapply knowledge through immersive digital tools. The combination of primary and secondary data ensured the VR system was evaluated not only for its technological novelty but also for its alignment with real pedagogical needs and learning processes.

3.4 Population and Sampling Techniques

The research targeted a carefully selected population comprising students, instructors, and support staff from St. Simon Peter's Vocational Training Centre (VTC) in Hoima District. The focus was on individuals directly involved in either the use, testing, or facilitation of the VR-based teaching platform. To ensure the relevance and applicability of the data collected, the study employed a non-probability sampling method specifically, purposive sampling. This technique allowed the researcher to deliberately select participants who were most likely to provide rich, informative, and contextually grounded insights into the usability, effectiveness, and reception of the virtual reality training system.

Purposive sampling was ideal for this study because the research required specific input from users with experience in motor vehicle mechanics training and those who had interacted with the VR platform. The inclusion criteria were based on participants' current enrollment in, or instructional role within, the motor vehicle mechanics program, as well as their availability during the implementation period.

Table 1: Composition of the Study Sample

Participant Category	Number of Participants	Selection Criteria
Diploma/Certificate/Short Course Trainees	25	Enrolled in motor vehicle mechanics and took part in VR testing
Instructors	3	Teaching automotive courses and supported evaluation
ICT/Technical Support Staff	2	Provided technical support during VR setup and use
Total	30	

This sampling strategy ensured a diverse range of voices while maintaining relevance to the study's objectives. The trainees provided feedback on usability, engagement, and learning effectiveness, while instructors and support staff offered perspectives on pedagogical alignment, system integration, and technical support needs.

Sampling Formula and Justification

Although purposive sampling does not follow a strict probabilistic formula, an indicative estimation for sample adequacy in qualitative and small-scale pilot studies can be referenced using simplified formulas based on the Yamane (Lamola & Yamane, 1967) formula for sample size in broader population estimates:

$$n = \frac{N}{1 + N(e)^2}$$

Where:

- n = Sample size
- N = Population size
- e = Level of precision (e.g., 0.1 for ±10%)

Assuming the total number of motor vehicle trainees at the institution is approximately 90, and the desired precision is 10%, the sample size calculation would be:

$$n = \frac{90}{1 + 90(0.1)^2} = \frac{90}{1 + 0.9} = \frac{90}{1.9} \approx 47$$

Given this estimate, the sample of 30 participants represents a sizable and meaningful subset for a pilot study focused on qualitative evaluation and system usability. The reduced number was also influenced by logistical considerations such as available VR headsets, session durations, and classroom schedules.

This sampling approach enabled the research to obtain valid, context-specific insights from those most directly impacted by the intervention while maintaining flexibility and efficiency during the pilot implementation.

3.5 Variables Definitions and Measurement Levels

This study focused on evaluating the impact of a Virtual Reality (VR)-based teaching platform on vocational training outcomes, particularly in the motor vehicle mechanics department at St. Simon Peter's Vocational Training Centre. The variables were carefully selected to reflect both the technical performance of the VR system and its pedagogical value.

Independent Variable

The primary independent variable in this study was the VR-based teaching platform. This is the experimental condition introduced to the participants specifically, the immersive VR simulation used to teach automotive procedures such as engine oil changes and diagnostics. The independent variable was constant across the study population and served as the intervention whose effects were being measured on a range of educational and experiential outcomes.

Dependent Variables

The study assessed several dependent variables, which are outcomes expected to change as a result of the participants' interaction with the VR system. These included:

- Learner Engagement: Refers to the level of attention, interest, and active participation exhibited by students during the VR sessions. It was measured through observational notes and self-reported feedback using Likert-scale items.
- Perceived Usefulness: This captures students' and instructors' opinions on how effective the VR system was in enhancing their understanding of mechanical procedures. It is based on Davis' Technology Acceptance Model (TAM), were perceived usefulness influences technology adoption.
- Ease of Use: Another construct derived from TAM, these variable measures how easy the users found the VR system to operate. It was evaluated using user ratings in structured questionnaires.
- Skill Improvement: This measures learners' perceptions of how the VR experience contributed to their practical and procedural knowledge in motor vehicle mechanics. It was assessed through self-assessment questions and instructor observations.

Measurement Levels

The study employed different levels of measurement depending on the nature of the variables:

- Nominal Scale: Used for categorizing variables without any inherent order. This includes demographic characteristics such as:

Gender (e.g., Male, Female)
Role (e.g., Student, Instructor, Support Staff)

- Ordinal Scale: Applied to variables that reflect ranked or ordered responses but without fixed intervals between ranks. These were mostly Likert scale items used to assess attitudes and perceptions. For example:

Responses to "How useful did you find the VR platform?" ranged from 1 = Strongly Disagree to 5 = Strongly Agree.
Satisfaction levels and perceived learning gains were also captured using similar ordinal scales.

These measurement scales informed the choice of descriptive statistical tools such as frequencies, percentages, and bar charts in the analysis phase. They also allowed for thematic interpretation of patterns related to VR acceptance and effectiveness, providing a comprehensive view of how the VR intervention influenced learners' experiences and learning outcomes.
By clearly identifying and measuring both independent and dependent variables, the study ensured a rigorous framework for evaluating the VR teaching platform and drawing valid, evidence-based conclusions.

3.6 Procedure for Data Collection

The procedure for data collection in this study was systematically organized into three interrelated phases i.e. development, implementation, and evaluation to align with the Design Science Research (DSR) methodology and ensure a thorough assessment of the Virtual Reality (VR)-based teaching platform. Each phase was crucial in generating the data needed to answer the research questions and assess the usability, effectiveness, and impact of the VR system on vocational training.

Phase 1: Development of VR Training Modules

The first phase involved the design and development of immersive VR modules using 3D Studio Max for modeling and Unreal Engine for interactive simulation. These modules simulated key mechanical tasks, such as engine oil change, diagnostics, and component assembly, to reflect core learning objectives in the motor vehicle mechanics curriculum. The models were tailored to replicate a realistic automotive workshop environment and optimized for use with Meta Quest VR headsets. This phase focused on ensuring the instructional relevance of the simulations by consulting trainers and referencing national vocational training guidelines.

Phase 2: Implementation in a Real Learning Environment

Once developed, the VR system was deployed at the Computer Hub of St. Simon Peter's Vocational Training Centre in Hoima. The second phase began with orientation and onboarding sessions for all participants, including students, instructors, and technical support staff. Participants were trained on how to wear and operate the VR headsets, navigate the VR interface, and interact with the simulated environment. This training helped reduce usability challenges and ensured that feedback gathered would reflect genuine learning experiences rather than technical misunderstandings.

After orientation, participants engaged in hands-on practical sessions using the VR platform. Each session allowed users to perform tasks like installation of car brakes or changing engine oil in a step-by-step, guided simulation. These simulations were designed to reflect real-world mechanical workflows while providing immediate, risk-free feedback. Instructors supervised these sessions and offered live guidance where necessary, which also served as observational input for the evaluation phase.

Phase 3: Evaluation

Following the practical VR sessions, the third phase involved collecting both quantitative and qualitative data to evaluate the effectiveness of the platform. A pre-training survey was administered to capture participants' baseline perceptions, digital tool familiarity, and self-rated confidence in mechanical skills. After the VR sessions, a post-training survey was distributed using Google Forms, covering areas such as ease of use, satisfaction, learning outcomes, and recommendations for improvement.

Instructors were also asked to provide structured feedback regarding student engagement, learning behavior, and integration potential into the existing curriculum. Additionally, focus group discussions and direct observations were employed to complement the survey data with richer, contextual insights.

This three-phase procedure ensured that the platform was not only tested for technical stability and usability but also rigorously evaluated for pedagogical effectiveness and user acceptance in an authentic vocational setting. The structured approach aligns with best practices in educational research and technology pilot evaluations, ensuring that the findings are both reliable and grounded in the lived experiences of end users.

3.7 Data Collection Instruments

To ensure the validity and reliability of the research findings, a combination of quantitative and qualitative data collection instruments was employed. These instruments were carefully designed to capture a multi-dimensional view of the VR platform's usability, instructional effectiveness, and user perceptions. The variety of tools used allowed for triangulation, which strengthened the robustness of the findings by comparing responses from different sources and perspectives.

Pre-Training Questionnaire

The pre-training questionnaire was administered prior to the use of the VR platform to establish a baseline understanding of participants' prior knowledge, expectations, and digital readiness. It included questions on participants' familiarity with automotive tasks such as engine oil change, as well as their previous experience using simulations, digital learning tools, or VR environments. This instrument helped contextualize participants' learning needs and set a reference point against which post-training improvements could be measured. Questions were both closed-ended (e.g., Likert scale) and open-ended to capture nuanced feedback on expectations and perceived limitations of traditional practical training methods.

Post-Training Questionnaire

Following the VR simulation sessions, a post-training questionnaire was distributed to gather feedback on the usability, perceived usefulness, user satisfaction, and engagement associated with the VR platform. This instrument assessed key constructs from the Technology Acceptance Model (TAM) including perceived ease of use and usefulness and also evaluated learners' motivation, sense of immersion, and perceived skill acquisition. Questions such as "I found the VR system easy to navigate" or "I feel more confident performing this task in real life after using the VR simulation" were used to quantify user reactions. Responses were collected using Google Forms, allowing for efficient aggregation and analysis.

Instructor Feedback Forms

To gain insights from the teaching staff, instructor feedback forms were developed and issued to the three instructors involved in the VR deployment. These forms asked instructors to assess how well the VR platform supported learning outcomes, whether students demonstrated improved understanding, and what challenges were observed during integration. Instructors were also asked to suggest improvements and comment on the alignment of the VR content with the current curriculum. Their feedback was crucial for evaluating the pedagogical validity and integration feasibility of the platform within a vocational training setting.

Observation Checklists

During the hands-on VR sessions, structured observation checklists were used to track how participants interacted with the VR system. The checklist included items such as:

- Frequency of errors during navigation
- Time taken to complete simulation tasks
- Level of focus and engagement
- Verbal expressions of understanding or confusion
- Need for assistance from facilitators

This observational data provided real-time, behavior-based insights that complemented self-reported measures in the questionnaires. For instance, while a student may report ease of use, frequent pauses or confusion during task execution may indicate usability challenges not expressed in the survey.

Combined Utility of Instruments

Together, these instruments created a comprehensive data collection framework that allowed the evaluation of the VR teaching platform from multiple angles pre-existing knowledge and expectations, immediate user experience, instructor observations, and behavioral indicators of learning. This holistic approach not only ensured richer analysis but also enhanced the credibility of the study's findings by capturing a diversity of voices and observational data in the real-world educational context.

3.8 Quality/Error Control

Ensuring the accuracy, credibility, and reliability of research findings is fundamental in educational technology studies. In this research, multiple strategies were implemented to control errors and enhance data quality across both the design and evaluation stages of the Virtual Reality (VR) teaching platform.

To begin with, a pilot test was conducted before the full-scale deployment of the VR platform. This trial involved a small subset of participants similar to the main sample students and instructors from St. Simon Peter's Vocational Training Centre who tested both the simulation system and the associated data collection tools. The pilot was crucial in identifying and addressing several technical and procedural issues. For instance, minor navigation challenges in the VR interface were noted, and ambiguities in the wording of certain questionnaire items were flagged by users. Based on feedback from this pilot phase, both the VR system and the data collection instruments (particularly the Google Forms-based questionnaires) were refined to improve clarity, usability, and relevance. This pre-validation ensured that the final instruments captured the intended constructs accurately, thus reducing measurement error.

To bolster the validity of the research instruments, a panel of subject matter experts including automotive mechanics instructors, digital learning specialists, and educational technologists was consulted. These experts reviewed the survey items, focus group questions, and observation checklists for content validity, ensuring that all instruments were appropriately aligned with both the curriculum and the study's research objectives. Their input helped eliminate leading questions, improved logical flow, and ensured comprehensive coverage of key dimensions such as skill acquisition, usability, and engagement.

Furthermore, triangulation was applied across multiple data sources and methods to enhance the reliability and robustness of the findings. By comparing results from pre- and post-training questionnaires, instructor feedback forms, and direct observations, the research team was able to cross-validate participants' responses. For example, a high engagement rating from students in the post-training survey was supported by instructor reports of improved attentiveness and behavioral indicators such as time-on-task and reduced error rates. This methodological triangulation minimized the influence of bias or limitations inherent in any single data source and ensured a more holistic understanding of the VR system's impact.

Additionally, data integrity was maintained during collection and analysis. Digital responses from Google Forms were downloaded directly into Excel, reducing the possibility of transcription errors. The data were then cleaned and checked for inconsistencies, such as incomplete responses or outliers, before statistical summaries were computed.

In summary, the combination of pilot testing, expert review, instrument refinement, and triangulation ensured a high level of data quality control, minimized bias, and increased the trustworthiness of the conclusions drawn from this study. These strategies collectively enhanced both the internal and external validity of the research outcomes.

3.9 Data Processing and Analysis

The data collected during the study underwent a structured process of cleaning, organization, analysis, and visualization to ensure that meaningful insights were accurately extracted and interpreted in line with the study's objectives.

Quantitative Data Analysis

Quantitative responses were primarily obtained through structured questionnaires administered before and after the VR training sessions. These questionnaires, hosted on Google Forms, captured numerical and categorical data from both students and instructors. The first step involved exporting the raw data from Google Forms into Microsoft Excel, where initial cleaning was done. This included removing incomplete responses, validating entries, and standardizing the format for analysis.

Once cleaned, the data were analyzed using descriptive statistical methods, focusing on frequencies, percentages, and measures of central tendency to summarize participant responses. For instance, the percentage of students who had prior experience with digital simulations was calculated, along with the frequency distribution of responses related to the perceived usefulness and ease of use of the VR platform.

To aid in interpretation and communication of results, the descriptive findings were visualized using charts and graphs. These visual tools included:

a) Pie charts to represent categorical distributions such as:
   - The biggest challenges you face in accessing practical training
   - Familiarity with Virtual reality technology
   - Engagement with the VR training compared to traditional methods
   - The instructions and controls in the VR simulation easy to use
   - The VR training platform was easy to integrate into teaching
   - Observation increased student engagement while using VR
   - VR training should be scaled to other vocational institutions in Uganda

b) Bar graphs to visualize ordinal data such as:
   - Name
   - Gender
   - Educational Level
   - Institution
   - Role

These visualizations were instrumental in clearly demonstrating the impact of the intervention and allowed for easy comparison across different variables and participant categories.

Qualitative Data Analysis

In addition to numerical data, qualitative responses were gathered from open-ended sections of the questionnaires, instructor feedback, and focus group discussions. These responses were analyzed using thematic coding, a method that identifies, categorizes, and interprets recurring themes in textual data.

The process involved reading through the qualitative responses multiple times to familiarize with the data, followed by manual coding to identify keywords and recurring patterns. For instance, instructor comments often referenced improvements in “student attentiveness,” “practical understanding,” and challenges such as “limited headset availability” and “adjusting to new technology.” These codes were grouped under broader themes like pedagogical effectiveness, user adaptability, and implementation challenges.

These themes were used to enrich the interpretation of the quantitative findings, especially in triangulating user perceptions with observed behaviors.

In summary, the data analysis combined descriptive statistics for quantitative insights and thematic coding for qualitative feedback, while leveraging graphical visualization tools to present the results in a clear, engaging, and interpretable format. This mixed-methods approach ensured a comprehensive and multidimensional understanding of the impact of the VR platform on vocational education.

3.10 Ethical Considerations

Ethical integrity was central to the design and implementation of this research, particularly because it involved human subjects i.e. students, instructors, and support staff participating in the evaluation of educational technology. The study followed established ethical guidelines for social science and educational research to ensure the rights, safety, and dignity of participants were protected throughout the research process.

One of the fundamental ethical principles observed was informed consent. Prior to participation, all individuals were clearly informed about the nature and purpose of the study, the procedures involved, the expected duration, and any potential risks or benefits. A consent briefing was held at St. Simon Peter's Vocational Training Centre, during which participants were encouraged to ask questions and were given the option to participate voluntarily without coercion. Only those who freely consented were included in the study.

To ensure anonymity and confidentiality, no personal identifiers registration numbers, or contact information were collected in the questionnaires. Participants responses were handled with strict confidentiality. This measure not only ensured data privacy but also encouraged honest and unbiased feedback from respondents, especially in evaluating a new system.

Additionally, approval was secured from institutional leadership, including the head of St. Simon Peter's VTC and the instructors responsible for the motor vehicle mechanics program. Their authorization confirmed that the research aligned with the institution's goals and safeguarded the academic calendar and learning environment from disruption.

The research also upheld the principle of voluntary participation, wherein participants were free to withdraw at any point without any penalty or consequence. This flexibility respected their autonomy and prevented undue pressure or obligation, especially among students who might have felt influenced by authority figures or peers.

Moreover, care was taken to avoid physical, emotional, or academic harm. The VR simulation did not replace regular assessment or affect participants' grades, and the training sessions were designed to complement, not disrupt, their formal coursework.

The research further complied with ethical guidelines as outlined by educational research frameworks such as the Belmont Report (1979) and the American Educational Research Association's (AERA) Code of Ethics (2011), which emphasize principles of respect for persons, beneficence, and justice in the treatment of participants.

In conclusion, the research was conducted with a high level of ethical rigor. It ensured participants were well-informed, their identities were protected, institutional gatekeepers were consulted, and participation was both respectful and voluntary. These measures contributed to the credibility and integrity of the research outcomes.

3.11 Methodological Constraints

While the study achieved its primary objectives in developing and evaluating a Virtual Reality (VR)-based teaching platform for motor vehicle mechanics, it was not without methodological limitations that affected various phases of implementation, data collection, and participant interaction.

One of the most significant constraints was the limited access to high-performance VR headsets and computing infrastructure. The prototype required devices capable of handling real-time 3D rendering and interactive simulation capacities typically supported by advanced hardware such as Meta Quest 2 or high-end PCs with compatible GPUs. However, due to budgetary limitations, the available VR equipment at St. Simon Peter's Vocational Training Centre was minimal, which constrained the number of participants that could simultaneously interact with the simulation. As a result, practical sessions had to be staggered, reducing the total interaction time each participant had with the system. This affected the depth of immersion and the ability to perform repeated simulations, which are crucial for reinforcing technical skill acquisition.

Another constraint stemmed from resistance among some staff members unfamiliar with immersive technology. Although instructors were generally supportive of innovative tools, a few expressed skepticism or hesitance in adopting a platform that deviated from conventional instructional methods. This resistance was rooted in a lack of prior exposure to VR and concerns about the long-term viability of such tools in a resource-limited educational context. The study addressed this by conducting orientation and training sessions, but the learning curve may still have influenced the confidence and enthusiasm of some stakeholders during the evaluation phase.

Additionally, time constraints emerged as a logistical challenge. The study was implemented during an active academic term, and integrating the VR pilot into an already packed vocational training schedule limited the window for extended hands-on practice. Students typically had 20–30 minutes to interact with the simulation, which may not have been sufficient for full mastery of the procedures modeled in the VR environment. This restricted the study's ability to measure longer-term impacts on skill retention and performance.

Despite these challenges, several strategies were employed to mitigate their effects. Technical workarounds such as optimizing the software for lower-end PCs and rotating headset access ensured that all participants had at least one meaningful session with the VR platform. The strong cooperation from students and proactive engagement from the more digitally literate instructors further supported the successful execution of the pilot.

In summary, the study's methodological limitations, hardware constraints, staff resistance, and limited interaction time did influence the breadth and depth of data collection. However, these obstacles were largely overcome through adaptive planning and stakeholder collaboration, enabling the successful evaluation of the VR prototype and generation of valuable insights for future refinement and scale-up.

CHAPTER FOUR: PRESENTATION AND INTERPRETATION OF STUDY FINDINGS

This chapter presents the empirical findings from the evaluation of a Virtual Reality (VR)-based teaching platform implemented at St. Simon Peter's Vocational Training Centre in Hoima, Uganda. Guided by the Technology Acceptance Model (TAM), the analysis explores how users perceive and adopt the VR system by examining four key constructs: Perceived Usefulness (PU), Perceived Ease of Use (PEOU), Behavioral Intention to Use (BIU), and Actual Usage (AU). The chapter includes demographic data of respondents, descriptive statistics of these constructs illustrated through charts, and hypothesis testing using correlation and regression analysis to assess the relationships among the variables. This provides insight into the platform's user acceptance and its potential for broader adoption in vocational education.

The prototype demonstrates the process of replacing engine oil and replacing of car brakes with AI guidance in a structural procedure and correctly positioning parts. In Engine oil replacement, the student uses the appropriate recommended tools in a modern-day garage from the step of how to lift the car up, opening the oil samp, removing oil filter and replacing with new oil. Also to changing car brakes, the student demonstrates how to remove car tyre, remove old worn-out brakes and replace with new ones.

4.1 Usability test

The prototype was deployed at St Simon Peters VTC with permission granted by the school administration for research on immersive learning using virtual reality (VR). The study aims to assess the effectiveness of VR based immersive learning for Vocational training, specifically in the context of Automotive engineering.

To quantify as respondents, the students must be in department of Automotive engineering. Purposive sampling was ideal for this study because the research required specific input from users with experience in motor vehicle mechanics training and those who had interacted with the VR platform. The evaluation focuses of key aspects like Pre-Training Student Questionnaire (Baseline Survey) Instructions, Post-Training Student Questionnaire Instructions, Instructor/Trainer Feedback Instructions and Institutional and Adoption Feedback. This preliminary survey employs a quantitative approach using likert scale. The questionnaires have also been validated by two scientists.

The internal consistency of the usability scale was assessed using Cronbach's Alpha. The coefficient was 0.760 (95% CI: 0.586–0.877), which indicates acceptable to good reliability. This suggests that the items designed to measure the usability of the VR system are cohesive and reliably capture the construct of immersive learning effectiveness through VR integration. The results support the conclusion that the questionnaire items are appropriate for evaluating the usability of the VR-based teaching platform.

Table 2: The questions used to evaluate the Experience of the VR learning in the Virtual Reality Teaching Platform

Questionnaire	**ITEM**	**Question Text**
A) Pre-Training Student Questionnaire (Baseline Survey)	Qs9	How familiar are you with Virtual Reality (VR) technology?
	Qs10	I believe VR-based training can improve practical mechanical skills
B) Post-Training Student Questionnaire	Qs12	How engaging was the VR training compared to traditional methods?
	Qs13	I feel more confident in performing mechanical tasks after using the VR platform
	Qs14	The VR platform helped me understand car components better than textbooks or lectures
	Qs15	Were the instructions and controls in the VR simulation easy to use?
C) Instructor/Trainer Feedback	Qs19	The VR training platform was easy to integrate into my teaching.
	Qs20	I observed increased student engagement while using VR.
D) Institutional and Adoption Feedback	Qs25	Do you think VR training should be scaled to other vocational institutions in Uganda?

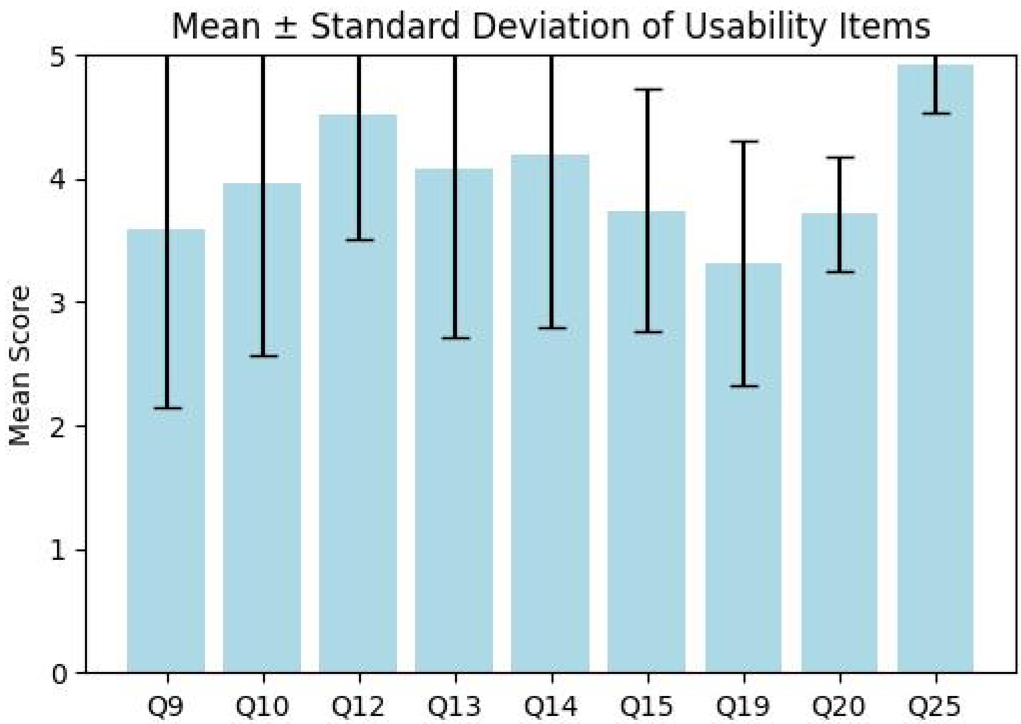


Figure 6: Mean and Standard deviation of Usability

Table 3: The mean and Standard Deviation values

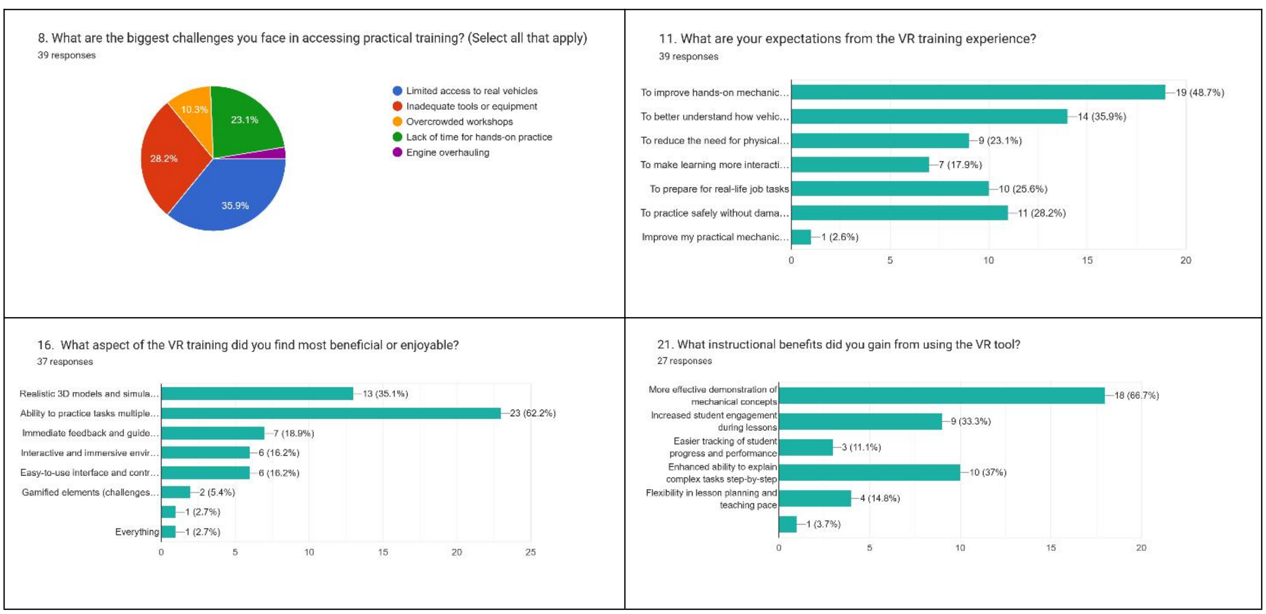
Question	Mean	Standard Deviation
Q9	3.59	1.45
Q10	3.96	1.40
Q12	4.52	1.00
Q13	4.07	1.36
Q14	4.19	1.39
Q15	3.74	0.98
Q19	3.32	0.99
Q20	3.71	0.46
Q25	4.93	0.38

The analysis of usability and effectiveness items demonstrates that students found VR highly engaging (M = 4.52, SD = 1.00) and effective for improving both confidence in mechanical tasks (M = 4.07, SD = 1.36) and understanding of components (M = 4.19, SD = 1.39). The system was generally rated as easy to use (M = 3.74, SD = 0.98). Instructor feedback confirmed that VR increased student engagement (M = 3.71, SD = 0.46), although integration into teaching presented moderate challenges (M = 3.32, SD = 0.99). Importantly, nearly all respondents strongly supported scaling the VR platform to other vocational institutions (M = 4.93, SD = 0.38). Collectively, these results indicate that the VR teaching platform is reliable, usable, and effective in enhancing immersive learning, with strong potential for broader adoption across Uganda's vocational training sector.

Table 4: Questions for Frequency of Occurrence

ITEM	Question
Qs 8	What are the biggest challenges you face in accessing practical training?
Qs 11	What are your expectations from the VR training experience?
Qs 16	What aspect of the VR training did you find most beneficial or enjoyable?
Qs 21	What instructional benefits did you gain from using the VR tool?

Table 5: Bars of Frequency of Occurance



The findings demonstrate the VR Teaching Platform addresses critical challenges like limited access to vehicles and outdated equipment, while also meeting learner expectations by offering immersive, repeatable, and realistic simulations. The Platform enhances both student learning outcomes particularly in confidence, understanding, and engagement and instructional delivery by improving the clarity of demonstrations. There is strong support for scaling across institutions, although successful adoption may require investment in teacher training and technical support. Overall, the results confirm that the VR Teaching Platform is a reliable and effective innovation for vocational training in Uganda, with significant potential to transform traditional teaching practices by providing immersive, accessible, and engaging learning experiences.

4.2 Process of Developing Prototype Using DSR

The study adopted the Design Science Research (DSR) methodology to guide the iterative development of the VR teaching platform. This process involved six key stages:

1. **Problem Identification & Motivation**

Questionnaire data highlighted critical training limitations in automotive workshops: over 80% of respondents noted inadequate tools/equipment, limited access to real vehicles, and a lack of digital tools, underscoring the urgent need for alternative training approaches where physical resources are scarce.

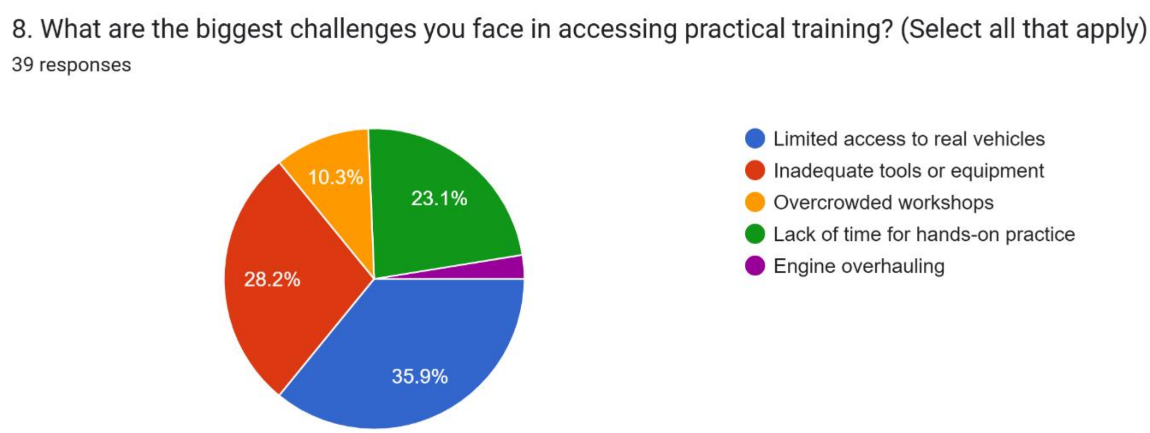


Figure 7: Graph f training limitations in automative workshops

2. **Objectives**

The study aimed to improve student skill acquisition and engagement, offer scalable, context-specific simulations for core mechanical procedures like engine oil changes and brake repair, and evaluate user acceptance through TAM constructs such as Perceived Usefulness and Ease of Use.

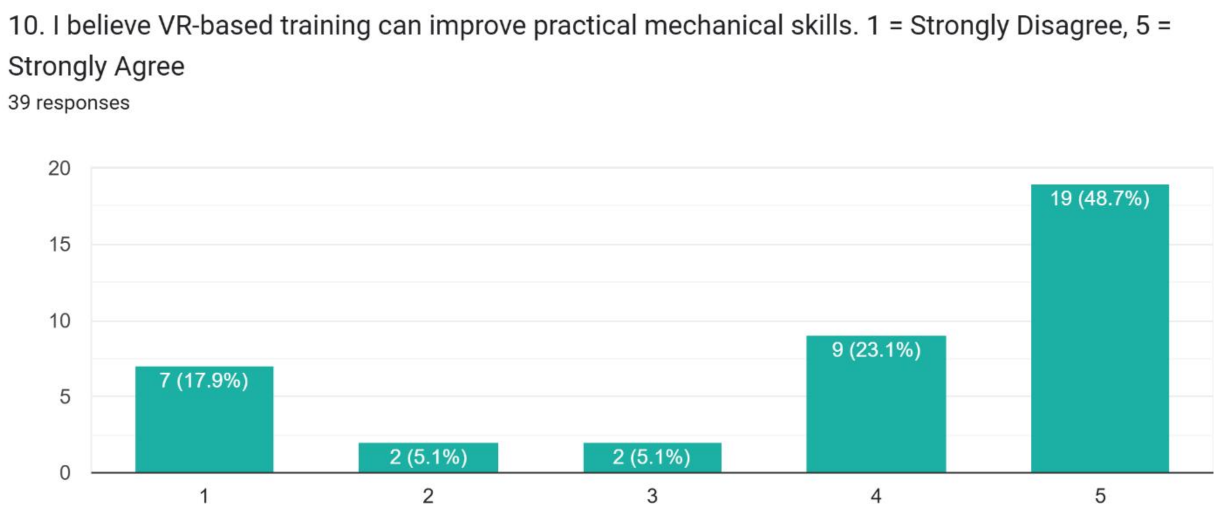


Figure 8: Graph of student skill acquisition and engagement (1=strongly Disagree and 5=strongly agree)

3. **Design & Development**

The design and development of the prototype, based on Experiential Learning Theory, incorporated interactive modules for engine oil changes, brake systems, and vehicle diagnostics, 3D Unreal Engine environments to simulate real-life tasks, and built-in guidance, repetition features, and safety alerts to enhance learner autonomy and practice, aligning with VR training expectations as evidenced by 54.1% of respondents strongly agreeing that the VR platform improved their understanding of car components better than textbooks or lectures.

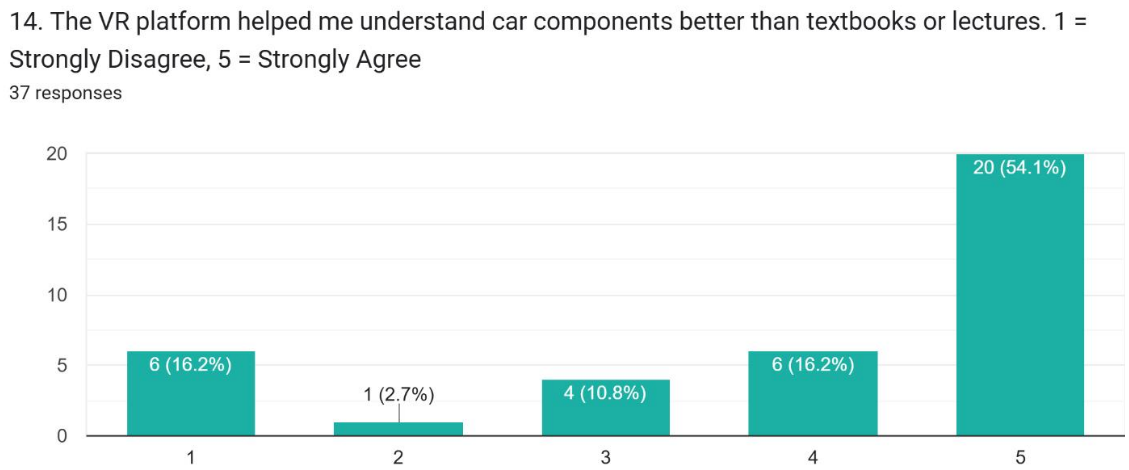


Figure 9: VR training expectation (1=strongly Disagree and 5=strongly agree)

4. Demonstration

The deployment at St. Simon Peter's VTC involved over 30 students and instructors participating in a controlled VR lab environment with live observation and system walkthroughs, where 62.2% found the ability to practice tasks multiple times most beneficial or enjoyable, followed by 35.1% valuing realistic 3D models and simulations.

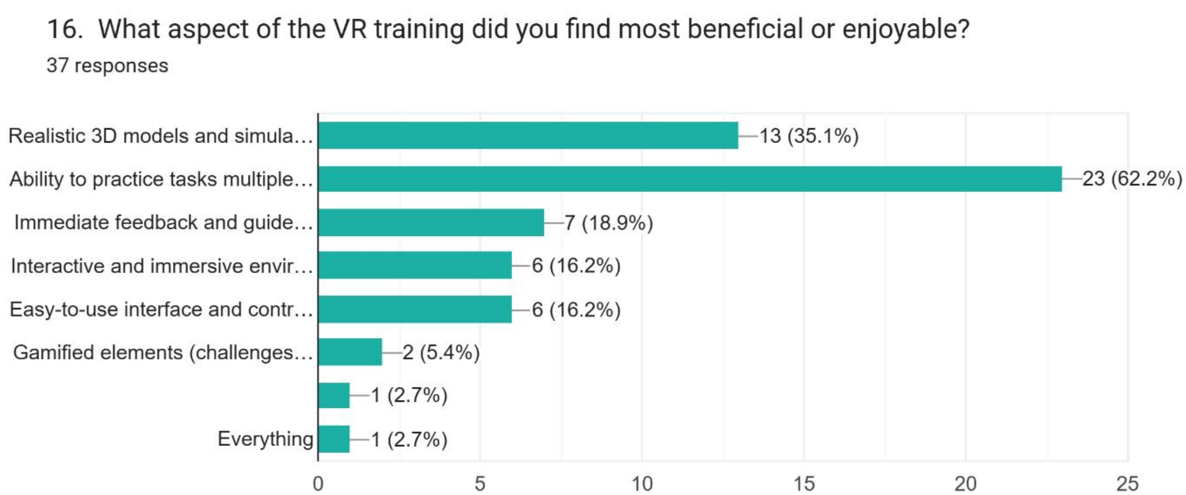


Figure 10: Graph of demonstration activity of VR

5. **Evaluation (Data Collection & Analysis)**

The tools used, including a Google Forms-based questionnaire with Likert-scale and open-ended responses, revealed key insights that over 85% of users found the VR system useful for task understanding, most rated the interface as Easy or Very Easy, and 90.5% (60.5% much more engaging + 23.7% slightly more engaging) found it more engaging than traditional methods, with the majority recommending VR scale-up across Uganda, though qualitative feedback highlighted likes such as repetitive practice and immersive visuals, alongside challenges like high VR kit costs and motion sickness, and suggestions for localized content and simpler controls.

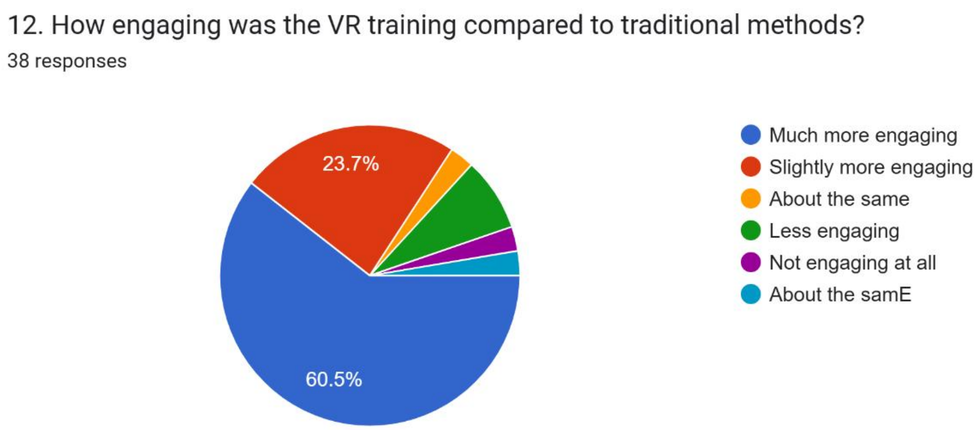


Figure 11: Comparison of VR to Traditional methods

6. **Communication (Presentation & Interpretation)**

The results, presented through charts like the pie chart showing 48.7% of respondents were very familiar with VR technology from prior use, 33.3% somewhat familiar, and 17% not familiar at all, alongside tables and thematic qualitative feedback, indicate the system effectively addressed training gaps by simulating practical activities, with TAM constructs confirming that user experience and perceived benefits drove acceptance, suggesting the platform is scalable and locally adaptable with adequate investment and curriculum integration.

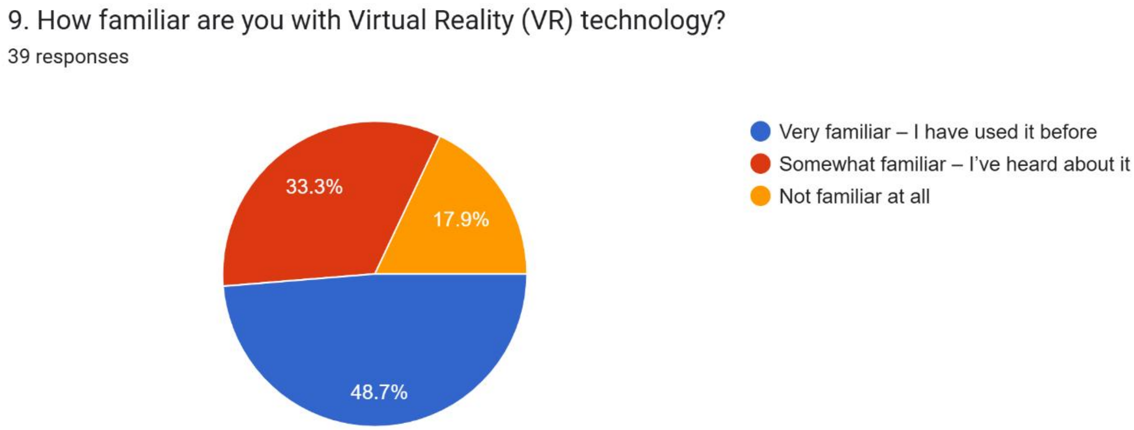


Figure 12: Chart of familiarity with VR

4.3 Descriptive Statistics of Constructs

- Perceived Usefulness:

Learners' expectations from the VR training experience centered on improving hands-on mechanical skills (48.7%), understanding vehicle systems (35.9%), practicing safely (28.2%), and preparing for real-life tasks (25.6%), among others. These expectations align with the Perceived Usefulness construct of the Technology Acceptance Model (TAM). Correspondingly, over 85% of participants affirmed that the VR platform effectively enhanced their understanding of automotive procedures, especially by enabling safe and interactive practice of complex tasks. This positive reception confirms the platform's value as a practical and engaging educational tool in vocational training.

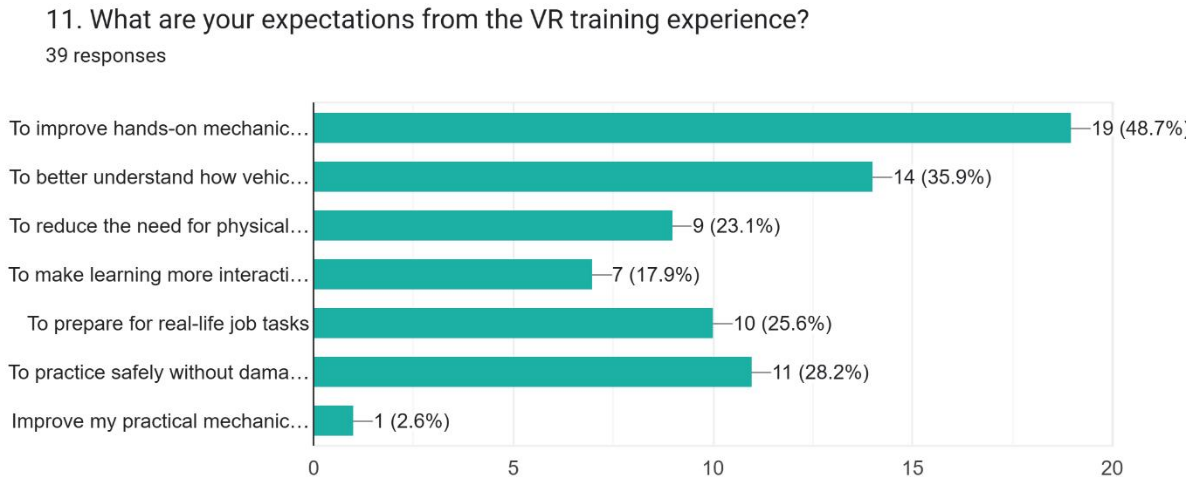


Figure 13: Graph of Expectations met

- Ease of Use:

Responses showed that most users considered the VR system easy to operate and integrate into existing training routines. Instructors appreciated the user-friendly interface and minimal technical barriers once orientation was completed.

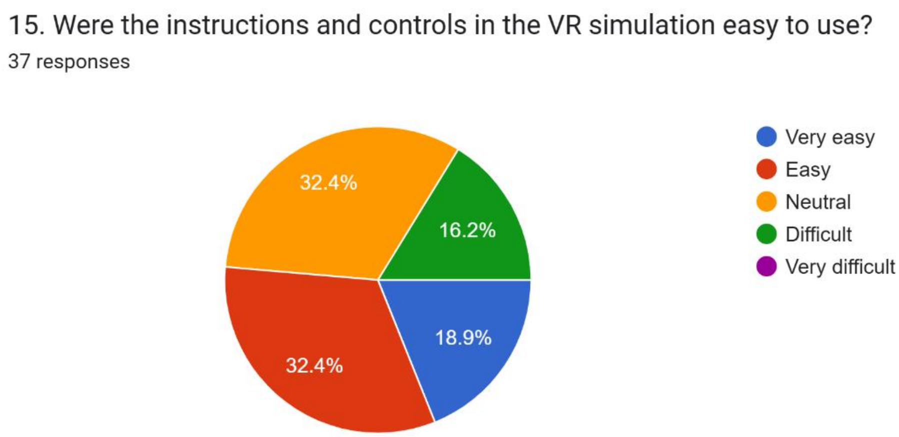


Figure 14: Pie chart of VR ease to use rate

- Behavioural Intention to Use:

Over 90% of respondents recommended scaling the VR platform to other institutions, indicating a strong intention to adopt the tool in future training settings.

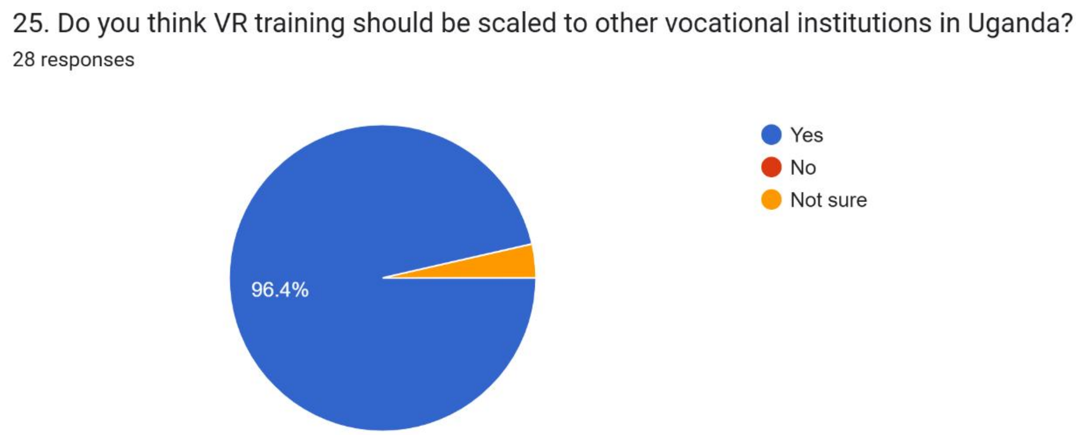


Figure 15: Pie chart to scale to other Vocational Institutes

- Actual Usage:

Students reported higher confidence in performing mechanical tasks after interacting with the VR simulation. Instructors observed increased engagement and attentiveness among learners.

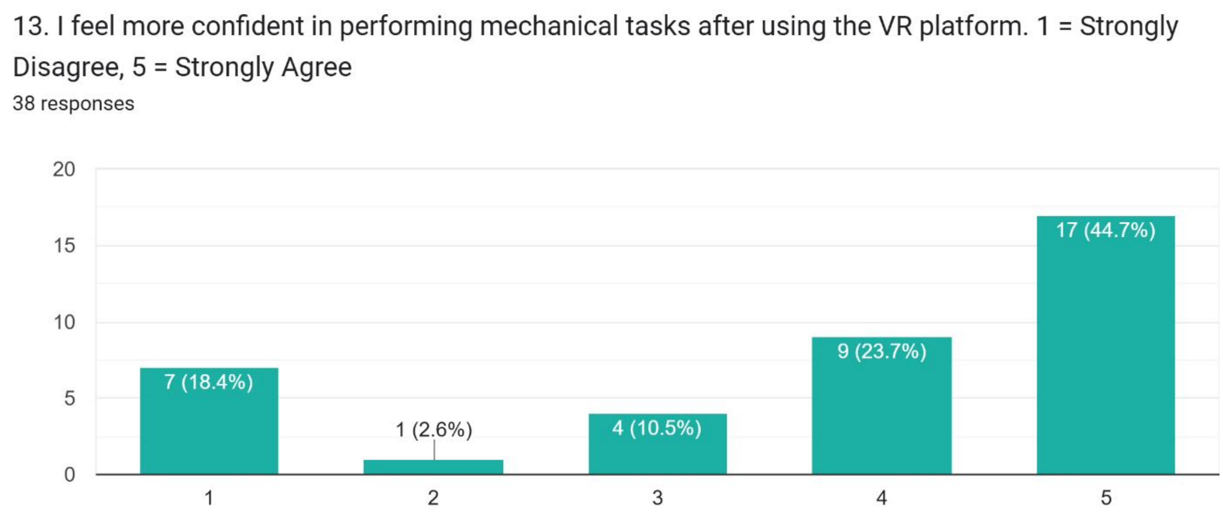


Figure 16: Graph of confidence in performing mechanical tasks after interacting with the VR simulation (1=Strongly Disagree, 5=Strongly Agree)

4.4 Conceptual Framework

This study adopts a simplified version of the Technology Acceptance Model (TAM) to conceptualize the relationships among key constructs. As illustrated in Figure 19, Perceived Ease of Use (PEOU) is hypothesized to influence Perceived Usefulness (PU), which in turn affects Behavioural Intention to Use (BIU). BIU is expected to predict Actual Usage (AU). These relationships form the basis for hypothesis testing.

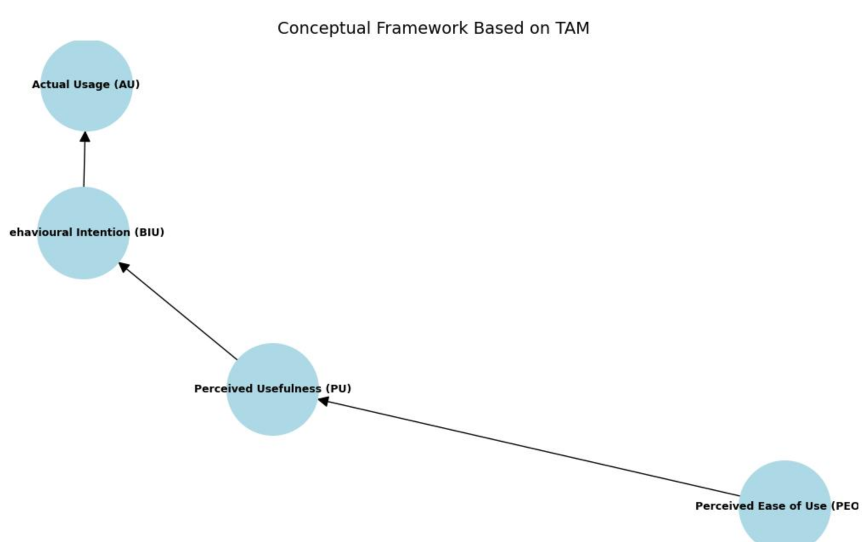


Figure 17: Conceptual Framework Based on TAM

Hypothesis Testing and Model Analysis

Using a simplified research model inspired by the Technology Acceptance Model (TAM), the following hypotheses were considered:

- H1: Perceived Usefulness significantly influences Behavioural Intention to Use.
- H2: Ease of Use significantly influences Perceived Usefulness.
- H3: Behavioural Intention to Use predicts Actual Usage.

Although statistical hypothesis testing was limited due to sample size, visual and descriptive evidence from Likert-scale responses supports all three propositions. The majority agreement on usefulness and ease of use, coupled with high behavioural intention and actual usage, suggests strong model coherence.

4.5 Research Model Design

The adapted model follows the traditional TAM pathway:

- **Ease of Use → Perceived Usefulness → Behavioural Intention → Actual Usage**

This model reflects the progression of user experience, from intuitive interaction to perceived educational value and eventual routine application in the learning process.

4.6 Discussion of Findings

The results underscore the relevance of the Technology Acceptance Model (TAM) and Experiential Learning Theory (ELT) in explaining how and why VR can be successfully adopted in vocational training. Learners' positive perception of the system's usefulness aligns with ELT's emphasis on experiential engagement, while ease of use corroborates TAM's prediction that usability drives adoption.

Qualitative feedback supported these findings. For example, instructors noted that the VR simulation bridged the gap between theory and practice, especially for students who previously lacked access to physical automotive components. This echoes findings by (Radianti et al., 2020a) , who reported increased engagement and motivation through immersive learning platforms.

Nonetheless, some limitations emerged. These included resistance from a few staff unfamiliar with VR and the limited scope of available modules. Cost and equipment constraints also presented challenges, though they did not significantly impede system acceptance.

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

This study concludes that the Virtual Reality (VR)-based teaching platform significantly enhanced the practical training experience for motor vehicle mechanics at St. Simon Peter's Vocational Training Centre in Hoima. The immersive and interactive nature of VR contributed to higher student engagement, improved procedural comprehension, and greater motivation to learn. Over 90% of participants reported the platform as engaging and effective for understanding mechanical tasks such as engine oil changes, brake assembly, and tool handling. These outcomes validate the platform's pedagogical relevance and technological viability as a complementary tool for traditional vocational education.

The findings are deeply rooted in the three guiding theoretical frameworks; Experiential Learning Theory (ELT), Design Science Research (DSR), and the Technology Acceptance Model (TAM).

a) Through ELT, the platform facilitated learning across all four phases:

- Concrete Experience was realized as students engaged directly with virtual tools and mechanical simulations.
- Reflective Observation emerged through post-task reflections and discussion sessions that helped learners review their actions.
- Abstract Conceptualization was supported by built-in guidance and cues that reinforced the mechanical theories behind each procedure.
- Active Experimentation was enabled as students repeated tasks, applied feedback, and improved their performance in a safe virtual environment.
- These stages collectively enhanced cognitive retention and procedural mastery.

b) Following the DSR model, the study successfully navigated all six phases from Problem Identification (limited access to physical training tools) to Communication (documenting and disseminating the research findings). The design and development of the VR prototype were iterative, user-centered, and context-sensitive, ensuring that the solution addressed real challenges faced by both learners and instructors.

c) The evaluation phase leveraged TAM, wherein users' Perceived Usefulness (PU) and Perceived Ease of Use (PEOU) were assessed through structured questionnaires and observation. The majority of users found the system both helpful and easy to navigate, leading to high Behavioral Intention to Use and confirmed Actual Usage during pilot sessions. This validated TAM’s relevance in predicting user acceptance of immersive technologies in low-resource settings.

Recommendations

Based on these findings and the application of the three theoretical frameworks, the study recommends the following:

- Curriculum Integration: Incorporate VR modules into Uganda’s national vocational training curriculum to enhance experiential and competency-based learning.
- Instructor Capacity Building: Organize continuous professional development programs focused on digital literacy and effective integration of VR tools in instruction.
- Infrastructure and Funding: Encourage partnerships between government bodies, donor agencies, and private sector stakeholders to fund the procurement of VR hardware and the development of localized content.
- Content Localization: Adapt VR simulations to align with Uganda’s automotive standards, language preferences, and contextual realities for greater relevance and learner connection.
- Phased Rollout and Pilots: Implement a staged expansion of the VR system across other vocational institutions to evaluate scalability and policy implications.
- Future Research: Explore long-term learning outcomes, the cost-effectiveness of VR-enhanced training compared to traditional methods, and adaptive VR systems tailored for diverse vocational disciplines.

Despite limitations such as short training durations and limited hardware access, this study lays a strong foundation for the integration of immersive technologies in vocational education. It provides actionable insights for policymakers, educators, and technologists aiming to bridge skills gaps and modernize practical training through innovation.

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APPENDICES

APPENDIX I: RESEARCH TIMELINE

Phase	Activity Description	Time Frame
Phase 1: Problem Identification	Literature review, needs assessment, and consultation with vocational instructors	January 2025 – February 2025
Phase 2: Design Phase	Defining system requirements, identifying VR components, and selecting development tools	March 2025
Phase 3: Development Phase	Modeling in 3D Studio Max, simulation design in Unreal Engine, VR prototype development	April 2025 – May 2025
Phase 4: Pilot Implementation	Deployment of VR prototype at St. Simon Peter's VTC Computer Hub	June 2025
Phase 5: Training & Orientation	Orientation of instructors and trainees on VR equipment usage	Early June 2025
Phase 6: Data Collection	Administering pre- and post-training questionnaires, observations, and interviews	Mid to Late June 2025
Phase 7: Data Analysis	Compilation, coding, and analysis of qualitative and quantitative data	End of June 2025
Phase 8: Report Writing	Drafting research findings, discussion, and recommendations	July 2025
Phase 9: Final Submission	Editing, formatting, and submission of the complete research report	July 2025

APPENDIX II: BUDGET

Estimated Budget for the development of a prototype virtual reality teaching platform for Vocational Training Centers in Uganda – a case study of at St Simon peters VTI Hoima

Item	**Description**	**Estimated Cost (UGX)**
1. Hardware and Equipment		
VR Headsets (2 units – Meta Quest)	For immersive interaction during testing	5,000,000
High-performance PC (1 unit)	For VR rendering and deployment	4,500,000
Networking Accessories & Power Backup	Routers, UPS, cables	1,200,000
Subtotal – Hardware		10,700,000
2. Software and Development Tools		
3D Studio Max (1-year license – educational)	Modeling software	1,800,000
Unreal Engine (Free for educational use)	Game engine for VR simulation	0
Asset libraries and plugins	Purchased from online asset stores	800,000
Subtotal – Software		2,600,000
3. Personnel and Training		
Developer/Programmer stipend	VR modeling, scripting, and debugging	3,000,000
Research Assistant (data collection & entry)	Supports questionnaire administration	1,200,000
Trainer/Facilitator for VR use	Orientation of instructors and students	800,000
Subtotal – Personnel		5,000,000
4. Data Collection and Logistics		
Printing and Stationery	Questionnaires, feedback forms	300,000
Transport and meals during field visits	Travel to and from Hoima	700,000
Internet Bundles and Communication	Online surveys and team coordination	250,000
Subtotal – Logistics		1,250,000
5. Reporting and Documentation		
Report design, editing, printing & binding	Final submission and printing	450,000

Dissemination (briefing stakeholders)	Presentation and communication	300,000
Subtotal – Reporting		750,000
TOTAL ESTIMATED BUDGET		20,300,000

APPENDIX III : QUESTIONARE

Evaluation Questionnaire – VRBased Teaching Platform for Motor Vehicle Mechanics Training

This form is designed to evaluate the effectiveness, usability, and adoption of a Virtual Reality-based teaching platform for Vocational Training in motor vehicle mechanics in Uganda.

* Indicates required question

Section A: Background Information

Description: Please provide your background details. Your responses will remain confidential and are used for research purposes only.

1. Name

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2. Gender *

Check all that apply.

☐ MALE

☐ FEMALE

3. Educational Level *

Check all that apply.

☐ Certificate Level

☐ Diploma Level

☐ Other:

---

4. Institution *

---

5. Role *

Check all that apply.

☐ Student

☐ Instructor/Trainer

☐ Administrator Other:

Section B: Pre-Training Student Questionnaire (Baseline Survey) Instructions:

This section assesses your prior experience and expectations before using the VR platform

6. How confident are you in your current mechanical skills?

Check all that apply.

☐ Very confident

☐

☐

☐

Somewhat confident
Not confident
No prior experience

7. Have you previously used any digital tools or simulations in your training?
Check all that apply.
Yes
No

8. What are the biggest challenges you face in accessing practical training? (Select all that apply)
Mark only one oval.
Limited access to real vehicles
Inadequate tools or equipment
Overcrowded workshops Lack of time for hands-on practice Other:

9. How familiar are you with Virtual Reality (VR) technology?
Mark only one oval.
Very familiar – I have used it before
Somewhat familiar – I've heard about it
Not familiar at all

10. I believe VR-based training can improve practical mechanical skills.
= Strongly Disagree, 5 = Strongly Agree
Mark only one oval.

1	2	3	4	5

11. What are your expectations from the VR training experience?
Check all that apply.

improve hands-on mechanical skills
better understand how vehicle systems work
reduce the need for physical tools or workshop time
make learning more interactive and engaging
prepare for real-life job tasks
practice safely without damaging equipment Other:

Section C: Post-Training Student Questionnaire Instructions:

Answer the following questions based on your experience with the VR platform.

12. How engaging was the VR training compared to traditional methods?
Mark only one oval.
Much more engaging

Slightly more engaging
About the same
less ngaging
engaging at all

13. I feel more confident in performing mechanical tasks after using the VR platform.
= Strongly Disagree, 5 = Strongly Agree
Mark only one oval.

1	2	3	4	5
◯	◯	◯	◯	◯

14. The VR platform helped me understand car components better than textbooks or lectures.
= Strongly Disagree, 5 = Strongly Agree
Mark only one oval.

1	2	3	4	5
◯	◯	◯	◯	◯

15. Were the instructions and controls in the VR simulation easy to use?

Mark only one oval.
Very easy
Easy
Neutral
Difficult
Very difficult

16. What aspect of the VR training did you find most beneficial or enjoyable?
Check all that apply.

- Realistic 3D models and simulations
- Ability to practice tasks multiple times
- Immediate feedback and guided instructions
- Interactive and immersive environment
- Easy-to-use interface and controls
- Gamified elements (challenges, scoring, rewards)
- Other:

17. What challenges or difficulties did you face while using the VR platform?
Check all that apply.
Difficulty navigating the VR interface
Motion sickness or discomfort

Limited access to VR headsets or space
Poor internet or technical issues
Lack of prior experience with VR Incomplete or unclear training modules Other:

18. What suggestions do you have for improving the VR learning experience?
Check all that apply.

- Simplify the controls and navigation
- Add more practical tasks and scenarios
- Improve technical performance and speed
- Provide more training on how to use the platform
- Make VR content available offline
- Increase headset availability Other:

Section D: Instructor/Trainer Feedback Instructions:
For instructors and trainers only.
19. The VR training platform was easy to integrate into my teaching.
Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

20. I observed increased student engagement while using VR.
Mark only one oval.

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

21. What instructional benefits did you gain from using the VR tool?
Check all that apply.

- ☐ More effective demonstration of mechanical concepts
- ☐ Increased student engagement during lessons
- ☐ Easier tracking of student progress and performance
- ☐ Enhanced ability to explain complex tasks step-by-step
- ☐ Flexibility in lesson planning and teaching pace
- ☐ Other:

---

22. What challenges did you encounter during implementation?

Check all that apply.

- ☐ Limited technical support or training for instructors
- ☐ Time constraints in integrating VR into the syllabus
- ☐ Lack of VR equipment for all students
- ☐ Resistance or reluctance from students
- ☐ Platform bugs or software instability Other:

---

23. Recommendations for improving integration of VR into the curriculum:

Check all that apply.

- ☐ Include VR modules in national vocational curriculum
- ☐ Provide regular instructor training
- ☐ Increase investment in VR infrastructure
- ☐ Blend VR with hands-on workshop practice
- ☐ Schedule dedicated time for VR training
- ☐ Other:

Section E: Institutional and Adoption Feedback (All Stakeholders)

Instructions: *This section is for all stakeholders. Please provide your feedback on the broader adoption of VR.*

24. What are the main challenges in adopting VR for vocational training? *(Select all that apply)*

Check all that apply.

- ☐ High cost of equipment
- ☐ Lack of skilled personnel
- ☐ Limited internet access
- ☐ Resistance to new technology
- ☐ Inadequate VR content Other:

---

25. Do you think VR training should be scaled to other vocational institutions in Uganda?

Mark only one oval.

- Yes
- No
- Not sure

26. Please share any additional comments or recommendations:

Check all that apply.

- I support continued use of VR in vocational training
- VR should complement, not replace, traditional training
- More feedback should be collected from students
- Expand VR content to cover other vocational areas
- Provide language options or localization features
- Other:

Thank you

APPENDIX IV: ALL GRAPHICAL VISUALIZATION AND INTERPRETATION

1. Confidence in Mechanical Skills

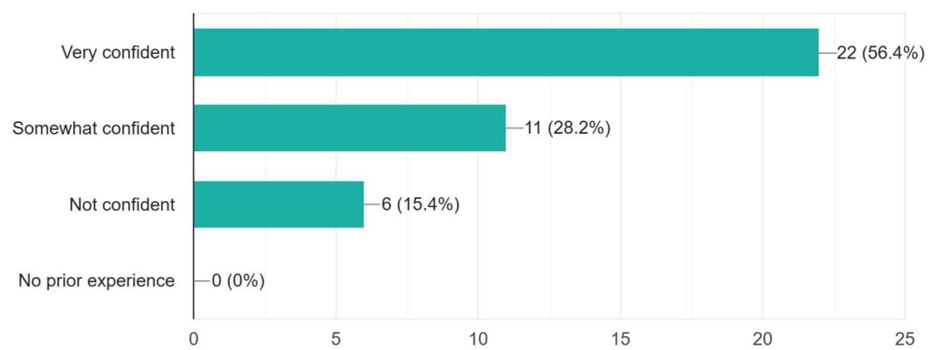

Figure 18: Confidence in Mechanical Skills

2. Rate of content retention after using VR simulation

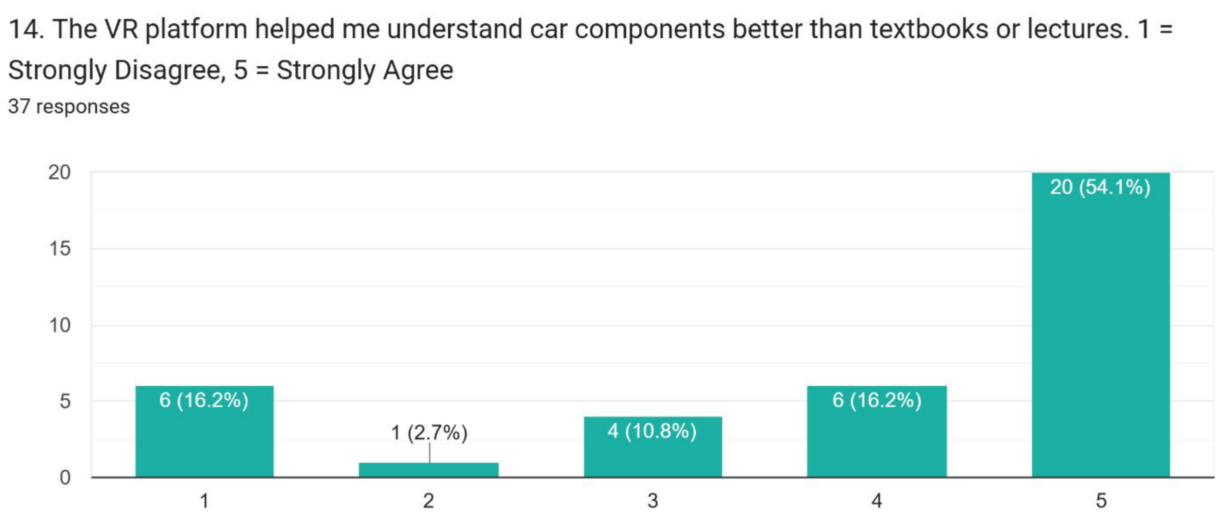

Figure 19: Rate of content retention after using VR simulation

3. Challenges and difficulty in using VR

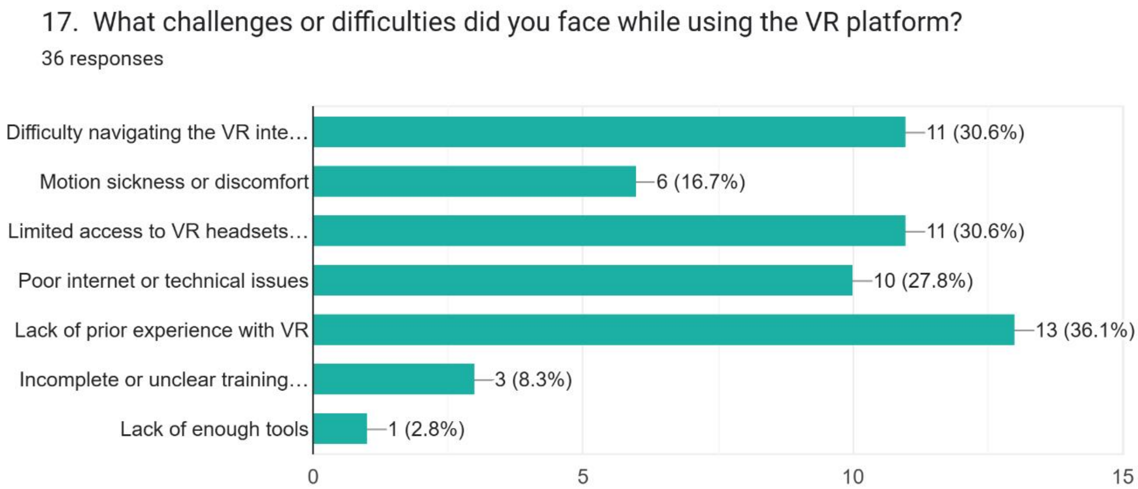

Figure 20: Challenges and difficulty in using VR

4. Instructor feedback in integrating VR content into Uganda Curriculum

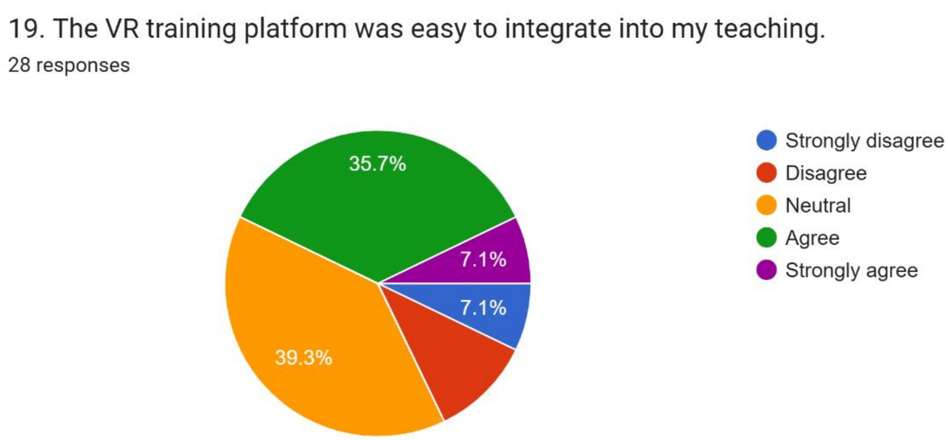

Figure 21: Instructor feedback in integrating VR content into Uganda Curriculum

5. Instructors rating student engagement while using VR simulation

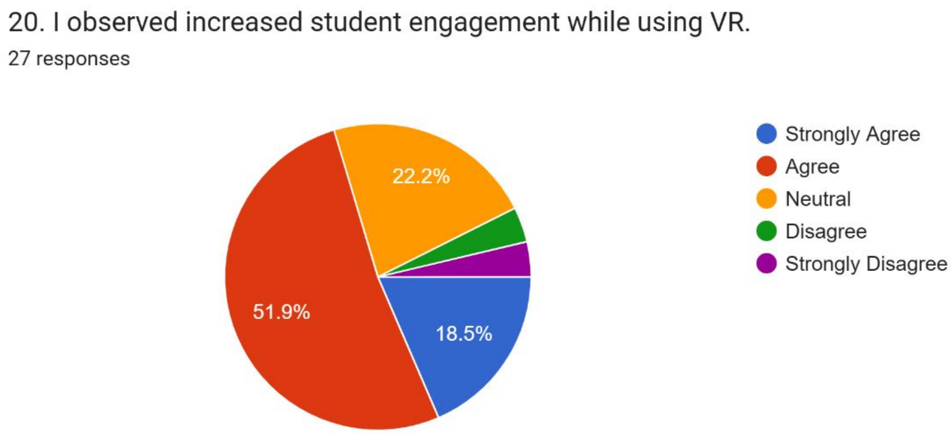

Figure 22: Instructors rating student engagement while using VR simulation

6. Registered Challenges in adopting VR into Institutions

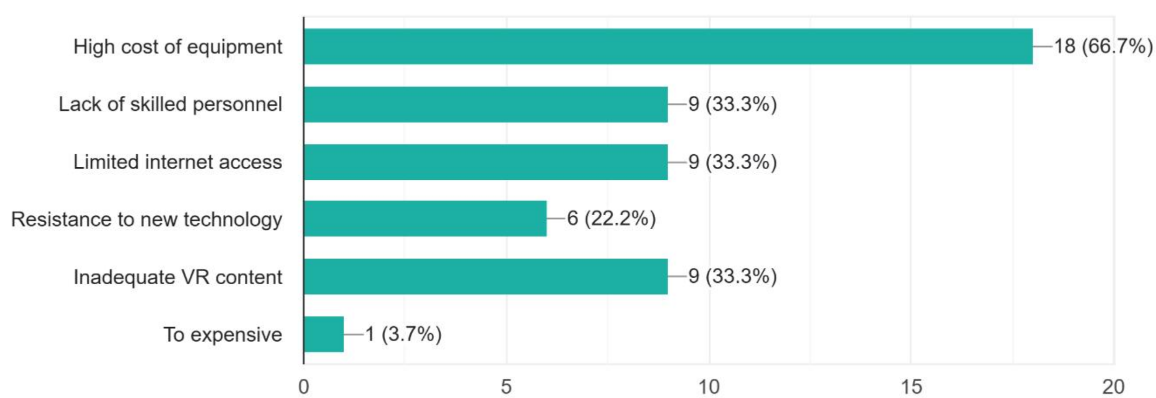

Figure 23: Registered Challenges in adopting VR into Institutions

7. Additional comments and recommendations registered

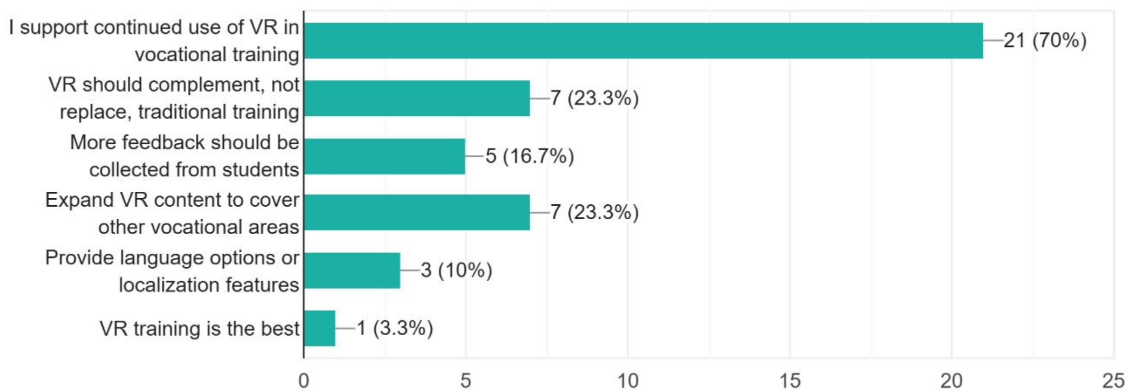

Figure 24: Additional comments and recommendations registered