VIRTUAL EMPORIUM ELEVATING SHOPPING EXPERIENCE WITH VIRTUAL REALITY IN DIGITAL MALL

DAMIA HUMAIRA BINTI ROSMAN

BACHELOR OF COMPUTER SCIENCE (INTERACTIVE MEDIA) WITH HONS

2024

FACULTY OF INFORMATION AND COMMUNICATION TECHNOLOGY

DAMIA HUMAIRA BINTI ROSMAN

BACHELOR OF COMPUTER SCIENCE (INTERACTIVE MEDIA) WITH HONS

2024

VIRTUAL EMPORIUM: ELEVATING SHOPPING EXPERIENCE WITH VIRTUAL REALITY IN DIGITAL MALL

DAMIA HUMAIRA BINTI ROSMAN

A thesis submitted
in fulfillment of the requirements for the degree of

BACHELOR OF COMPUTER SCIENCE (INTERACTIVE MEDIA) WITH HONS

FACULTY OF INFORMATION AND COMMUNICATION TECHNOLOGY

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DECLARATION

I declare that this thesis entitled “Virtual Emporium: Eleveting Shopping Expereinces with Virtual Reality in Digital Mall“ is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :.....

Name : DAMIA HUMAIRA BINTI ROSMAN

Date : 6 SEPTEMBER 2024

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Bachelor of Computer Science (Interactive Media)

IKMAL FAIQ ALBAKRI BIN MUSTAFA ALBAKRI
Pensyarah
Jabatan Media Interaktif
Fakulti Teknologi Maklumat dan Komunikasi
Universiti Teknikal Malaysia Melaka (UTeM)

Signature :.....

Supervisor Name : IKMAL FAIQ ALBAKRI BIN MUSTAFA ALBAKRI

Date : 6 SEPTEMBER 2024

DEDICATION

To my family, friends, and mentors.

Your unwavering support, encouragement, and guidance have been invaluable throughout this journey. Thank you for being my inspiration.

ABSTRACT

This research project, titled "Virtual Emporium: Elevating Shopping Experiences with Virtual Reality in Digital Mall," aims to create an immersive and engaging VR shopping environment within a digital mall setting. The ADDIE (Analysis, Design, Development, Implementation, and Evaluation) methodology is a systematic approach to instructional design that has been adapted for the development of virtual reality (VR) shopping experiences. The Design phase focuses on developing a prototype VR shopping environment using Unreal Engine 5.3. This includes creating realistic 3D models of the shopping mall, stores, and products, as well as designing intuitive user interfaces, navigation paths, and interactive AI-powered features. Storyboarding and technical specifications are also defined during this phase to ensure the integration of a secure payment gateway within the VR environment. The Development phase involves programming the interactive elements, such as product catalogues, AI behaviours, and user interfaces, utilizing the capabilities of Unreal Engine 5.3. Rigorous testing is conducted to ensure functionality, performance optimization, and compatibility across VR devices supported by the engine. The Implementation phase involves rolling out the developed VR shopping environment for user testing and training. Data collection methods, such as surveys and analytics tools, are integrated to gather user feedback and interaction data. This phase also includes the deployment of the VR application to various platforms, such as SteamVR and the Oculus Store. The Evaluation phase analyses the usage patterns, user interactions, and satisfaction levels within the virtual shopping mall. Comparisons with industry standards provide insights for improving the virtual mall's functionality and user experience. Feedback from users is also gathered to assess satisfaction levels and identify areas for further enhancement. By systematically applying the ADDIE model to the VR shopping project, this research aims to create a compelling and immersive virtual shopping experience that integrates advanced features such as interactive AI and virtual payment systems, meeting user expectations and driving engagement within the virtual retail environment.

ABSTRAK

Projek penyelidikan ini, bertajuk "Emporium Maya: Meningkatkan Pengalaman Membeli-belah dengan Realiti Maya dalam Pusat Beli-belah Digital," bertujuan untuk mewujudkan persekitaran beli-belah VR yang mengasyikkan dan menarik dalam persekitaran pusat membeli-belah digital. Metodologi ADDIE (Analisis, Reka Bentuk, Pembangunan, Pelaksanaan, dan Penilaian) ialah pendekatan sistematik kepada reka bentuk pengajaran yang telah disesuaikan untuk pembangunan pengalaman membeli-belah realiti maya (VR).Fasa Reka Bentuk memfokuskan pada pembangunan prototaip persekitaran beli-belah VR menggunakan Enjin Unreal 5.3. Ini termasuk mencipta model 3D realistik pusat beli-belah, kedai dan produk, serta mereka bentuk antara muka pengguna yang intuitif, laluan navigasi dan ciri dikuasakan AI interaktif. Papan cerita dan spesifikasi teknikal juga ditakrifkan semasa fasa ini untuk memastikan penyepaduan gerbang pembayaran selamat dalam persekitaran VR. Fasa Pembangunan melibatkan pengaturcaraan elemen interaktif, seperti katalog produk, tingkah laku AI dan antara muka pengguna, menggunakan keupayaan Unreal Enjin 5.3. Ujian ketat dijalankan untuk memastikan kefungsian, pengoptimuman prestasi dan keserasian merentas peranti VR yang disokong oleh enjin. Fasa Pelaksanaan melibatkan pelancaran persekitaran beli-belah VR yang dibangunkan untuk ujian dan latihan pengguna. Kaedah pengumpulan data, seperti alat tinjauan dan analitik, disepadukan untuk mengumpulkan maklum balas pengguna dan data interaksi. Fasa ini juga termasuk penggunaan aplikasi VR ke pelbagai platform, seperti SteamVR dan Oculus Store. Fasa Penilaian menganalisis corak penggunaan, interaksi pengguna dan tahap kepuasan dalam pusat beli-belah maya. Perbandingan dengan piawaian industri memberikan pandangan untuk menambah baik fungsi pusat membeli-belah maya dan pengalaman pengguna. Maklum balas daripada pengguna juga dikumpulkan untuk menilai tahap kepuasan dan mengenal pasti bidang untuk peningkatan selanjutnya. Dengan menggunakan model ADDIE secara sistematik pada projek beli-belah VR, penyelidikan ini bertujuan untuk mencipta pengalaman membeli-belah maya yang menarik dan mengasyikkan yang menyepadukan ciri-ciri canggih seperti AI interaktif dan sistem pembayaran maya, memenuhi jangkaan pengguna dan mendorong penglibatan dalam persekitaran runcit maya.

ACKNOWLEDGEMENT

First and foremost, I owe my deepest gratitude to my parents who believed in my potential even when I doubted it myself. Your patience, wisdom, and constant guidance have been the backbone of this thesis. Without your relentless support, I would still be stuck on page one.

I would also like to extend my heartfelt thanks to my supervisor Encik Faiq. Your insights have shaped this work in more ways than I can count, and your ability to point out my mistakes with a smile has been truly remarkable.

To my fellow friends, especially Luqman, Aziera, and Farah, thank you for the countless hours spent in the lab, the late-night study sessions, and the much-needed coffee breaks.

Lastly, I must acknowledge my laptop, for enduring endless hours of abuse, and my bed, for being a silent witness to my nocturnal study habits.

As I close this chapter, I realize that this journey, while arduous, has been filled with moments of laughter, tears, and everything in between. And now, as I bid farewell to the project that consumed my life, I leave you with a piece of advice: If you ever feel too happy, start a project. It's guaranteed to bring you back to reality.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

UTeM	-	Universiti Teknikal Malaysia Melaka
Virtual Reality	-	*VR*
3D	-	*3 Dimension*
XR	-	*Extended Reality*
AR	-	*Augmented Reality*
MR	-	*Mixed Reality*
HMD's	-	*Head Mounted Display*
Ai	-	*Artificial Intelligence*
SUS	-	*System Usabilty Scale*
SSQ	-	*Simulator Sickness Questionnaire*
IMC	-	*In-Game Movement Control*

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

The rise of COVID-19 has significantly impacted both sellers and buyers, as restrictions prevent physical store visits due to the ongoing spread of the virus. This has led to an increased reliance on online shopping for groceries and other necessities. While many shops offer online platforms, the experience is often limited to phone browsing. Considerable thought has been devoted to the future of shopping and how technology will shape the retail industry. Witnessing the transformative impact of social media and technological advancements, now, the emergence of VR shopping is anticipated as a significant player. Utilizing headsets, this technology offers an immersive experience where customers can explore virtual stores, interact with avatar staff, view products in 3D, and even customize items before making a purchase. Virtual shopping transcends the conventional online browsing experience. It enables customers to engage with products, navigate virtual store layouts, and interact with virtual assistants. Its objective is to replicate the sensory aspects of physical shopping through digital that can revolutionize user experience by providing an immersive environment akin to shopping in-store.

Therefore, by using this opportunity an immersive virtual reality simulation will be developed that enabling shoppers to visualize products within the context of their daily lives. This simulation will aim to create a seamless and engaging experience that may revolutionize a new style of virtual shopping that aligned with the terms of “virtual emporium”.

1.2 Problem Statement

Making difficult decisions about purchases can be difficult for shoppers, especially when choosing items like shoes that require careful consideration. This procedure can cause confusion and takes up significant amounts of time. Furthermore, the problem becomes worse by insufficient product visualization, especially for online shoppers who find it difficult to properly visualize items like clothing. As a result, shoppers frequently return the products because they find that the colour, size, or style of what they ordered does not match what they had in mind. To make matters worse, traditional marketing strategies often fall to effectively promotes an item's unique features, resulting in ineffective marketing campaigns that failed to attract consumers' interest.

In contrast, recent technology has revolutionized consumer purchasing, and virtual reality shopping is about to have its own significant impact. This is due to the fact that virtual reality (VR) technology has the potential to transform the way people shop by enabling immersive and interactive ways to experience stores (Xi & Hamari, 2021).

Therefore, by using this opportunity and also addressing the visualization problems faced by the shoppers. An immersive virtual reality simulation will be developed that enabling shoppers to visualize products within the context of their daily lives. This simulation will aim to create a seamless and engaging experience that may revolutionize a new style of virtual shopping that aligned with the terms of “virtual emporium”.

1.3 Aim

The main goal of the project is to develop an immersive virtual reality (VR) shopping experience that addresses the limitations of traditional and current online shopping.

1.4 Research Objective

The main goal of the project is to develop an immersive virtual reality (VR) shopping experience that addresses the limitations of traditional and current online shopping. By leveraging VR technology, the project aims to:

i) To identify the mechanics needed to build a virtual world.

ii) To develop an immersive virtual emporium shoppimg mall simulation.

iii) To evaluate the usability of the virtual reality shopping mall in terms of user interaction, easiness of use, and satisfaction within the immersive environment.

1.5 Scope of Research

The scope of this research are as follows:

- Target audience: Adults and teenagers
- Platform: Unreal Engine 5.3
- Genre: VR (Virtual Reality), simulation
- Theme: Exploration

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Shopping is an activity that is not only essential but also enjoyable for many people around the world. It involves the process of browsing, selecting, and purchasing goods and services, either in physical stores or online. From daily necessities like groceries to luxury items such as designer clothes and high-tech gadgets, shopping caters to a wide range of needs and desires.

The experience of shopping has evolved significantly over time. Traditionally, people would visit local markets or stores, engaging in face-to-face interactions with sellers. Today, the rise of e-commerce has transformed shopping into a digital experience, allowing consumers to purchase almost anything from the comfort of their homes with just a few clicks. This shift has introduced a new level of convenience, but it also comes with its own set of challenges, such as ensuring the security of online transactions and managing the environmental impact of increased packaging and delivery services.

Shopping also has cultural and social dimensions. It can be a social activity, where friends and family bond over shared experiences in shopping malls or markets. In many cultures, shopping is an integral part of festivals and celebrations, contributing to the local economy and reflecting societal values.

Understanding the psychology behind shopping behaviour, such as the influence of advertising, the role of branding, and the impact of consumer reviews, is crucial for businesses aiming to meet the needs of their customers effectively. Moreover, sustainable and ethical shopping practices are gaining importance as consumers become more aware of the environmental and social implications of their purchases.

2.2 Shopping Experience

According to Jones (1999), the shopping experience includes all of a customer's interactions and perceptions while purchasing goods or services. This involves not just the physical act of purchasing, but also the emotional, sensory, and psychological responses elicited throughout the transaction. (Xiao & Nicholson, 2012)

2.2.1 Type of Mall Services

Howard (2007) states that, Malls are no longer just retail centres they are complex hubs meant to provide visitors with a complete and enriching experience. Malls have grown to include varied services that cater to their clients' varying requirements and interests, in addition to a vast range of retail establishments (Coleman, 2007). These services range from basic necessities like information desks, clean restrooms, and easy parking facilities to leisure and entertainment options like theatres, arcades, and eating experiences ranging from food courts to gourmet restaurants. Furthermore, malls prioritise consumer pleasure and safety by offering amenities such as lounging areas, Wi-Fi access, and strong security measures. Malls seek to create surroundings where shopping becomes more than just a transactional activity, but a memorable and entertaining experience.

Table 2.1 Customer Amenities (K. Lee & Safian, 2017)

Customer Amenities	Type	Description
	Information Desk	Staffed information counters to assist visitors with directions, store information, and general inquiries.
	Restroom	Clean and well-maintained restrooms, often including family restrooms and baby changing stations.
	Wi-Fi Access	Free or paid Wi-Fi services throughout the mall for customer convenience.
	Seating Areas	Comfortable seating areas and lounges where shoppers can rest.

Table 2.2 Safety and Security (Christopher et al., 2015)

Safety and Security	Type	Description
	Security Personnel	Trained security staff to ensure the safety and security of visitors.
	Surveillance Camera	CCTV systems to monitor activities and prevent theft or other incidents.
	Medical Assistant	First aid stations and access to medical professionals for emergencies.
	Lost and Found	Services to help visitors recover lost items.

Table 2.3 Convenience

Convenience	Type	Description
	Parking Facilities	Ample parking spaces, including valet parking, reserved spots for families and individuals with disabilities, and electric vehicle charging stations (González-González et al., 2020).
	ATMs and Banking Services	ATMs and sometimes full-service bank branches within the mall (*Empirical Determination and Evaluation of Factors That Impact ATM Placement*, 2015).
	Currency Exchange	Services for exchanging foreign currency (Ahmad et al., 2020).

2.2.2 Physical Shopping Mall

A physical shopping mall goes beyond a collection of stores; it's a vibrant hub where retail, dining, and entertainment merge, offering an immersive consumer experience (“Retail Environments,” 2016). Whether nestled in urban centers or serene suburbs, these complexes invite exploration with flagship stores and unique boutiques. Beyond shopping, malls serve as social hubs for meals, gatherings, and community events. They blend convenience with excitement, catering to diverse tastes and occasions, shaping modern consumer culture.

2.2.2.1 Payment in Shopping Mall

Westermeier (2020) and Hassan et al. (2020) state that payment in the context of a physical shopping mall refers to the transaction process where a customer exchanges money or other forms of payment for goods or services provided by a retailer.

According to Moghavvemi et al. (2021), the payment system within a shopping mall encompasses the infrastructure and processes that facilitate transactions between customers and retailers. It typically includes various payment methods such as cash, credit cards, debit cards, mobile wallets, and possibly alternative forms like gift cards or store credits. The mall's checkout process may feature traditional cashier stations, self-service kiosks, or mobile checkout options, ensuring convenience and efficiency for shoppers. Security measures are paramount, with technologies like chip-enabled cards, PIN verification, and secure payment gateways safeguarding customers' sensitive financial information. Policies regarding returns, refunds, and exchanges are also integral, ensuring clarity and fairness in customer transactions. Additionally, promotions, discounts, and loyalty programs may influence payment decisions, with options for using coupons, applying for store credit cards, or redeeming points. The emergence of contactless payment methods and advancements in technology further enhance the payment experience, reflecting ongoing trends toward convenience and customer-centricity within mall environments.

2.2.2.2 Security and Privacy Issue in Shopping Mall

As the adoption of mobile payments continues to grow, security and privacy risks remain major barriers for customers (Chang & Yeh, 2020). Customers are particularly apprehensive about the potential for their sensitive financial and personal information to be compromised, with fears of unauthorized access resulting in monetary losses and identity theft (Writer, 2023)(Yin et al., 2018)(Chang & Yeh, 2020).

Recent research has highlighted several key security and privacy concerns that customers face when making payments in physical mall environments. Participants in studies have reported experiencing challenges related to mental model development, pre-purchase anxiety, and trust issues, despite enjoying the convenience and ease-of-use of mobile payment services. These findings suggest the need for greater attention to be paid to the user experience and the incorporation of robust trust mechanisms to alleviate customer concerns.

One of the primary security threats associated with mobile payments in physical malls is the risk of near-field payment attacks. Malicious actors may attempt to intercept payment information exchanged between the customer's device and the point-of-sale terminal using techniques such as eavesdropping, man-in-the-middle attacks, or relay attacks (Nseir et al., 2013)(Yin et al., 2018). If successful, these attacks could enable unauthorized access to sensitive financial data and facilitate fraudulent transactions. Researchers have also highlighted the dangers of phishing attacks targeting mobile payment users (Yin et al., 2018). Phishers may attempt to lure customers into revealing their login credentials or payment information by creating convincing fake mobile payment apps or email messages that appear to be from legitimate financial institutions or merchants. Such attacks could not only lead to

financial losses but also undermine customer trust in the security of mobile payment systems. To address these security and privacy concerns, researchers have proposed various strategies. Safeguarding customer data through practices such as encryption, secure payment processing, and robust data breach prevention measures can help mitigate the risks of unauthorized access and misuse of sensitive information. Additionally, the development of user-friendly authentication mechanisms that enhance customer trust, such as biometric authentication or multi-factor authentication, can strengthen the overall security of the mobile payment ecosystem.

2.2.3 Virtual Shopping Mall

The use of computer technology to ceate a simulated environment is known as virtual reality, or VR (Burdea & Coiffet, 2003). With the use of virtual reality (VR) technology, people may interact with three-dimensional (3D) virtual surroundings in a manner that is similar to that of the real world. The development of a virtual world, or a computer-generated 3D scene or environment, is the core idea of virtual reality. Users can explore, interact, and analyse these virtual environments in real time. One important use for this technology is in virtual manufacturing, where it is used to mimic the fabrication and assembly processes, enabling "manufacturing in the computer" (Abbas et al., 2023).

2.2.3.1 Payment in Virtual Reality

Virtual reality (VR) environments support the use of digital payment methods, including mobile applications and contactless payments, to enable transactions for virtual goods and services. Additionally, IoT-enabled devices, such as VR-controlled vending machines, can facilitate cashless and automated payments via mobile apps and payment gateways (Li et al., 2024).

Payment Gateways: VR platforms can incorporate multiple payment gateways, offering users a diverse array of payment options. These options include various payment methods and user accounts with different levels of access (Steurer, 2011).

2.2.3.2 Security and Privacy Issue in Virtual Reality

According to Claramunt et al. (2023) and Ling et al. (2019), due to the possibility of unauthorised access to sensitive data, including financial and personal information exchanged over the internet during VR transactions, payment mechanisms in virtual reality (VR) raise serious security and privacy concerns. While authentication techniques like two-factor authentication, biometric verification, and strong passwords are vital in avoiding unwanted access, encryption is necessary to reduce hazards during data transmission (Ling et al., 2019) (Claramunt et al., 2023).

Another concern is the potential for side-channel attacks, where hackers may infer sensitive data or keystrokes by observing users' movements or gestures in a virtual reality environment (Claramunt et al., 2023).

For example, computer vision-based attacks can recognise frames where a user touches a touchpad to simulate typing on a virtual keyboard, while motion sensor-based attacks can take use of internal device sensors to collect orientation angles and derive keystrokes (Claramunt et al., 2023). In addition, privacy issues are brought up by the usage of artificial intelligence (AI) in payment systems. AI-powered systems have the ability to examine user preferences and behaviour, which could result in targeted advertising and data breaches (Divya & Mallik, 2022).

2.3 Extended Reality

Based on Pregowska et al. (2023) Extended reality (XR), which includes computer-altered realities, is the term used to group together virtual reality (VR), augmented reality (AR), and mixed reality (MR). Immersion experiences that blend digital and physical components are a feature of XR, allowing for the cohabitation of virtual and physical objects in artificial settings as well as real-time interactions.

People can interact with things and other people through avatars in a fully virtual environment by using virtual reality (VR). Virtual reality (VR), which is usually accessed through head-mounted displays (HMDs), substitutes the user's perspective of the actual world with a 3D scene created by a computer (Pregowska et al., 2023).

Augmented reality (AR) is intricately linked with virtual reality (VR), embodying a technology that originated decades ago and is currently undergoing accelerated development and evolution (Arena et al., 2022).

Mixed reality (MR) is defined in the document as a conceptual framework that is independent of any particular technology or mode of execution. Rather, it emphasises the fusion of virtual and physical components (Young et al., 2011).

The actual and virtual worlds are combined with mixed reality (MR) technology to provide consumers with an immersive and engaging experience. The document that is included states that MR has important uses in the aviation sector, including aeronautical engineering, improving passenger experiences, and many other facets of airline operations (Jiang et al., 2023).

2.4 Project Previous

This section addresses the visual representation of shopping mall design and examines the integration of interactive elements as applied within their research project.

2.4.1 Virtual Reality Shopping Mall Design

A research project was conducted by Okahashi et al. (2013) and the team, the virtual street was meticulously crafted by capturing a series of 1500 photographs, taken at regular intervals of a few meters. This extensive photographic documentation spanned both the interiors and exteriors of various shops situated within the bustling downtown shopping precinct of an actual city in New Zealand. The process involved a detailed and systematic approach to ensure that every aspect of the area was authentically represented in the virtual environment.

Another research project published in the Journal of Management Information Systems explores the implications of viewing product models in a three-dimensional (3D) format by Peukert et al. (2019), researchers aimed to understand the impact of 3D visualization on consumer behavior and decision-making processes. Participants interacted with product models presented in a 3D virtual environment, enabling them to examine products from various angles and gain a more comprehensive understanding of their features and attributes.

2.4.2 Interactive Elements

According to Okahashi et al. (2013), that the assessment of realistic cognitive function using virtual reality (VR) technology presents substantial potential for future clinical rehabilitation applications. However, various challenges have been identified in the deployment of these systems for patients with cognitive dysfunction in Japan. A primary concern is that several VR systems necessitate the use of a joystick, which proves to be particularly challenging for individuals who lack familiarity with personal computer operations. These findings underscore the need for more user-friendly interfaces and tailored solutions to enhance the usability of VR systems in clinical settings.

The tasks designed for users involved memorizing a list of items, locating specific shops, selecting items, and smoothly completing various shopping tasks. These activities assessed both memory retention and navigational skills within the virtual environment, offering valuable insights into cognitive function and the potential applications of VR technology in cognitive rehabilitation (Okahashi et al., 2013).

The research project published in the Journal of Management Information Systems have employed the interactive component in this study involves utilizing varying degrees of immersion to present products to participants. Specifically, participants engaged with the virtual shopping environment through two distinct experiences:

- High Immersion: Participants engaged with a fully immersive virtual reality setting utilizing a head-mounted display (HMD).
- Low Immersion: Participants examined three-dimensional product models using a desktop computer.

The various degrees of immersion made it easier to investigate how each one affects user experience and adoption intentions in the context of online purchasing (Peukert et al., 2019).

2.4.3 Comparison Between Traditional and Visual Shopping Experience

To obtain a deeper understanding of the underlying issues and their complexities, a comparative analysis of traditional and virtual shopping experiences is necessary to identify commonalities and differences between them, as well as to gain insights into their distinct performance metrics, user satisfaction levels, and overall efficacy (Bahadori et al., 2020) (Friedel et al., 2023).

Table 2.4 Comparison Traditional and Visual Shopping

Aspect	Traditional Shopping	Virtual Reality Shopping
Customer Engagement	Moving physically within stores (Barth, 2007)	virtual world that is fully immersive (Lee & Chung, 2005b)
Interaction with Product	Actual handling of items (Schnack et al., 2019)	Engagement with virtual product representations (Jin et al., 2017)
Interaction with Staff	Direct communication (Ing et al., 2019)	Chatbots or virtual helpers (Vyavhare et al., 2018)
Environment	Physical retail establishments (Zhang et al., 2021)	Virtual stores that are modelled (Lee & Chung, 2005a)

Decision Making Progress	Quick evaluation of the product(Van Den Berg et al., 2021)	Comparing and exploring products virtually(Hsu et al., 2020)
Purchasing Process	Conventional checkout procedures (Aloysius et al., 2019)	Purchase through interactive displays (Darehshiri et al., 2022) (Petersen et al., 2022)

CHAPTER 3

METHODOLOGY

3.1 Introduction

The methodology chapter is fundamental to any robust scientific study and serves as a detailed blueprint for conducting and evaluating the research. This section outlines the systematic approach adopted to address the research questions, offering transparency and reliability in the methods chosen.

3.2 Methodology

Methodology refers to the systematic approach, procedures, and techniques used to conduct research or achieve a specific goal. It encompasses the overall strategy that outlines how data will be collected, analyzed, and interpreted. Methodology is important because it ensures the research or project is conducted in a structured and consistent manner, allowing for reliable and valid results. It also provides transparency, enabling others to understand and replicate the process, thus enhancing the credibility and accuracy of the findings.

3.2.1 Proposed Methodology

This thesis introduces an integrated analytical approach for evaluating virtual reality shopping experiences, using the ADDIE model (Analysis, Design, Development, Implementation, Evaluation). Widely effective in instructional design, ADDIE is applied innovatively to VR environments. The figure below illustrates the project methodology.

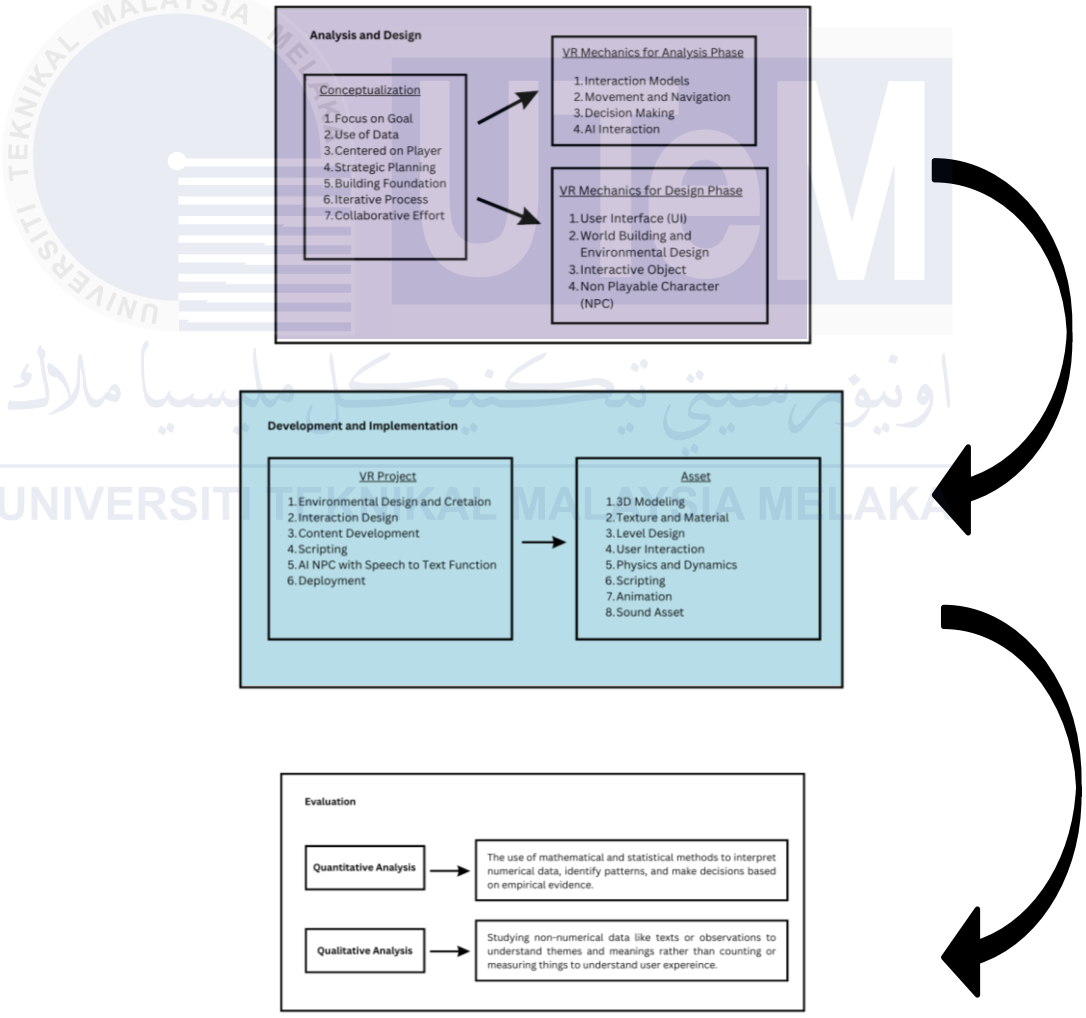


Figure 3.1 Proposed Methodology Framework of ADDIE

3.2.2 Experimental Setup

Table 3.1 Experimental Setup Analysis

Analysis		
Objective	**Data Collection**	**Outcome**
Conduct a comprehensive analysis of current VR shopping trends and technologies to understand user expectations and technological feasibility.	Gather insights through literature review, market research, and consultations with VR experts and potential users.	Define project objectives, including creating an immersive shopping experience with interactive AI, seamless navigation, and integrated payment systems within Unreal Engine 5.3.

Table 3.2 Experimental Setup Design

Design			
Prototype Creation	**Interactive Design**	**Storyboarding**	**Technical Specifications**
Develop a prototype VR shopping environment using Unreal Engine 5.3,	Continuously refines user interfaces, navigation paths and AI interactions	Design narratives or scenarios that guide users through the virtual shopping	Define technical requirements for integrating a secure payment gateway into the

focusing on realistic 3D models of the shopping mall, stores and products.	based on user feedback and usibility testing.	experience, emphasizing exploration, product discovery, and interactive AI interactions.	VR environment, ensuring seamless transactions within the virtual world.

Table 3.3 Experimental Setup Development

Development		
Programming and Integration	**Testing**	**Quality Assurance**
Utilize Unreal Engine 5.3 capabilities to program interactive elements such as product catalogs, AI behaviors, and user interfaces.	Conduct rigorous testing to ensure functionality, performance optimization, and compatibility across VR devices supported by Unreal Engine 5.3	Implement debugging processes and performance enhancements to ensure a smooth and immersive VR shopping experience.

Table 3.4 Experimental Setup Implementation

Implementation		
Development	**User Training**	**Data Collection**
Roll out the developed VR shopping environment for user testing and evaluation, ensuring accessibility and ease of use.	Provide guidance and tutorials within the VR environment to familiarize users with navigation, product browsing and AI interactions.	Collect user feedback through surveys, interviews, or analytics tools to gauge user satisfaction, usability, and effectiveness of AI interactions and virtual payment systems.

Table 3.5 Experimental Setup Evaluation

Evaluation			
User Feedback	**Performance Metrics**	**Comparison**	**Iterative Improvement**
Analyze feedback to identify strength, weaknesses, and areas for improvement in	Evaluate usage data (example, time spent, click-thriugh rates, transaction completion rates) to measure the	Compare evaluation results against initial project objectives and benchmarks to assess the project's success and	Incorporate user feedback and evaluation findings into interative updates and refinements of the VR shopping

the VR shopping experience	success of the virtual payment system and overall user engagement.	identify opportunities for further engancement.	environment, aiming to enhance user satisfaction and optimize performance.

By systematically applying the ADDIE model to the VR shopping project in a shopping mall environment using Unreal Engine 5.3, it can ensure a structured approach to design, development, implementation, and evaluation. This approach helps in creating a compelling and immersive virtual shopping experience that integrates advanced features such as interactive AI and virtual payment systems, meeting user expectations and driving engagement within the virtual retail environment.

3.2.3 Parameters

Table 3.6 Parameters Analysis Phase

Analysis Phase			
User Needs	Technological Capabilities	Market Research	Potential Challenges
Preferences and expectations for VR shopping experiences.	Hardware and software requirements, including the capabilities of Unreal Engine 5.3.	Trends in VR shopping and user engagement data.	Identified technical and user-experience challenges

Table 3.7 Parameters Design Phase

Design Phase				
User Interface	Interaction design	Visual and Audio Elements	AI Behavior	User Flow
Ease of navigation, layout of the virtual mall, and accessibility features.	Mechanisms for product exploration, AI interactions, and transaction processes.	Quality of 3D models, textures, animations, and sound effects.	Responsiveness and realism of AI interactions within the virtual mall.	Pathways for users to explore, view, and purchase products

Table 3.8 Parameters Development Phase

Development Phase				
Programming Efficiency	Integration	Compatibility	Usability	Testing and Debugging
Code quality and optimization for performance.	Seamless integration of 3D models, AI, and payment systems.	Performance across different VR devices.	User-friendliness and intuitiveness of the VR environment.	Identification and resolution of bugs and performance issues.

Table 3.9 Parameters Implementation Phase

Implementation Phase			
User Onboarding	Deployment Stability	Data Collection Methods	User Engagement
Effectiveness of tutorials and guidance within the VR environment.	Reliability of the VR application in real-world use.	Tools and techniques for gathering user interaction data and feedback.	Levels of user interaction with the VR environment and AI.

Table 3.10 Parameters Evaluation Phase

Evaluation Phase			
User Satisfaction	Performance Metrics	Comparative Analysis	Improvement Areas
Feedback from users regarding their experience.	Time spent, interaction patterns, transaction completion rates, and AI interaction effectiveness.	Comparison of results against predefined objectives and benchmarks.	Identified areas for refinement based on user feedback and performance data.

Table 3.11 Parameters Documentation and Reporting

Documentation and Reporting		
Process Documentation	Outcome Reporting	Iteration Records
Detailed records of each phase's activities, decisions and outcomes.	Summarizations of findings, including success, challenges and future recommendations.	Documentation of iterative improvements and updates made based on evaluation feedback.

3.2.4 Equipment

Table 3.12 Equipment Analysis Phase

Analysis Phase	
Computers	Hogh performance computer for conducting research, data analysis, and communcation.
Survey Tools	Online survey platform (e.g,. Google Forms) for gathering usser preferences and exoectations
Data Analysis Software	Tools like Excel

Table 3.13 Equipment Design Phase

Design Phase	
Design Software	Programs like Adobe Photoshop, Canva
3D Modeling Software	Blender
Prototyping Tools	Unreal Engine 5.3

Table 3.14 Equipment Development Phase

Development Phase	
Unreal Engine 5.3	The primary development environment for creating and programming the VR shopping experience.
High-Performance Development Computers	Machines equipped with powerful GPUs (e.g., NVIDIA RTX series), CPUs, and ample RAM to handle VR development and rendering.

VR Headsets	Oculus Rift for testing and developing the VR environment.

Table 3.15 Equipment Implementation Phase

Implementation Phase	
Deployment Platforms	VR platforms (e.g., SteamVR, Oculus Store) for distributing the VR application to users.
User Testing Facilities	Spaces equipped with VR headsets and computers to facilitate user testing sessions.
Feedback Collection Tools	Survey and analytics tools integrated within the VR environment to collect user feedback and interaction data.
User Training Resources	Manuals, tutorials, and in-VR guidance systems to help users navigate and use the VR shopping environment.

Table 3.16 Equipment Evaluation Phase

Evaluation Phase	
Analytics Software	Tools to analyze interaction data and user feedback collected during the implementation phase.
User Interaction Recording	Software to record and analyze user interactions within the VR environment for detailed behavioral insights.

Table 3.17 Equipment Documentation and Reporting Phase

Docmentation and Reporting Phase	
Documentation Tools	Software like Microsoft Word, Google Docs, and Notion for documenting the methodology, process, and findings.
Presentation Software	Tools like Microsoft PowerPoint or canva

Equipping the team with these tools and technologies ensures that each phase of the ADDIE methodology is effectively implemented, leading to the successful development, deployment, and evaluation of the VR shopping project.

3.2.5 Limitation of Proposed Methodology

The detailed and thorough nature of each phase in the ADDIE model can result in a lengthy process. This extended timeline may delay the overall project, particularly in environments where rapid development and deployment are essential.The traditional ADDIE model follows a linear sequence, which can be inflexible. This rigidity might hinder the ability to accommodate changes or iterative improvements that are often necessary in the dynamic and evolving field of VR development.Implementing the ADDIE methodology requires substantial resources, including skilled personnel, high-performance hardware, and advanced software tools. This resource intensity can lead to significant costs, which might be challenging for projects with limited budgets.The comprehensive nature of the ADDIE model adds complexity to the project management process. Careful coordination and management of various activities and teams across all phases are necessary, which can be challenging and time-consuming. Although the ADDIE model includes an evaluation phase, it may not emphasize continuous user feedback and rapid prototyping as strongly as agile methodologies. This potential oversight can result in designs that are less user-centered and may not fully meet user needs and expectations.

The ADDIE model may struggle to adapt to unexpected changes in project scope or requirements. In innovative fields like VR development, where new challenges and opportunities frequently arise, this lack of flexibility can be a significant drawback.

Conducting the final evaluation at the end of the process may reveal critical issues that necessitate extensive rework. These issues could have been addressed earlier with more frequent, iterative testing and feedback loops, reducing the need for significant adjustments late in the project. Scaling the VR shopping project to incorporate more complex interactions, larger environments, or advanced AI features may introduce challenges that the linear ADDIE model might not efficiently handle. This limitation can affect the project's ability to grow and evolve in response to user demands and technological advancements. Understanding these limitations can help in planning and implementing strategies to mitigate potential challenges, ensuring a more flexible and adaptive approach when using the ADDIE methodology for the VR shopping project.

3.3 Phase 1-Analysis and Design

The first phase centers on strategic planning and iterative processes, emphasizing a solid foundation focused on the player experience. Data-driven insights guide collaborative efforts, aligning with research on VR in shopping malls to achieve goal-oriented development and meticulous design. The following steps outline the necessary actions for this phase.

3.3.1 Conceptualization

By integrating these principles into both the Analysis and Design phases, the virtual reality open-world shopping mall can be conceptualized and developed to deliver a compelling, immersive, and user-centric shopping experience in the virtual space.

Table 3.18 Conceptulaization

Conceptualization	Analysis	Define the primary goals of the virtual shopping mall, such as creating an immersive and engaging shopping experience, facilitating seamless transactions, and ensuring user satisfaction.
	Design	Develop a detailed plan to achieve these goals, including designing intuitive navigation, realistic product interactions,

		and secure payment methods within the virtual environment.
Use of Data	Analysis	Collect and analyze user preferences, VR usage data, shopping behaviors, and technical requirements to inform design decisions.
	Design	Utilize insights from data analysis to shape the layout of the virtual mall, choose product categories, customize user interfaces, and optimize performance for various VR platforms.
Centered on Player	Analysis	Understand the demographics, interests, and expectations of potential users to tailor the virtual shopping experience to their needs.
	Design	Implement user-centered design principles to create a user-friendly interface, personalized recommendations, and interactive product showcases that enhance user engagement and satisfaction.
Strategic Planning	Analysis	Plan for scalability, future updates, and integration of new features based on

		market trends and technological advancements.
	Design	Strategically map out the virtual mall's architecture, content management system, and backend infrastructure to support ongoing development, maintenance, and expansion.
Building Foundation	Analysis	Define technical requirements, platform compatibility, and performance benchmarks necessary for a seamless VR shopping experience.
	Design	Establish a robust foundation by creating detailed wireframes, prototypes, and 3D models of virtual spaces, ensuring alignment with technical specifications and user experience goals.
Iterative Process	Analysis	Continuously gather user feedback, conduct usability testing, and iterate on design concepts to refine the virtual shopping mall.
	Design	Implement an iterative development cycle to incorporate improvements, address

		usability issues, and enhance features based on real-time user data
Collaborative Effort	Analysis	Engage with potential users
	Design	Share expertise

3.3.2 Virtual Reality Mechanic for Analysis Phase

The proposed framework outlines the essential mechanics required for both the Analysis and Design phases. These phases are crucial for enhancing user engagement within the virtual reality shopping mall environment, ensuring it becomes more interactive. Figure 3.2 below show how the user interacts with the products.

Figure 3.2 VR mechanics

Based on the concept illustrated in the Figure 3.3 AI interactions are proposed to be integrated into the virtual world. The AI will be designed to assist users by providing answers to inquiries about products they are interested in. This feature aims to simulate the experience of interacting with a salesman in a traditional shopping mall, but through an AI interface.

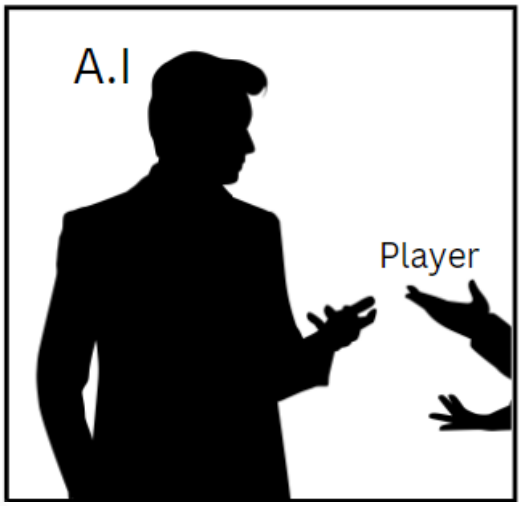


Figure 3.3 AI

3.3.3 Virtual Reality Mechanic for Design Phase

The virtual world will be equipped with an intuitive user interface (UI) strategically placed to seamlessly guide users into their shopping or interactive experience right from the moment they enter the initial scene. This UI aims to engage users immediately, offering clear pathways to explore products or engage in interactive elements within the virtual environment. By providing a straightforward and visually appealing interface, our goal is to ensure that users can navigate and enjoy their virtual shopping or interactive adventure effortlessly from the outset. Figure 3.4 below shows the illustration of start and quit menu.

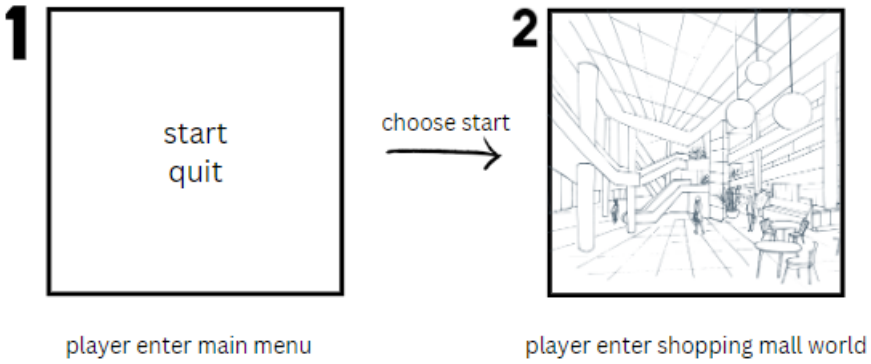


Figure 3.4 Start Quit Button

Figure 3.5 below shows the illustration for the main menu, showing the options for Exit and Start.

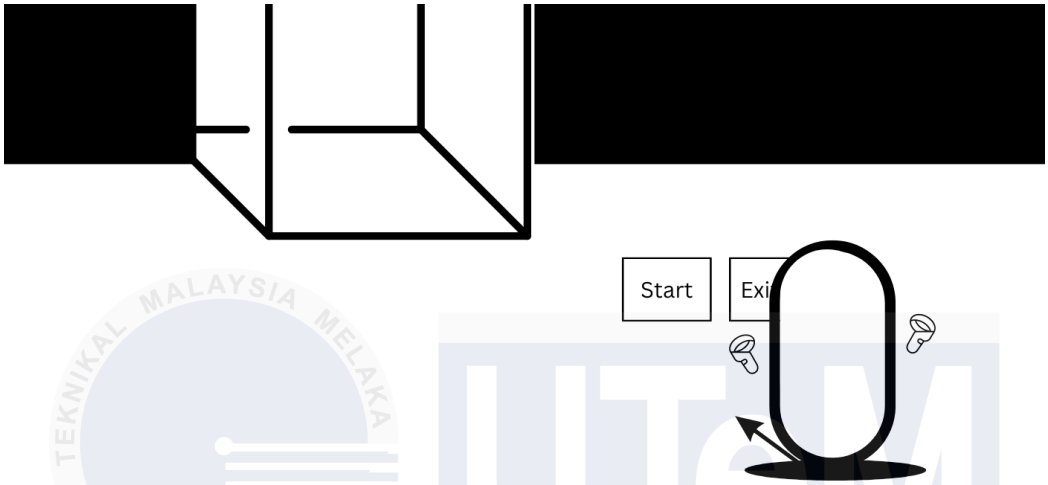


Figure 3.5 Illustration front mall UI

For the AI characters to be placed inside the shops, ideas have been developed to design these characters using Ready Player Me. This platform allows for the creation of customizable 3D avatars that can be integrated into virtual environments, making it a suitable tool for developing interactive and engaging AI characters for the shopping experience. By using Ready Player Me, these characters can be tailored to fit the aesthetic and functional needs of the virtual reality mall, enhancing the overall user experience. Figure 3.6 and Figure 3.7 below shows the illustration of Convai character.

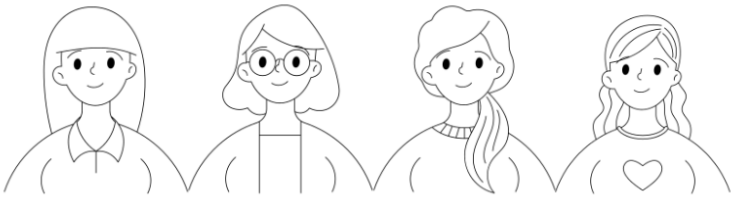


Figure 3.6 Illustration AI woman

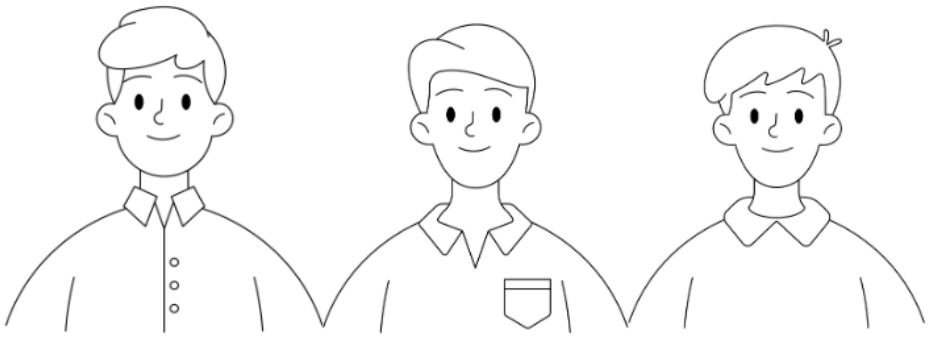


Figure 3.7 Illustration Ai man

3.4 Phase 2 – Development and Implementation

3.4.1 VR Project

The second objective of the project is focused on creating an immersive simulation game utilizing Virtual Reality (VR). This game aims to transport players into a detailed and lifelike virtual environment where they can engage in various interactive experiences. By leveraging VR technology, the simulation will offer a highly realistic and captivating experience, allowing players to explore, interact with elements, and participate in challenges or scenarios designed to enhance their overall engagement and enjoyment. The goal is to deliver a compelling and memorable gaming experience that showcases the potential of VR in creating immersive simulations.

3.4.2 Environmental Design and Creation

The Figure 3.8 below illustrates an example of a mall environment that needs to be transformed into a 3D model. The larger the mall environment, the more extensive the shops within it, and consequently, more time will be required to model it using Blender.

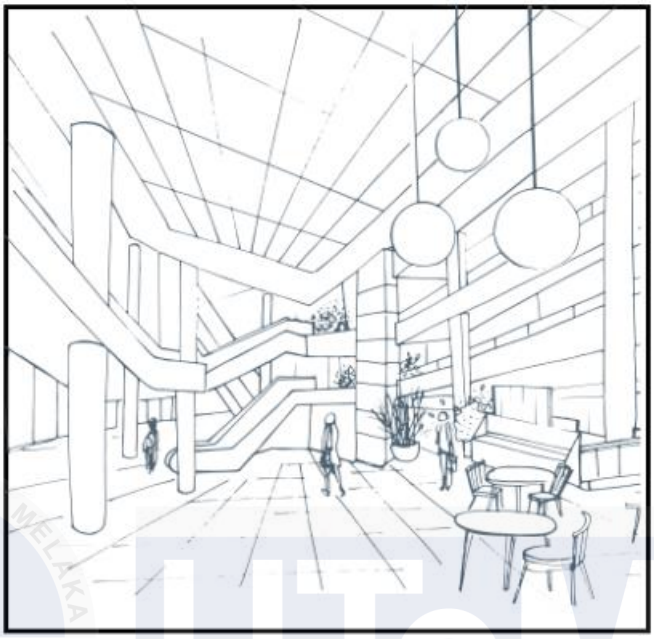


Figure 3.8 Sketch Mall

Figure 3.9 3D Mall

Creating high-resolution textures and materials is crucial for enhancing realism. Tools like Blender Kit are particularly useful for achieving this. Figure 3.10 and Figure 3.11 below shows the illustration for the levels inside the virtual reality mall.

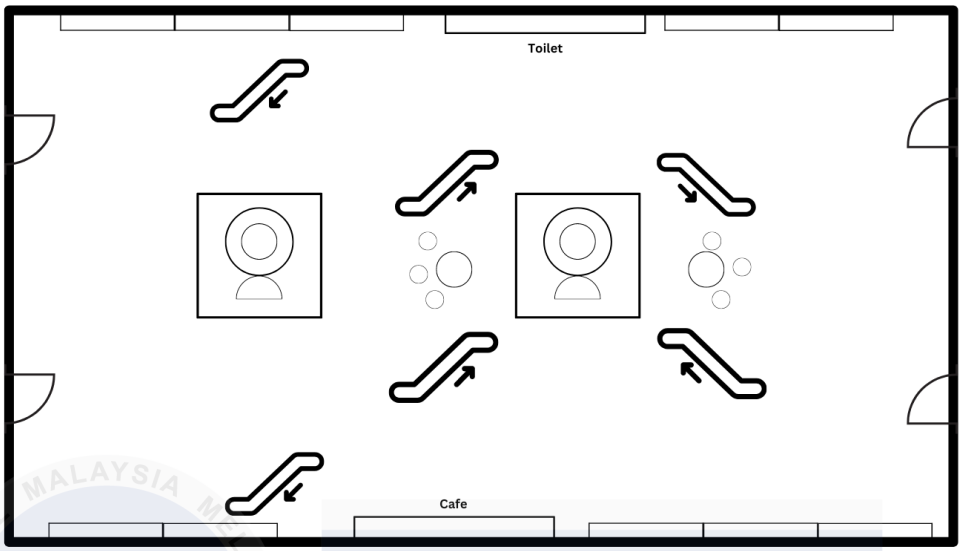


Figure 3.10 First Mall Level

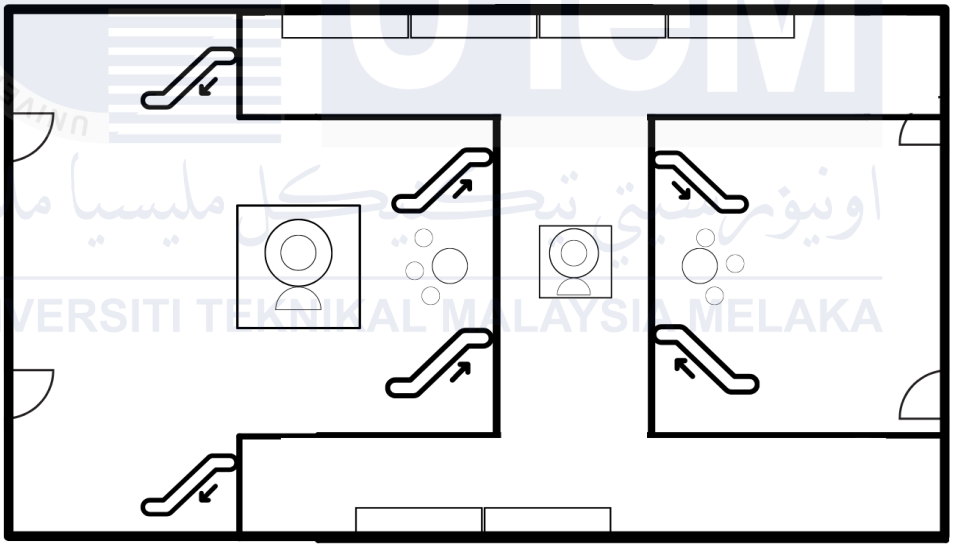


Figure 3.11 Second Mall Level

3.4.3 Interaction Design

To enhance user interaction, develop user interfaces and interaction mechanisms such as hand tracking, gaze control, and controller inputs. For instance, hand tracking can be used to grab objects like clothes inside the mall. Additionally, implementing locomotion will make moving around the mall feel like actual walking.

Based on Figure 3.2 itself show an example of user interaction in VR is navigating a virtual shopping mall. Using hand tracking, users can reach out and grab items like clothes, examining them closely as if they were in a real store.

Controller inputs can enhance the experience by providing precise control over movements and actions. Additionally, implementing realistic locomotion, such as virtual walking based on Figure 3.13, can make the experience of roaming the mall feel more immersive and natural.

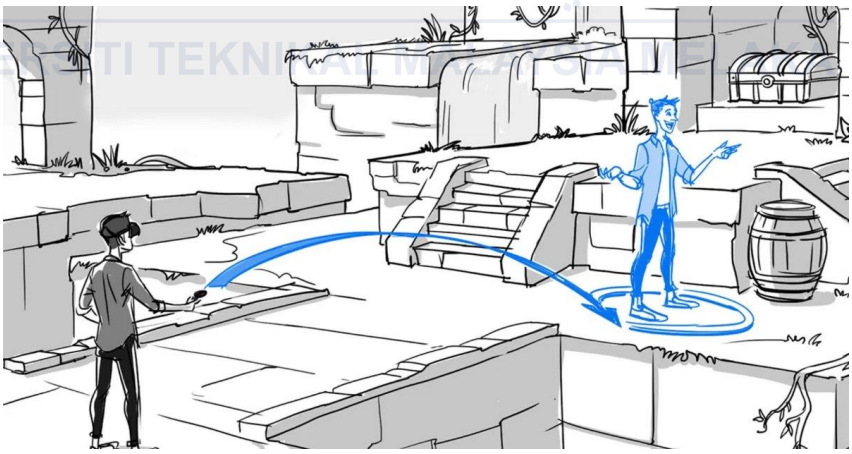


Figure 3.12 Basic Teleportation in VR template

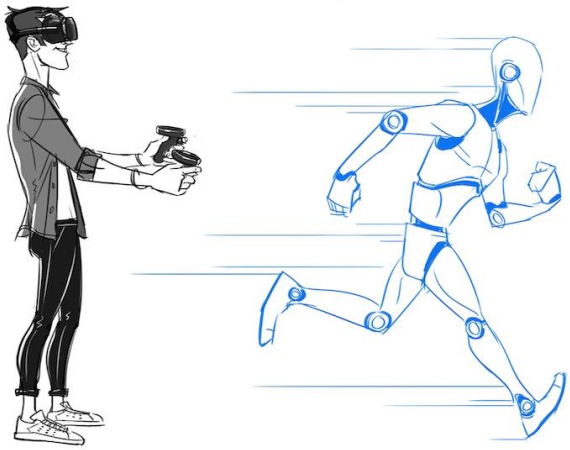


Figure 3.13Staying at one place but move anywhere

3.4.4 Content Development

Audio production involves creating immersive soundscapes, ambient sounds, and voiceovers to enhance the overall experience. Tools like Pixabay are ideal for finding these audio elements. For instance, in a virtual mall environment, the soundscape might include the murmur of a bustling crowd, background music playing throughout the mall, people chatting, and the distinctive sounds of cashier machines. These audio details contribute significantly to the realism and immersion of the virtual experience.

Animation within the virtual world includes NPCs walking around the mall, chatting with other NPCs, and sitting. These animations can be sourced from Mixamo. The Figure 3.14 below shows what is inside the Mixamo web page.

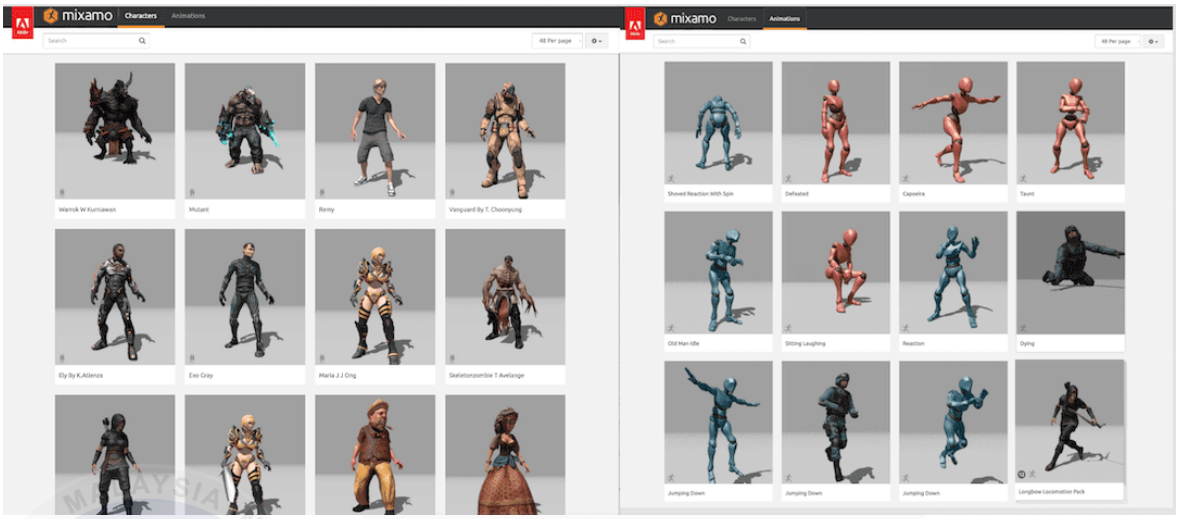


Figure 3.14 Mixamo Web

Animating characters and objects in the virtual world aims to provide lifelike movements and interactions.

3.4.5 Scripting

Scripting involves creating scripts for game mechanics, AI behaviors, and event triggers in Unreal Engine. Developers use a mix of C++ for performance and control and Blueprint visual scripting for rapid prototyping. Blueprints provide a user-friendly interface where developers connect nodes to define interactions and behaviors visually. This approach allows for collaborative development, refining gameplay without extensive coding. Together, these methods create immersive virtual worlds with detailed interactions that enhance player engagement. The Figure 3.15 below show an example of blueprint in unreal engine.

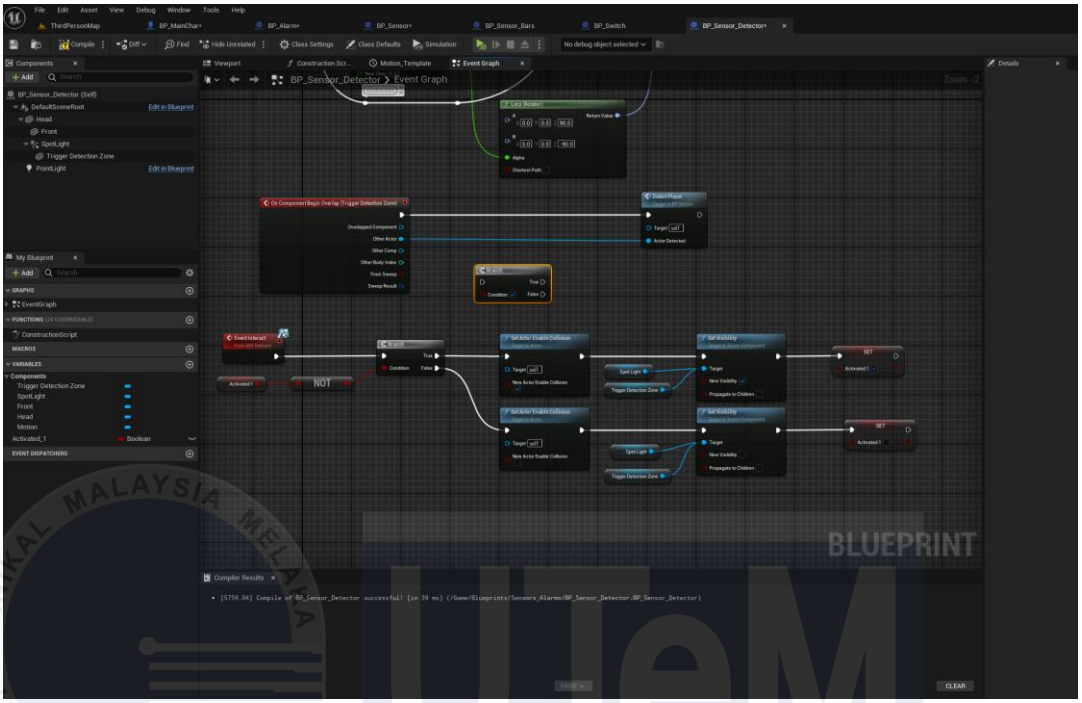


Figure 3.15 Blueprint

3.4.6 AI with Speak to Text Function

This project plans to integrate a conversational AI, specifically a ConvAI AI, into the virtual environment. Users will interact with the AI using a speech-to-text function for a more immersive experience, allowing natural spoken communication instead of typing on a keyboard to understand and respond to NPC dialogues effectively.

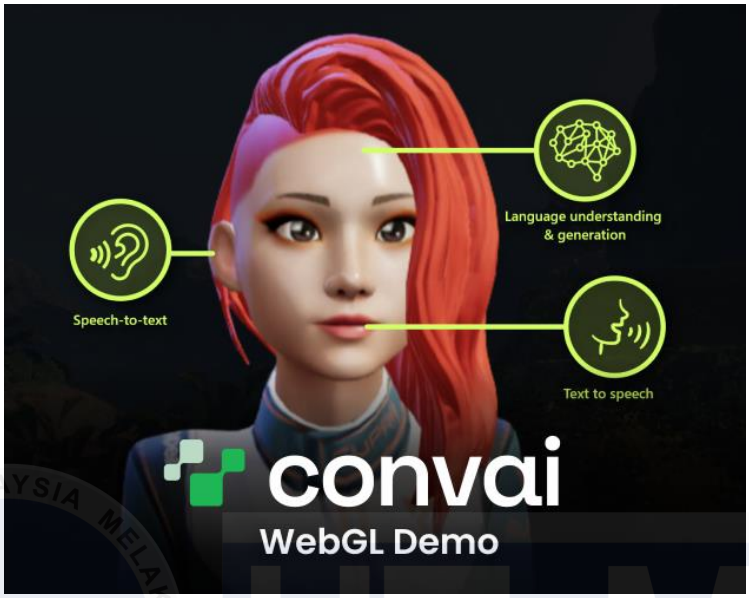


Figure 3.16 Convai

The project aims to utilize a Conversational AI based on Figure 3.16 above, specifically the ConvAI model, integrated with the character from Ready Player Me.

3.4.7 Deployment

Integrating the VR project with platforms like Oculus. This integration aims to deliver seamless and compelling VR experience tailored to Oculus users.

Figure 3.17 Oculus VR headset used in the project

3.5 Evaluation

To fulfill the third objective outlined in the proposed methodology, the final phase involved conducting an evaluation focused on the extracted motions. This evaluation included both qualitative and quantitative analyses.

3.5.1 Quantitative Analysis

The quantitative analysis took place during the evaluation phase of the research. The proposed method was tested for usability and potential simulation sickness. Usability was measured using the System Usability Scale (SUS). To assess any effects, such as dizziness or sickness, the Simulation Sickness Questionnaire (SSQ) was administered before and after participants used the VR headset and experienced the simulation.

3.5.1.1 Participant

At SMK Datin Onn Jaafar Batu Pahat, 12 students from Lower 6, along with their teachers, participated in the testing. The group was predominantly Chinese, with only one Malay student among them. While most of the students primarily spoke Chinese, only a few were fluent in English. A handful of students had previous experience with VR devices, which added an interesting dynamic to the session. Despite the language barrier, all participants, including the teachers, completed the SUS questionnaire, providing valuable insights into the experience.

3.5.1.2 System Usability Scale (SUS)

The System Usability Scale (SUS) was utilized to assess the ease of use and overall user experience of the proposed method. During the post-evaluation phase, participants were asked to complete the SUS questionnaire, which provided crucial data on how they interacted with and perceived the system. This feedback was instrumental in understanding the strengths and areas for improvement in the design, helping to ensure that the final product meets user expectations and needs.

The SUS inside Table contains ten items that participants need to answer from 1 (strongly disagree) to 5 (strongly agree).

Table 3.19 SUS content

1	How would you rate your overall experience with the virtual reality simulation?
2	Did you experience any physical discomfort during or after using the VR headset?
3	Did you notice any eye strain or visual discomfort while using the VR headset?
4	Did you feel any motion sickness during or after the VR experience?
5	Did you experience any balance issues or coordination problems after removing the VR headset?
6	Have you had any lingering physical symptoms?
7	Did you experience any unexpected fatigue or tiredness after the VR session?
8	Were you able to navigate and interact with the virtual environment easily?
9	Did you encounter any technical issues or glitches during the simulation?
10	Was the VR headset comfortable to wear throughout the session?

The System Usability Scale (SUS) survey consists of 10 statements, which respondents rate

on a scale from 1 to 5 based on their level of agreement. To analyze these ratings, a specific formula is used: for odd-numbered statements (1, 3, 5, 7, and 9), subtract 1 from the response value. For example, if the response to statement 5 is 3, it is adjusted to 2 (3 - 1). For even-numbered statements (2, 4, 6, 8, and 10), subtract the response from 5. If the response to statement 4 is 3, it is adjusted to 2 (5 - 3). Once all responses are adjusted, they are summed and then multiplied by 2.5 to determine the final SUS score.

In a spreadsheet, the formula for this calculation is:

=(B2-1) + (5-C2) + (D2-1) + (5-E2) + (F2-1) + (5-G2) + (H2-1) + (5-I2) + (J2-1) + (5-K2)

This formula simplifies the calculation of the SUS score, eliminating the need for manual computation. Additionally, a small piece of code can be used to automate these calculations, further streamlining the process and minimizing the potential for errors.

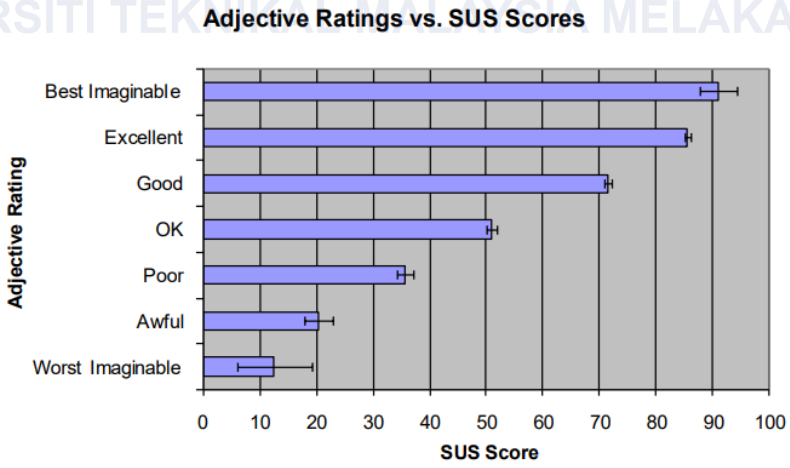


Figure 3.18 SUS Scores

Based on the Figure 3.18 above, a research project conducted by Bangor et al. (2009) utilized the SUS score to evaluate their project's usability. This scoring method provided a clear metric for assessing how user-friendly and effective the project was, helping to gauge

its overall performance and areas for improvement. By applying this well-established scale, the researchers were able to systematically measure and interpret user feedback, ensuring a thorough and objective evaluation of their project's design and functionality.

3.5.1.3 Simulation Sickness Questionnaire (SSQ)

The Simulator Sickness Questionnaire (SSQ) is a commonly used instrument for evaluating symptoms of motion sickness and discomfort that people may feel when using simulated environments, especially in virtual reality (VR) settings (Gonçalves et al., 2024).

These 11 SSQ questions inside Table _ below have been thoughtfully selected to evaluate the virtual mall project. Each question is designed to capture different aspects of motion sickness and discomfort that users might experience while navigating through the virtual environment. By including these specific questions, the goal is to gain a comprehensive understanding of how the virtual mall affects users and to identify any issues that may impact their overall experience. This careful selection ensures that the feedback gathered will be valuable for improving the project's design and enhancing user comfort.

Table 3.20 SSQ content

1	Are you currently experiencing any symptoms of illness (e.g., fever, cough, headache)?
2	Do you have a history of seizures or epilepsy?
3	Are you currently taking any medications that might affect your balance or vision?
4	Do you have any known heart conditions or respiratory issues?
5	Are you currently pregnant or suspect that you might be pregnant?

6	Do you have any vision impairments or conditions that affect your sight?
7	Are you wearing contact lenses or glasses?
8	Do you have any hearing impairments or use hearing aids?
9	Do you suffer from motion sickness or dizziness?
10	Do you have any conditions affecting your balance or coordination?
11	Have you had any recent surgeries or injuries, particularly involving the head, neck, or spine?

3.5.2 Qualitative Analysis

This qualitative analysis project looks into how people use a virtual shopping mall, gathering feedback to measure their satisfaction. By using expert review questionnaires, it compares the mall's performance with industry standards, providing important insights to improve both its functionality and user experience.

3.5.2.1 Expert Review

Expert reviews are vital for refining a virtual reality mall, as they offer deep insights and industry expertise. Their feedback helps identify issues and areas for improvement that may not be evident to regular users. By comparing the mall's design and functionality with industry standards, experts ensure the virtual environment is high-quality, user-friendly, and competitive. Their recommendations lead to significant enhancements in the overall user experience.

Two experts from the business industry and two academic experts with experience in VR projects were selected for the review. The business experts assess whether the virtual reality mall is suitable for future shopping experiences. Meanwhile, the academic experts provide deep insights into VR technology and design principles. Together, their combined expertise ensures a thorough evaluation of the virtual reality mall, balancing industry standards with technical excellence to gauge its readiness for the future of shopping.

3.6 Summary

This chapter follows the ADDIE methodology, organized into three distinct phases essential for developing a virtual world open-world shopping mall: Analysis, Design and Development, and Implementation and Evaluation. The Analysis phase focuses on conceptualization, aiming to define project objectives, identify the target audience, and establish functional requirements crucial for creating a virtual shopping experience that meets user needs. Moving into the Design and Development phase, the project blueprint takes shape with detailed designs for the mall's layout, user interface, and interactive elements, ensuring alignment with VR technology standards to enhance immersion and usability. Concurrently, Development activities involve building and integrating features like object interactions and payment systems, laying the groundwork for a robust virtual environment. The final phase, Implementation and Evaluation, involves deploying the virtual mall for user interaction and collecting both quantitative data (such as user engagement metrics and transaction volumes) and qualitative feedback (including user experiences and satisfaction levels). This analysis informs iterative improvements and optimizations, aiming to refine the virtual shopping mall continuously.

CHAPTER 4

IMPLEMENTATION

4.1 Introduction

This chapter applies the ADDIE methodology to implement "Virtual Emporium: Elevating Shopping Experiences with Virtual Reality in Digital Mall." It starts with analyzing project goals and audience needs. Then, it designs and develops the virtual mall, focusing on user interface and VR integration. Finally, after launching, it evaluates user engagement and feedback to refine and enhance the virtual shopping experience continually.

4.2 Phase1 – Analysis Design

This chapter explain the implementation of the virtual emporium: elevating shopping experiences with virtual reality in digital mall based on methodology discussed in Chapter 3.

4.2.1 Map

In Unreal Engine's world map for the virtual shopping mall, the implementation focuses solely on creating an open-world environment within the interior of the mall. This design excludes exterior areas and emphasizes the detailed construction of the Tuah mall's indoor spaces.

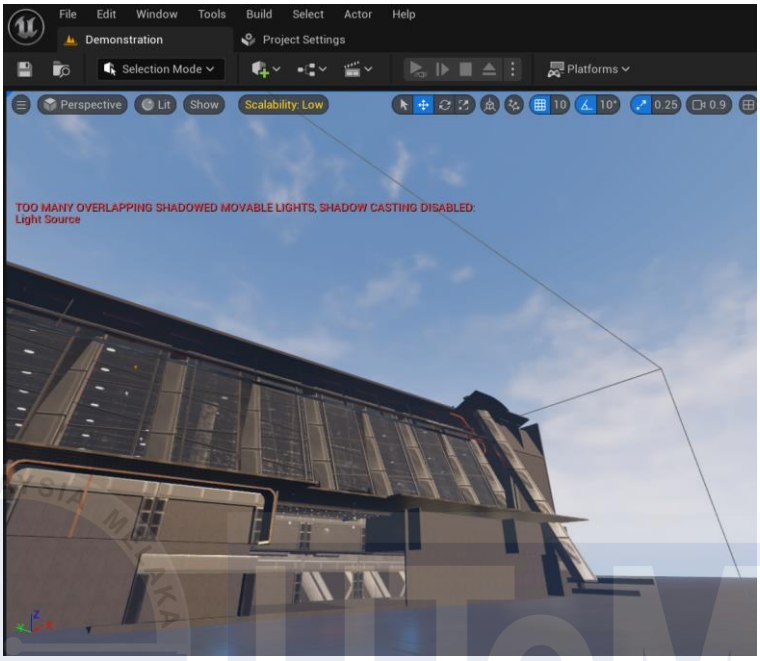


Figure 4.1 Demonstration Map Outside Mall

The interior inside of Figure 4.2 below, allows users to explore, ride escalators, and browse products, much like they would in a real-life physical mall.

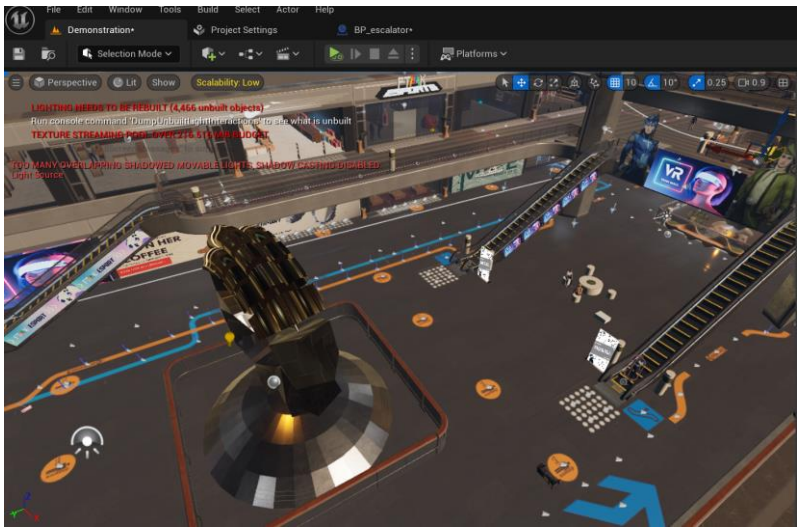


Figure 4.2 Demonstration Map Inside Mall

Inside the mall, there are three featured stores: Mike's Shoe Store, FTMK Esport Shop, and Uniklo. In each store, users can lift products and view them in 360 degrees.

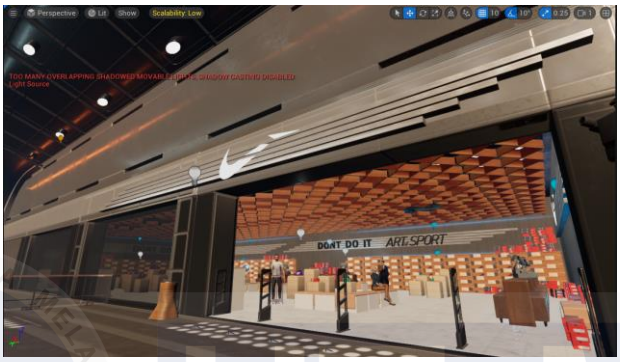


Figure 4.3 Mike shoes store

Figure 4.4 FTMK E-sport

Figure 4.5 Uniklo

By using the blueprint template for objects with the grab functionality, we only need to change the meshes to implement this feature.

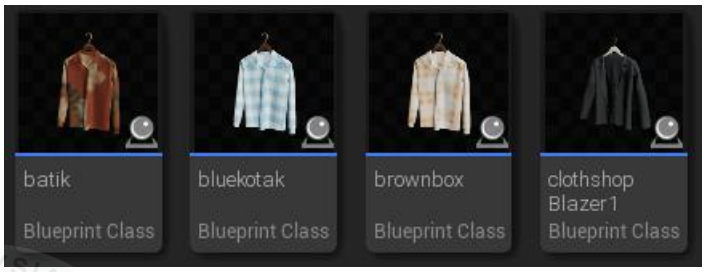


Figure 4.6 Blueprints Actor for Uniko Clothes

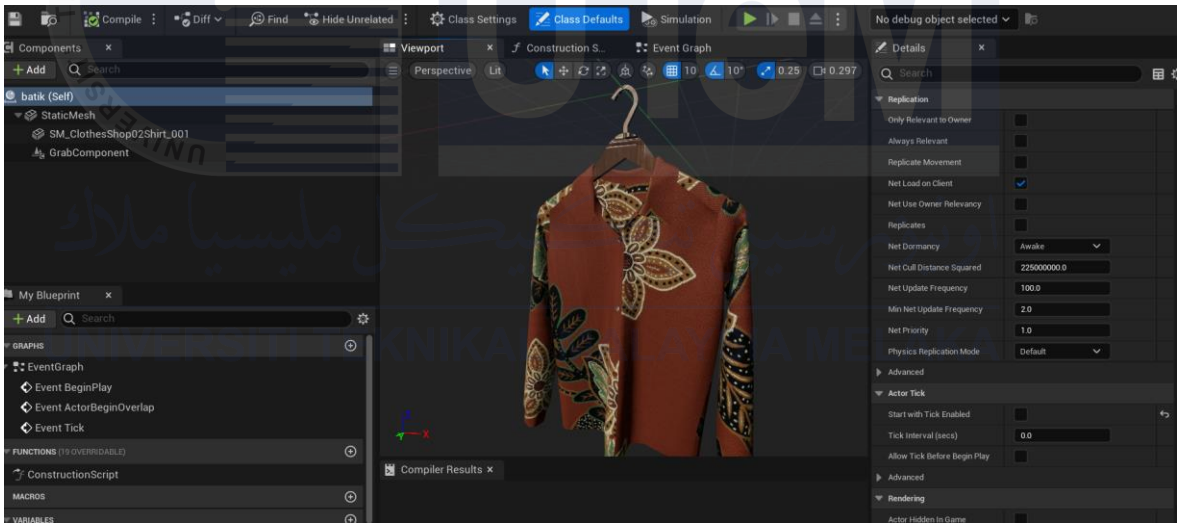


Figure 4.7 Blueprints for Batik Cloth

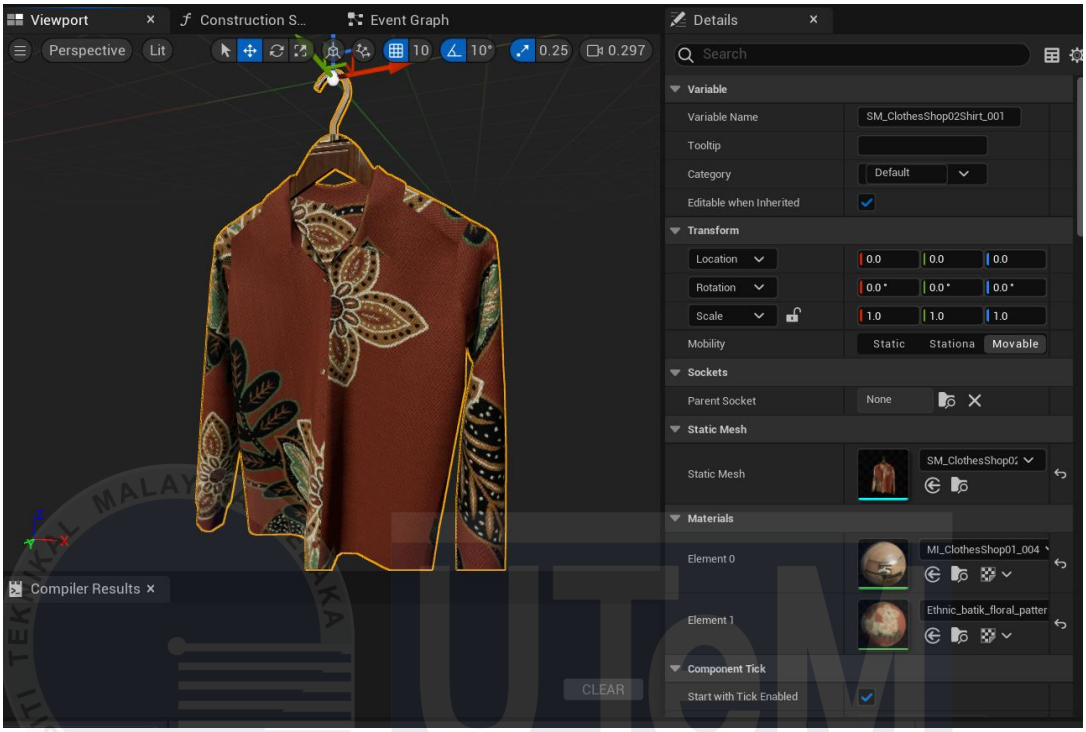


Figure 4.8 Blueprints Change Static Mesh

In addition to the demonstration map, another map is being created for the main menu. The background of the main menu features a partial view of the mall's interior. It includes buttons for starting shopping and quitting the game. The "Start" button initiates the shopping experience, while the "Quit" button exits the game. The Figure 4.9 below show the main menu map.

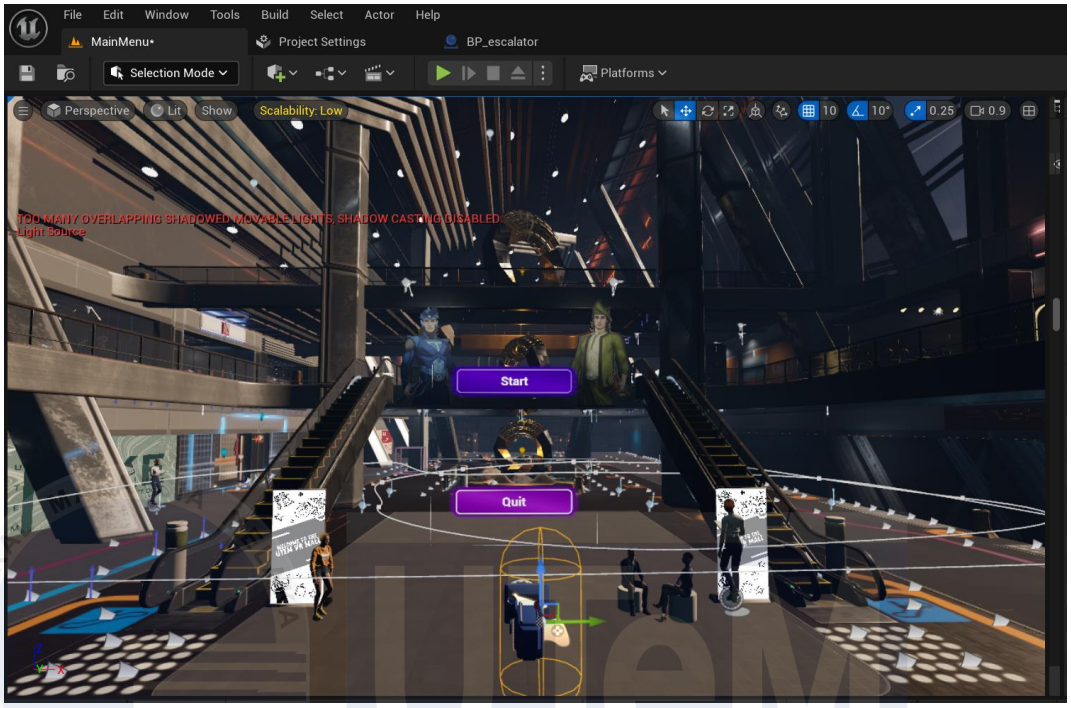


Figure 4.9 Main menu map

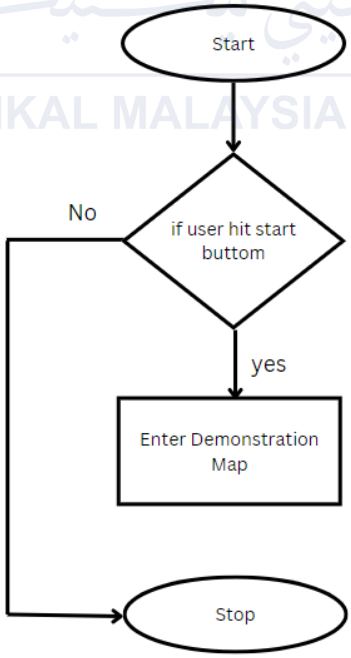


Figure 4.10 Flowchart of the main menu map function

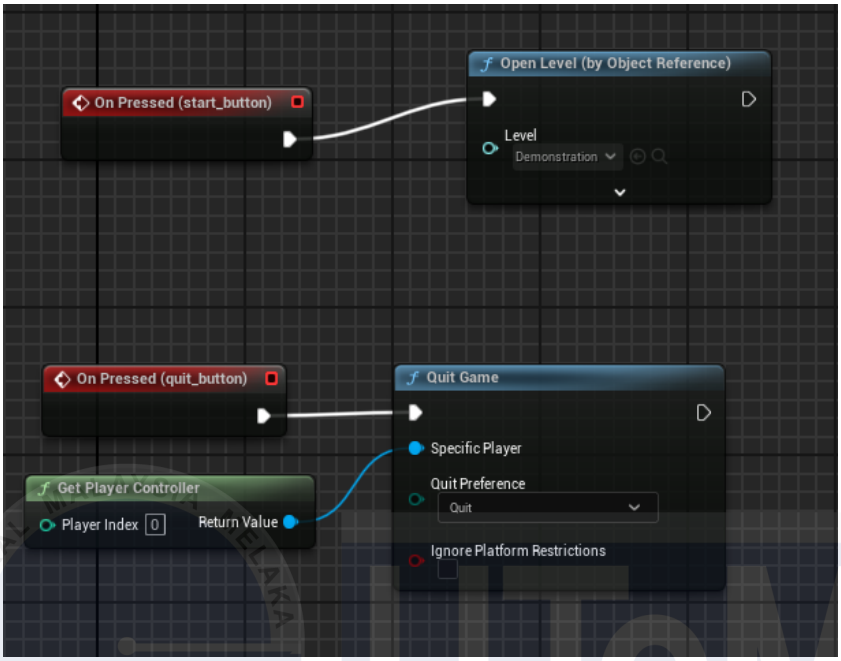


Figure 4.11 Event Graph for Start Quit Button

4.3 Phase 2 – Development and Implementation

The second phase is about combining the Development and Implementation phases for a VR open world project involves a seamless integration of activities to ensure that the project is built, tested, deployed, and maintained effectively

4.3.1 Ready Player Me

Ready Player Me is a platform that allows users to create customizable 3D avatars for virtual reality (VR) experiences. It benefits VR projects by providing a simple and efficient way to generate high-quality, personalized avatars that can be used across various VR applications, enhancing user engagement and immersion. Additionally, it supports cross-platform compatibility, making it easier to integrate these avatars into different VR environments. The Figure 4.12 below show the Ready Player Me customization

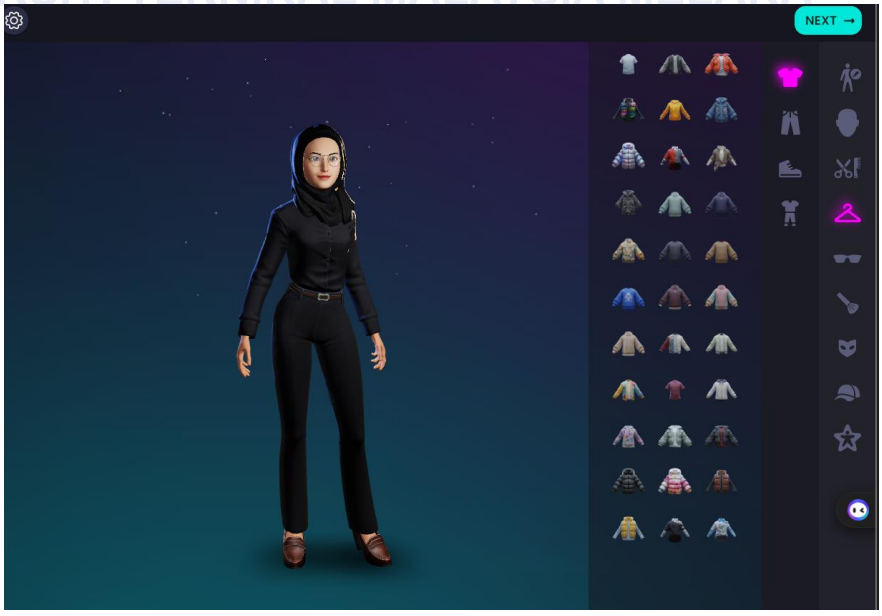


Figure 4.12 Ready Player Me customization

In Ready Player Me character customization, there are eight sections: choosing gender and body size, face features and skin colors, a variety of hairstyles and colors, clothes, spectacles, accessories, makeup, masks, and headwear. These options help users customize their characters to their own preferences.

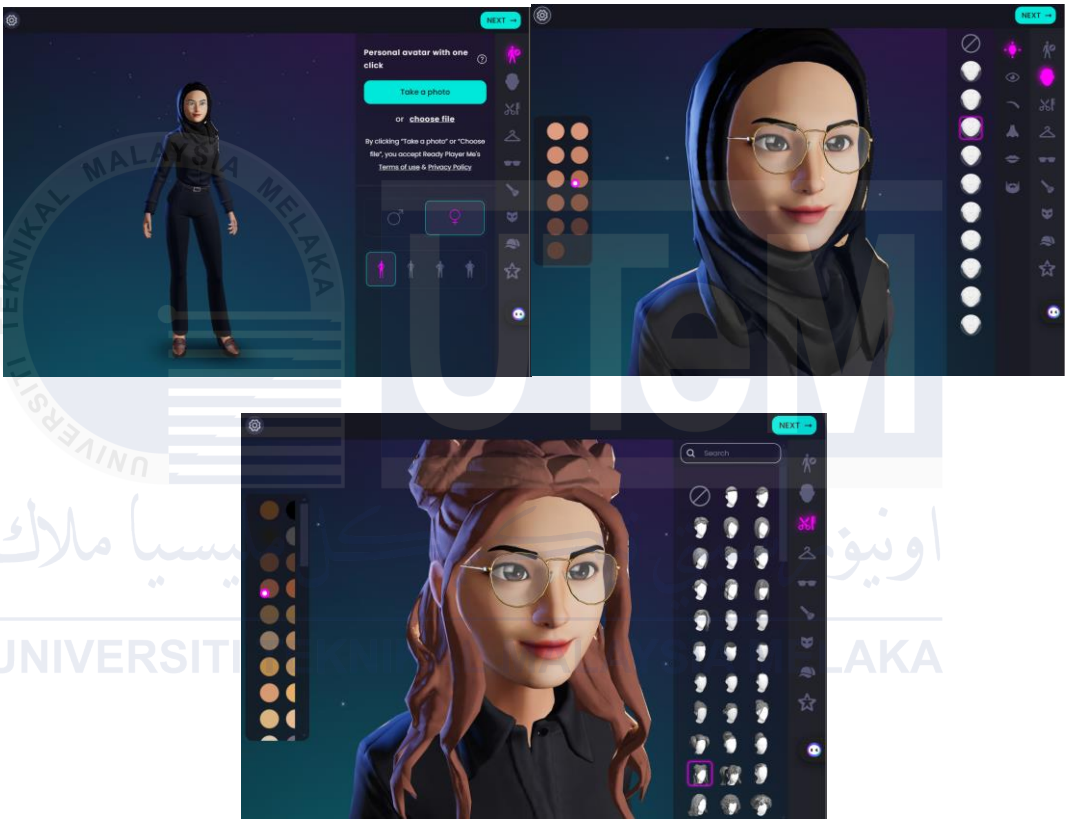


Figure 4.13 Set of Ready Player Me Customization

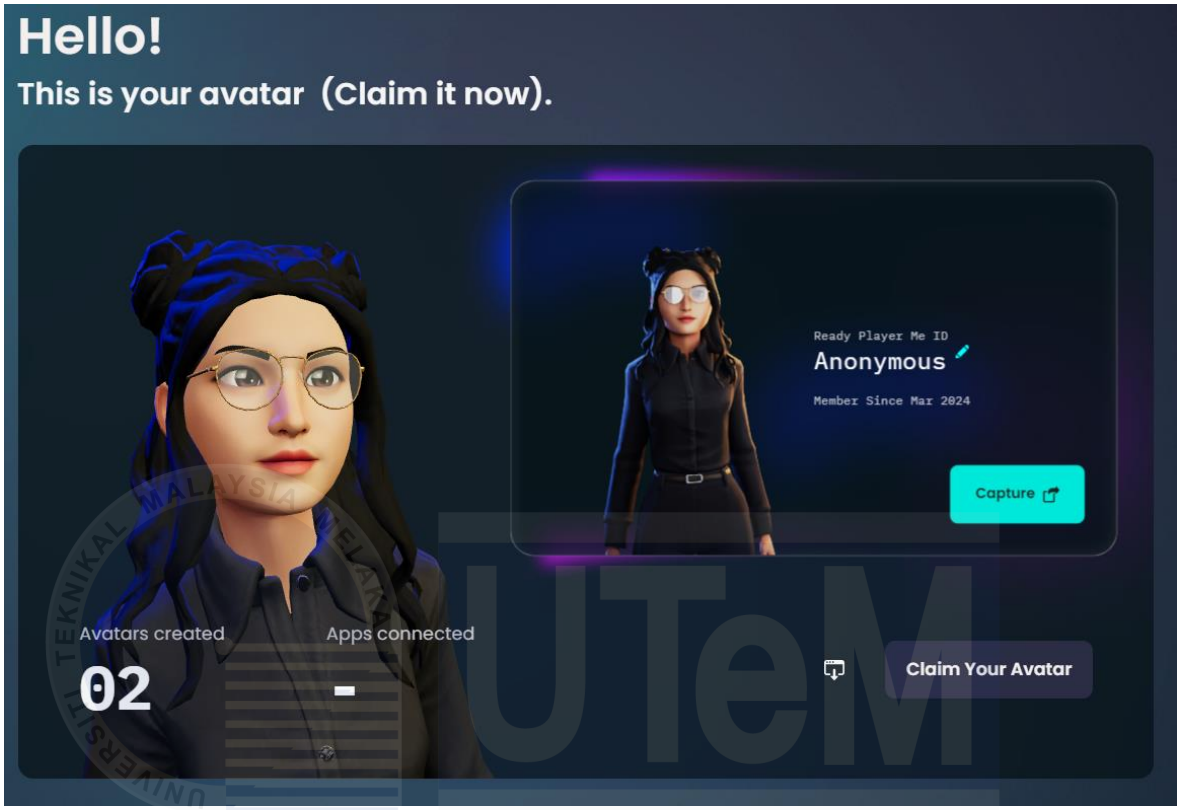


Figure 4.14 Final Product for Ready Player Me Customization

4.3.2 Convai

Convai combines the capabilities of Ready Player Me and AI to create interactive and personalized virtual experiences. Ready Player Me provides customizable 3D avatars, allowing users to design their virtual identities with detailed options for gender, body size, facial features, skin colors, hairstyles, clothing, and accessories. By integrating AI, Convai enhances these avatars with advanced interaction capabilities, enabling them to respond intelligently to user inputs and engage in lifelike conversations. This combination creates a more immersive and dynamic virtual environment, enhancing user engagement and making virtual interactions feel more natural and intuitive.

Inside the character description, a background story is included to give each character their own role and personality. This helps the characters appear more intelligent and responsive to users. The character voice is chosen as Ashley, a female American, because it sounds natural and the accent is easy for users to understand.

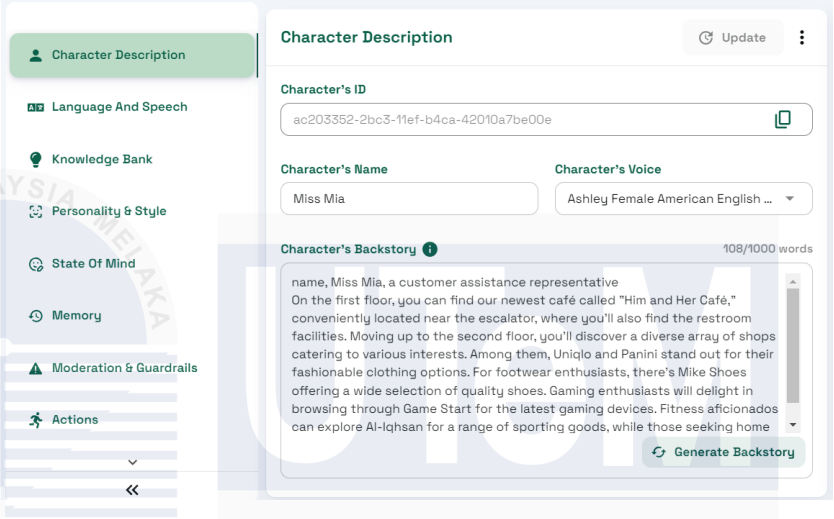


Figure 4.15 Convai Charcater Description

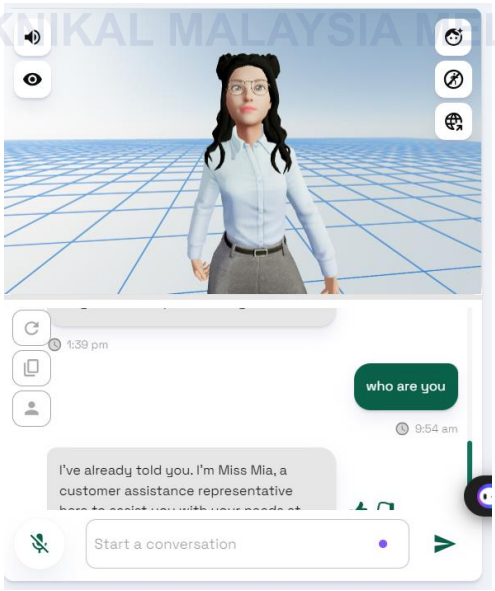


Figure 4.16 Output Chatbox with Convai AI

The conversation between the user and Convai AI is working, allowing seamless interaction between the user and the AI.

Table 4.1 List of Convai Implementation

Convai Character	Position in VR Mall
Miss Mia 	
Hadi 	
Sarah 	

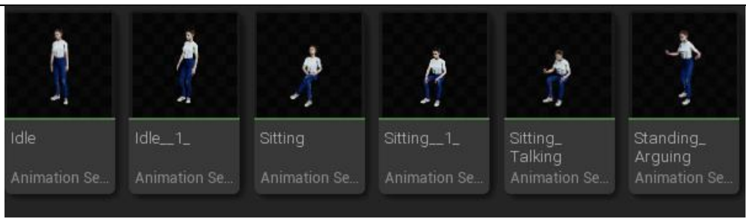
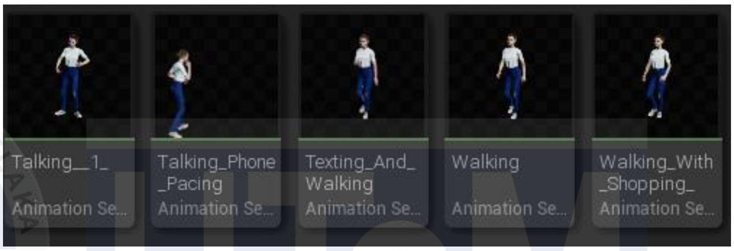
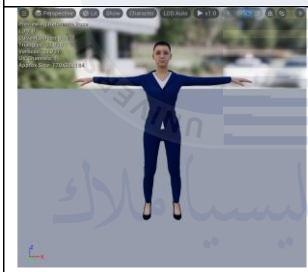
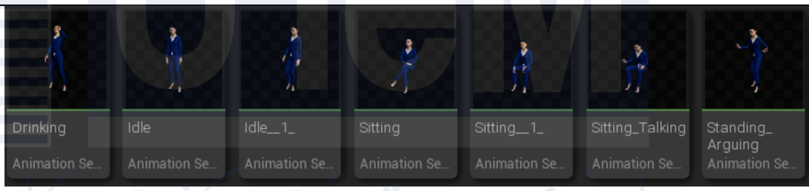
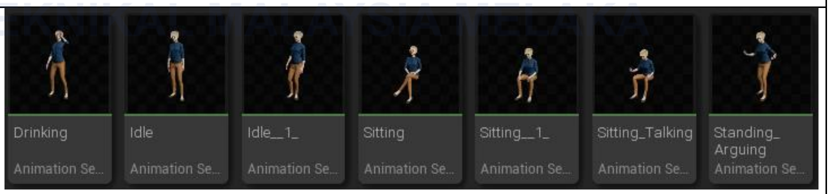
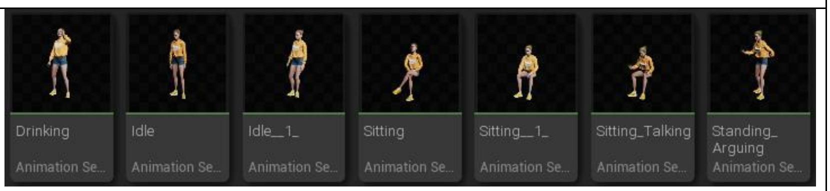
Zety 	

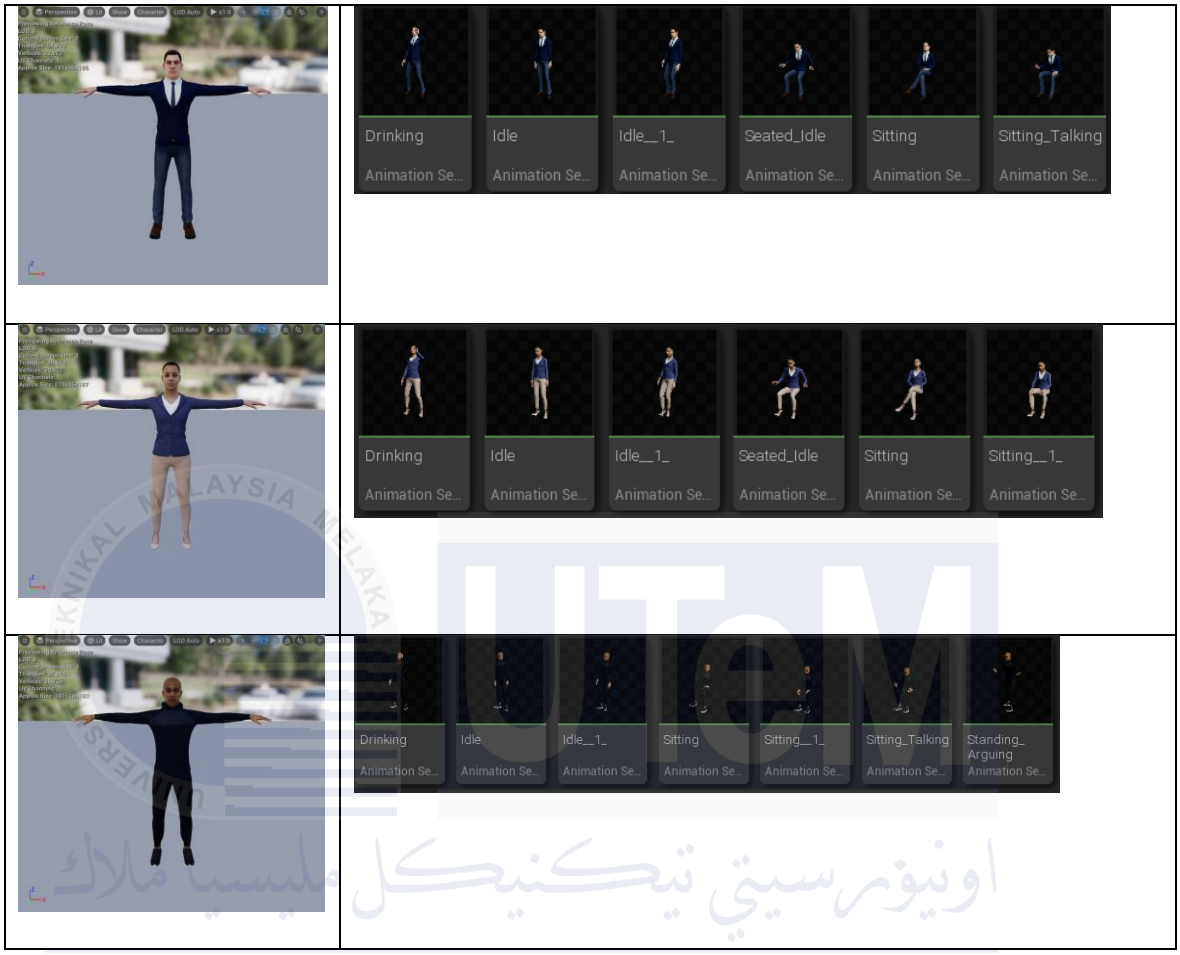
After the final design, character description, and voice have been chosen, each character is assigned a unique ID. This ID is then pasted into the character ID slot inside Unreal Engine 5.3. The output of each character is then displayed in the virtual world, the same as in table 4.1 above.

4.3.3 Mixamo

Mixamo is an online platform owned by Adobe that provides a wide range of 3D character models, animations, and rigging services. It is designed to simplify the process of creating and animating 3D characters for use in various applications, including video games, virtual reality (VR), augmented reality (AR), films, and other digital media. The table below shows the list of Mixamo animations for each NPC character placed inside the virtual mall. These animations will be connected using splines in Unreal Engine to make the characters walk and roam inside the mall.

Table 4.2 List of Mixamo Character and Animation

Mixamo Character	Animation
	 
	
	
	



Inside the Character Blueprint viewport, a spline is inserted into the character.

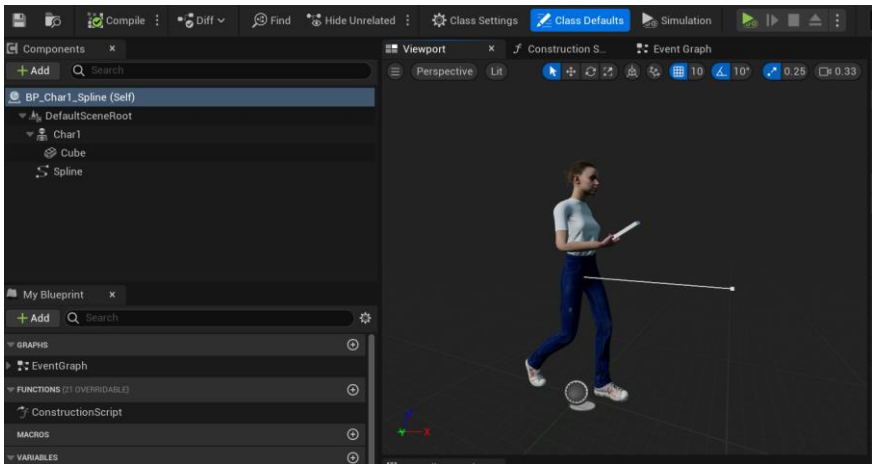


Figure 4.17 Spline Character

Based on the Figure 4.17 the spline helps the character follow the designated path, which has been created using the spline. The length of the spline can be resized as needed. The Figure 4.18 show the blueprint of the character spline.

tern

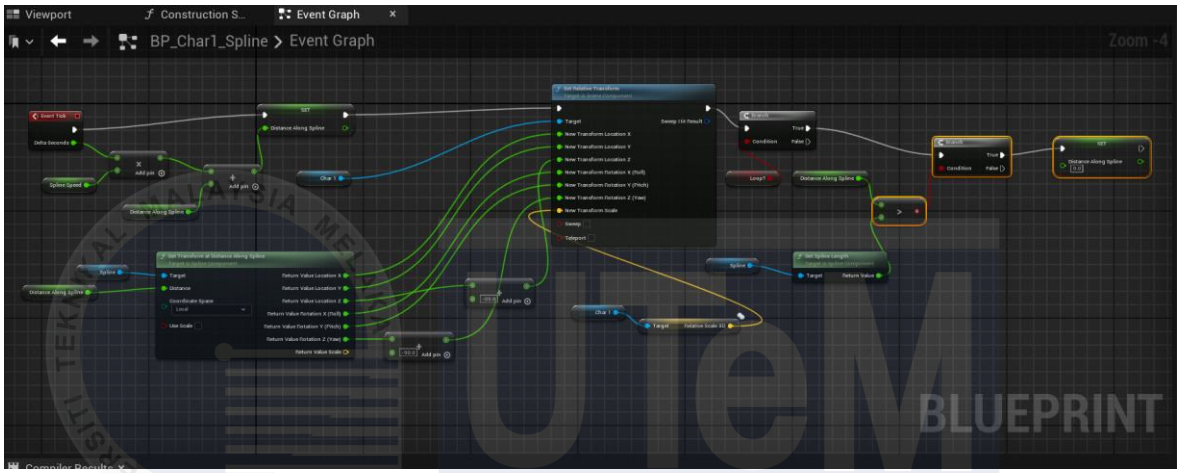


Figure 4.18 Character Spline

4.3.4 GUI

Every game and software have its own GUI, and this project also implements a unique GUI. Bright buttons with purple and blue backgrounds are used to ensure users notice the GUI, especially since the background is already complex. This design choice helps users focus on the buttons.

Figure 4.19 GUI Main Menu

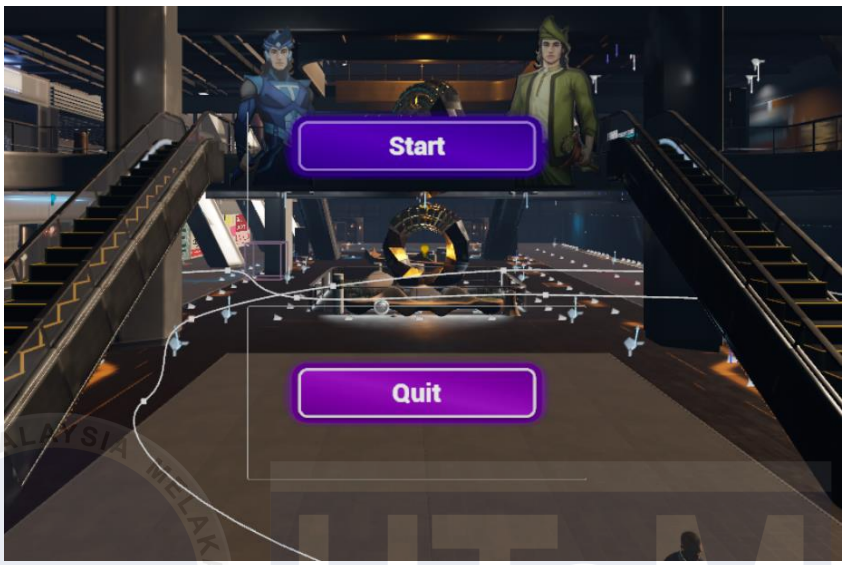


Figure 4.20 Main Menu Widget in 3D World Space

4.3.5 Locomotion

Locomotion in virtual reality (VR) refers to the methods and techniques used to move a user's viewpoint or avatar within a virtual environment. Effective locomotion is crucial for creating immersive and comfortable VR experiences. Figure 4.21 below shows the blueprint of the implementation of locomotion inside Virtual Emporium Mall.

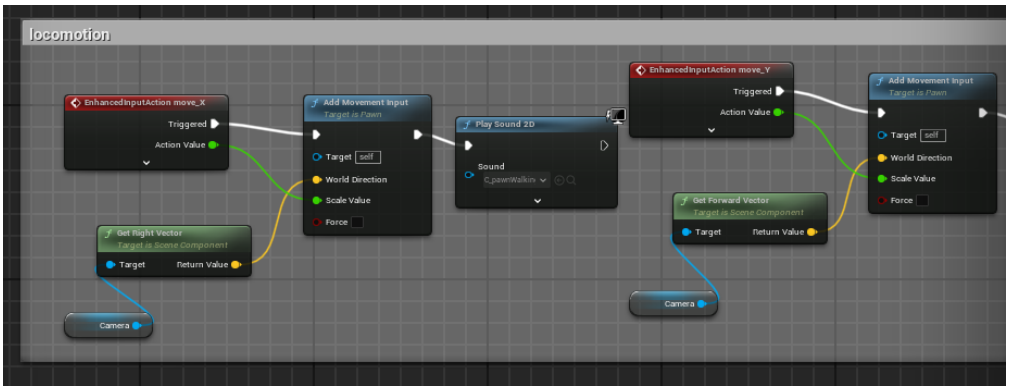


Figure 4.21 Locomotion blueprint

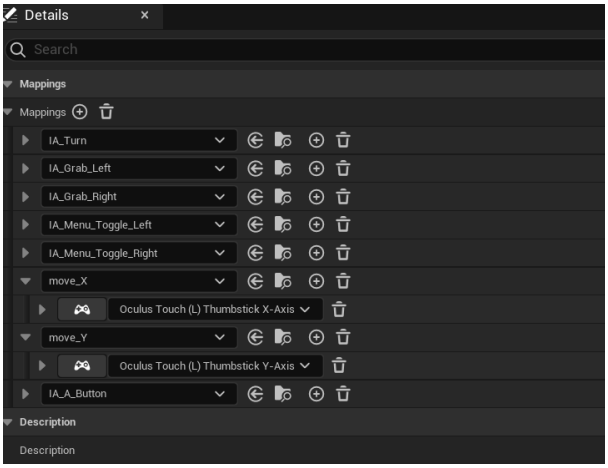


Figure 4.22 IMC Default

To ensure that the locomotion works well, another input needs to be included in the input file "move x" and "move y". These inputs will then be implemented inside IMC Default to connect with the console thumbstick of the Oculus headset. Figure 4.22 above shows the implementation of the "move x" and "move y" inputs.

4.3.6 Web Browser

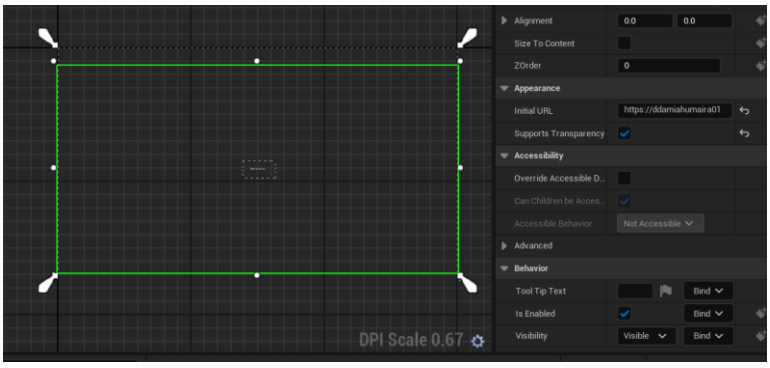


Figure 4.23 Widget Web Browser

A web browser is a software application used to access and navigate the internet. In the case of the Virtual Emporium project, the web browser is used to enable users to make payments within the virtual world, avoiding the high cost of a payment gateway. A Wix website serves as an alternative payment method, requiring users to browse the website from inside the virtual environment. Figure 4.23 above shows the widget of the web browser.

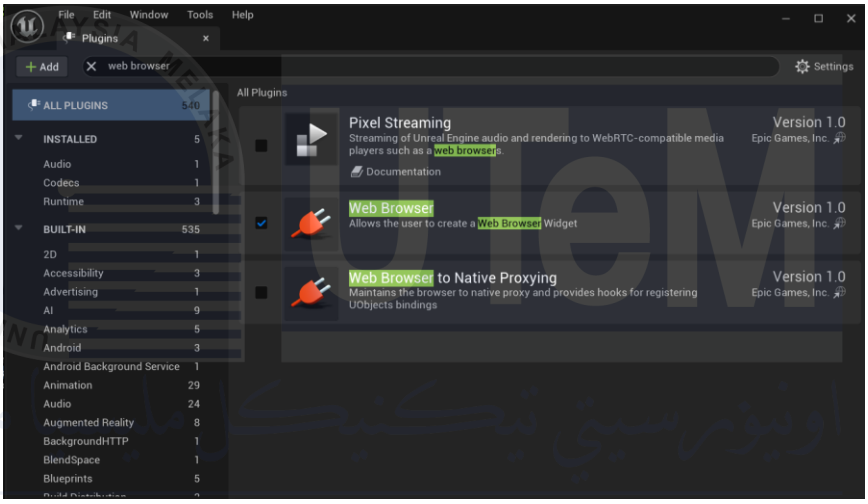


Figure 4.24 Web Browser Plugin

To enable the web browser inside the Virtual Emporium mall, Unreal Engine 5 provides a free web browser plugin that can be implemented by simply dragging and dropping the canvas panel, vertical box, and web browser components. This setup allows the project to integrate web browsing functionality seamlessly. Figure 4.24 above displays the plugin within Unreal Engine 5.3.

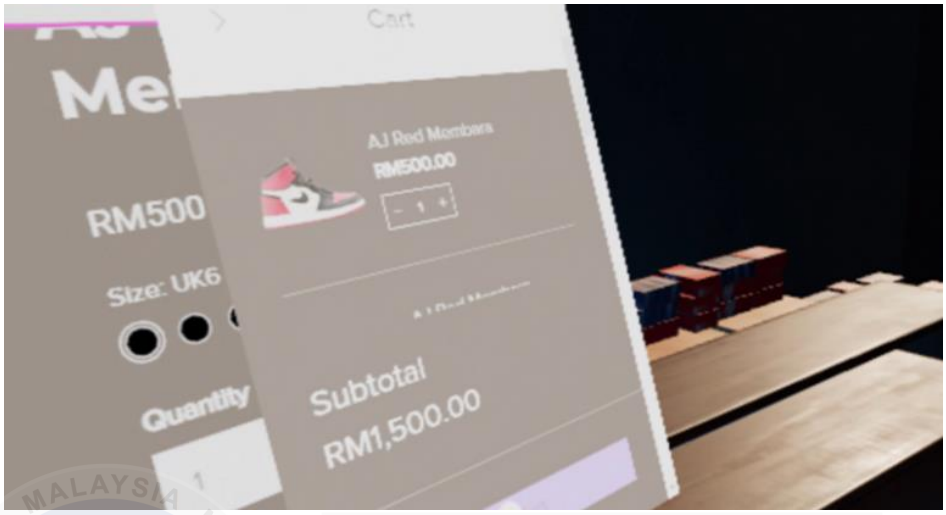


Figure 4.25 Output Web Browser

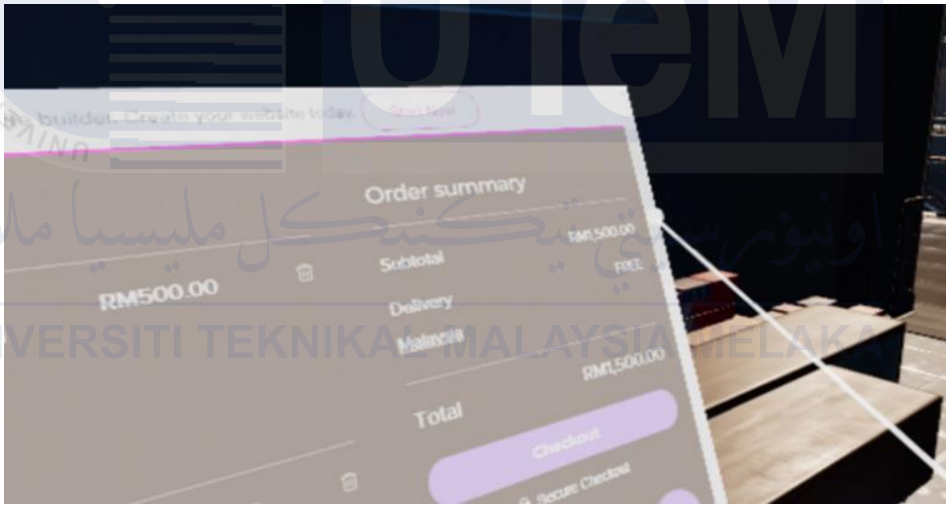


Figure 4.26 Order Summary User

4.4 Summary

This chapter provides a detailed discussion of the research methodology previously outlined in Chapter 3. The virtual emporium: elevating shopping experiences with virtual reality in digital mall were thoroughly explained, particularly in terms of the procedures and executions.

CHAPTER 5

RESULT AND EVALUATION

5.1 Introduction

This chapter delves into the comprehensive results and detailed evaluation process conducted during the study. The focus is on the insights gathered through the use of questionnaires, which were designed to capture feedback from both users and experts during the testing phase. Specifically, the System Usability Scale (SUS) was employed to assess overall usability, while pre- and post-Session Simulator Sickness Questionnaires (SSQ) were used to evaluate any potential discomfort or symptoms experienced before and after the virtual reality experience. By analyzing the responses from both user and expert perspectives, a thorough understanding of the system's performance, user satisfaction, and the effectiveness of the virtual reality shopping mall environment is provided. This chapter presents these findings in detail, highlighting key trends, observations, and areas for improvement based on the collected data.

5.2 Quantitative Analysis

5.2.1 System Usability Scale (SUS)

The user testing process was conducted at SMK Datin Onn Batu Pahat, where 12 students and 2 teachers participated in evaluating the virtual reality project. The testing took place in a dedicated office space, providing a controlled environment for the participants,

who were all from the Lower 6 classes. Table below shows the System Usability (SUS) data table.

Table 5.1 The System Usability Scale (SUS) Data Table

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Raw Score	Final Score
P1	3	3	4	3	5	1	5	2	3	3	28	70
P2	4	3	5	3	4	2	3	2	4	2	28	70
P3	5	2	5	4	4	1	4	5	4	4	26	65
P4	4	4	4	2	3	1	4	4	3	4	23	57.5
P5	5	3	3	1	5	1	5	1	3	3	32	80
P6	3	3	4	4	4	2	5	3	3	3	24	60
P7	4	1	3	3	3	3	4	3	4	3	25	62.5
P8	3	1	3	2	4	3	4	3	4	3	26	65
P9	3	3	2	3	4	3	3	3	3	4	19	47.5
P10	4	2	4	3	5	2	5	1	3	3	30	75
P11	5	3	3	5	5	2	5	3	5	3	27	67.5
P12	5	3	5	1	5	1	5	1	3	3	34	85
P13	3	5	4	3	4	2	5	3	3	4	22	55
P14	5	2	5	2	4	2	5	1	3	3	32	80
P15	5	3	4	1	5	1	5	2	5	3	34	85
P16	3	4	4	2	4	3	5	2	4	2	27	67.5
P17	4	5	5	2	4	3	5	2	4	2	28	70
P18	4	4	4	2	4	2	4	2	4	2	28	70
P19	4	2	4	1	4	1	4	2	5	1	34	85
Average												69.342

The System Usability Scale (SUS) score for the evaluated VR system averaged 69.342, based on the responses from 17 participants. This score, which is slightly below the industry benchmark of 69, suggests that the system's usability is close to average but could benefit from some enhancements. While many participants found the system easy to use and believed it would be quickly learned by most people, there were noted concerns regarding its complexity and perceived inconsistencies. Some users also found the system cumbersome at times. Overall, the SUS score of 68.38 indicates that the system is functional but has room for improvement. Addressing the identified issues, such as simplifying the

interface and ensuring greater consistency, could enhance the user experience and lead to a higher SUS score in future assessments.

5.2.2 Simulation Sickness Questionnaire (SSQ)

To ensure a thorough assessment, each participant was first asked to complete a pre-Session Simulator Sickness Questionnaire (pre-SSQ) to gauge their initial state before engaging with the virtual reality experience. Following this, the students and teachers were individually invited to immerse themselves in the VR project, allowing them to interact and explore the virtual environment.

Once the testing was completed, participants were required to fill out two additional questionnaire which is the post-Session Simulator Sickness Questionnaire (post-SSQ). Figure 5.1 below shows the radar chart SSQ scores.

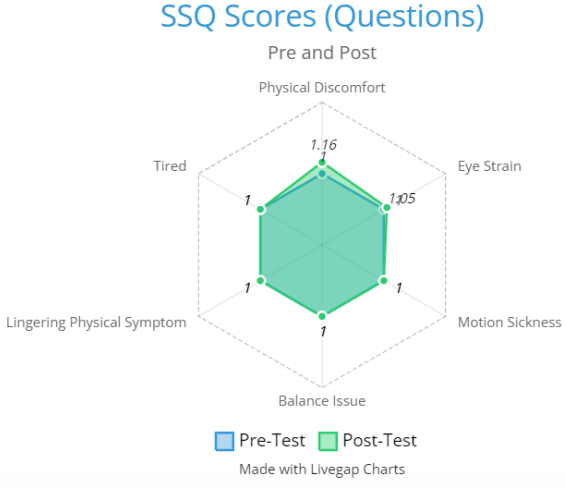


Figure 5.1 SSQ Score

The results from the Simulator Sickness Questionnaire (SSQ) scores inside Figure 5.1 above, reveal some interesting insights into the participants' experiences before and after the VR test. The radar chart shows a minor increase in the SSQ (Simulator Sickness Questionnaire) scores for Physical Discomfort and Eye Strain after a virtual reality session. Specifically, Physical Discomfort rose from 1 to 1.16, and Eye Strain increased from 1 to 1.05. This suggests that participants experienced slightly more discomfort and eye strain following the session. Meanwhile, other symptoms, such as Motion Sickness, Balance Issues, Lingering Physical Symptoms, and Tiredness, remained unchanged, with both pre-test and post-test scores staying at 1. This indicates that while there was a slight increase in some symptoms, most remained stable throughout the session.

5.3 Qualitative Analysis

5.3.1 Expert Review

For expert testing, a valuable approach involves usability testing with an expert panel evaluation. This method entails assembling a group of experts familiar with the system being assessed. This approach ensures that the evaluation is thorough and offers a deep understanding of the system's usability from a professional standpoint (Amin et al., 2022).

5.3.2 Expert Bibliography

The first expert, Shafina binti Abd Karim Ishigaki, is a distinguished lecturer at FTMK. Her impressive background includes pioneering research on holographic telepresence, mixed reality telepresence, and holographic displays, which has significantly

advanced the field. Her innovative work in these areas has earned her recognition as a top expert in virtual technologies. Currently, she teaches motion graphics, bringing a wealth of knowledge and expertise to the review of the virtual reality mall project.

The second expert, Madam Fatin Alia, is a respected lecturer at FTMK with a focus on virtual reality courses. Her in-depth knowledge and hands-on guidance in teaching VR make her an ideal expert for reviewing the virtual reality mall project. Her experience in the field ensures a well-rounded evaluation, bringing practical insights and a deep understanding of VR technology to the assessment.

The third expert is Rosli bin Othman, a seasoned professional from the business industry. He serves as a co-curriculum senior assistant and is also actively involved in managing the SMK Datin Onn Koperasi. His extensive experience in handling the school cooperative provides him with valuable insights into business operations and user engagement. His expertise makes him a key contributor to evaluating the virtual reality mall project, offering practical perspectives on its potential for future business applications and market integration.

The final expert from the business industry is Benson Tey, who works as a distributor of educational books through his company, Edaran Buku Mestika. With his extensive experience in the book distribution business, he brings a valuable perspective to the review of the virtual reality mall. His role involves understanding market needs and customer

preferences, making him well-suited to assess how the virtual mall could fit into the future of business and consumer engagement.

5.4 Expert Review Result

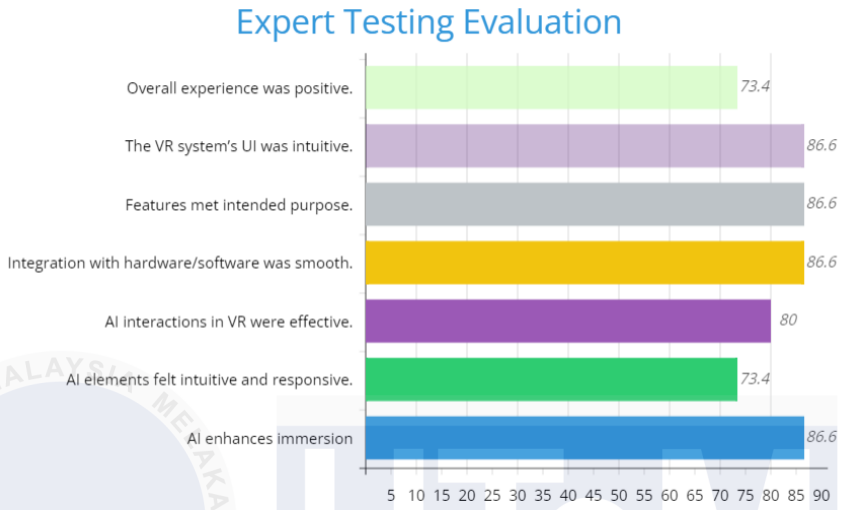


Figure 5.2 Expert Feedback

Based on the ratings inside Figure 5.2 above provided by the participants, the overall evaluation of the VR system reveals several key insights. Participants found the VR system's user interface to be quite intuitive, with an average rating of approximately 4.33 out of 5, translating to an 86.6% satisfaction level. The system's integration with other hardware and software received a solid average rating of 4.00, or 80%, indicating effective compatibility. However, the features and functionalities of the VR system were rated slightly lower, with an average of 3.67 (73.4%), suggesting room for improvement in meeting the intended purposes.

In terms of AI interactions, participants rated the effectiveness of these interactions highly, with an average of 4.33, reflecting a strong 86.6% satisfaction. The responsiveness and intuitiveness of the AI elements were also rated highly at 4.33 (86.6%), indicating that the AI contributed positively to the VR experience. Overall, the VR system received a mixed

review with an average rating of 3.67 (73.4%) for the overall experience, showing that while certain aspects were well-received, others could benefit from enhancements to achieve a more consistent level of satisfaction.

Experts were asked in the questionnaire to identify what they consider to be the key strengths of the virtual reality mall system. They were also requested to provide recommendations for enhancing both the user experience and the system's functionality. In their responses about key strengths, most experts highlighted aspects like:

The 3D environment, assets and AI integration

Design of the mall, well build mall and immersive, realistic environment

While for the recommendation to enhance the virtual reality mall, their response is:

Add hologram effect like GSC VR advertisement.

Add mirror feature that allows users to see themselves trying on items

The experts identified several key strengths of the virtual reality mall system, highlighting its well-crafted 3D environment, high-quality assets, and effective AI integration, as well as its immersive and realistic design. For recommendations, they suggested incorporating hologram effects for advertisements and adding a mirror feature to

let users see themselves trying on items. Implementing these suggestions will enhance the project, making it more engaging and immersive. These improvements will guide future work, ensuring the system evolves to offer an even better user experience and functionality.

5.5 Conclusion

This chapter concludes the examination of results and feedback from the virtual reality mall study. The analysis reveals that the VR experience was generally well-received, though there were some areas needing improvement.

Participants found the VR environment engaging, but some reported issues with navigation and visual clarity. Minor increases in discomfort and eye strain were noted, though there was a reduction in motion sickness and tiredness, indicating overall positive user experience.

Experts highlighted the strengths of the well-designed 3D environment, high-quality assets, and effective AI integration. Recommendations for enhancements include incorporating hologram advertisements and adding a mirror feature for virtual try-ons.

Overall, while the VR mall system performs well, there are opportunities for refinement. The feedback and suggestions provided will guide future development efforts to enhance the system's immersion and user satisfaction.

CHAPTER 6

PROJECT CONCLUSION

6.1 Observation of Strength and Weakness

In this chapter, involves analysing both the positive aspects and areas needing improvement in the project. In the context of a VR mall project, this means identifying effective elements such as smooth navigation or engaging visuals and addressing problematic areas, such as technical glitches or confusing interfaces. Building on strengths enhances features that are most enjoyable for users, while recognizing and addressing weaknesses leads to targeted improvements. This approach not only refines the current system but also guides future development and testing efforts, contributing to a more successful and user-friendly virtual reality mall.

6.2 Proposition for Improvement

The expert feedback highlights several key areas for improvement in the payment process of the virtual reality mall project. Addressing these issues can significantly enhance the user experience and streamline the payment workflow.

1. Ensure Accurate Navigation for Viewing Purchase Output:

The first issue involves ensuring that the output from items purchased in the mall matches what is displayed on the website. To address this, implementing a robust synchronization system between the VR environment and the website is crucial. This could involve real-time data integration, where any item selected or

purchased within the VR mall is immediately reflected on the website. Additionally, thorough testing and quality assurance should be conducted to ensure consistency across both platforms, minimizing discrepancies and enhancing user confidence in the transaction process.

2. Simplify the Checkout Process:

The checkout process, which currently requires the user to use both hands (left hand to view the panel and right hand to make selections), has been described as cumbersome. To improve this, redesigning the user interface for the payment system to allow one-handed operation could be beneficial. Implementing gesture-based controls or voice commands to navigate and confirm payments could also make the process more intuitive and less physically demanding. This change would make the payment experience smoother, especially in a VR environment where ease of interaction is paramount.

3. Enhance Payment Website Accessibility and Usability:

The difficulty in opening the payment website and the brightness level making it hard to see the content clearly are significant usability concerns. Optimizing the website for faster load times by minimizing heavy scripts or large images can resolve issues related to the website struggling to open. Additionally, offering a dark mode or adjustable brightness settings within the VR environment could help users comfortably view and interact with the payment site. Ensuring that the website is responsive and

user-friendly in various lighting conditions will make the payment process more accessible and pleasant.

By implementing these improvements, the payment process within the VR mall will become more seamless, user-friendly, and reliable, addressing the concerns raised by the experts and enhancing the overall virtual shopping experience.

6.3 Contribution

The contributions to the virtual reality (VR) mall project focused on enhancing user experience, improving system functionality, and integrating expert feedback. Key efforts included conducting user and expert testing at SMK Datin Onn Batu Pahat, where valuable insights were gathered to identify areas for improvement. This led to a redesign of the payment process, addressing issues like cumbersome checkout sessions and website accessibility. Additionally, AI features were integrated to make the mall more interactive and immersive. These efforts collectively shaped the VR mall into a more refined, user-friendly, and engaging virtual shopping experience.

6.4 Conclusion

In conclusion, the virtual reality (VR) shopping mall project successfully achieved its primary objectives, creating an immersive shopping experience that addresses the limitations of traditional and current online shopping.

Firstly, the project identified the essential mechanics needed to build a virtual world, establishing the foundational elements required for a seamless and engaging VR environment. Secondly, an immersive virtual emporium shopping mall simulation was developed, offering users a realistic and interactive shopping experience within the virtual space. Finally, the usability of the VR shopping mall was thoroughly evaluated, focusing on user interaction, ease of use, and overall satisfaction. The insights gained from user testing and expert feedback were instrumental in refining the system, ensuring that the VR mall provides a user-friendly and enjoyable experience.

Through these efforts, the project not only met but exceeded its goals, paving the way for more advanced and immersive VR applications in the future of shopping.

REFERENCES

Abbas, J. R., O'Connor, A., Ganapathy, E., Isba, R., Payton, A., McGrath, B., Tolley, N., & Bruce, I. A. (2023). What is Virtual Reality? A healthcare-focused systematic review of definitions. *Health Policy and Technology*, *12*(2), 100741. https://doi.org/10.1016/j.hlpt.2023.100741

Aloysius, J. A., Arora, A., & Venkatesh, V. (2019). Shoplifting in mobile checkout settings: cybercrime in retail stores. *Information Technology & People*, *32*(5), 1234–1261. https://doi.org/10.1108/itp-06-2018-0292

Anshika, N., Kumar, A., Thakur, S., Thakur, K., & Singh, G. (2023). Enhanced efficiency and customer engagement through the online shopping arcade with vendor recommendation and Pre-Booking system. *International Conference on Computing, Communication, and Intelligent Systems (ICCCIS)*. https://doi.org/10.1109/icccis60361.2023.10425280

Amin, S. F. . M., Sharif, S., Taat, M. S., Madjapuni, M. N., & Mariappan, M. (2022). IMPLEMENTATION OF USABILITY TESTING USING EXPERT PANEL EVALUATION METHOD IN THE EVALUATION PHASE OF M-SOLAT ROBOT MODULE. https://www.semanticscholar.org/paper/IMPLEMENTATION-OF-USABILITY-TESTING-USING-EXPERT-IN-Siti-Fauziah-Sharif/70e550fe95b2394d8626d0cd53e6f46c2b1347f1

Arena, F., Collotta, M., Pau, G., & Termine, F. (2022). An overview of augmented reality. *Computers*, *11*(2), 28. https://doi.org/10.3390/computers11020028

Bahadori, S., Collard, S., Williams, J. M., & Swain, I. (2020). Why do people undergo THR and what do they expect to Gain—A comparison of the views of patients and health care professionals. *Journal of Patient Experience*, *7*(6), 1778–1787. https://doi.org/10.1177/2374373520956735

Bangor, A., Kortum, P., & Miller, J. (2009). Determining what individual SUS scores mean: adding an adjective rating scale. *Journal of Usability Studies Archive*, *4*(3), 114–123. http://uxpajournal.org/wp-content/uploads/pdf/JUS_Bangor_May2009.pdf

Barth, J. (2007). Customer engagement and the operational efficiency of wine retail stores. *International Journal of Wine Business Research*, *19*(3), 207–215. https://doi.org/10.1108/17511060710817230

Burdea, G., & Coiffet, P. (2003). Virtual Reality Technology. *Presence*, *12*(6), 663–664. https://doi.org/10.1162/105474603322955950

Claramunt, L., Rubio-Medrano, C. E., Baek, J., & Ahn, G. (2023). *SpaceMediator: Leveraging authorization policies to prevent spatial and privacy attacks in mobile augmented reality*. https://www.semanticscholar.org/paper/SpaceMediator%3A-Leveraging-Authorization-Policies-to-Claramunt-Rubio-Medrano/97e39dea7ab15cd85fd8894935f4e14c02ea985c

Coleman, P. (2007). Shopping environments. In *Routledge eBooks*. https://doi.org/10.4324/9780080480909

Darehshiri, M., Asl, M. G., Adekoya, O. B., & Shahzad, U. (2022). Cross-spectral coherence and dynamic connectedness among contactless digital payments and digital communities, enterprise collaboration, and virtual reality firms. *Technological Forecasting & Social Change/Technological Forecasting and Social Change*, *181*, 121764. https://doi.org/10.1016/j.techfore.2022.121764

Divya, D., & Mallik, H. (2022). *APPLICATION OF ARTIFICIAL INTELLIGENCE IN THE PAYMENT SYSTEM*. https://www.semanticscholar.org/paper/APPLICATION-OF-ARTIFICIAL-INTELLIGENCE-IN-THE-Divya-Mallik/7c6379e6650c382c4d66a4cfb5209b470572fbdb

Dozio, N., Marcolin, F., Scurati, G. W., Ulrich, L., Nonis, F., Vezzetti, E., Marsocci, G., La Rosa, A., & Ferrise, F. (2022). A design methodology for affective Virtual Reality. *International Journal of Human-computer Studies*, *162*, 102791. https://doi.org/10.1016/j.ijhcs.2022.102791

Friedel, A. L., Siegel, S., Kirstein, C. F., Gerigk, M., Bingel, U., Diehl, A., Steidle, O., Haupeltshofer, S., Andermahr, B., Chmielewski, W., & Kreitschmann-Andermahr, I. (2023). Measuring Patient Experience and Patient Satisfaction—How are we doing it and why does it matter? A comparison of European and U.S. American approaches. *Healthcare*, *11*(6), 797. https://doi.org/10.3390/healthcare11060797

Hassan, A., Shukur, Z., & Hasan, M. K. (2020). An efficient secure electronic payment system for E-Commerce. *Computers*, *9*(3), 66. https://doi.org/10.3390/computers9030066

Howard, E. (2007). New shopping centres: is leisure the answer? *International Journal of Retail & Distribution Management*, *35*(8), 661–672. https://doi.org/10.1108/09590550710758649

Hsu, W., Chen, P., & Chen, C. (2020). An exploration of the impact of virtual reality interfaces on online shopping. *Information Resources Management Journal*, *33*(2), 19–39. https://doi.org/10.4018/irmj.2020040102

Ing, P., Ivan, L. R. V., & Osman, Z. (2019). The relationship between Malaysian supermarket In-Store shopping experiences and positive Word-of-Mouth. *International Journal of Marketing Studies*, *11*(2), 115. https://doi.org/10.5539/ijms.v11n2p115

Jiang, Y., Tran, T. H., & Williams, L. (2023). Machine learning and mixed reality for smart aviation: Applications and challenges. *Journal of Air Transport Management*, *111*, 102437. https://doi.org/10.1016/j.jairtraman.2023.102437

Jin, W., Sun, Y., Wang, N., & Zhang, X. (2017). Why users purchase virtual products in MMORPG? An integrative perspective of social presence and user engagement. *Internet Research*, *27*(2), 408–427. https://doi.org/10.1108/intr-04-2016-0091

Jones, M. (1999). Entertaining Shopping Experiences: an exploratory investigation. *Journal of Retailing and Consumer Services*, *6*(3), 129–139. https://doi.org/10.1016/s0969-6989(98)00028-9

Kwok, A. O. J., & Koh, S. G. M. (2020). COVID-19 and extended reality (XR). *Current Issues in Tourism*, *24*(14), 1935–1940. https://doi.org/10.1080/13683500.2020.1798896

Lee, K. C., & Chung, N. (2005a). A web DSS approach to building an intelligent internet shopping mall by integrating virtual reality and avatar. *Expert Systems With Applications*, *28*(2), 333–346. https://doi.org/10.1016/j.eswa.2004.10.013

Lee, K. C., & Chung, N. (2005b). A web DSS approach to building an intelligent internet shopping mall by integrating virtual reality and avatar. *Expert Systems With Applications*, *28*(2), 333–346. https://doi.org/10.1016/j.eswa.2004.10.013

Lee, K. C., & Chung, N. (2008). Empirical analysis of consumer reaction to the virtual reality shopping mall. *Computers in Human Behavior*, *24*(1), 88–104. https://doi.org/10.1016/j.chb.2007.01.018

Lepouras, G., & Vassilakis, C. (2006). Adaptive virtual reality shopping malls. In *IGI Global eBooks* (pp. 1–6). https://doi.org/10.4018/978-1-59140-799-7.ch001

Li, J., Arora, S. S., Fawaz, K., Kim, Y., Liu, C., Meiser, S., Minaei, M., Shirvanian, M., & Wagner, K. (2024). Exploring the interplay between interaction experience and security perception of payment authentication in virtual reality. *Conference Proceedings*. https://doi.org/10.1109/vrw62533.2024.00318

Ling, Z., Li, Z., Chen, C., Luo, J., Yu, W., & Fu, X. (2019). *I know what you enter on Gear VR*. https://www.semanticscholar.org/paper/I-Know-What-You-Enter-on-Gear-VR-Ling-Li/48926fe2499996de383f3df9b473ed7831da5bcc

Moghavvemi, S., Mei, T. X., Phoong, S. W., & Phoong, S. Y. (2021). Drivers and barriers of mobile payment adoption: Malaysian merchants' perspective. *Journal of Retailing and Consumer Services*, *59*, 102364. https://doi.org/10.1016/j.jretconser.2020.102364

Morimoto, T., Kobayashi, T., Hirata, H., Otani, K., Sugimoto, M., Tsukamoto, M., Yoshihara, T., Ueno, M., & Mawatari, M. (2022a). XR (Extended Reality: Virtual Reality, Augmented Reality, Mixed Reality) Technology in Spine Medicine: status quo and Quo vadis. *Journal of Clinical Medicine*, *11*(2), 470. https://doi.org/10.3390/jcm11020470

Morimoto, T., Kobayashi, T., Hirata, H., Otani, K., Sugimoto, M., Tsukamoto, M., Yoshihara, T., Ueno, M., & Mawatari, M. (2022b). XR (Extended Reality: Virtual Reality, Augmented Reality, Mixed Reality) Technology in Spine Medicine: status quo and Quo vadis. *Journal of Clinical Medicine*, *11*(2), 470. https://doi.org/10.3390/jcm11020470

Negotiating Tradition, modernity and Identity in consumer space: A study of a shopping mall and revived coffeehouse - ProQuest. (n.d.). https://www.proquest.com/docview/2652593297?pq-origsite=gscholar&fromopenview=true&sourcetype=Dissertations%20&%20Theses

Nelson, P. (1970). Information and consumer behavior. *Journal of Political Economy*, *78*(2), 311–329. https://doi.org/10.1086/259630

Okahashi, S., Seki, K., Nagano, A., Luo, Z., Kojima, M., & Futaki, T. (2013). A virtual shopping test for realistic assessment of cognitive function. *Journal of Neuroengineering and Rehabilitation*, *10*(1), 59. https://doi.org/10.1186/1743-0003-10-59

Ouellet, É., Boller, B., Corriveau-Lecavalier, N., Cloutier, S., & Belleville, S. (2018). The Virtual Shop: a new immersive virtual reality environment and scenario for the

assessment of everyday memory. *Journal of Neuroscience Methods*, *303*, 126–135. https://doi.org/10.1016/j.jneumeth.2018.03.010

Petersen, G. B., Petkakis, G., & Makransky, G. (2022). A study of how immersion and interactivity drive VR learning. *Computers and Education/Computers & Education*, *179*, 104429. https://doi.org/10.1016/j.compedu.2021.104429

Peukert, C., Pfeiffer, J., Meißner, M., Pfeiffer, T., & Weinhardt, C. (2019). Shopping in virtual reality stores: The influence of immersion on system adoption. *Journal of Management Information Systems*, *36*(3), 755–788. https://doi.org/10.1080/07421222.2019.1628889

Pregowska, A., Osial, M., & Gajda, A. (2023). What will the education of the future look like? How have Metaverse and Extended Reality affected the higher education systems? *Metaverse Basic Appl. Res.*, *3*, 57. https://doi.org/10.56294/mr202457

Retail environments. (2016). In *Routledge eBooks* (pp. 70–94). https://doi.org/10.4324/9781315605920-10

Schnack, A., Wright, M. J., & Holdershaw, J. L. (2019). An exploratory investigation of shopper behaviour in an immersive virtual reality store. *Journal of Consumer Behaviour*, *19*(2), 182–195. https://doi.org/10.1002/cb.1803

Steurer, M. (2011). A webshop for digital assets in virtual worlds supported by a 3D object representation. *Institute of Interactive Systems and Data Science*, 171–176. https://graz.pure.elsevier.com/en/publications/a-webshop-for-digital-assets-in-virtual-worlds-supported-by-a-3d-

Trindade, N. V., Ferreira, A., Pereira, J. M., & Oliveira, S. (2023). Extended reality in AEC. *Automation in Construction*, *154*, 105018. https://doi.org/10.1016/j.autcon.2023.105018

Van Den Berg, P., Larosi, H., Maussen, S., & Arentze, T. (2021). Sense of place, shopping area evaluation, and shopping behaviour. *Geographical Research*, *59*(4), 584–598. https://doi.org/10.1111/1745-5871.12485

Vyavhare, S. B., Sonawane, M., Dange, R. T., & Chavan, A. A. (2018). Virtual shopping application by using "Virtual Reality Technology." *Journal of Emerging Technologies and Innovative Research*, *5*(4), 738–741. http://www.jetir.org/papers/JETIR1804349.pdf

Westermeier, C. (2020). Money is data – the platformization of financial transactions. *Information, Communication & Society*, *23*(14), 2047–2063. https://doi.org/10.1080/1369118x.2020.1770833

What is virtual reality? (2015). In *Association for Computing Machinery eBooks* (p. 9). https://doi.org/10.1145/2792790.2792793

Xiao, S. H., & Nicholson, M. (2012). A Multidisciplinary Cognitive Behavioural Framework of Impulse Buying: A Systematic Review of the literature. *International Journal of Management Reviews*, *15*(3), 333–356. https://doi.org/10.1111/j.1468-2370.2012.00345.x

Young, J., Sharlin, E., & Igarashi, T. (2011). What is mixed reality, anyway? considering the boundaries of mixed reality in the context of robots. In *Springer eBooks* (pp. 1–11). https://doi.org/10.1007/978-94-007-0582-1_1

Zhang, J. Z., Chang, C., & Neslin, S. A. (2021). How Physical stores Enhance Customer value: The importance of product inspection depth. *Journal of Marketing*, *86*(2), 166–185. https://doi.org/10.1177/00222429211012106

APPENDIX A: SMK DATIN ONN JAAFAR TESTING EVENT

The students and teachers tested the virtual reality mall, and questionnaires were given to them before and after testing the virtual environment inside the VR headset to evaluate their user experience.

APPENDIX B: SUS

Instruction: Please answer the System Usability Scale (SUS) question below based on:

1 – Strongly disagree | 2 – Disagree | 3 – Neutral | 4 – Agree | 5 – Strongly agree

No.	Question	1	2	3	4	5
1	I think that I would like to use this VR system frequently.					
2	I found the VR system unnecessarily complex.					
3	I thought the VR system was easy to use.					
4	I think that I would need the support of a technical person to be able to use this VR system.					
5	I found the various functions in this VR system were well integrated.					
6	I thought there was too much inconsistency in this VR system.					
7	I would imagine that most people would learn to use this VR system very quickly.					
8	I found the VR system very cumbersome to use.					
9	I felt very confident using the VR system.					
10	I needed to learn a lot of things before I could get going with this VR system					

APPENDIX C: PRE-SSQ

Instruction: Please answer the System Usability Scale (SUS) question below based on:

1 – None | 2 – Mild | 3 – Moderate | 4 – Significant | 5 – Severe

No.	Question	1	2	3	4	5
1	Are you currently experiencing any symptoms of illness (e.g., fever, cough, headache)?					
2	Do you have a history of seizures or epilepsy?					
3	Are you currently taking any medications that might affect your balance or vision?					
4	Do you have any known heart conditions or respiratory issues?					
5	Are you currently pregnant or suspect that you might be pregnant?					
6	Do you have any vision impairments or conditions that affect your sight?					
7	Are you wearing contact lenses or glasses?					
8	Do you have any hearing impairments or use hearing aids?					
9	Do you suffer from motion sickness or dizziness?					
10	Do you have any conditions affecting your balance or coordination?					
11	Have you had any recent surgeries or injuries, particularly involving the head, neck, or spine?					

APPENDIX D: POST-SSQ

Instruction: Please answer the System Usability Scale (SUS) question below based on:

1 – None | 2 – Mild | 3 – Moderate | 4 – Significant | 5 – Severe

No.	Question	1	2	3	4	5
1	How would you rate your overall experience with the virtual reality simulation?					
2	Did you experience any physical discomfort during or after using the VR headset?					
3	Did you notice any eye strain or visual discomfort while using the VR headset?					
4	Did you feel any motion sickness during or after the VR experience?					
5	Did you experience any balance issues or coordination problems after removing the VR headset?					
6	Have you had any lingering physical symptoms?					
7	Did you experience any unexpected fatigue or tiredness after the VR session?					
8	Were you able to navigate and interact with the virtual environment easily?					
9	Did you encounter any technical issues or glitches during the simulation?					
10	Was the VR headset comfortable to wear throughout the session?					

APPENDIX E: EXPERT TESTING

Instruction: Please answer the System Usability Scale (SUS) question below based on:

No.	Question	1	2	3	4	5
1	How would you rate your overall experience with the virtual reality simulation? (1 - Very Poor, 5 - Excellent)					
2	Did you face any challenges navigating the virtual environment? (1 - Very Poor, 5 - Excellent)					
3	Were the features and functionalities of the VR system adequate for its intended purpose? (1 – Very Inadequate, 5 – Very Adequate)					
4	How effective were the AI interactions within the VR environment? (1-Non Effective, 5-Very Effective)					
5	Were the AI elements responsive and intuitive? (1-Not all Responsive, 5-Very Responsive)					
6	How did the AI enhance or detract from your overall VR experience? (1 - Very Poor, 5 - Excellent)					
7	How would you rate the visual quality of the VR experience (e.g., graphics, resolution)? (1 - Very Poor, 5 - Excellent)					
8	How ergonomic were the controls and interaction devices? (1 - Very Poor, 5 - Excellent)					

What do you consider the key strengths of this VR system?

What areas need the most improvement according to your expert opinion?

What improvements or additional AI features would you suggest for enhancing the VR system?

Do you have any recommendations for enhancing the user experience and functionality?