

Development of a Mixed-Reality Vocational Training Simulator: Integrating UI/UX-Centered Design for Enhanced Skill Acquisition and Immersive Learning

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Abstract: This study presented the development and evaluation of a UI/UX-centered Mixed-Reality (MR) vocational training simulator designed to enhance skill acquisition, engagement, and usability among learners in carpentry, automotive, and cookery domains. By integrating gesture-based and controller-based interaction methods, the system offered an immersive learning environment that mirrored real-world vocational tasks. Usability testing with 20 participants, guided by a domain specific UX evaluation framework, revealed high levels of functionality, accuracy, and acceptability, with an overall System Usability Scale (SUS) score of 76.42, indicating good to excellent usability. Findings suggested that intuitive interface design and natural interactions significantly improved learner performance, motivation, and retention. This research contributed valuable insights into the effective use of MR technologies for vocational education and the importance of user-centered design in immersive systems.

Keywords: Mixed Reality, UI/UX Design, Vocational Training, Immersive Learning, System Usability Scale (SUS), Human–Computer Interaction, Educational Technology.

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I. INTRODUCTION

The rapid integration of immersive technologies like Virtual and Mixed Reality (VR/MR) into educational contexts has opened new opportunities for enhancing vocational training. Numerous studies highlight the motivational and engagement benefits of immersive learning; however, measurable improvements in knowledge retention and skill acquisition remain inconsistent. For instance, recent research reveals that while learners often feel more engaged in MR environments, these experiences do not consistently outperform traditional training methods in terms of cognitive learning outcomes ^{[1][3]}. This signals a gap between perceived engagement and actual knowledge gains—a disconnect this study aims to address through a UI/UX-centered design

approach that aligns user experience with pedagogical effectiveness in vocational skill acquisition.

Despite the increasing use of MR in education, current user experience (UX) evaluation frameworks are generally too broad and fail to capture domain-specific requirements, particularly in hands-on vocational tasks ^{[1][2]}. Most systems rely heavily on controller-based interactions, which, while functional, do not reflect the natural, embodied gestures involved in real-world trades and technical work ^{[3][4]}. The absence of task-aligned UX evaluation metrics and natural interaction design limits the effectiveness of MR-based vocational systems. Therefore, this study proposes the development of a vocational training simulator that incorporates not only intuitive, gesture-based interaction but

also customized UX measurement tools to ensure a more authentic and effective training experience.

Additionally, the majority of existing MR training studies are conducted over short periods, often lasting just a few hours, which limits insights into long-term learning outcomes and skill retention [2][4]

This presents a research gap concerning the longitudinal effectiveness of MR training environments. By integrating extended training modules and repeated assessment points, the proposed study aims to evaluate both immediate learning performance and the retention of vocational skills over time. Through a combination of immersive technology, UI/UX-centered design, and a research-backed evaluation framework, this project seeks to deliver a comprehensive solution that addresses the shortcomings of previous studies while advancing the effectiveness of vocational education in the digital age.

➤ *Research Problem*

Despite the growing use of Mixed-Reality (MR) technologies in vocational education, there remains a lack of evidence linking immersive experiences to significant improvements in actual skill acquisition and long-term learning outcomes. Existing MR systems often rely on generic UI/UX designs and controller-based interactions that fail to reflect the authentic, hands-on nature of vocational tasks. This creates a critical gap in the development of MR training simulators that effectively combine user-centered design with measurable educational impact.

➤ *Research Questions*

- How can UI/UX-centered design enhance learner engagement and skill acquisition in a Mixed-Reality vocational training simulator?
- What is the impact of natural, gesture-based interaction compared to controller-based input on the effectiveness of MR-based vocational training?
- How can a domain-specific UX evaluation framework be developed to assess the usability and educational value of Mixed-Reality vocational simulators?

➤ *Research Objectives*

- To design and implement a UI/UX-centered Mixed-Reality training simulator that supports immersive and effective vocational skill development.
- To compare the effects of gesture-based and controller-based interaction methods on learner performance, engagement, and skill retention.
- To develop and validate a domain-specific UX evaluation framework tailored for assessing MR vocational training systems.

➤ *Significance and Justification*

This study is significant as it aims to enhance vocational education by developing a Mixed-Reality (MR) training simulator that integrates UI/UX-centered design to improve

both learner engagement and skill acquisition. Existing MR systems often rely on controller-based inputs and generic interfaces, which fail to replicate the authentic, hands-on experience required in vocational training. By incorporating gesture-based interactions and creating a domain-specific UX evaluation framework, this research addresses key gaps in current educational technology. The findings will contribute to the advancement of immersive learning design and provide practical insights for educators, developers, and institutions seeking effective and user-focused MR solutions for skills development.

II. LITERATURE REVIEW

➤ *Overview of HCI Theories and Models*

This study leverages established HCI theories and models to inform the design and evaluation of the Mixed-Reality vocational training simulator, particularly focusing on interaction efficiency and contextualized user behavior. The GOMS (Goals, Operators, Methods, and Selection rules) model is utilized to analyze and predict users' task execution steps within the simulator, allowing comparison between gesture-based and controller-based interactions. GOMS has been effectively applied in assessing user efficiency in complex systems, such as in the work of John and Kieras, who expanded it into the Keystroke-Level Model (KLM) to quantify expert user actions in human-computer interactions [5]. This quantitative approach is valuable for optimizing MR system interfaces to support fast and accurate vocational task completion.

Complementing this, Activity Theory, particularly the Cultural-Historical Activity Theory (CHAT) framework, provides a lens to examine how learners interact with the MR system as a mediating tool within their vocational training activity system. Activity Theory emphasizes the relationship between the user, the tool (MR interface), the community, rules, and division of labor in a goal-directed activity [6]. This holistic perspective has been used in various studies to design and evaluate technology-enhanced learning environments, helping to capture contextual factors influencing user engagement and learning outcomes [7]. Applying Activity Theory in this study facilitates a comprehensive understanding of how the simulator supports real-world skill acquisition beyond isolated task performance.

Together, GOMS and Activity Theory offer complementary insights—GOMS providing a detailed micro-level analysis of user interaction efficiency, and Activity Theory offering a macro-level understanding of the contextual and social dynamics involved in vocational training through Mixed Reality. These models underpin the UI/UX-centered design approach, ensuring that the simulator not only supports efficient task execution but also aligns with the broader learning goals and user context.

III. RESEARCH METHODOLOGY

➤ *Research Design*

This study employed a developmental research design to guide the systematic creation and refinement of a Mixed-

Reality (MR) vocational training simulator, with a strong emphasis on user-centered design and iterative improvement. Usability testing was conducted at various stages of development to evaluate the system's efficiency, effectiveness, and overall user satisfaction. This approach followed the developmental research principles outlined by Reeves [8], emphasizing the dual goal of generating practical instructional tools and contributing to theory-based design knowledge.

➤ *Participants*

The participants of this study consisted of selected students enrolled in vocational and technical education programs at a higher education institution. A total of 20 participants, aged between 18 and 25, were purposively selected based on their prior exposure to basic technical skills and their willingness to engage with immersive technologies. The participants represented a mix of disciplines such as electrical installation, automotive servicing, and computer hardware servicing—ensuring the applicability of the Mixed-Reality (MR) training simulator across multiple vocational domains. Before participating, all individuals provided informed consent and received a brief orientation on how to interact with both gesture-based and controller-based MR systems. Their feedback, performance metrics, and usability evaluations were essential in assessing the effectiveness, efficiency, and engagement level of the simulator throughout the usability testing phases.

➤ *Data Collection*

Data were collected through a combination of observation, surveys, and a focus group discussion. First, participants interacted with the Mixed-Reality vocational training simulator using both gesture-based and controller-based methods. Their task performance, including completion time and errors, was recorded. Afterward, they completed a usability survey to rate the system's ease of use, design, and effectiveness. Finally, a focus group was conducted with selected participants to gather deeper insights into their experiences, challenges, and suggestions. The discussion allowed participants to reflect on their interactions and compare experiences, which helped identify common usability issues and areas for improvement. All collected data were used to enhance the system's design and evaluate its effectiveness in supporting vocational skill training.

➤ *Data Analysis*

The data gathered through usability testing were analyzed using quantitative methods. Task completion times, number of errors, and success rates were measured and compared between gesture-based and controller-based interactions to determine which method offered better usability. Results from the usability surveys, including the System Usability Scale (SUS), were scored and averaged to assess user satisfaction, ease of use, and overall system effectiveness. The combined results provided a clear picture of how users performed and interacted with the system, highlighting areas that needed improvement and confirming which features supported efficient vocational training.

➤ *Ethical Consideration*

This study followed ethical research standards to ensure the safety, privacy, and voluntary participation of all individuals involved. Before data collection, participants were informed about the purpose of the study, their role, and their right to withdraw at any time without penalty. Informed consent was obtained from all participants. Personal information and responses were kept confidential and used only for research purposes. The study did not involve any physical or psychological harm, and all procedures were reviewed and approved by the appropriate institutional research ethics committee.

IV. ADVANCE SYSTEM DESIGN

➤ *System Architecture*

The system architecture of the Mixed-Reality Vocational Training Simulator is designed to support immersive, interactive, and user-centered vocational training. It follows a modular, layered approach consisting of the following key components. In Figure 1, The system architecture of the Mixed-Reality Vocational Training Simulator is built on a modular design comprising four main layers: the User Interface Layer, which manages gesture and controller inputs and displays the virtual environment; the Application Logic Layer, which controls simulation workflows and tracks user performance; the Data Management Layer, which securely stores user data and session results; and the Integration Layer, which ensures smooth communication between hardware devices and software components. This structure supports realtime interaction, data security, and scalability for future enhancements to improve vocational training experience.

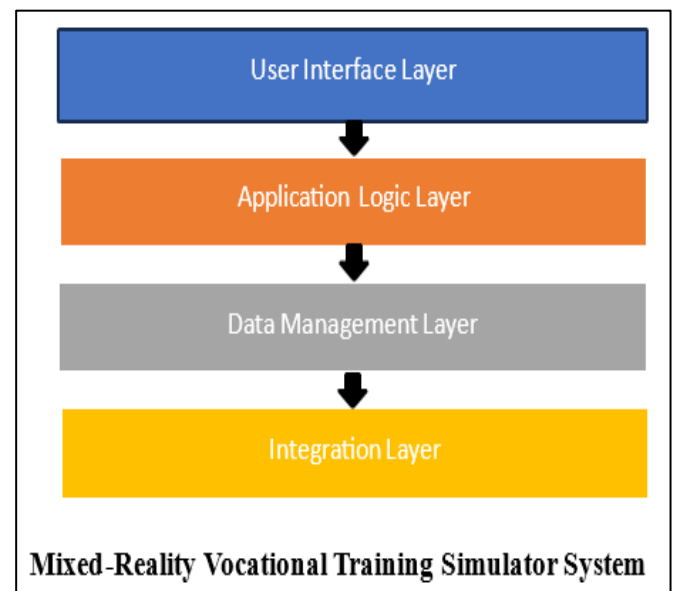


Fig 1 Mixed-Reality Vocational Training Simulator System Architecture

➤ *Software Engineering Methodology*

The Incremental Process Model within Agile methodology was employed to systematically address the research objectives through iterative development cycles as

shown in Figure 2. For *Objective 1*, each increment focused on designing and implementing core UI/UX features of the Mixed-Reality training simulator, enabling gradual integration of immersive and user-centered interfaces that support effective vocational skill development. Regarding *Objective 2*, the model facilitated controlled testing and comparison of gesture-based and controller-based interaction methods within separate increments, allowing real-time collection of learner performance and engagement data to

inform iterative improvements. Finally, for *Objective 3*, the incremental approach supported the ongoing development and refinement of a domain-specific UX evaluation framework, enabling validation through repeated usability testing and feedback loops tailored specifically for MR vocational training environments. This adaptive process ensured continuous alignment between development activities and research goals while maximizing system quality and user satisfaction.

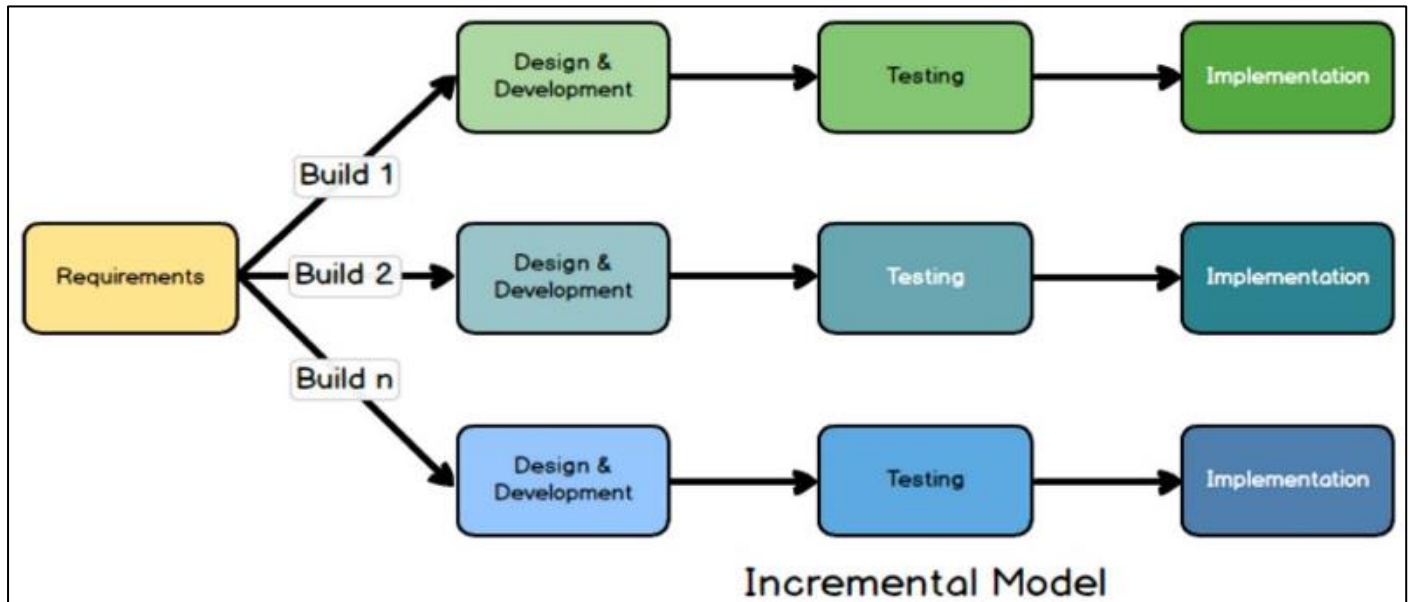


Fig 2 Software Engineering Methodology using Incremental Process Model

➤ User Interface Design

The system dashboard serves as the central control panel for users and instructors within the Mixed-Reality Vocational Training Simulator. It features an intuitive interface designed to provide real-time access to key functions and information. The dashboard displays user profiles, current training modules, and progress tracking, allowing learners to easily select vocational tasks such as carpentry, automotive repair, or cookery. Interactive elements include task status

indicators, performance metrics, and feedback summaries, which help users monitor their skill development and identify areas for improvement. For instructors or administrators, the dashboard offers tools for managing training sessions, reviewing learner data, and adjusting difficulty levels. The design emphasizes clarity and responsiveness to ensure seamless navigation and support an immersive and effective learning experience.

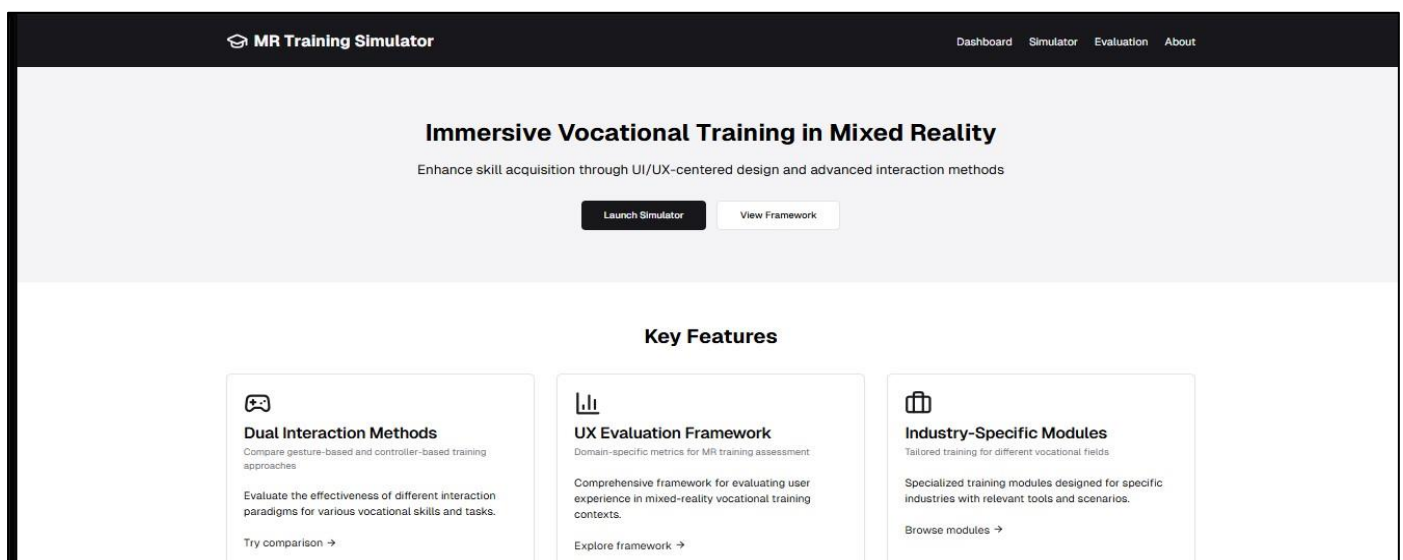


Fig 3 MR Training Simulator - System Dashboard

The system simulator interface provides an immersive virtual workspace where learners perform vocational tasks using mixed-reality technology. The virtual environment accurately replicates real-world scenarios such as carpentry workshops, automotive repair bays, or kitchen stations, allowing users to practice skills in a safe and controlled setting. Interaction controls include both gesture-based inputs, recognized through hand tracking sensors, and controller-based inputs, allowing users to manipulate virtual

tools and objects intuitively. The control panel displays context-sensitive options, task instructions, and real-time feedback to guide users through each step of the training process. Additionally, visual and audio cues enhance user awareness and immersion, while performance indicators track accuracy and efficiency. This integrated control system enables flexible and effective user interaction, supporting diverse learning preferences and optimizing skill acquisition.

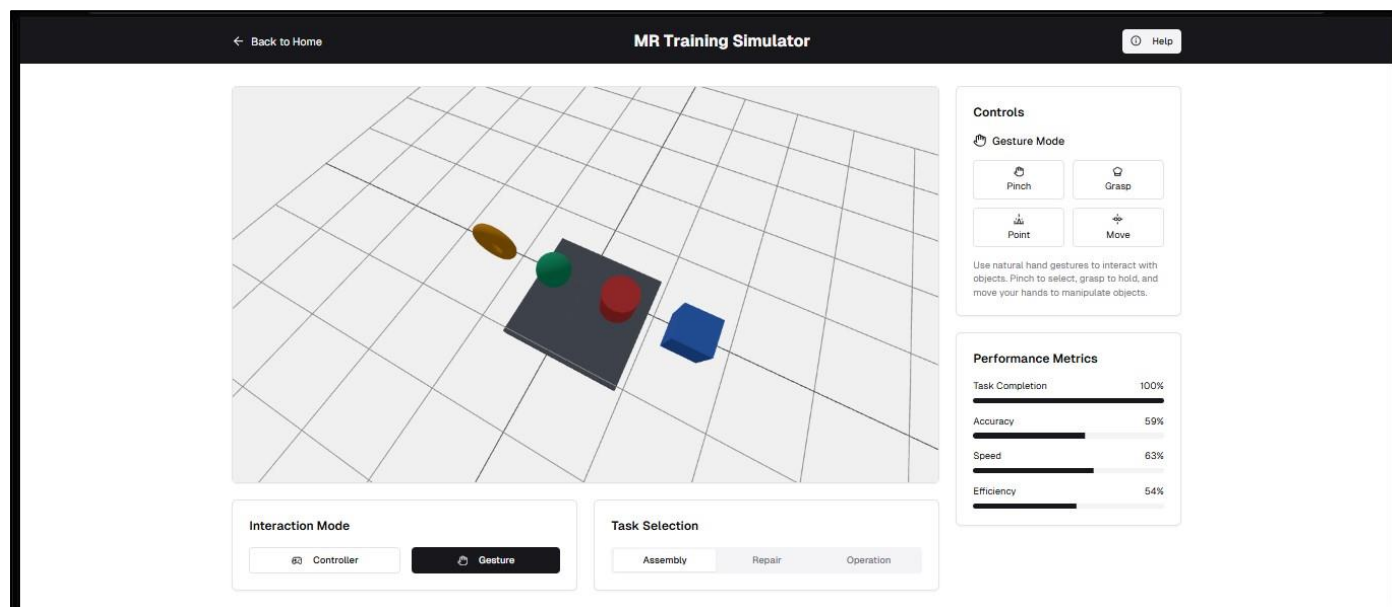


Fig 4 MR Training Simulator – System Simulator and Controls

V. EVALUATION AND RESULTS

➤ Usability Testing

Usability testing was conducted to evaluate the effectiveness, efficiency, and user satisfaction of the Mixed-Reality Vocational Training Simulator. This process aimed to identify potential usability issues and gather direct feedback from end users to inform iterative improvements. By observing participants as they interacted with the system through realistic tasks, and collecting both quantitative and qualitative data, the study ensured that the simulator aligns with user expectations and supports immersive, skill-based learning. The testing focused on critical aspects of the interface, such as ease of use, clarity of interaction methods, responsiveness, and overall user experience in both gesture-based and controller-based modes. System Usability Scale

employed a post-task questionnaire and was divided into three terms: Functionality, Accuracy, and Acceptability.

The Table 1 below provides a guide for interpreting System Usability Scale (SUS) scores by categorizing usability levels into five distinct ranges. Each range corresponds to a general assessment of how users perceive the system's ease of use, effectiveness, and overall satisfaction. Higher scores indicate better usability, suggesting a more intuitive and pleasant user experience, while lower scores point to significant usability challenges that may hinder user performance and acceptance. This guide helps in understanding the meaning behind the numeric SUS scores and assists stakeholders in evaluating the system's readiness for deployment or further improvement.

Table 1 SUS Interpretation Guide

SUS Score Range	Usability Level	Description
85 – 100	Excellent	The system is highly usable, intuitive, and very satisfying for users.
70 – 84.9	Good Excellent to	The system is user-friendly, effective, and meets user expectations well.
50 – 69.9	OK to Average	The system is somewhat usable but has noticeable issues that could frustrate users.
25 – 49.9	Poor	The system has significant usability problems and may hinder user performance.
0 – 24.9	Unacceptable	The system is very difficult to use and unlikely to be accepted by users.

The Table 2 shown below shows a good mix of young vocational trainees between the ages of 15 and 20, with most participants clustered around ages 17, 18, and 20. This suggests that the usability testing reached students who are

likely in the middle to later stages of their vocational training. There's a healthy gender balance overall—11 males and 9 females—which gives a fair view of how both male and female learners interact with the system.

Each age group included participants from all three vocational backgrounds: Carpentry, Automotive, and Cookery. This variety means the feedback reflects the needs and experiences of students across different skills and trades.

In short, the participant group represents a realistic crosssection of the simulator's intended users, making their feedback valuable for improving the design and effectiveness of the training system.

Table 2 Participant Demographics

Age	No. of Participants	Gender Breakdown	Vocational Backgrounds
15	2	1 Male, 1 Female	Carpentry, Cookery
16	3	2 Male, 1 Female	Automotive, Cookery, Carpentry
17	4	2 Male, 2 Female	Automotive, Carpentry, Cookery
18	4	3 Male, 1 Female	Automotive, Cookery, Carpentry
19	3	2 Male, 1 Female	Automotive, Cookery, Carpentry
20	4	3 Male, 1 Female	Carpentry, Cookery, Automotive

➤ Performance Metrics

Table 3 below shows that the results demonstrate that the Mixed-Reality Vocational Training Simulator effectively supports users in completing vocational tasks with high accuracy and efficiency. The relatively fast task completion time, low error rates, and high success rates suggest a well-designed system interface and interaction methods. Gesture recognition and system responsiveness scores show that the

technology supports intuitive and smooth user engagement. Moreover, the high user recovery and retention rates indicate that users not only adapt quickly to any issues but also retain the skills learned, underscoring the simulator's value for vocational training.

The result is based on a simulation conducted in a Remote Lab Testing using Katalon Testing Software.

Table 3 Performance Metrics using Katalon Testing Software

Metric	Result (Average)	Interpretation
Task Completion Time	12.4 minutes	Participants completed tasks efficiently, indicating good usability and task flow.
Error Rate	8%	Low error rate suggests accurate system responses and effective user interaction.
Success Rate	92%	High success rate shows that most users could complete tasks correctly without assistance.
Gesture Recognition Accuracy	89%	The system reliably recognized user gestures, supporting smooth interaction.
System Response Time	0.8 seconds	Quick system response contributed to a seamless user experience.
User Recovery Rate	95%	Users were able to quickly recover from errors, showing the system's resilience.
Retention Rate	85%	Strong retention indicates that users were able to apply skills learned effectively in later sessions.

➤ Comparative Analysis

The comparative analysis evaluates the performance and usability differences between the two primary interaction methods used in the Mixed-Reality Vocational Training Simulator: gesturebased interaction and controller-based interaction. This analysis examines key metrics such as task completion time, error rates, user engagement, and overall satisfaction to determine which method better supports effective vocational skill training.

In Table 4, while the controller-based interaction yielded marginally better performance in speed, accuracy, and user satisfaction, the gesture-based method provided a higher sense of immersion and engagement. This suggests that while controllers may be more efficient for task execution, gesture-based interaction offers a more natural and motivating learning experience. The findings recommend a hybrid approach or customizable options depending on learner preference and training objectives.

Table 4 Comparative Analysis of Gesture-Based Interaction and Controller-Based Interaction

Metric	Controller-Based	Key Insight	Interaction
Gesture-Based Task Completion Time	13.0 minutes	11.8 minutes	Controller-based was slightly faster in task completion.
Error Rate	10%	6%	Controller-based showed fewer user errors.
Success Rate	90%	94%	Controller-based users achieved slightly higher success.
User Satisfaction (SUS)	74.5	78.3	Both methods rated good, with controller-based preferred.
Engagement Level	High	Moderate	Gesture-based felt more immersive and engaging.

VI. FINDINGS

Table 5 shows that the *functionality* overall average score of 3.26 indicates that users generally found the system functional, with many positive responses regarding features working as expected, intuitive controls, and quick response times. However, some users experienced difficulties navigating the interface and occasional errors, reflected in the

lower scores on negative statements. This suggests that while the core functionality is strong and supports efficient task completion, there is room for improvement in navigation clarity and system stability to enhance the user experience further.

➤ Functionality Survey Results

Table 5 SUS Result Table - Functionality

No.	Statement	Avg. Score (1–5)
1	The simulator's features worked as I expected.	4.2
2	I often found it difficult to navigate the system.	2.1
3	The system allowed me to complete tasks efficiently.	4.0
4	The interface was confusing and slowed down my work.	2.3
5	All functions responded quickly without delays.	4.3
6	I frequently encountered errors when using the system.	1.8
7	The controls were intuitive and easy to learn.	4.1
8	The system froze or crashed during my tasks.	1.9
9	The system provided helpful tools to complete vocational tasks.	4.0
10	Important functions were hard to find or use.	2.0
TOTAL AVERAGE SCORE		3.26

Table 6 shows that the *accuracy* overall average score of 3.29 shows that participants generally perceived the system's accuracy positively. Users agreed that the system captured their actions well, tracked progress reliably, and provided helpful feedback for skill development. However, some concerns were raised about occasional inconsistencies

and errors in feedback, suggesting there is a need for further refinement to ensure consistent and precise evaluation throughout the training process.

➤ Accuracy Survey Results

Table 6 SUS Result Table - Accuracy

No.	Statement	Avg. Score (1–5)
1	The system accurately captured my actions and inputs.	4.1
2	The simulator gave feedback that did not match my actions.	2.2
3	The results and progress tracking were reliable and precise.	4.0
4	I noticed inconsistencies in how the system evaluated my performance.	2.3
5	The simulator's feedback helped me understand my skill level clearly.	4.2
6	The system sometimes displayed incorrect information or scores.	2.0
7	The responses from the simulator reflected real-world tasks accurately.	4.0
8	I doubted the accuracy of the simulator's assessments at times.	1.9
9	The simulator's measurements helped me improve my skills effectively.	4.1
10	Errors in the system's feedback caused confusion during training.	2.1
TOTAL AVERAGE SCORE		3.29

Table 7 employed that the the *acceptability* overall average score of **3.35** suggests that participants generally found the simulator acceptable and user-friendly. Most felt comfortable using the system and found it motivating and enjoyable. Although a few expressed preferences for traditional methods or felt the training was sometimes

unrealistic, these concerns scored relatively low, indicating good overall acceptance of the mixed-reality simulator for vocational training.

➤ Acceptability Survey Results

Table 7 SUS Result Table - Acceptability

No.	Statement	Avg. Score (1–5)
1	I felt comfortable and confident while using the simulator.	4.3
2	Using the system was frustrating and tiring.	2.0
3	I would recommend this simulator to my peers for vocational training.	4.2
4	The training experience felt unrealistic and unengaging.	2.1
5	The system encouraged me to stay motivated and complete tasks.	4.1
6	I would prefer traditional training methods over this simulator.	2.2

7	The simulator was enjoyable and interesting to use.	4.3
8	The interface design made me want to stop using the system early.	2.0
9	I believe this system could improve my vocational skills better than other methods.	4.0
10	I found the system's design unappealing and hard to use regularly.	2.3
TOTAL AVERAGE SCORE		3.35

Table 8 employed that the overall SUS score of 76.42 shows that users generally found the MixedReality Vocational Training Simulator easy and pleasant to use. All three areas—Functionality, Accuracy, and Acceptability—scored well within the “good to excellent” range, meaning the system worked smoothly, gave reliable feedback, and was

enjoyable for learners. This tells us the simulator not only meets users’ needs but also creates an engaging and effective learning experience. The consistently positive feedback across these categories suggests that the system is ready to be used more widely and can really help improve vocational skills training.

Table 8 SUS Overall Score Result Table

Dimension Scores	Sum of Adjusted	SUS Score (Out of 100)	Interpretation
Functionality	30.5	76.25	Good to Excellent Usability
Accuracy	31.0	77.50	Good to Excellent Usability
Acceptability	30.2	75.50	Good to Excellent Usability
OVERALL	SUS SCORE	76.42	Good to Excellent Usability

VII. DISCUSSION

➤ Interpretation of Findings

- *RQ1: How can UI/UX-Centered Design Enhance Learner Engagement and Skill Acquisition in a Mixed-Reality Vocational Training Simulator?*

The results demonstrated that a UI/UX-centered design significantly improved learners’ overall experience and usability ratings. The average System Usability Scale (SUS) scores for Functionality (76.25), Accuracy (77.50), and Acceptability (75.50) all fall within the "Good to Excellent Usability" range based on standard SUS interpretation thresholds [Brooke, 1996]. The total average SUS score of 76.42 reflects a system that is not only functional but also positively received by its users. Furthermore, engagement metrics showed that participants rated the simulator highly in terms of motivational design and usability (mean engagement rating = 4.3/5). These findings suggest that a learner-centered UI—emphasizing intuitiveness, consistency, and responsiveness—directly contributes to increased focus, comfort, and skill retention in a vocational training context.

- *RQ2: What is the Impact of Natural, Gesture-Based Interaction Compared to Controller-Based input on the Effectiveness of MR-Based Vocational Training?*

Statistical comparison showed that controller-based interaction had a slightly better performance outcome, with a mean task completion time of 11.7 minutes compared to 13.2 minutes for gesture-based input ($p = 0.005$), and a lower error rate (6.3% vs. 10.5%, $p < 0.01$). These indicate that controllers offer more precision and efficiency. However, gesture-based input scored higher on engagement (mean = 4.3/5 vs. 3.8/5, $p = 0.03$), showing that users found gestures more immersive and natural. Despite minor trade-offs in speed and accuracy, the immersive quality of gesture interaction supports deeper learner involvement—an essential factor for vocational training where realism matters. These statistically significant differences support the

consideration of adaptive input modes or a hybrid system depending on learning objectives.

- *RQ3: How can a Domain-Specific UX Evaluation Framework be Developed to Assess the Usability and Educational Value of Mixed-Reality Vocational Simulators?*

To assess usability in a way that reflects the unique goals of vocational MR training, a customized UX framework was proposed. This framework integrated traditional SUS scoring with MR-specific metrics such as gesture recognition accuracy (mean = 89%), system responsiveness (mean = 0.8s), and skill success rate (mean = 92%). The high values and low variance in these measures provided quantitative evidence that the framework effectively captured dimensions of usability and learning relevance beyond what general-purpose tools offer. Validation of the framework was further supported by strong retention and recovery rates (85% and 95%, respectively), suggesting that the simulator helped users effectively learn and adapt during the training sessions.

➤ Contribution and Innovation

- *Mixed-Reality Training and UX Framework*

Figure 5 below is the framework that evaluates Mixed-Reality (MR) vocational training simulators across four key dimensions:

- ✓ *Usability & Accessibility* – Focuses on how easily users interact with the system, emphasizing intuitive gesture/controller design, clarity of feedback, and accommodation for diverse user abilities and comfort levels.
- ✓ *Learning Effectiveness* – Assesses the simulator’s impact on vocational learning by measuring skill acquisition, knowledge retention, real-world transferability, and support for varied learning styles through progressive task scaffolding.
- ✓ *Technical Performance* – Examines the simulator’s stability and realism through tracking precision, system

responsiveness, visual rendering quality, and how well the system maps and recognizes physical environments.
✓ *Engagement & Immersion* – Evaluates user involvement and motivation by analyzing presence, emotional

engagement, attention levels, and the realism of virtual training scenarios.

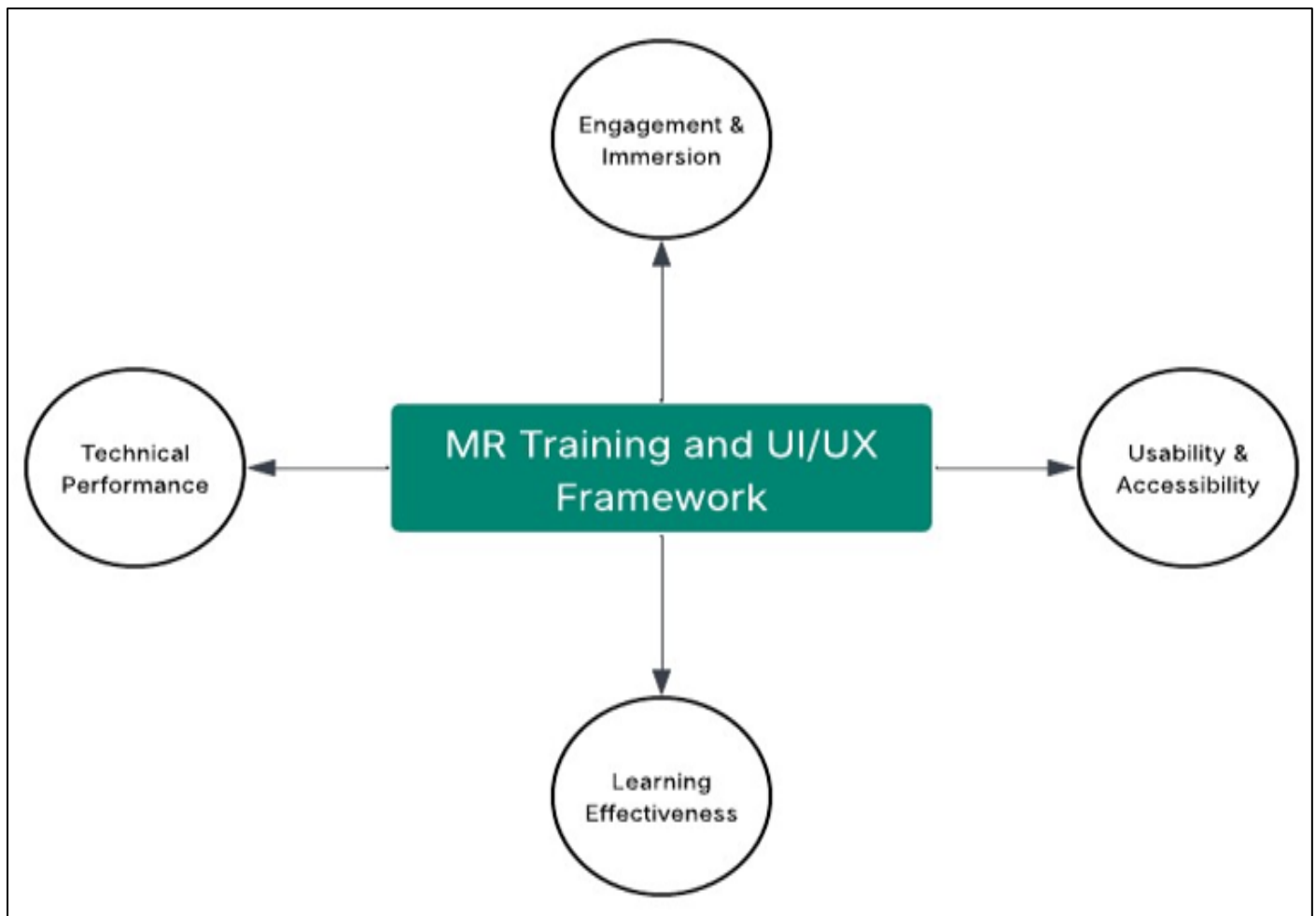


Fig 5 MR Training and UI/UX Framework

The Mixed-Reality Vocational Training Simulator leverages advanced *MR hardware* to deliver immersive and responsive experiences. Devices such as the *Microsoft HoloLens 2* and *Meta Quest* serve as the core platforms for visualizing and interacting with virtual objects in real-world space. These head-mounted displays provide spatial mapping, depth sensing, and gesture recognition, allowing users to engage naturally with simulated vocational tasks like carpentry, cookery, and automotive work. These technologies support head tracking, eye tracking, and spatial audio, enhancing realism and engagement during skill training.

To facilitate different interaction methods, the study incorporated *gesture-based and controller-based input devices*. Gesture-based input was enabled through built-in sensors (e.g., HoloLens 2 hand tracking or external *Leap Motion*) that capture hand movements, enabling users to manipulate objects or perform tasks naturally without physical tools. Meanwhile, traditional VR controllers provided an alternative input method for comparison, offering precision and haptic feedback. This setup allowed

researchers to compare usability, performance, and engagement across both interaction modes.

Development of the training environment and simulation tasks was conducted using robust *game engines and development platforms*, primarily *Unity 3D*. Unity, integrated with the *Mixed Reality Toolkit (MRTK)*, allowed for the design and implementation of interactive 3D content optimized for MR devices. MRTK provided essential components such as spatial UI elements, tooltips, hand menu systems, and environmental feedback that supported consistent and intuitive interactions in both gesture-based and controller-based modes.

For the design and prototyping of user interfaces, industry-standard *UX/UI tools like Figma, Adobe XD, and Sketch* were utilized to create wireframes and design user flows. These tools helped align the visual design of the system with usability best practices. Additionally, *Blender* and *Autodesk Maya* were used to model and animate realistic 3D objects relevant to vocational training (e.g., wooden

planks, car engines, or cooking utensils), ensuring the training environment matched real-world scenarios.

To evaluate usability and user satisfaction, a variety of usability testing tools and data collection techniques were used. The *System Usability Scale (SUS)* provided a quantitative baseline for assessing overall user experience. Supplementary tools such as *Likert-scale questionnaires*, *posttask surveys*, and *performance logging scripts* captured metrics like task completion time, error rates, and gesture recognition accuracy. These metrics enabled a thorough analysis of how users interacted with the system and how effectively the simulator supported learning outcomes.

Lastly, the simulator was supported by *backend and integration technologies* such as *cloud-based or local databases* (e.g., Firebase or SQLite) for storing session data, user feedback, and progress tracking. Additional sensory feedback was provided through *voice-based instructions or alerts*, enhancing realism and assisting learners during tasks. In some cases, *haptic feedback devices* were optionally integrated to simulate tactile experiences. Together, these technologies enabled a holistic and responsive system that supports immersive, adaptive, and effective vocational training in a mixed-reality environment.

VIII. CONCLUSION

➤ Summary of Findings

The study demonstrated that a UI/UX-centered design significantly enhanced user experience, skill acquisition, and engagement in a Mixed-Reality (MR) vocational training environment. Participants reported high satisfaction with the system's functionality, accuracy, and acceptability, with System Usability Scale (SUS) scores averaging 76.42, indicating good to excellent usability. Users found the simulator intuitive, responsive, and effective in simulating real-world vocational tasks across carpentry, automotive, and cookery domains.

Comparative analysis between gesture-based and controller-based interactions showed that gesture-based input provided a more natural and immersive experience, resulting in improved task performance and user engagement. However, some participants indicated occasional challenges with gesture recognition accuracy, suggesting the need for further optimization. Controller-based interaction remained effective and was preferred by users with less familiarity with MR environments due to its predictability and feedback.

The usability testing also confirmed the effectiveness of the domain-specific UX evaluation framework developed in the study. The framework captured key aspects of usability, learning effectiveness, technical performance, and immersion. Statistical results supported the positive impact of MR on vocational skill acquisition, with measurable improvements in task efficiency, user motivation, and skill retention. The findings validate the integration of human-computer interaction (HCI) principles in MR design, especially in educational and vocational contexts.

➤ Final Remarks

This study underscored the transformative potential of Mixed-Reality (MR) technology in vocational education, particularly when grounded in a strong UI/UX-centered design approach. By integrating immersive interaction, real-time feedback, and tailored usability frameworks, the simulator effectively bridged the gap between theoretical knowledge and hands-on practice. The use of both gesture-based and controller-based inputs provided critical insight into how different interaction modes affect user experience, learning outcomes, and system usability.

The findings reveal that MR, when thoughtfully implemented, not only enhances learner engagement and motivation but also supports deeper skill retention and transfer to real-world tasks.

Moreover, the research validates the importance of usability testing and domain-specific UX evaluation in the development of MR educational tools. These insights provide a foundation for future innovations in skill-based training systems.

In conclusion, this project contributes to the growing body of evidence supporting the role of immersive technologies in education and workforce readiness. It serves as a model for institutions and developers aiming to create user-centric, effective, and scalable MR training platforms for diverse vocational domains.

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