NEAR EAST UNIVERSITY

INSTITUTE OF GRADUATE STUDIES

DEPARTMENT OF ARCHITECTURE

ENHANCING USER EXPERIENCE IN ARCHITECTURE THROUGH VIRTUAL REALITY DESIGN REVIEWS

M.Sc. THESIS

MUSTAPHA ABDULMUMINI

Nicosia

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M.Sc. THESIS

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October, 2024

Approval

We certify that we have read the thesis submitted by Mustapha Abdulmumini titled **"Enhancing User Experience in Architecture through Virtual Reality Design Reviews"** and that in our combined opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science in Architecture.

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Declaration

I hereby declare that all information, documents, analysis, and results in this thesis have been collected and presented according to the academic rules and ethical guidelines of the Institute of Graduate Studies, Near East University. I also declare that as required by these rules and conduct, I have fully cited and referenced information and data that are not original to this study.

Mustapha Abdulmumini

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Mustapha Abdulmumini

Abstract

Enhancing User Experience in Architecture through Virtual Reality Design Reviews

Abdulmumini, Mustapha

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This study investigates the utilization of Meta Quest 3 and Unreal Engine 5 in architectural design reviews to enhance user experience and optimize design processes. Through a mixed methods approach incorporating usability testing and questionnaire surveys, the impact of virtual reality technology on architectural workflows is examined, focusing on user experience, design preferences, and decision-making processes. Literature from virtual reality, design reviews, user experience, architecture visualization, and spatial experience informs the theoretical framework, highlighting the potential of VR technology to revolutionize traditional design review methods. The research design employs Unreal Engine to develop a highly immersive VR environment optimized for Meta Quest 3, leveraging features such as nanite, dynamic lighting, and others. Usability testing with 7 participants and a survey with 213 respondents provide insights into the developed system's effectiveness in facilitating spatial understanding, design visualization, and overall immersion. Findings reveal overwhelmingly positive feedback regarding the VR environment's visual quality, comfort, and responsiveness, with participants expressing a preference for immersive VR design over traditional methods and other VR alternatives. Recommendations for optimizing the use of Meta Quest 3 and Unreal Engine 5 in architecture design reviews are proposed, these recommendations serve as guidelines for architects and stakeholders willing to adopt VR technology to enhance design processes.

***Key Words*:** User Experience, Virtual Reality, Design Reviews, Stakeholder Collaboration, Spatial Experience.

Özet

Sanal Gerçeklik Tasarım İncelemeleri ile Mimarlıkta Kullanıcı Deneyiminin Geliştirilmesi

Mustapha Abdulmumini

M.Sc., Mimarlık Bölümü

Ekim, 2024, (127) sayfa

Bu çalışma, kullanıcı deneyimini geliştirmek ve tasarım süreçlerini optimize etmek amacıyla mimari tasarım incelemelerinde Meta Quest 3 ve Unreal Engine 5'in kullanımını araştırmaktadır. Kullanılabilirlik testi ve anket araştırmalarını içeren karma yöntem yaklaşımı aracılığıyla, sanal gerçeklik teknolojisinin mimari iş akışları üzerindeki etkisi, kullanıcı deneyimine, tasarım tercihlerine ve karar verme süreçlerine odaklanılarak inceleniyor. Sanal gerçeklik, tasarım incelemeleri, kullanıcı deneyimi, mimari görselleştirme ve mekansal deneyimden elde edilen literatür, teorik çerçeveyi bilgilendirerek VR teknolojisinin geleneksel tasarım inceleme yöntemlerinde devrim yaratma potansiyelini vurguluyor. Araştırma tasarımı, Meta Quest 3 için optimize edilmiş, nanit, dinamik aydınlatma ve diğerleri gibi özelliklerden yararlanan son derece sürükleyici bir VR ortamı geliştirmek için Unreal Engine'i kullanıyor. 7 katılımcıyla yapılan kullanılabilirlik testi ve 213 katılımcıyla yapılan bir anket, geliştirilen sistemin mekansal anlayışı, tasarım görselleştirmesini ve genel sürükleyiciliği kolaylaştırmadaki etkinliğine dair içgörü sağlıyor. Bulgular, sanal gerçeklik ortamının görsel kalitesi, konforu ve duyarlılığına ilişkin son derece olumlu geri bildirimleri ortaya koyuyor; katılımcılar, geleneksel yöntemlere ve diğer sanal gerçeklik alternatiflerine kıyasla sürükleyici sanal gerçeklik tasarımını tercih ettiklerini ifade ediyor. Mimari tasarım incelemelerinde Meta Quest 3 ve Unreal Engine 5'in kullanımını optimize etmeye yönelik öneriler önerilmektedir; bu öneriler, tasarım süreçlerini geliştirmek için VR teknolojisini benimsemeye istekli mimarlar ve paydaşlar için kılavuz görevi görmektedir..

Anahtar Kelimeler: Kullanıcı Deneyimi, Sanal Gerçeklik, Tasarım Incelemeleri, Paydaş Işbirliği, Mekansal Deneyim.

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List of Abbreviations

VR	Virtual Reality
UX	User Experience
BIM	Building Information Modelling
CAD	Computer-Aided Design
UCD	User-centred design
SPSS	Statistical Package for Social Sciences
AI	Artificial Intelligence
AR	Augmented Reality
HMD	Head Mounted Display
CAVE	Cave Automatic Virtual Environment

CHAPTER I

Introduction

In the Introduction Section, general information about the thesis is given: the problem status, purpose, importance and limitations of the research are stated. In addition, important concepts in the thesis are explained.

This study investigates the use of Meta Quest 3 and Unreal Engine 5 in architecture design review to address limitations in traditional visualization methods. The statement of the problem is conventional design reviews, relying on static images and physical models, often fall short in capturing the immersive qualities of architectural spaces, leading to potential misunderstandings and poor design outcomes. VR technology, by creating realistic, interactive environments, holds promise for overcoming these limitations, yet its integration into architecture remain challenging. The aim of the study is to explore VR's usability, performance and impact on design reviews, ultimately establishing guidelines and best practices for VR integration in Architecture. The research questions include how Meta Quest 3 influences user experience, how design preferences change with VR compared to traditional methods and the best practices for implementing VR to optimize design quality and client satisfaction. The hypothesis is VR improves design review quality, efficiency and satisfaction with Meta Quest 3 and Unreal Engine offering particular advantages.

The significance of this study is that this research aims to bridge the gap in understanding VR's impact on architectural practice, offering practical insights into enhancing design outcomes and user experience with Meta Quest 3 and Unreal Engine 5. The findings provide architects and stakeholders with guidance on effectively incorporating VR, improving design process quality and efficiency. The Gap in literature found in the literature review was, Although VR is recognized for its immersive potential, few studies address its systemic application and best practices in architectural design reviews, particularly using the latest available hardware and software. This study contributes by creating a comprehensive VR workflow, starting with initial design in Revit, refined in Sketch Up and finalized in

Unreal Engine 5. Usability testing with & participants and a survey of 213 respondents support a mixed methods approach revealing VR's benefits in enhancing spatial understanding, engagement and comfort in architectural visualization.

In contemporary architecture, the process of design reviews plays a huge role in ensuring the success of architectural projects. Traditionally, architects and designers rely on static drawings, 3D models, and physical scale models to communicate design concepts to clients, stakeholders, and project teams. While these methods offer valuable insights into the formal aspects of architecture, they often fail to capture the experimental qualities of architectural spaces. (Kalisperis et al., 2002). Virtual reality technology has emerged as a transformative tool in architecture, offering the potential to bridge this gap by providing immersive and interactive experiences of architectural designs.(Mahdavinejad et al., 2018) By simulating realistic environments, VR enables users to explore architectural spaces in a way that closely resembles real-world experiences.(Baals & Freiheit, 2020). This capability has significant implications for design review processes, as it allows stakeholders to engage with architectural designs on a deeper level gaining insights into the relationships between spaces, materials, lighting, and circulation that are not possible through traditional means. The focus of this study is to explore how Unreal Engine 5 can be used with the Meta Quest 3 VR headset to enhance the user experience in architecture through virtual reality design reviews and see how this combination compares with other options available in the industry. Unreal Engine 5, developed by Epic Games, is a cutting-edge game engine renowned for its real-time rendering capabilities and photo-realistic graphics (Unreal Engine, 2023). It provides architects and designers a powerful platform for creating highly detailed and visually immersive architectural visualizations. Complementing Unreal Engine 5, the Meta Quest 3 VR headset, manufactured by Meta, offers users a high-quality VR experience with its high-resolution displays, intuitive controls, and wireless design (Oculus, 2023). The Meta Quest 3's ergonomic design, fair price, and ease of use make it an ideal platform for experiencing architectural designs in VR, enabling architects, designers, and clients to immerse themselves in virtual environments without constraints. By leveraging the capabilities of Unreal Engine 5 and the Meta Quest 3 VR headset, Architects and designers can conduct more effective design reviews, facilitating better communication, collaboration, and decision-making throughout the architectural design process. This research aims to investigate the usability, performance, and impact of VR design reviews on architectural practice, identifying best practices and design guidelines for incorporating VR into the architectural workflow.

Statement of the Problem

Despite advancements in architectural visualization techniques, traditional design review processes often struggle to convey the spatial qualities of architectural designs effectively. Static drawings, 3D models, and physical scale models, while important for conveying formal aspects of architecture, often fall short of capturing the immersive and spatial qualities of architectural spaces. This limitation can lead to misunderstandings, misinterpretations, and poor design outcomes. VR technology presents a promising solution to this problem by offering immersive and interactive experiences of architectural designs. By simulating realistic environments, VR enables users to explore architectural spaces in a highly immersive and intuitive manner, by providing spatial relationships, materials, lighting, and circulation that are not achievable through traditional methods. However, the effective integration of VR into the architectural design process remains a challenge, requiring a deeper understanding of its usability, performance, and impact on design decision-making processes.

Purpose of the Study

The research is aimed at finding out how the combination of Unreal Engine and the Meta Quest 3 VR headset can be used to enhance the user experience in architecture through virtual reality design reviews, and also:

1. To understand the usability and performance characteristics of Unreal Engine 5 for architectural visualization purposes.
2. To understand how the Meta Quest 3 VR headset contributes to the immersive qualities of architectural spaces experienced in VR.
3. To identify the best practices and design guidelines for conducting effective VR design reviews in architectural practice.

Research Questions

The questions that this research aims to solve are:

1. What is the impact of Meta Quest 3 on user experience in architecture design reviews, and how can Meta Quest 3 be optimized to enhance the user experience?
2. How do architectural design preferences and decision-making processes differ when using Meta Quest 3 and Unreal Engine compared to traditional design review methods and other VR alternatives?
3. What are the key design guidelines and best practices for implementing Meta Quest 3 and Unreal Engine in architecture design reviews to optimize the user experience?
4. How does implementing Meta Quest 3 and Unreal Engine in architecture design reviews affect design quality, efficiency, and client satisfaction?

Research Hypotheses

Virtual reality improves architectural design reviews, and using Meta Quest 3 and Unreal Engine leads to better design quality, efficiency, and client satisfaction. Implementing design guidelines optimizes the user experience.

Significance of the Study

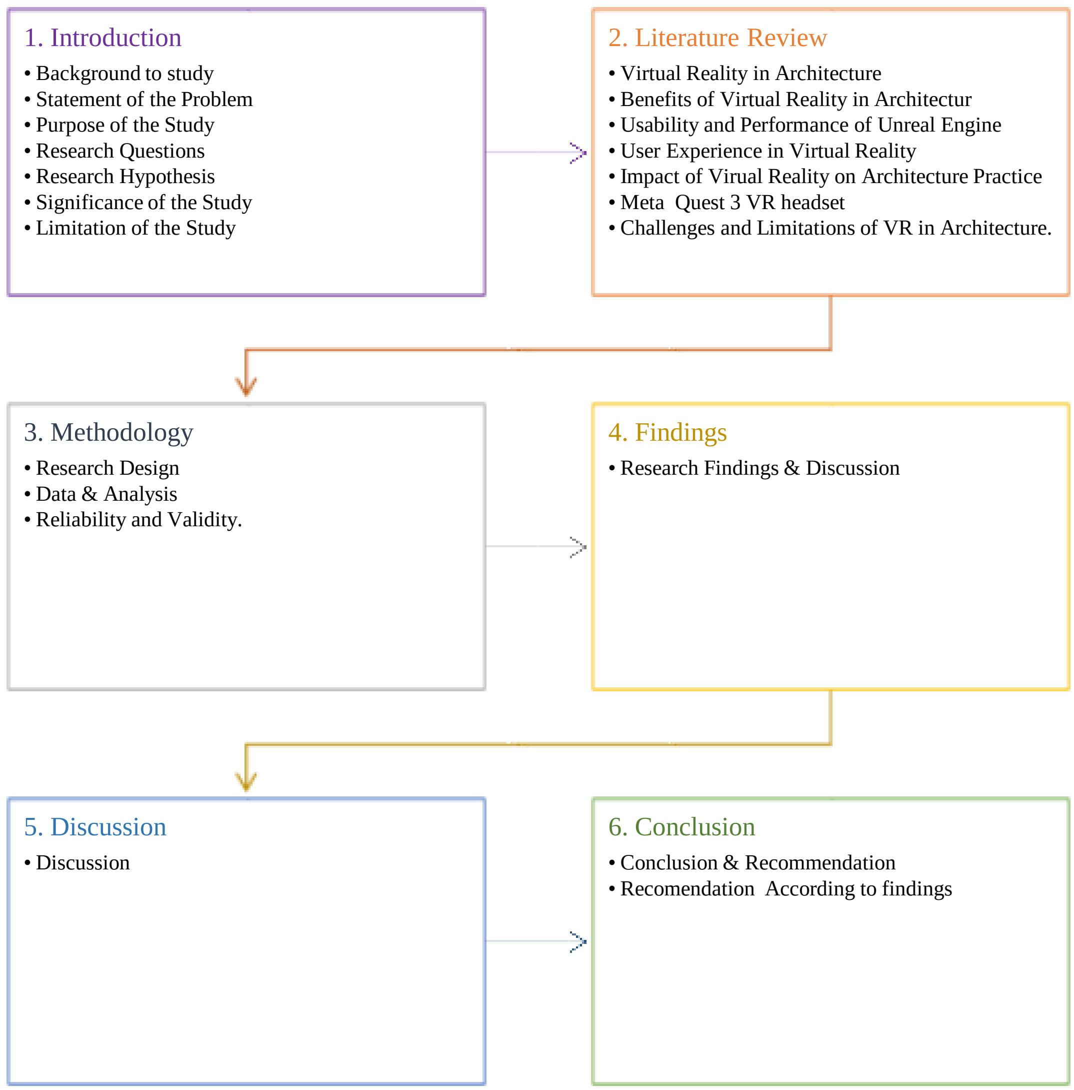
The outcomes of this study aim to contribute significantly to the understanding of how Meta Quest 3 and Unreal Engine can be strategically employed to enhance the user experience in architecture design reviews. By providing practical design guidelines and best practices, the research aims to empower architects and stakeholders to navigate the integration of VR technologies effectively, thereby optimizing the quality and efficiency of the design process.

Research Outline

The research outline includes the study layout, structure, and methods used to reach the aim. It includes an introduction highlighting the research topic, a literature review that summarizes previous studies, a methodology section showing the research's approach, findings presenting the results, a discussion section explaining the findings, and a conclusion section summarizing the study and making recommendations.

Figure 1

Research Outline



(Authors Work, 2024)

Limitations

The study's findings may be specific to the particular context, VR technology, and design scenarios employed in the research. It is essential to acknowledge that the results may not apply to all VR systems or architectural design contexts.

Definition of Terms

Virtual Reality

Virtual Reality refers to the computer-generated simulation of an environment that allows users to interact with and experience it as if they were physically present in that environment. VR typically involves the use of specialized hardware such as head-mounted displays (HMDs) and input devices to immerse users in virtual environments. These environments can be entirely fictional or based on real-world settings, and they often provide a sense of presence and immersion through realistic visuals, sounds, and interactions (Sherman & Craig, 2003).

Design Reviews

Design reviews are formal or informational evaluations of design concepts, proposals, or projects conducted to assess their quality, feasibility, and adherence to specific guidelines. In architecture, design reviews typically involve presenting an architectural design to stakeholders, such as clients, peers, and project teams, for feedback, critique, and approval. These reviews serve as critical checkpoints in the design process, facilitating communication, collaboration, and design-making among stakeholders (Burdett, 2016).

User Experience

User Experience covers all aspects of an individual's interaction with a product, service, or system, including their perceptions emotions, and behaviors before, during, and after interaction. In the context of architecture and design, user experience refers to the subjective experience of individuals such as architects, designers, clients, and users when engaging with architectural spaces, environments, or digital representations. This includes factors such as usability, satisfaction, immersion, and emotional response (Hassenzahl & Tractinsky, 2006).

Architecture Visualization

Architectural Visualization involves the creation and presentation of visual representations of architectural designs, typically using computer-generated imagery (CGI), 3D modelling, and rendering techniques. It encompasses a range of visual communication methods from hand-drawn sketches and diagrams to photorealistic renderings and virtual reality simulations. Architectural visualization is used to convey design ideas, spatial relationships, and aesthetic qualities to clients, stakeholders, and project teams throughout the design process (Portman, 2005).

Spatial Experience

Spatial Experience refers to the subjective perception and interpretation of architectural space by individuals as they navigate and interact with their surroundings. It encompasses sensory perceptions, such as sight, sound, and touch as well as cognitive and emotional responses to spatial qualities, such as scale, proportions, light, and materials. Spatial experience is influenced by factors such as architectural design, environmental context, and personal preferences and it plays a crucial role in shaping how individuals perceive and engage with built environments (Pallasmaa, 2005)

CHAPTER II

Literature Review and Related Research

The Literature review focused on virtual reality, design reviews, user experience and spatial experience exploring their qualities and connections to architectural visualization. This chapter presents these relationships through an analysis of previous research and relevant articles, including a review of related research about virtual reality used in a collaborative architectural design process and an exploration of virtual reality-enhanced experience in an exhibition-like space to establish a theoretical foundation.

Theoretical Framework

User Experience Design

User experience design in virtual reality architecture design reviews is pivotal for crafting meaningful and effective interactions between users and virtual environments (Pallasmaa, 2012). UX design ensures that VR experiences are both visually appealing and functionally intuitive, facilitating seamless navigation and engagements for architects, stakeholders, and clients (Mahdavinejad et al., 2018). Key components of UX design include usability, focusing on intuitive controls and efficient navigation (Hassenzahl, 2010); immersion, striving to create a sense of presence within virtual spaces (Wilson, 2002); satisfaction, aiming to fulfil users' needs and expectations (Hassenzahl, 2010); and emotional engagement, showing emotional responses to foster deeper connections with design concepts (Sanders & Stappers, 2008). Theoretical frameworks such as the Technology Acceptance Model (Davis,1989) and the User Experience Honeycomb by Peter Morville (Morville, 2004) provide insights into users' acceptance and adoption of VR technology, as well as guidelines for optimizing the quality of VR experiences across various dimensions. In essence, UX design in VR architecture design reviews is essential for enhancing usability, satisfaction, and emotional engagement, ultimately leading to more informed decision-making and better design outcomes.

Spatial Cognition and Perception

Spatial cognition and perception play a crucial role in understanding how users interact with and interpret virtual architectural spaces (Merleau-Ponty, 1962). Spatial cognition covers the mental processes involved in perceiving, navigating, and comprehending spatial environments within virtual reality (Hassenzahl, 2010). This includes factors such as spatial presence, which refers to the sense of being physically present within the virtual environment (Slater & Willbur, 1997), and perception of scale, which influences users' understanding of the size and proportions of architectural elements (Ferrer & Brain, 2018). Additionally, users' sense of navigation within VR spaces impacts their ability to explore and engage with architectural designs effectively (Mahdavinejad et al., 2018). Theoretical frameworks such as Spatial Presence theory (Witmer & Singer, 1998) and concepts from environmental psychology (Gifford, 2007) provide insights into how users perceive and experience virtual architectural environments, shedding light on the cognitive processes underlying their interactions. By understanding spatial cognition and perception, architects and designers can create more immersive and intuitive VR experiences that enhance users' understanding and appreciation of architectural designs.

Architectural Theory and Design Principles

Architecture theory and design principles provide a foundational framework for understanding and evaluating virtual architectural environments within the context of virtual reality design reviews (Pallasmaa, 2012). Architectural theory covers a range of principles and concepts that guide architectural design practice, including considerations of aesthetics, functionality, phenomenology, and semiotics (Bertin, 2010). Aesthetic principles dictate the visual qualities and artistic expression of architectural design, influencing users' emotional responses and perceptions within VR environments (Norberg-Schulz, 1980). Functional considerations address the practical aspects of design, ensuring that virtual spaces are conducive to their intended use and support efficient navigation and interaction (Schneider& Till, 2001). Phenomenological theories explore how users experience and perceive architectural spaces, emphasizing the subjective qualities of spatial experience and the role of sensory perception in shaping user interactions with VR environments (Merleau-Ponty, 1962). Semiotics examines the symbolic meaning and communication of architectural elements, informing the use of signs, symbols, and cultural references within virtual architectural designs (Bertin, 2010). Theoretical frameworks such as Vitruvius's principles of firmtas, utilitas, and venustas (Vitruvius Pollio et al., 1999), architectural phenomenology (Pallasmaa, 2012), and semiotics (Bertin, 2010) provide theoretical underpinnings for evaluating the aesthetic, functional and experiential qualities of virtual architectural environments in VR design reviews. By integrating architectural theory and design principles, architects and designers can create immersive and impactful VR experiences that effectively communicate design concepts and foster meaningful user engagements.

Relationship between the Concepts

Understanding the relationships between user experience design, spatial cognition & perception and architectural theory & design principles is crucial for enhancing VR based architectural design reviews. User experience design principles inform how users interact with and perceive VR environments, directly influencing their spatial cognition and overall satisfaction. Spatial cognition & perception theories provide insight into how users mentally and physically navigate VR spaces, impacting their sense of presence and immersion. Architectural Theory & design principles underpin the creation of VR environments, ensuring they are aesthetically pleasing, functional and meaningful. By integrating these concepts, the study can explore how VR technology can transform architectural design reviews, enhancing communication, collaboration and decision making processes. Table 13 below summarises these relationships.

Table 1

Relationship between the Concepts

Concept	Relationship	Explanation
User Experience Design	Spatial Cognition and Perception	UX design principles influence how users perceive and interact with spatial environments in VR.
	Architectural Theory and Design Principles	UX design aims to optimize the aesthetics and functional and

		experiential qualities of architectural designs in VR.
Spatial Cognition and Perception	User Experience Design	Spatial cognition influences users' immersion, satisfaction, and emotional engagement in VR architectural experiences.
	Architectural Theory and Design Principles	Spatial cognition shapes users' perception of architectural elements, spaces, and atmosphere in VR environments.
Architectural Theory and Design Principles	User Experience Design	Architectural principles guide the design of VR experiences to enhance usability, immersion, and satisfaction for users.
	Spatial Cognition and Perception	Architectural principles inform spatial organization and design decisions that influence users' cognitive perception in VR.

(Author's Work, 2024)

Explanation of Relationships

User Experience Design and Spatial Cognition/Perception: UX design principles inform the design of VR experiences to optimize users' spatial perception, navigation, and sense of presence within architectural spaces.

User Experience Design and Architectural Theory/Design Principles: UX design aims to integrate architectural principles and design aesthetics to create immersive and aesthetically pleasing VR experiences that meet users' needs and preferences.

Spatial Cognition and Perception and Architectural Theory/Design Principles: Architectural theory and design principles influence spatial cognition by shaping users' perception and interpretation of architectural forms, spaces, and atmosphere in VR environments.

This theoretical framework illustrates the interconnectedness of UX design, spatial cognition and perception, and architectural theory and design principles in shaping the user experience of VR architecture design reviews. By considering these concepts holistically, the study can provide insights into how VR technology can enhance architectural design processes and user engagement.

Virtual Reality in Architecture

Virtual Reality technology has increasingly become a transformative tool in architecture, revolutionizing the way architects, designers, and clients visualize and experience architectural designs. This section provides a general overview of the historical development, key milestones, and current trends of VR in architecture, demonstrating its evolution and potential to reshape the architectural design process.

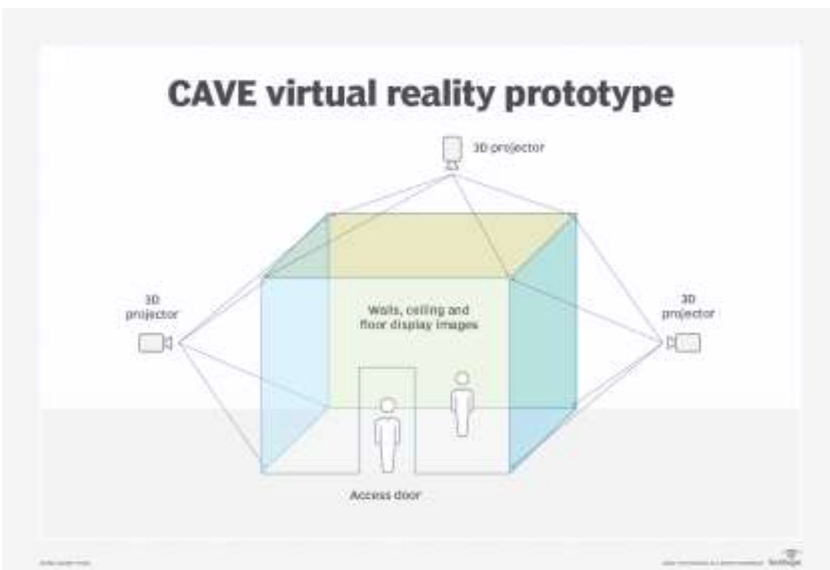
Historical Development of Virtual Reality in Architecture*:* The historical development of virtual reality in architecture traces back to early experimentation and conceptualization of immersive environments. This section explores the key milestones and influential developments that have shaped the introduction of VR technology into the architectural practice.

The roots of VR can be traced back to the 1960s and 1970s when pioneering researchers and technologists began exploring the possibilities of creating immersive computer-generated environments. Ivan Sutherland's "Ultimate Display" concept, proposed in his seminal paper envisioned a virtual world where users could interact with digital environments in real-time (Sutherland, 1995). In the following decades, researchers such as Myron Krueger and Ivan Sutherland continued to advance the field of VR through experiments with interactive installations and sensor-based interfaces. Krueger's pioneering work on responsive environments demonstrated the potential for creating immersive spatial experiences through interactive technologies (Krueger, 1977).

The 1990s saw the emergence of commercial VR systems that brought immersive experiences to a wider audience. One of the most notable developments was the introduction of CAVE (Cave Automatic Virtual Environment) by researchers at the University of Illinois at Urbana-Champaign in 1991. The cave was a room-sized virtual reality environment consisting of multiple screens surrounding the user, thereby providing a highly immersive experience as shown in Figure 2 below. (Cruz-Neira et al., 1992). Another influential VR system of the 1990s was the Virtual Reality Modelling Language (VRML), an open standard for creating 3D virtual worlds on the internet. VRML enabled architects and designers to showcase their projects in virtual environments accessible through web browsers, opening up access to VR technology and architectural visualization (Nadeau & Moreau, 1995).

Figure 2

How the CAVE prototype worked



(Tech Target, 2022)

Throughout the 2000s and 2010s, VR technology became increasingly integrated into architectural practice, driven by advancements in hardware, software, and rendering technologies. Architectural firms began using VR as a tool for design exploration, visualization, and communication, enabling clients and stakeholders to experience architectural spaces in immersive virtual environments. The introduction of consumer-grade VR hardware such as Oculus Rift and HTC Vive, further accelerated the adoption of VR in architecture, making immersive experiences more accessible and affordable. (Burry et al., 2015).

The historical development of VR in architecture shows a path of experimentation, innovation, and integration. From early concepts of immersive environments to the prospects of widespread adoption of VR technology in architectural practice, the evolution of VR is on course to reshape the way architects conceive, communicate, and experience architectural designs. As VR continues to advance and evolve, its role in architecture is in a position to expand, offering new possibilities for creativity, collaboration, and user engagement.

Design Reviews

Design reviews play a critical role in the architectural design process, serving as a mechanism for evaluating, refining, and validating design concepts before they are implemented. The primary objective of design reviews in architecture is to evaluate the quality, feasibility, and suitability of architectural designs across various stages of the design process. This includes conceptual, schematic, and detailed design phases, each focusing on different aspects of the project. Design reviews aim to critique architectural proposals from multiple perspectives, including functionality, aesthetics, sustainability, and compliance with building codes and regulations (Burdett, 2016). As shown in figure 3 below, design reviews also seek to foster collaboration and communication among project stakeholders, including architects, clients, engineers, consultants, and end users. By soliciting feedback and input from diverse stakeholders, Design reviews help architects identify design challenges anticipate potential issues, and explore alternative design solutions to optimize project outcomes (Sakr et al., 2020).

Figure 3

Traditional Architecture Design Review

(ArchDaily, 2015)

Importance of Design Reviews: The importance of design reviews in architecture cannot be overstated, as they serve several critical functions throughout the design process as stated in Table 1 below.

Table 2

Importance of Design Reviews.

Quality Assurance	Design review ensures that architectural designs meet high standards of quality and excellence. By putting designs through extensive analysis and evaluation, design review helps architects identify design flaws, inconsistencies, and deficiencies that may compromise the integrity and functionality of the built environment (Burdett, 2016).
Risk Reduction	Design reviews help reduce risks associated with architectural projects by identifying and addressing potential issues early in

	the design process. By conducting thorough assessments and evaluations, design review enables architects to anticipate challenges, reduce risks, and implement preventive measures to avoid costly errors and delays during construction (Sudjic, 2011).
Client Satisfaction	Design review plays a vital role in ensuring client satisfaction by aligning architectural designs with client needs, preferences, and expectations. By actively involving clients in the design review process, architects can get feedback, address concerns, and incorporate client input into the design development, fostering a sense of ownership and collaboration (Kalay, 2004).
Compliance and Regulation	Design review ensures compliance with building codes, zoning, regulations, and other legal requirements governing architectural projects. By assessing designs for compliance with regulatory standards, design review helps architects navigate complex legal regulatory landscapes, ensuring that designs adhere to safety, accessibility, and environmental standards (Burdett, 2016).

(Author's Work, 2024)

Design reviews play a pivotal role in architectural practice by serving as a mechanism for evaluating, refining, and validating design concepts to ensure they meet project objectives, client requirements, and regulatory standards. By subjecting designs to thorough assessments and critique, design review helps architects identify design challenges, reduce risks, and optimize project outcomes. With its emphasis on quality assurance, risk reduction, client satisfaction, and regulatory compliance, design reviews remain an indispensable aspect of the architectural design process, contributing to the creation of safe, functional, and aesthetically pleasing built environments.

Methods and Approaches to Design Reviews: Design review covers a variety of methods and approaches aimed at evaluating, refining, and analysing architectural designs. Table 2 below explains the various types of design review methods:

Table 3

Methods of Design Reviews.

Traditional Methods	Contemporary Methods
1. In-Person Meetings and Presentations: This often involves face-to-face meetings where architects present their designs to clients, stakeholders, and project teams. These meetings provide an opportunity for direct interaction, discussion, and feedback, allowing stakeholders to ask questions, express concerns, and provide input on design decisions (Burdett, 2016).	1. Digital Tools and Visualization Technologies: With advancements in digital and visualization technologies, architects have access to a wide range of software applications for conducting design reviews. Building Information Modelling (BIM) software allows architects to create detailed digital models of architectural projects, enabling stakeholders to visualize and analyse designs in 3D (Eastman et al., 2011). Additionally, Virtual reality technology enables architects to immerse stakeholders in virtual environments, providing a realistic and interactive experience of architectural designs (Mahdavinejad et al., 2018).
2. Peer Critiques and Design Workshops: This involves architects and designers critiquing each other's work in a collaborative setting. These sessions encourage constructive criticism, creative brainstorming, and knowledge sharing among colleagues, fostering a culture of continuous	2. Collaborative Platforms and Online Reviews: This offers an alternative approach to design reviews, allowing stakeholders to review and comment on designs remotely. Platforms such as BIM 360 Trimble Connect enable architects to share project data, collaborate in real time and gather feedback from distributed teams and

improvement and peer learning (Zeisel, 1981).	clients (Sakr et al., 2020). Inline reviews streamline the design process, making it more accessible, efficient, and inclusive for all stakeholders.

(Author's Work, 2024)

Integrated Design Review Processes: An emerging trend in design reviews is the integration of multiple methods and technologies to create holistic and multidimensional review processes. Integrated design review processes combine traditional methods with digital tools and technologies to leverage the strengths of each approach (Kalay, 2004). For example, architects may use a combination of in-person meetings, digital modelling, and VR simulations to facilitate comprehensive and effective design reviews that address diverse stakeholder needs and preferences.

Design reviews in architecture cover a variety of methods and approaches ranging from traditional in-person meetings to contemporary digital tools and technologies. While traditional methods such as in-person meetings and peer critiques remain common, advancements in digital tools, visualization technologies, and collaborative platforms have transformed the way design reviews are conducted. Integrated design review processes that combine multiple methods and technologies offer a comprehensive and multidimensional approach to evaluating architectural designs, fostering collaboration, creativity, and innovation in architectural practice.

Benefits and Challenges of Design Reviews: Design reviews offer a multitude of benefits to all the stakeholders involved in the industry contributing to the overall success of architectural projects, but they also face several challenges and limitations that can impact their effectiveness and outcome, as discussed in table 3 below. Understanding these challenges is crucial for architects and stakeholders to reduce risks and optimize the design review process.

Table 4

Benefits and Challenges of Design Reviews.

Benefits of Design Reviews	Challenges of Design Reviews
1. Transparency and Collaboration: Design reviews foster transparency and collaboration among project stakeholders by providing a platform for open communication and dialogue (Zeisel, 1981). Through collaborative design review sessions, architects and other stakeholders can share ideas, concerns, and feedback, ensuring that everyone's perspectives are considered in the design process (Sakr et al., 2020).	1. Time Constraints: One of the primary challenges of design reviews is time constraints, particularly in fast-paced construction projects (Sudjic, 2011). Design review processes often need to adhere to strict project schedules and deadlines, leaving limited time for thorough evaluation and feedback. As a result, design reviews may be rushed, leading to incomplete assessments and missed opportunities for improvement.
2. Shared Understanding of Design Intent: Design reviews help establish a shared understanding of the design intent and project goals among project team members (Burdett, 2016). By presenting design concepts and discussing their rationale, architects can ensure that stakeholders have a clear understanding of the design objectives, functional requirements, and aesthetic considerations driving the project.	2. Budget Limitations: Pose another significant challenge to design review processes, especially for projects with constrained financial resources (Burdett, 2016). Allocating sufficient resources for comprehensive design reviews, including personnel, technology, and facilities can be challenging, particularly for smaller firms or public sector projects.

3. Identification and Resolution of Design Conflicts: Design reviews serve as a platform for identifying and resolving design conflicts and inconsistencies early in the design process (Kalay, 2004). By scrutinizing design proposals and soliciting feedback from diverse perspectives, architects can proactively address potential conflicts, ensuring that the design meets functional, technical, and regulatory requirements.	3. Conflicting Stakeholder Interests: Design reviews often involve multiple stakeholders with diverse interests and priorities, leading to conflicts and disagreements (Zeisel, 1981). Conflicting stakeholder interests can disrupt the design review process, causing delays, compromises, and design decisions, particularly when stakeholders have different goals or preferences.
4. Risk Mitigation: Design reviews help mitigate risks associated with architectural projects by identifying and addressing potential issues before they impact project outcomes (Sudjic, 2011). By conducting thorough assessments and evaluations, architects can anticipate challenges, assess the feasibility of design solutions, and implement preventive measures to minimize risks.	4. Rushed Decisions and Compromise Solutions: In response to time constraints and budget limitations, the design review process may be at risk of rushed decisions and compromise solutions (Kalay, 2004). Architects and stakeholders may feel pressured to make quick decisions or settle for suboptimal design solutions to meet project deadlines or budgetary constraints, compromising the quality and integrity of the design
5. Optimization of Design Solutions: Design reviews facilitate the optimization of design solutions to meet user needs, preferences, and	5. Missed Opportunities for Innovation: The pressure to adhere to project schedules and budgets may result in missed opportunities for

performance criteria (Burdett, 2016). By soliciting feedback from clients, end users, and other stakeholders, architects can refine design proposals, include user preferences, and fine-tune design details to enhance functionality, usability, and satisfaction.	innovation and creativity in design review processes (Sudjic, 2011). Design review meetings focused on addressing immediate challenges or resolving conflicts may overlook innovative design ideas or alternative solutions that could enhance project outcomes.

(Author's Work, 2024)

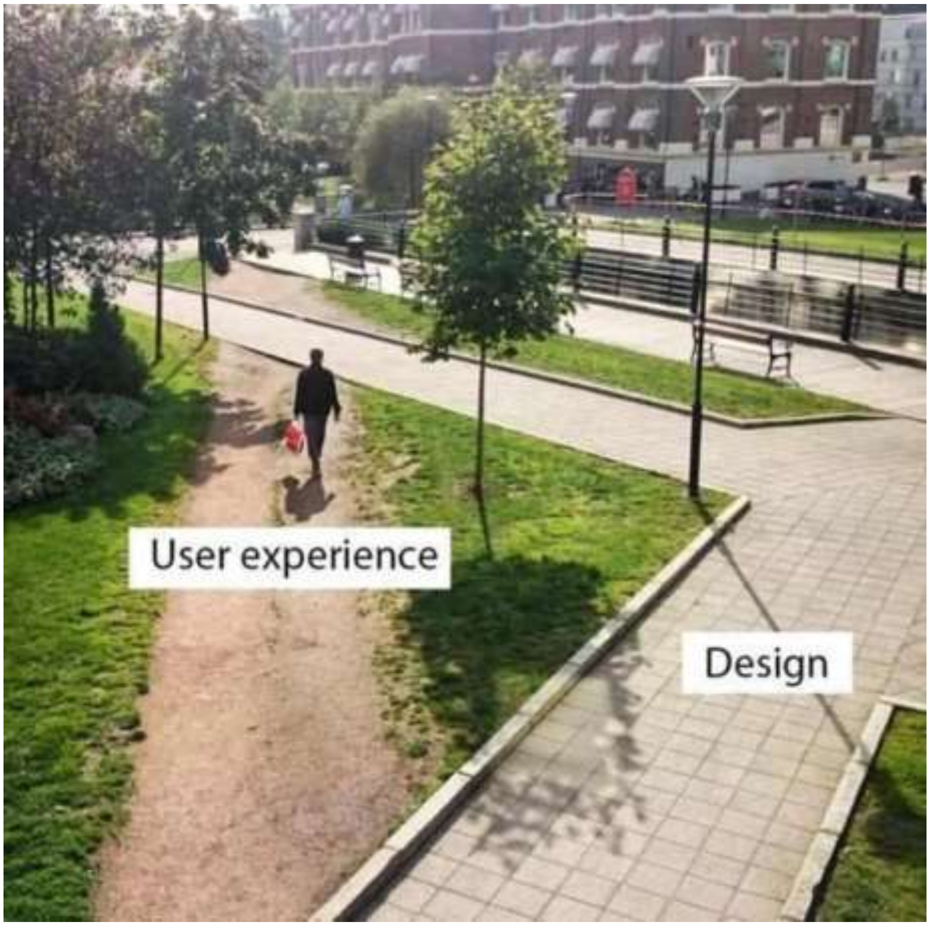
Design reviews offer many benefits in architecture which help architects meet user needs and project objectives, but they also face several challenges and limitations, addressing these challenges requires careful planning, effective communication, and commitment to prioritizing design excellence and project success.

User Experience

User experience in architecture covers the perception and interaction of users with architectural spaces, including sensory, cognitive, emotional, and behavioural aspects (Lew, 2006). Figure 4 below perfectly explains the importance of UX and reflects how individuals perceive, navigate, and engage with built environments, influencing their comfort, satisfaction, and overall well-being (Krukar, 2018), Enhancing UX in architecture is crucial for creating environments that meet the diverse needs and preferences of users, fostering a sense of belonging, identity, and connection to a place (Schneider & Till, 2001). Several factors influence user experience in architecture, including spatial layout, circulation patterns, lighting, materials, colours, acoustics, and environmental quality (Zeisel, 1981). These factors interact dynamically to shape users' perceptions, emotions, and behaviours within architectural spaces, contextual factors such as cultural norms, social dynamics, and historical significance also play a significant role in shaping user experience (Rapoport, 1990).

Figure 4

An image showing the importance of User Experience in Design



(Medium, 2017)

Methods for Assessing User Experience: Methods for assessing user experience in architecture are crucial for understanding how individuals perceive, interact with, and derive meaning from built environments, the methods are:

1. Surveys and Questionnaires: Surveys and questionnaires are commonly used to gather quantitative and qualitative data on user experience in architecture. These tools typically consist of structured or open-ended questions designed to assess users 'perceptions, preferences, and satisfaction levels regarding specific aspects of architectural spaces (Hassenzahl, 2010). Table 4 below discusses the strengths and limitations of surveys and questionnaires.

Table 5

Strengths and Limitations of Surveys and Questionnaires.

Strengths	Limitations
They allow architects to collect large data from a diverse range of users in a relatively short period. They provide insights into users' subjective experiences, attitudes, and preferences, enabling architects to identify patterns, trends, and areas for improvement.	They may yield subjective responses that are influenced by respondents' biases, expectations, and mood states. The design of survey questions and response options can also affect the validity and reliability of the data collected. Careful attention must be paid to survey design, administration, and analysis to ensure the accuracy and relevance of findings.

(Author's Work, 2024)

2. Interviews and Focus Groups: Interviews and focus groups involve direct interaction with users to explore their experiences perceptions and needs in greater depth. These qualitative research methods allow architects to gain insights into users' behaviours, emotions, and motivations within architectural contexts (Sanders & Stappers, 2008). Table 5 below discusses strengths and limitations of interviews and focus groups.

Table 6

Strengths and Limitations of Interviews and Focus Groups.

Strengths	Limitations
It facilitates open-ended discussions and rich narratives, providing detailed insights into users' experiences and perspectives. They allow architects to probe deeper into specific issues, clarify ambiguities, and explore diverse viewpoints, enriching the	It requires significant time, resources, and expertise to conduct effectively. They may be influenced by the dynamics of group interactions, power differential, and social desirability biases. The small sample sizes typical of qualitative research may limit the

understanding of user needs and preferences.	generalizability of findings to broader populations.

(Author’s Work, 2024)

3. Observations and Behavioural Mapping: Observation and behavioural mapping involves systematically observing users’ behaviours, movements, and interactions within architectural spaces. These methods provide objective data on how users navigate use and adapt to their environments, shedding light on spatial patterns, usage dynamics, and usability issues (Moudon & Hubb, 1997). Table 6 below discusses strength and limitations of observation and behavioural mapping.

Table 7

Strengths and Limitations of Observations and Behavioural Mapping.

Strengths	Limitations
It offers real-time insights into users’ behaviours, movements, and interactions within architectural spaces. They provide concrete evidence of how spaces are used in practice, helping architects identify spatial inefficiencies, circulation difficulties, and usability challenges.	It requires careful planning, trained observers, and standardized protocols to ensure reliability and consistency. They may be limited in capturing subjective experiences, emotions, and cognitive processes that influence user behaviour, and observations may be influenced by the observer’s biases.

(Author’s Work, 2024)

4. Post-Occupancy Evaluations: Post-occupancy evaluations involve systematically assessing users’ satisfaction, performance, and well-being in completed architectural projects. It typically combines multiple methods, including surveys, interviews, observations, and physical measurements, to comprehensively evaluate the effectiveness and impact of architectural designs (Hassenzahl, 2010). Table 7 below discusses the strength and limitations of post occupancy evaluations.

Table 8

Strengths and Limitations of Post-Occupancy Evaluations.

Strengths	Limitations
It provides valuable feedback on how well architectural designs meet users' needs, preferences, and expectations. They offer insights into the long-term usability, functionality, and sustainability of built environments, informing future design decisions and improvements.	It requires access to completed buildings and ongoing collaboration with building owners, occupants, and facility managers. They may be time-consuming, costly, and logistically challenging to conduct, Particularly for large-scale projects or complex buildings. It may be influenced by recall biases, social desirability biases, and changes in user perceptions over time.

(Author's Work, 2024)

Various methods can be used to assess user experience in architecture each offering unique insights into user perceptions, behaviours, and needs. By combining quantitative and qualitative approaches, architects can gain a comprehensive understanding of how architectural designs impact users' experiences and well-being, informing design decisions that prioritize user-centred outcomes.

Implications for Architectural Practice: User experience has significant implications for architectural practice, influencing design decision-making, project outcomes, and the role of architects in shaping built environments. Understanding and prioritizing UX in architectural practice can lead to more responsive, inclusive, and human-centred design solutions. Some key implications are discussed in table 8 below:

Table 9

Implications for Architectural Practice.

User-centred Design Approach	Embracing a user-centred approach is important for architects to create environments that meet the diverse needs and preferences of users (Sanders & Stappers, 2008), This approach involves actively involving end-users in the design process through participatory design methods, co-creation workshops, and user feedback sessions
Inclusive Design Practices	Prioritizing UX in architecture requires architects to adopt inclusive design practices that consider the diverse needs and abilities of all users, including individuals with disabilities, sensory sensitivities, and cultural backgrounds (Imms et al., 2015). Designing for inclusivity ensures that architectural spaces are accessible, equitable, and accommodating to everyone.
Human Centred Performance Metrics	Evaluating architectural projects based on human-centred performance metrics is essential for assessing their impact on user experience and well-being (Hassenzahl, 2010). Architects may use post-occupancy evaluations and user feedback mechanisms to measure user satisfaction, comfort, productivity, and health outcomes in completed buildings.
Collaborative Design Processes	Embracing UX in architecture requires architects to adopt collaborative design processes that involve multi-disciplinary teams and stakeholders throughout the design and construction phases (Sanders & Stappers, 2008). Collaboration facilitates cross-disciplinary insights, creative

	unity, and collective problem-solving, leading to more innovative and responsive design solutions,
Continuous Learning and Adaptations	Prioritizing UX in architectural practice requires architects to engage in continuous learning and adaptation, staying ahead of emerging trends, technologies, and user preferences (Sanders & Stappers, 2008). Architects must be open to feedback, experimentation, and continuous design processes to evolve their practice and deliver better outcomes for users.

(Author's Work, 2024)

User experience is a fundamental aspect of architecture, shaping how individuals perceive, engage with, and derive meaning from built environments. By understanding the factors influencing user experience and adopting user-centred design approaches, architects can create environments that are responsive, adaptable, and enriching for users. Prioritizing user experience in architectural practice not only enhances the functionality and usability of spaces but also contributes to human well-being satisfaction and quality.

Architecture Visualization

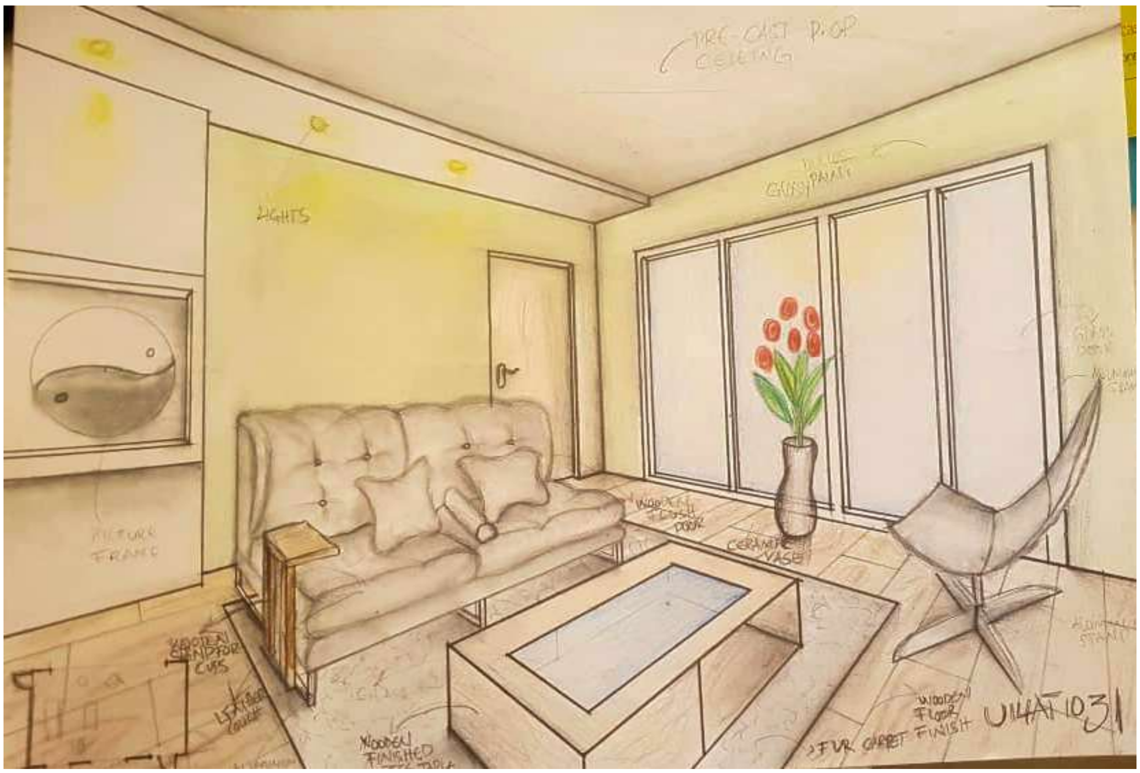
Architecture visualization plays a crucial role in architectural practice, enabling architects to communicate design concepts, explore spatial relationships, and convey the intended experience of built environments. Architecture visualization covers various techniques and technologies used to represent architectural designs visually, ranging from hand-drawn sketches and physical models to digital renderings and immersive simulations (Ferrer & Brain, 2018). Visualization serves as a powerful communication tool, allowing architects to convey design ideas, stimulate emotional responses and facilitate decision-making among clients, stakeholders, and project teams (Groat & Wang, 2013).

Methods and Tools for Architecture Visualization: The following are the tools for architectural visualization:

1. Hand drawn Sketches and Diagrams: Hand-drawn sketches and diagrams serve as indispensable instruments for architectural visualization. These tools empower architects to delve into design concepts, refine their ideas, and convey spatial relationships intuitively (Bertin, 2010). Sketches adeptly capture the gestural qualities and conceptual essence of architectural forms, allowing for the swift and fluid expression of design ideas as shown in figure 5 below.

Figure 5

Freehand Sketch of a Living Room



(Authors work, 2019).

2. Digital Rendering and Animation: Architects can leverage digital rendering and animation software to create highly realistic visual representations of their architectural designs, thereby significantly enhancing the overall realism and visual appeal of their projects (Krawczyk, 2019) as shown in figure 6 below. This technology provides architects with the ability to utilize advanced rendering tools such as Twin motion, V-ray, and Lumion, which empower them to generate not only high-quality images but also captivating animations and immersive virtual tours of their architectural endeavours.

Figure 6

3D Render of a Car Dealership

(Authors work, 2023).

3. Virtual Reality and Augmented Reality: Virtual reality (VR) and augmented reality (AR) technologies have revolutionized the way architects and designers interact with architectural designs. These innovative technologies provide highly immersive visualization experiences, allowing users to not only visualize but also interact with virtual architectural designs in a truly immersive manner (Mahdavinejad et al., 2018). By donning VR headsets such as Oculus Rift and HTC Vive, architects can step into virtual environments that provide a true-to-life experience, enabling them to evaluate designs at a human scale as shown in figure 7 below. This capability greatly enhances spatial comprehension, enabling architects to gain a deeper understanding of the design and its impact. Furthermore, the use of VR and AR facilitates design validation, as architects can effectively assess various design elements and make informed decisions based on their virtual experiences.

Figure 7

A Man Exploring the Virtual World.

(Johanhanegraaf, 2016).

4. Physical Models and Mock-ups: Physical models and mock-ups are widely recognized as essential tools for visualizing architectural designs. They provide tangible and interactive representations that enable architects, designers, and clients to physically explore and engage with the proposed structures. According to (Schneider and Till 2001), these models can take various forms, from basic massing models to intricate scale replicas, offering valuable insights into the dimensions, proportions, and materiality of the envisioned architectural compositions, as shown in figure 8 below.

Figure 8

An Exterior 3D Model of a House

(Thibautmalet, 2017).

Applications of Architecture Visualization across Design Stages: Architecture visualization finds applications across various stages of the design process, from conceptual stages to design development, presentation, and construction documentation, explained in Table 9 below.

Table 10

Applications of Architecture Visualization across Design Stages.

Conceptual Phase	Architecture visualization is used during the conceptual phase to explore and communicate initial design renderings or simple 3D models to visualize preliminary design concepts, spatial relationships, and massing studies. Visualization helps architects convey the comprehensive design vision and generate enthusiasm among clients and stakeholders for the proposed project.

Design Development	During the design development phase, architecture visualization plays a crucial role in refining design proposals, testing design options, and communicating design intent to project stakeholders. Architects use digital modelling software to create detailed 3D models of architectural projects, incorporating building elements, materials, and contextual factors. Visualization enables architects to evaluate design alternatives, analyse spatial relationships, and optimize building performance.
Presentation and Communication	Architecture visualization is used extensively for presentation and communication purposes, enabling architects to convey design proposals convincingly and effectively to clients, stakeholders, and regulatory authorities. Architects create photorealistic renderings, animations, and visualizations to illustrate design concepts, showcase design features and evoke emotional responses. Visualization enhances the comprehensibility and persuasiveness of design presentations, helping stakeholders visualize the proposed project in its intended context.
Design Review and Feedback	Architecture visualization facilitates design review and feedback processes by providing stakeholders with visual representations of architectural designs for evaluation and critique. Architects use visualization to get feedback from clients, end users, and project team members, enabling stakeholders to assess design proposals, provide input, and make informed decisions. Visualization promotes transparency, collaboration, and building agreement between

	stakeholders, ensuring that design solutions meet project requirements and stakeholder expectations.
Construction Documentation	Architecture visualization is utilized for creating construction documentation, including drawings, specifications, and schedules to guide the construction process accurately. Architects use visualizations to generate 2D drawings, 3D models, and construction details that convey design intent and technical specifications to contractors, subcontractors, and building officials. Visualization enhances the clarity, accuracy, and comprehensiveness of construction documentation, reducing errors, conflicts, and remodeling during construction.

(Author’s Work, 2024)

Architectural visualization is an essential aspect of the architectural practice, enabling architects to communicate design ideas effectively, engage stakeholders, and enhance the quality of design outcomes. By leveraging a diverse range of visualization methods and tools, architects can create compelling visualizations that convey the essence of architectural designs and enrich the design process.

Spatial Experience

Spatial experience in architecture refers to the general perception and interpretation of architectural spaces by individuals, encompassing their sensory impressions, cognitive interpretations, emotional responses, and bodily interactions (Pallasmaa, 2005). It reflects the dynamic relationship between people and their surroundings, influencing how individuals perceive, navigate, and occupy architectural environments (Merleau-Ponty, 1962). Understanding and enhancing the spatial experience is crucial for architects and designers to create responsive environments, enriching and meaningful for users. By considering the experimental qualities of space, architects can design environments that engage the senses, evoke emotions, and promote well-being, fostering a sense of connection, identity, and belonging among users (Norberg-Schulz, 1980).

Factors Influencing Spatial Experience: Several factors influence spatial experience in architecture, such as spatial configuration, sensory stimuli, contextual factors and embodied perception, which is further discusses in table 10 below.

Table 11

Factors Influencing Spatial Experience.

Spatial Configuration	The arrangement, organization, and proportions of architectural elements within a space influence how users perceive and navigate built environments. Factors such as spatial hierarchy, scale, symmetry, and rhythm shape users' spatial experiences and interactions (Gibson, 1979).
Sensory Stimuli	Sensory stimuli, including visual, auditory, tactile, olfactory, and proprioceptive cues, contribute to users' sensory experiences within architectural spaces. Light, colour, texture, sound, temperature, and scent influence users' perceptions, emotions, and behaviours shaping their spatial experiences (Stamps, 2005).
Contextual Factors	Contextual factors, such as cultural norms, social dynamics, historical significance, and environmental context, play a significant role in shaping spatial experience. Users' cultural backgrounds, social interactions, and contextual expectations influence how they interpret and engage with architectural spaces (Rapoport, 1990).
Embodied Perception	Embodied perception refers to the embodied and sensorimotor aspects of spatial experience, emphasizing the role of the body in shaping how individuals perceive and navigate architectural

	environments (Pallasmaa, 2012). Bodily movements, gestures, and sensations mediate users' interactions with space, influencing their spatial awareness and engagement.

(Author's Work, 2024)

Methods for Assessing Spatial Experience: Assessing spatial experience in architecture requires a multidimensional approach that considers subjective, objective, and embodied dimensions of experience (Holl et al., 2006). Methods for measuring spatial experience are further discussed in table 11 below.

Table 12

Methods for Assessing Spatial Experience.

Qualitative Inquiry	Qualitative research methods, such as interviews, observations, and phenomenological inquiry, provide insights into users' subjective experiences, perceptions, and interpretations of architectural spaces (Seamon, 2000).
Environmental Psychology	Environmental psychology techniques, such as behavioural mapping, spatial analysis, and experience sampling, offer quantitative tools for studying users' spatial behaviours, preferences, and well-being within built environments (Gifford, 2007).
Virtual Reality and Augmented Reality	Virtual reality and augmented reality technologies enable users to immerse themselves in virtual environments and experience architectural spaces first-hand (Mahdavinejad et al., 2018). VR and AR simulations provide opportunities for users to explore, interact with, and evaluate architectural designs in immersive digital environments.

(Author's Work, 2024)

Implications for Architectural Design and Practice: Understanding and prioritizing spatial experience in architectural design has several implications for design decision-making and project outcomes, which are further discussed in table 12 below.

Table 13

Implications for Architectural Design and Practice.

1. User-centred Design	Prioritizing spatial experience requires architects to adopt a user-centred design approach, actively involving end users in the design process through participatory design methods, co-creation workshops, and user feedback sessions (Sanders & Stappers, 2008).
Sensory Design	Sensory design strategies, such as attention to light, colour, texture, sound, and scent, enable architects to create environments that engage the senses, evoke emotions, and promote well-being (Stamps, 2005).
Contextual Sensitivity	Contextual sensitivity involves considering the cultural, social, and environmental context of architectural projects to create spaces that resonate with users' cultural identities, social practices, and ecological values (Rapoport, 1990).
Embodied Design	The embodied design emphasizes the role of the body in shaping spatial experience, encouraging architects to design environments that support embodied perception, movement, and interaction (Pallasmaa, 2012).

(Author's Work, 2024)

How Colours Affect Spatial Experience: Light and dark colours significantly influence spatial experience and the perceived size of a place within architectural environments (Stamps, 2005). Light colours, such as white or pale hues, tend to create an illusion of spaciousness and openness (Gifford, 2007). They reflect more light, making surfaces appear brighter and expanding the visual boundaries of a space. Rooms painted in light colours often feel larger and airier, fostering a sense of freedom and relaxation. On the other hand, dark colours, like deep blues or rich browns can evoke feelings of intimacy and cosiness (Stamps, 2005). Dark hues absorb light, creating shadows and adding depth to surfaces. While they may visually shrink a space, dark colours can also make a space warm and sophisticated. In smaller areas, the strategic use of dark colours can enhance a sense of enclosure, making the space feel more cocooning and inviting. Figures 9 to 17 below show how much the colour can affect the spatial experience of the same room by the application of light and dark colours.

Figure 9

An Image Showing How a Light Colour Makes a Space Appear Bigger

(Leadesign, 2020).

Figure 10

An Image Showing How Dark Colours Make a Space Appear Smaller

(Leadesign, 2020).

Figure 11

An Image Showing How Having A Light Coloured Ceiling And Darker Walls Make The Room Appear To Have Increased Headroom.

(Leadesign, 2020).

Figure 12

An Image Showing How Having A Coloured Ceiling And Lighter Walls Make The Room Appear To Have Shorter Headroom, And Also Makes It Appear Wider.

(Leadesign, 2020).

Figure 13

An Image Showing Applying Darker Colours to the Lower Part of the Wall Can Also Make the Space Appear To Have Shorter Headroom

(Leadesign, 2020).

Figure 14

An Image Showing How Applying A Darker Colour to the Wall at the Back Can Reduce the Perceived Depth of A Room

(Leadesign, 2020).

Figure 15

An Image Showing That Applying Darker Colours to the Feature Wall and the Ceiling Can Make the Space Appear To Be Wider and Shorter

(Leadesign, 2020).

Figure 16

An Image Showing That Applying Darker Colours to the Walls on the Side Makes the Room Appear Narrower and Taller

(Leadesign, 2020).

Figure 17

An Image Showing Applying Darker Colours to the Walls on the Side and the Ceiling Makes the Feature Wall More Highlighted and Can Also Make the Space Appear Deeper

(Leadesign, 2020).

The choice between light and dark colours in architectural design can significantly impact the perceived size and atmosphere of a place. By carefully considering the spatial qualities and intended ambiance, architects and designers can utilize colour effectively to manipulate perceptions of space as shown in the figures above, and create environments that resonate with occupants on an emotional and experiential level.

Spatial experience is a fundamental aspect of architecture, shaping how individuals perceive, navigate, and inhibit built environments. By understanding the factors influencing spatial experience and adopting design strategies that prioritize sensory engagement, contextual sensitivity, and embodied perception, architects can create responsive environments, enriching, and meaningful for users.

Related Research

Virtual Reality Used in a Collaborative Architectural Design Process (P. Frost & P. Warren, 2000).

This study looks into the innovative use of VR technology in this case the (CAVE) to enhance collaborative efforts in architectural design. This study examines potential of VR to transform the design process by enabling architects, clients, engineers and other stakeholders to engage in a shared virtual environment. This immersive setting aims to improve communication, facilitate better visualization of design concepts, streamline decision making. By providing a platform where all parties can interact with and experience the architectural model in real-time, VR is proposed as a powerful tool to address common challenges in collaborative design such as misunderstandings and miscommunications that arise from traditional 2D drawings and isolated 3D models. The overarching goal of the research is to evaluate how effectively VR can enhance the overall design process, making it more efficient and cohesive.

Findings: Some key findings of the research are;

i. The study found that VR significantly enhances collaboration among different stakeholders involved in the architectural design process. The immersive nature of VR allows participants to experience the design in a shared virtual space, which improves communication and understanding of design concepts and proposals.

ii. VR provides a more effective means of visualizing architectural designs compared to traditional 2D drawings or even 3D models viewed on a computer screen. The ability to navigate and interact with a full scale virtual model helps stakeholders to better understand spatial relationships, proportions and aesthetics.

iii. The use of VR in design process leads to more efficient decision making. Stakeholders can quickly identify and address design issues in the virtual environment, reducing the need for multiple revisions and facilitating a more streamlined design process. The real-time feedback and interaction capabilities of VR contribute to quicker consensus and problem resolution.

Recommendations: Some of the recommendations this research provides are;

i. Architectural firms should adopt VR technology to enhance collaboration and communication among stakeholders. By providing a shared virtual environment, VR can help bridge the gap between different perspectives and improve overall design outcome.

ii. To effectively implement VR in the design process, firms should invest in the necessary VR infrastructure, including high quality VR headsets, motion tracking systems and powerful computing hardware. This investment will ensure that VR experience is smooth, immersive and conducive to collaborative work.

iii. It is important to provide training for all stakeholders on how to use VR tools effectively. Familiarization sessions can help users become comfortable with navigating and interacting within the virtual environment, thereby maximizing the benefits of VR technology.

iv. Regular feedback from users should be gathered to continuously improve the VR tools and processes. This iterative approach will help in identifying and addressing any usability issues, ensuring that the technology evolves in line with the needs of the users.

v. VR should be integrated with existing architectural design workflows to complement traditional methods. This hybrid approach can leverage strengths of both VR and conventional design techniques, resulting in a more comprehensive and effective design process.

Museum beyond Physical Walls: An Exploration of Virtual Reality-Enhanced Experience in an Exhibition-Like Space (Rahimi et al., 2022)

This study explores how VR can extend traditional museum exhibits beyond physical confines, offering new dimensions of interaction and engagement. Motivated by the need to attract and engage a diverse, digitally-inclined audience, the study examines the impact of VR on visitor engagement, educational outcomes and accessibility. Through experiments and case studies, the researchers found that VR creates immersive, interactive environments that enhance learning and make cultural resources more accessible. Key themes includes heightened immersion and interactivity provided by VR, its educational benefits and its potential to improve access to museum experiences. This exploration highlights the need for museums to rethink their educational and cultural missions in the digital age.

Findings: Some of the important findings of this research are;

i. The study found that VR significantly increases visitor engagement by providing immersive experiences that are not possible in traditional museum settings. Visitors could interact with exhibits in a more dynamic way, leading to a deeper understanding and appreciation of the content.

ii. VR enhanced museum experiences were shown to have substantial educational benefits. Visitors retained more information and showed a greater interest in learning when they interacted with exhibits through VR.. The interactive nature of VR allows for complex concepts to be demonstrated in a more accessible and comprehensible manner.

iii. VR technology can make museum experiences more accessible to a broader audience, including those who may not be able to visit physical museum spaces due to geographical, physical or financial constraints. This inclusivity ensures that a diverse audience can engage with cultural and educational content.

Recommendations: This research makes several recommendations, including;

i. Museums should consider integrating VR technology into their exhibits to enhance visitor engagement and educational outcomes. This can be done through dedicated VR stations or by developing VR apps that visitors can use on their devices.

ii. To effectively implement VR, museums should collaborate with VR experts and developers. This partnership can help create high quality, immersive experiences that are both educational and engaging.

iii. Museums should prioritize making VR experiences accessible to all visitors. This includes ensuring that VR content is designed with inclusivity in mind, accommodating various needs and preferences.

iv. Implementing VR in museums should be an iterative process. Continuous evaluation and feedback from visitors are essential to refine and improve the VR experiences, ensuring they meet the educational and engagement goals.

v. Museums should develop educational programs that incorporate VR as a key component. This can enhance the overall learning experience and provide a unique way for visitors to interact with exhibits.

CHAPTER III

Methodology

In this section, a detailed overview of the research methodology has been provided. This will be followed by a comprehensive presentation of the subheadings that organize the subsequent content. Each subheading offers insights into specific aspects of the research, enhancing the reader's understanding of the overall framework and objectives of the study.

Research Design

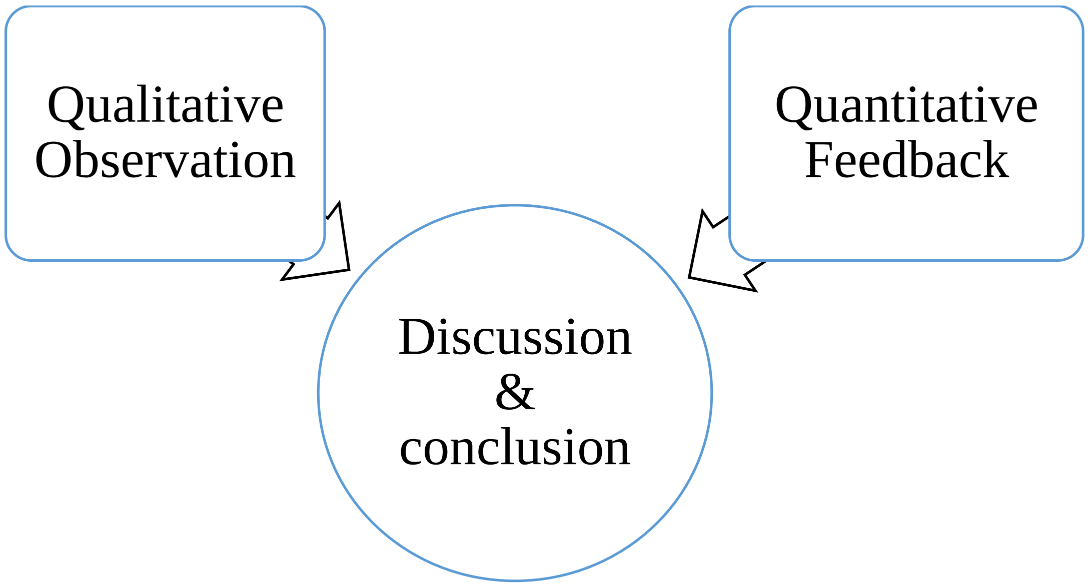
The research design outline proposes a mixed-method approach to explore user experience in virtual reality architecture design reviews. The process begins with the design of a one-bedroom cabin using Autodesk Revit, subsequently importing it to Sketch Up for furniture addition, and finally exporting it to Unreal Engine 5 for VR development.

This ensures a comprehensive evaluation of the VR environment. Usability testing will then be conducted on the Meta Quest 3 headset, focusing on aspects such as ease of navigation, spatial understanding, visual clarity, interactivity, user engagement, task completion efficiency, comfort and ergonomics, user satisfaction, and identification of technical issues. Observations during testing will be key to assessing these parameters. Additionally, questionnaires will be distributed to stakeholders, who will interact with the VR environment developed in Unreal Engine 5 before providing feedback.

This dual approach of qualitative observation and quantitative feedback collection as shown in figure 24 below, aims to provide a holistic understanding of user experience and inform the integration of VR into architecture design processes effectively.

Figure 18

Research Design



(Author's Work, 2024).

Population and Sample

To guarantee that this study's findings may be applied to a wider context outside of the sample and generalized to the entire group under consideration, the population refers to the total group of persons who share a trait that is of interest to the researchers. Thus, this study's population consists of architects and stakeholders involved in the architectural design process, particularly those interested in using virtual reality technology for design reviews.

The sample will be drawn from this population, consisting of a diverse group of architects and stakeholders who have varying levels of experience and familiarity with VR technology. Additionally, users who will participate in the usability testing with the Meta Quest 3 headset will be included in the sample. The selection criteria for participants will prioritize individuals with relevant expertise in architecture design and VR technology, ensuring that insights gathered are representative of the target population and can inform the development of design guidelines and best practices effectively.

Data Collection Tools

The data collection tools employed in the study encompass both qualitative and quantitative methods to comprehensively assess user experience in the virtual reality architecture design reviews. Qualitative data will primarily be gathered through usability testing of the app developed in Unreal Engine 5 on the Meta Quest 3 headset. During these tests, participants will explore the virtual world created and their interactions and experiences will be recorded. This approach allows for the observation of system effectiveness, efficiency, and satisfaction, focusing on parameters such as ease of navigation, spatial understanding, visual clarity, interactivity, user engagement, task completion efficiency, comfort and ergonomics, user satisfaction, and identification of technical issues. Quantitative data will be collected through questionnaires distributed to architects and stakeholders post-VR experience. These questionnaires will provide structured insights into participants' perceptions and preferences regarding the VR design review process, allowing for statistical analysis to identify trends and patterns. According to Nielsen, 2020, conducting usability tests with 5 users can identify about 85% of usability problems, this study was able to conduct usability tests on 7 people and was able to receive 213 replies from the questionnaire. By employing a combination of these data collection tools, the study aims to obtain a comprehensive understanding of user experiences and inform the integration of VR technology into architecture design processes effectively.

Data Collection Procedures

The data collection procedure for this study involved a combination of qualitative and quantitative methods to comprehensively assess user experience in virtual reality architecture design reviews.

For qualitative data collection, usability testing was conducted using the Meta Quest 3 headset. Participants were guided through specific design review tasks, such as exploring the virtual space, interacting with objects, and evaluating design elements. Their interactions and observations were observed and recorded, capturing detailed insights into aspects like ease of navigation, spatial understanding, visual clarity, interactivity, user engagement, task completion efficiency, comfort and ergonomics, user satisfaction, and identification of technical issues.

Quantitative data was gathered through structured questionnaires distributed to architects and stakeholders after their VR experience. These questionnaires were designed to get numerical responses to various aspects of the VR design review process, allowing for statistical analysis to identify trends and patterns. Participants rated their experiences based on predefined criteria, providing quantitative insights into their perceptions and preferences regarding VR technology in architecture design. These procedures enabled the study to obtain a comprehensive understanding of user experiences in VR architecture design reviews, combining rich qualitative insights from usability testing with quantitative data from structured questionnaires.

Data Analysis Procedures

The data analysis procedures for this study involved both qualitative thematic analysis and quantitative statistical analysis to comprehensively interpret the collected data. For qualitative data analysis, thematic analysis was applied to the observations and recordings from the usability testing sessions. This involved identifying patterns, themes, and recurring issues within the data related to aspects such as ease of navigation, spatial understanding, visual clarity, interactivity, user engagement, task completion efficiency, comfort and ergonomics, user satisfaction, and technical issues. These qualitative findings were then organized and interpreted to provide insights into the user experience in VR architecture design reviews.

The quantitative data analysis was conducted using the Statistical Package for Social Sciences (SPSS) statistics computer program. The analysis is presented in figures, diagrams, tables, and charts. This statistical analysis allowed for the identification of trends, patterns, and relationships within the quantitative data, providing numerical insights into participants' perceptions and preferences regarding the VR design review process.

The findings from both qualitative thematic analysis and quantitative statistical analysis were then synthesized and presented in various formats. These formats will help communicate the results of the analysis, making the findings accessible and understandable to both researchers and stakeholders. The combination of qualitative and quantitative data analysis methods provided a comprehensive understanding of user experience in VR architecture design reviews, contributing valuable insights to the field.

Reliability and Validity

The reliability and validity of the study were ensured through rigorous methodologies and careful considerations. Reliability was upheld by establishing standardized protocols for both usability testing sessions and questionnaire administration, ensuring consistency across participants and minimizing variability in responses. The use of established tools such as the Meta Quest 3 headset for usability testing and structured questionnaires further enhanced reliability by providing consistent methods of measurement. Validity was also addressed through the selection of appropriate measures and instruments, aligning with the research objectives to comprehensively assess user experience in VR architecture design reviews. Construct validity was ensured by including multiple dimensions of user experience and employing established data analysis techniques such as thematic and statistical analysis. By adhering to these principles, the study upheld the trustworthiness and credibility of findings, contributing valuable insights to the field of VR architecture design.

CHAPTER IV

Enhancing User Experience in Architecture through Virtual Reality Design Reviews

This chapter intends to focus on the data acquired during the study, offer a clear analysis of the data, and provide the findings of the analysis together with their interpretations.

Table 14 below outlines the process and analysis of the usability testing with seven participants, alongside the subsequent survey and highlights how combining these methods provided a well-rounded assessment of the VR system. The study utilized Unreal engine 5 and Meta Quest 3, which are the latest hardware and software technologies available for developing a highly immersive architectural design review experience. Key features such as Nanite for optimizing model detail, dynamic lighting and high quality materials from Quixel Megascans library contributed to the visual realism and interactive quality of the system. Table 14 below also provides a step by step view of the creation, testing and evaluation of the VR system, showcasing how the integration of Unreal Engine 5 and Meta Quest 3 effectively enhances user experience in architectural visualization.

Table 14

Breakdown of how the Mixed Method Approach Provided Comprehensive Results.

Stage	Process	Description	Tools Used	Outcome
Usability Test Setup	Creating a VR system using Unreal Engine 5 and Meta Quest 3.	The one bedroom cabin was designed using Autodesk Revit, Sketchup for furnishing and Unreal	Autodesk Revit, Sketchup, Unreal Engine 5, Meta Quest 3, PC with Intel Core i7-8750H, GTX	An interactive VR model for architecture design review was created, incorporating high quality materials from Quixel Megascans

		Engine 5 to create the virtual environment. The final VR system was viewed in Meta Quest 3 using Quest link for a high quality immersive experience.	1080 8GB VRAM.	and dynamic lighting with Nanite optimization.
Conducting Usability Testing	Engaging 7 participants in VR based design reviews	7 participants interacted with the virtual environment in Meta Quest 3. Their experiences, observations and feedback on usability visual realism and system functionality were recorded. The testing	Meta Quest 3, Unreal Engine 5, Observation, User Feedback	Participants gave detailed feedback on realism, comfort and immersive experience. They praised elements like material quality, ease of navigation and light effects. One minor issue with

		focused on the headset's comfort, interaction with design elements, spatial awareness and performance.		headset fit was noted.
Data Analysis from Usability Testing	Analysing the feedback from participants	Participant responses were thematically analysed identify patterns in user experience. Positive points included immersion and spatial understanding. Technical issues like lag after	Thematic analysis, Observation	The results from usability testing highlighted strengths in immersion and realism, with areas for improvement in performance and user comfort

		prolonged use were minor.		
Proceeding to Survey	Developing a survey based on usability test feedback	Based on the findings from the usability tests, a survey was created to collect broader quantitative data from a larger audience. The survey aimed to confirm the usability test findings and explore additional aspects like satisfaction, previous VR experience and technical issues encountered.	Questionnaire, SPSS	213 participants responded to the survey, providing insights into user satisfaction, experience and technical challenges with Meta Quest 3

Mixed Method Analysis(Usability Tests + Survey)	Combining qualitative and quantitative data for comprehensive results.	The mixed method approach allowed for a comprehensive analysis of the VR system. The qualitative data from usability tests gave depth to user experience insights, while the quantitative survey responses provided broader validation of those findings. This combined approach ensured a balanced and well-rounded evaluation.	Thematic analysis, SPSS, Mixed method analysis.	Results confirmed that Meta Quest 3 and Unreal Engine 5 significantly enhanced spatial awareness and design comprehension. Participants reported high satisfaction, with minimal technical issues.

Final System and Evaluation	Using Unreal Engine 5 and Meta Quest 3 as the latest hardware/software	Unreal Engine 5's advanced rendering and Meta Quest 3's cutting edge VR technology were utilized to create a high quality, interactive design review experience. Features like Nanite, dynamic lighting and Quixel Megascans advanced materials, while Meta Quest 3 provided an immersive and comfortable user experience.	Unreal Engine 5, Meta Quest 3, PC(Intel Core i7-8750H, GTX 1080 8GB VRAM)	The study demonstrated the effectiveness of Meta quest 3 in architecture design reviews, optimizing both user experience and design quality. It showcased the potential of the latest available hardware and software for enhancing architectural visualization.

(Author's Work, 2024).

Thematic Analysis of the Usability Testing

In the usability testing phase involving seven participants, the thematic analysis revealed valuable insights into various aspects of user experience in VR architecture design reviews.

Ease of Navigation

In the usability testing phase involving seven participants, the assessment of ease of navigation revealed a notable satisfaction among users with the intuitiveness and responsiveness of navigation controls within the environment. Participants reported a seamless experience in navigating through the virtual space, highlighting the ease with which they could navigate and interact with the doors and other elements. This positive feedback underscores the effectiveness of the navigation system in facilitating user exploration and engagement within the VR architecture design reviews. The consistent feedback from multiple participants suggests stability in the navigation controls, enhancing user experience and overall satisfaction.

Spatial Understanding

The assessment of spatial understanding showcased remarkable insights into the participants' abilities to perceive and interact with the virtual environment. Participants demonstrated a clear sense of spatial awareness and proficiency in navigating the VR architecture design review. Notably, participants were able to identify subtle changes, such as a 10% reduction in the scale of the sofas, indicating a high level of attention to detail and spatial awareness. This ability to notice subtle alterations underscores the effectiveness of the VR environment in conveying spatial information accurately. The findings suggest that participants were capable of interpreting spatial relationships within the virtual space, highlighting the effectiveness of the VR platform developed by this study in facilitating immersive and realistic experiences for architecture design reviews.

Visual Clarity

Feedback regarding visual clarity showed unanimous appreciation for the high-quality graphics and lifelike representation of design elements within the VR environment. Participants consistently praised the realism of materials, particularly highlighting the wooden floors and fabric used for the sofas. This collective acknowledgment indicates the effectiveness of the VR platform in conveying visual clarity, immersing users in an environment that closely resembles real-world architectural settings. Participants' remarks regarding the authenticity of materials not only validate the visual clarity of the VR experience but also emphasize its potential to enhance the realism and effectiveness of architecture design reviews.

Interactivity

The exploration of interactivity highlighted the enthusiasm and engagement brought about by the interactive features within the VR architecture design reviews. Participants expressed satisfaction and excitement with the interactive functionalities offered by the virtual environment. Specifically, participants were pleased with the ability to open and close doors, a feature that added a sense of realism and interactivity to the experience. They were also excited about the dynamic manipulation of sunlight within the environment, expressing delight at the opportunity to observe how the movement of the sun affected shadows outside the house and the amount of light streaming through windows from within. These interactions not only enhanced user engagement but also provided valuable insights into the potential for VR technology to simulate real-world scenarios and facilitate experiential learning in architecture design reviews.

User Engagement

The level of user engagement was notably high, with participants expressing enthusiasm and satisfaction throughout the VR architecture design review. Observations consistently highlighted participants’ high levels of enthusiasm and interest in exploring the virtual environment. Participants were notably happy and eager to continue exploring, demonstrating a keen interest in checking the details of the design. Participants did not express boredom or motion sickness throughout the entire experience, indicating sustained engagement and enjoyment. Some participants even remarked that the experience felt so enjoyable and did not feel like work, showcasing the immersive and engaging nature of the VR environment. These observations showcase the effectiveness of VR technology in fostering user engagement and interest in architecture design reviews.

Task Completion Efficiency

The task completion efficiency was notably high, as participants were able to review the building design effectively and efficiently within the VR environment. Participants demonstrated proficiency in completing design review tasks with ease. They expressed appreciation for various aspects of the design including colour choices, furniture selection, window positioning for ventilation, the layout of the kitchenette, the placement and type of lighting fixtures, and the overall functionality of the plan. These observations indicate that participants were able to navigate and assess the design elements comprehensively, highlighting the effectiveness of the VR platform in facilitating efficient and thorough architecture design reviews.

Comfort and Ergonomics

Feedback on comfort and ergonomics highlighted the overall satisfaction with the Meta Quest 3 headset. Participants generally found the headset comfortable, with several noting it as the most comfortable headset they had used so far. However, one participant encountered initial difficulty fitting the headset due to her hair, though adjusting it fixed the issue. The ergonomic shape of the controllers was also praised, enhancing the overall usability of the VR system. While most participants did not notice the weight of the headset, some remarked that looking down occasionally made them more aware of its weight. These insights into the comfort and ergonomics of the VR equipment provide valuable feedback for further refinement and improvement, ensuring optimal user experience in architecture design reviews.

User Satisfaction

User satisfaction was notably high, with participants expressing positive views on the immersive nature of the VR experience. Participants consistently praised the level of immersion offered by the virtual environment, highlighting its ability to transport them into the architectural space. Several participants remarked on the realism and authenticity of the experience, noting how it enhanced their engagement and enjoyment which made them take their time and review it well which in turn made them notice things they would normally overlook, like lighting fixtures and how they affect the space, during the design review. These positive views on the immersive nature of the VR experience show its effectiveness in creating an engaging and immersive environment for architecture design reviews, contributing to overall user satisfaction and positive perceptions of the VR technology.

Technical Issues

Technical issues were noted, on rare occasions, during prolonged use of the VR headset. Participants reported that after a few hours of consistent use, the headset would become slightly warm, which was generally tolerable but noticeable. Some participants experienced occasional slight lag or glitches during their VR sessions when the headset got warm. While these technical issues did not significantly detract from the overall usability of the system, they show the need for ongoing optimization and refinement of the VR technology to ensure a seamless and uninterrupted user experience.

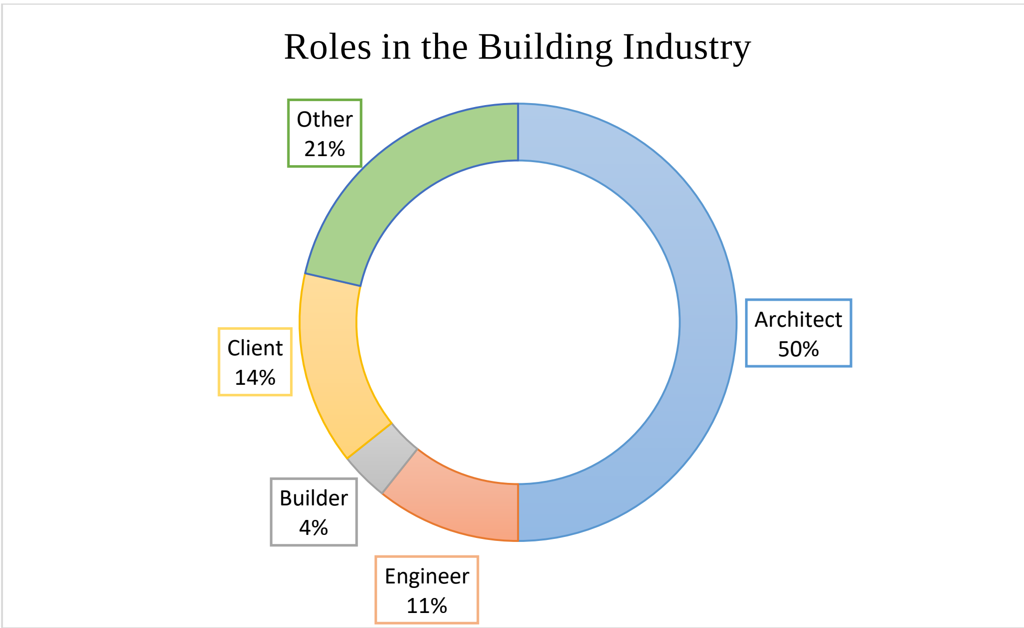
Statistical Analysis of the Questionnaire

It's essential to focus on the demographic information provided by the participants. Understanding the demographics helps in contextualizing the responses and identifying potential trends or patterns based on participants' roles and experience levels in the field. Analysing the demographic section allows for insights into how different groups of participants, such as architects, engineers builders, or clients, perceive the user experience in architecture design reviews using Meta Quest 3. The years of experience in the field can also provide valuable context regarding participants' familiarity with virtual reality technology and their past experiences with VR systems or headsets. With 213 responses collected, analysing the demographic section becomes crucial for segmenting and interpreting data effectively, thereby enhancing the overall understanding of the user experience with Meta Quest 3 in virtual reality architecture design reviews.

Role

Figure 19

Role in the Building Industry



(Author's Work, 2024).

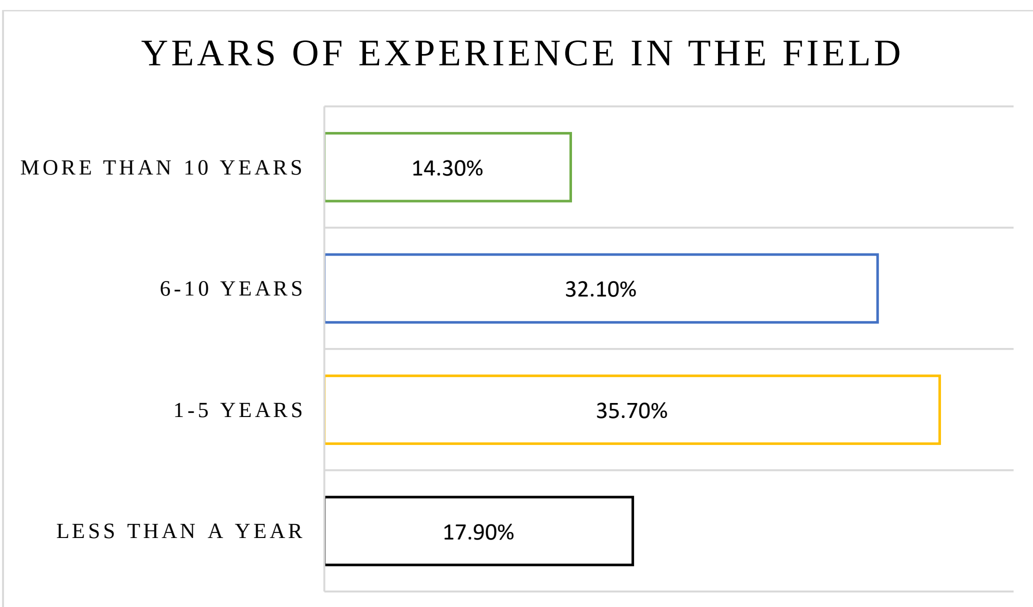
In figure 25 above, Architects represent the largest proportion with 50 % indicating their significant involvement and interest in virtual reality architecture design reviews. Engineers constitute 11% of the respondents, suggesting a notable but smaller representation compared to architects. Builders and clients make up 4% and 14% respectively, reflecting their engagement in the design review and their potential stake in the outcomes. The "Other" category comprises 21% of respondents, which includes various stakeholders like interior designers, project managers, or consultants, highlighting the diverse range of professionals interested in exploring VR technology for architecture design reviews. The distribution of roles provides a comprehensive perspective on the demographic composition of the participants, offering valuable insights into their respective perspectives and priorities in utilizing virtual reality for architectural reviews.

Years of Experience in the Field

The breakdown of years of experience in the field based on 213 responses as shown in figure 26 below, provides valuable insights into the level of expertise and tenure of participants in the building industry. Notably, a significant portion of respondents, 35.7%, have between one to five years of experience, suggesting a substantial presence of relatively early career professionals in the study. Following closely, 32.1% of participants have six to ten years of experience, indicating a substantial representation of mid-career individuals. Additionally, 17.9% of participants have more than 10 years of experience, signifying a presence of seasoned professionals with extensive industry knowledge. Finally, 14.3% of respondents have less than a year of experience, highlighting the inclusion of newcomers to the field, potentially bringing fresh perspectives to the study. The distribution of experience levels offers a comprehensive view of the participant pool, covering a wide range of expertise and perspectives, which enriches the analysis of user experience in virtual reality architecture design reviews.

Figure 20

Years of Experience in the Field

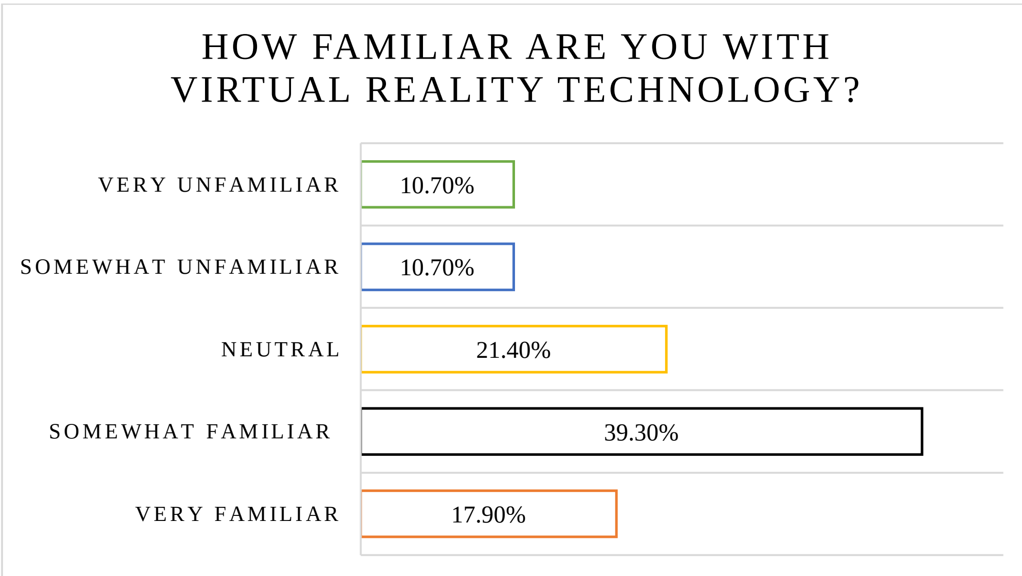


(Author’s Work, 2024).

Familiarity with Virtual Reality Technology

Figure 21

Familiarity with Virtual Reality



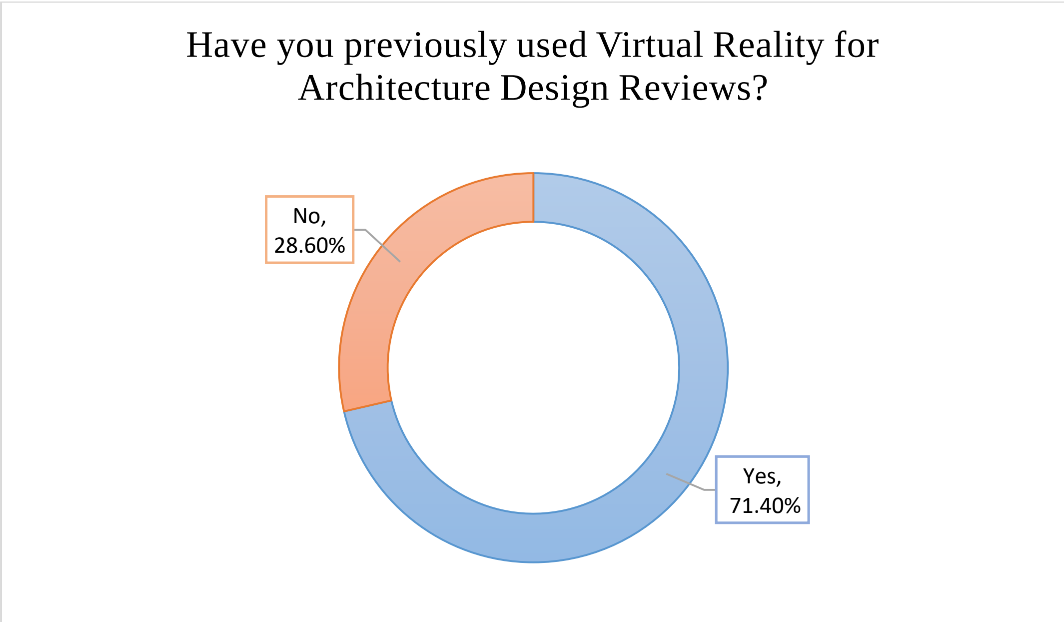
(Author's Work, 2024).

Participants' familiarity with virtual reality technology varies across a spectrum of expertise. As shown in figure 27 above a notable, 17.9% of respondents indicate being very familiar with VR technology, showcasing a substantial portion of participants who possess a high level of proficiency in this domain. Additionally, 39.3% of participants report being somewhat familiar with VR technology, indicating a significant majority with at least some degree of knowledge or exposure to VR systems. A notable portion, 21.4%, express a neutral stance, suggesting a diverse mix of familiarity levels among respondents. Furthermore, 10.7% of participants report being somewhat unfamiliar with VR technology, indicating a smaller yet still present group requiring more exposure or experience. Similarly, another 10.7% of respondents state being very unfamiliar with VR technology, underscoring the presence of individuals who may require more education or training in this area. The distribution of familiarity levels highlights the diverse range of experiences and expertise among participants, which is crucial for understanding their perceptions and experiences with virtual reality architecture design reviews.

Previous Usage of Virtual Reality for Architecture Design Reviews

Figure 22

Have you previously used Virtual Reality for Architecture Design Reviews?



(Author's Work, 2024).

Based on the 213 responses, the majority of participants as shown in figure 28 above, constituting 71.4%, indicate prior usage of virtual reality for architecture design reviews. This significant proportion suggests a prevalent level of adoption and familiarity with VR technology among respondents, with a substantial number having already experienced a form of it previously. Conversely, 28.6% of respondents report no previous usage of virtual reality for architecture design reviews, signifying a smaller yet notable contingent of participants who are new to or have not yet explored the potential of VR in this context. The disparity in responses underscores the varying levels of exposure and experience with VR technology among participants, which is essential for gauging their perspectives and expectations regarding the use of Meta Quest 3 for architecture design reviews.

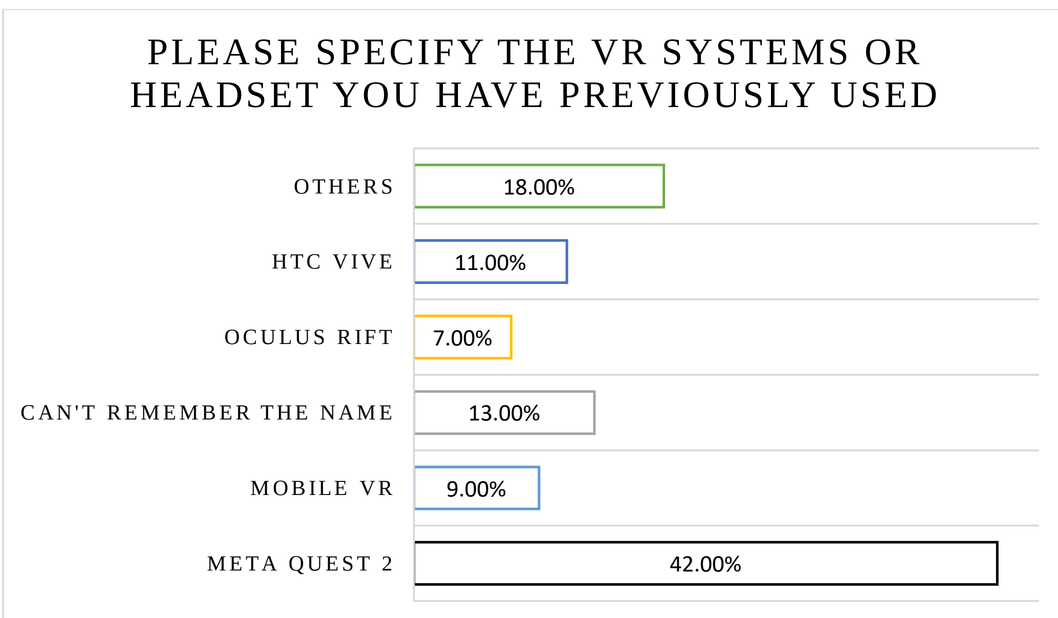
Specifying the Type of VR Headset previously used

Those who indicated prior usage of virtual reality for architecture design reviews specified various VR systems or headsets. As shown in figure 29 below a notable, 42%

of participants reported using the Meta Quest 2, suggesting a significant prevalence of this specific device within the architecture design review context. Additionally, 9% mentioned using Mobile VR, highlighting the utilization of mobile VR solutions for design evaluation purposes. Interestingly, 13% of respondents could not recall the name of the VR system they had previously used, indicating a potential lack of brand recognition or distinctiveness in their prior experiences. 7% reported using the Oculus Rift, while 11% mentioned the HTC Vive, indicating the presence of high-end VR systems among participants. The category "others" constituted 18% of responses, suggesting a diverse array of VR systems or headsets beyond the specified options. This distribution of responses reflects the diverse range of VR technologies used in architecture design reviews, underscoring the need to consider various platforms when evaluating user experiences with Meta Quest 3.

Figure 23

Please specify the VR systems or headsets you have previously used



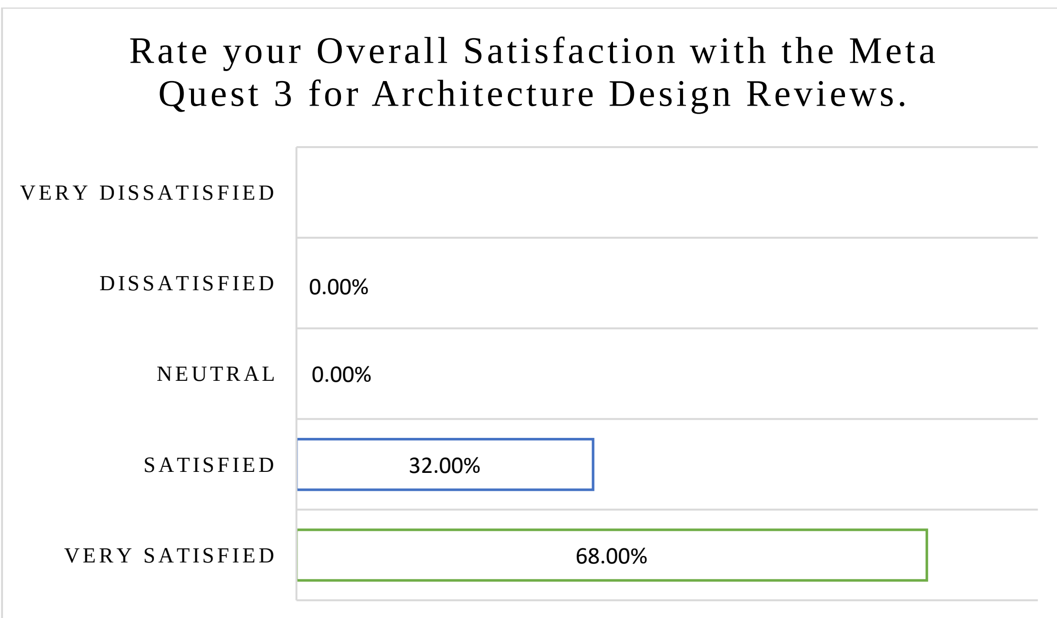
(Author's Work, 2024).

Overall Satisfaction with the Meta Quest 3 for Design Reviews

The overall satisfaction with the Meta Quest 3 for architecture design reviews is notably high as shown in figure 30 below. A majority of respondents, constituting 68%, reported being very satisfied with their experience, indicating a strong level of approval and contentment with the Meta Quest 3 headset and the design developed in Unreal engine for conducting design reviews. Additionally, 32% of participants expressed satisfaction, further reinforcing the positive sentiment towards the program developed for this study. Importantly, no respondents indicated neutrality, dissatisfaction, or very dissatisfied responses, suggesting a lack of negative feedback regarding the prototype design created for this study and its suitability for architecture design reviews. This overwhelmingly positive feedback underscores the effectiveness and satisfaction with the prototype created and shown on the Meta Quest 3 as a very good way to facilitate architecture design evaluations in virtual reality, highlighting its potential to enhance the user experience and streamline design processes in the industry.

Figure 24

Please rate your overall satisfaction with the Meta Quest 3 for architecture design reviews.



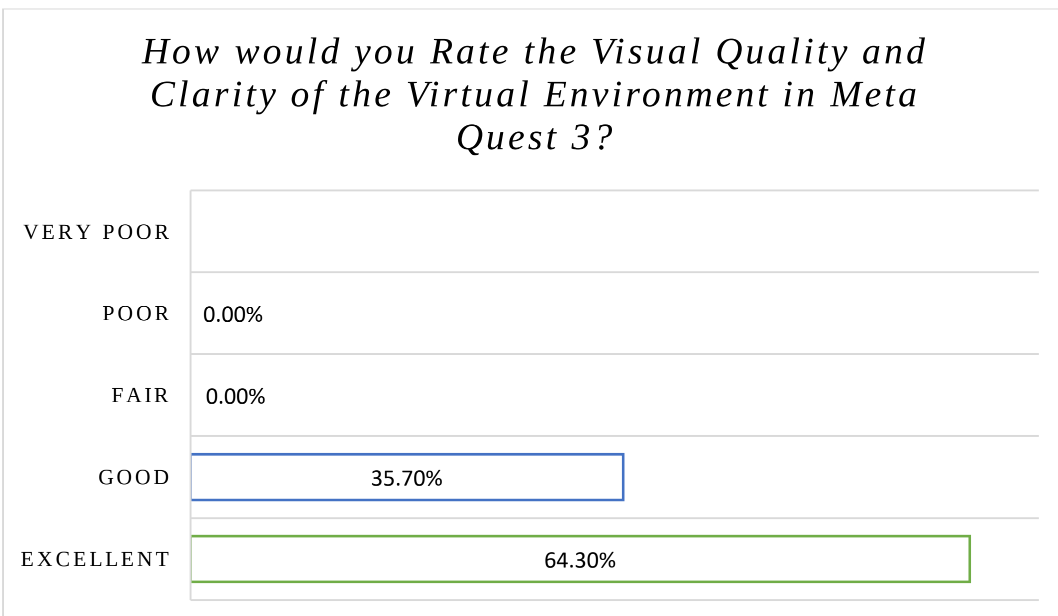
(Author's Work, 2024).

Visual Quality and Clarity of the Virtual Environment in Meta Quest 3

The visual quality and clarity of the virtual environment displayed for this study in Meta Quest 3 are highly rated as shown in figure 31 below. A significant majority of respondents, comprising 64.3%, rated the visual quality and clarity as excellent, indicating a superior level of satisfaction with the immersive visuals provided by the VR environment created by this study and the Meta Quest 3 used to display it. Additionally, 35.7% of participants rated the visual quality as good, further reinforcing the positive sentiment towards the clarity and fidelity of the visual environment. Importantly, no respondents rated the visual clarity as fair, poor, or very poor, suggesting a lack of significant issues or deficiencies in the visual presentation provided by the VR environment developed and hosted on the Meta Quest 3. This overwhelmingly positive feedback underscores the effectiveness of the system developed by this study in delivering high-quality visual experiences for architecture design reviews in virtual reality, thereby enhancing user satisfaction.

Figure 25

How would you Rate the Visual Quality and Clarity of the Virtual Environment in Meta Quest 3?



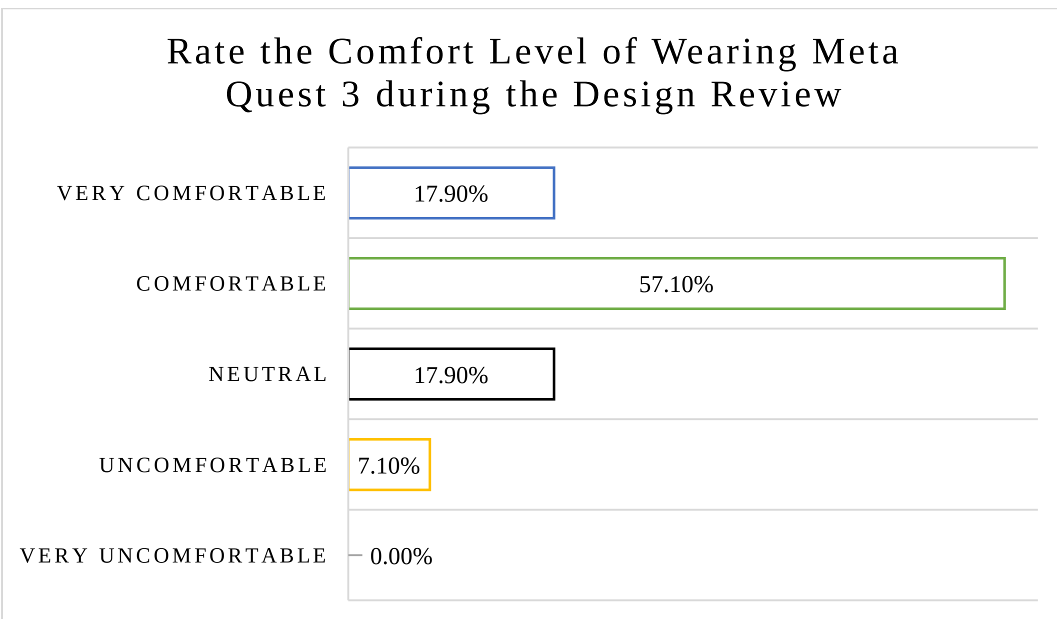
(Author’s Work, 2024).

Comfort Level of Wearing Meta Quest 3 during the Design Review

The comfort level of wearing the Meta Quest 3 during design reviews is generally positive as shown in figure 32 below. A majority of respondents, compromising 57.1%, rated the comfort level as comfortable, indicating a satisfactory experience with wearing the headset during the design evaluation process. Additionally, 17.9% of participants reported feeling very comfortable, further reinforcing the positive sentiment towards the comfort provided by the Meta Quest 3. Importantly, no respondents rated the comfort level as very uncomfortable, highlighting a lack of significant discomfort or issues with wearing the headset. A smaller percentage, 7.1%, reported feeling uncomfortable, while 17.9% expressed neutrality towards the comfort level. Overall, the majority of respondents rated the comfort level positively, suggesting that the Meta Quest 3 provides a comfortable and wearable experience for architecture design reviews in virtual reality, thereby contributing to overall user satisfaction and engagement in the design evaluation process.

Figure 26

Rate the Comfort Level of Wearing Meta Quest 3 during the Design Review.



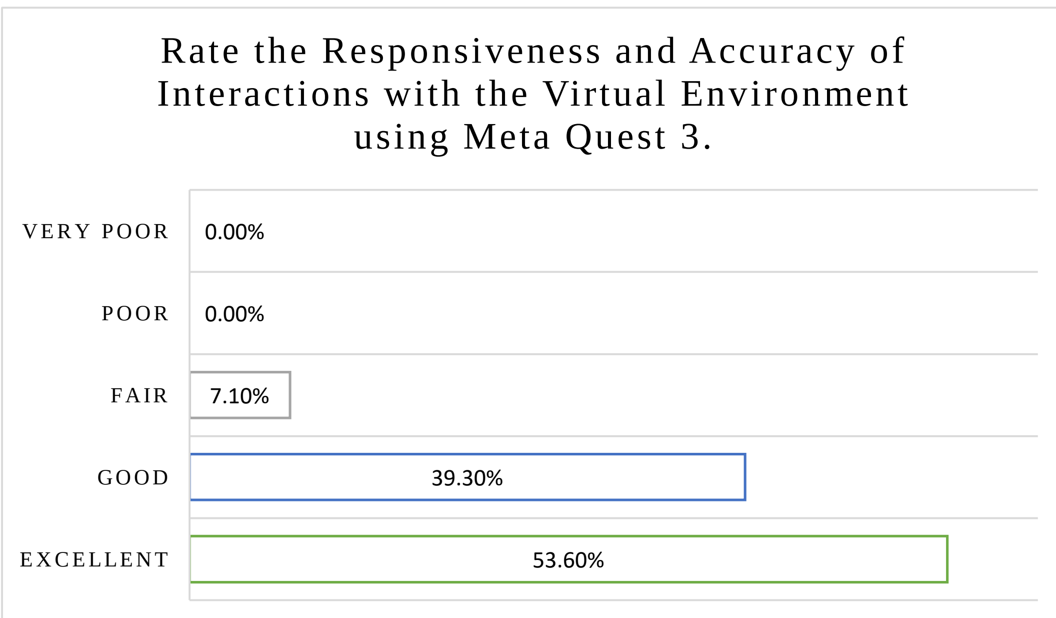
(Author’s Work, 2024).

Responsiveness and Accuracy of Interactions with the Virtual Environment

The responsiveness and accuracy of interactions with the virtual environment using Meta Quest 3 are predominantly rated positively as shown in figure 33 below. A majority of respondents, comprising 53.6%, rated the representatives and accuracy as excellent, indicating a high level of satisfaction with the precision and effectiveness of interactions within the virtual environment. 39.3% of participants rated the responsiveness and accuracy as good, further reinforcing the positive sentiment towards the reliability and effectiveness of interactions. Importantly, no respondents rated the responsiveness and accuracy as poor or as very poor, suggesting a lack of significant issues or deficiencies in this aspect of the experience. A smaller percentage, 7.1% rated it as fair, indicating a minor proportion of participants who may have encountered slight issues with responsiveness or accuracy. The overwhelmingly positive feedback underscores the effectiveness of the Meta Quest 3 in facilitating responsive and accurate interactions within the virtual environment, thereby enhancing user satisfaction and engagement in architecture design reviews.

Figure 27

Rate the responsiveness and accuracy of interactions with the virtual environment using Meta Quest 3.



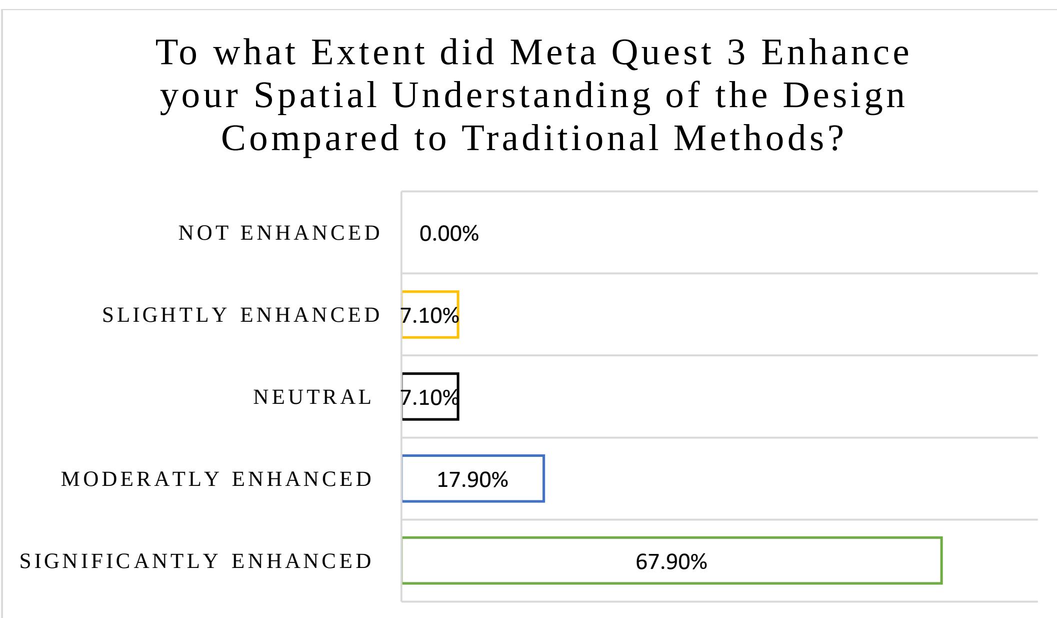
(Author’s Work, 2024).

Enhancing Spatial Awareness in the Virtual Environment Compared to Traditional Methods

The extent to which Meta Quest 3 enhances spatial understanding of the design compared to traditional methods is overwhelmingly positive as shown in figure 34 below. The majority of respondents, comprising 67.9%, indicated that Meta Quest 3 significantly enhanced their spatial understanding, suggesting that the immersive virtual reality provided by this study offers a substantial improvement over traditional methods. Additionally, 17.9% of participants reported that this system moderately enhanced their spatial understanding, further reinforcing the positive impact of the VR technology on participants' perception of spatial relationships within the design. Importantly, no respondents indicated that this system did not enhance their spatial understanding at all, highlighting the effectiveness of the VR experience in facilitating a deeper comprehension of architectural designs. A small percentage, 7.1%, reported feeling neutral or slightly enhanced, indicating a minor proportion of participants who may have had mixed experiences with the spatial understanding provided by the system developed by this study. The overwhelmingly positive feedback underscores the significant role of this system in enhancing spatial understanding and facilitating more comprehensive architecture design reviews in virtual reality.

Figure 28

To what extent did Meta Quest 3 enhance your spatial understanding of the design compared to traditional methods?



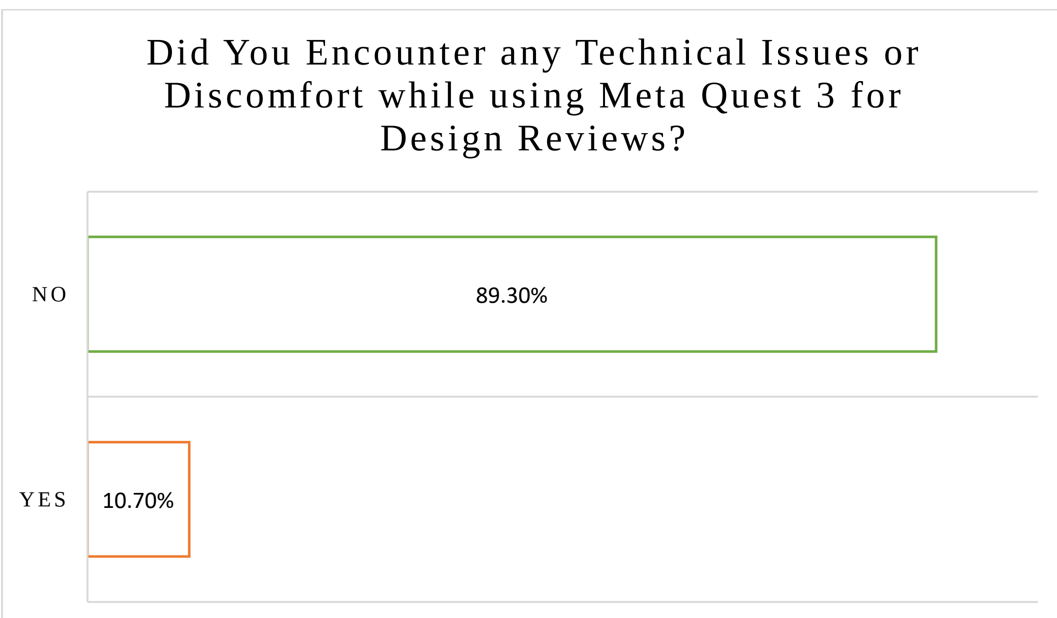
(Author's Work, 2024).

Technical Issues or discomfort Encountered while using Meta Quest 3 for Design Reviews

The incidence of encountering technical issues or discomfort while using this system for design reviews is relatively low as shown in figure 35 below. A minority of respondents, comprising 10.7%, reported encountering technical issues or discomfort during their usage of this system. This indicates that while there were some challenges experienced by a small proportion of participants, the majority, totaling 89.3%, did not encounter any such issues. The low incidence of technical issues or discomfort suggests a generally smooth and satisfactory user experience with this system during architecture design reviews. It is important to note that addressing any reported technical issues or discomfort could further enhance the overall user experience and satisfaction with the VR technology.

Figure 29

Did you encounter any technical issues or discomfort while using Meta Quest 3 for design reviews?



(Author’s Work, 2024).

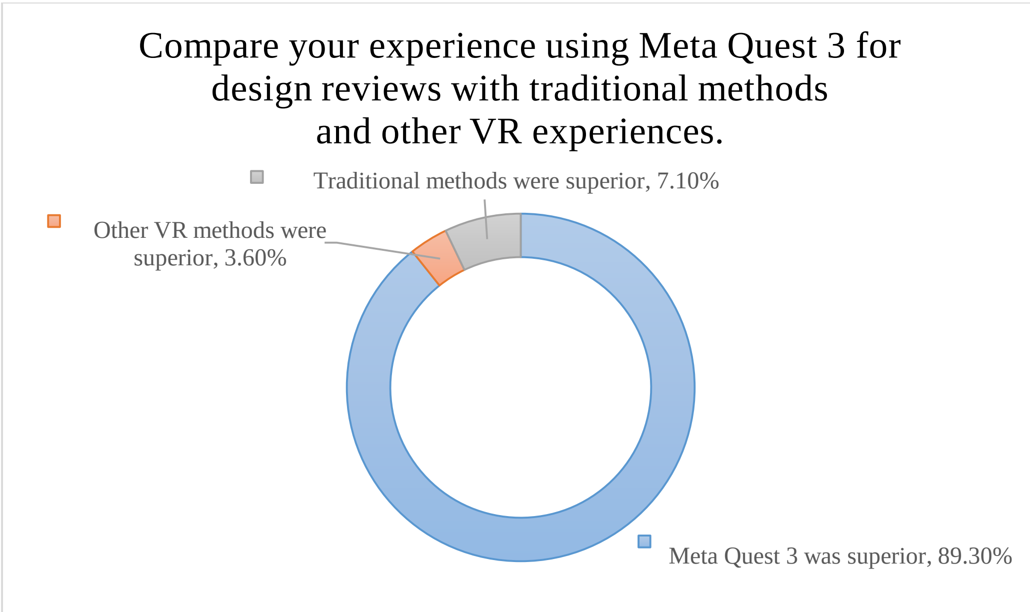
Among the 213 responses in this study, 10.7% of participants reported encountering technical issues or difficulties while using this system for VR design reviews. Although the incidence was relatively low, participants who experienced challenges provided valuable insights into potential areas for improvement. Specific technical issues mentioned by respondents included occasional lag or delays in the VR environment, difficulties with headset fit or comfort, and minor glitches in interaction responsiveness. While these issues did not significantly impede the overall usability of this system, addressing them could further enhance the user experience and optimize the functionality of the VR system. These reported technical issues underscore the importance of ongoing refinement and optimization efforts to ensure a seamless and enjoyable experience for all users engaging in architecture design reviews by adopting the proposed system.

Comparative Analysis between this system and other available systems in the industry.

The comparison of experiences using the system proposed by this study for design reviews with traditional methods and other VR experiences overwhelmingly favoured this system as shown in figure 36 below. A significant majority of respondents, comprising 89.3%, reported that their experience using this system was superior compared to traditional methods and other VR experiences. This indicates a strong preference for the immersive virtual reality experience developed by this study over conventional methods and alternative VR systems. A small percentage, 3.6% percent, felt that other VR experiences were better suggesting that there may be room for improvement or optimization in certain aspects of this system functionality. Additionally, 7.1% of participants indicated that traditional methods were superior, highlighting a minority viewpoint that may stem from specific preferences or limitations encountered with the VR technology. The overwhelmingly positive feedback regarding this system's superiority underscores its effectiveness in revolutionizing architecture design reviews and enhancing the user experience in virtual reality.

Figure 30

Compare your experience using Meta Quest 3 for design reviews with traditional methods and other VR experiences.



(Author's Work, 2024).

Specific Positive Experiences or Benefits gained using this VR system.

Based on the open-ended responses from 213 participants, the positive experiences and benefits gained from using the system developed by this study in design reviews are diverse and substantial. Participants highlighted several key advantages, including the improvement of design quality, the ability to visualize and experience designs in a realistic and immersive manner, and a better understanding of spatial relationships with the design. Many respondents appreciated the clarity and realism of the virtual environment, noting specific details such as traces of plaster on the wall that enhanced the authenticity of the experience. Participants also valued the comfort and ease of use of the Meta Quest 3 compared with other VR headsets, emphasizing its role in facilitating detailed examination of design without causing discomfort or headaches. The responses show the significant positive impact of the VR system developed by this study in enhancing the design review process, improving spatial awareness, and providing clients with a comprehensive understanding of architectural designs in the virtual environment.

Challenges or Areas of Improvement identified using this VR System

Based on the open-ended responses from 213 participants. The identified challenges and areas for improvement while using this VR system in design reviews were relatively limited. While some participants expressed no specific challenges or areas for improvement, others mentioned aspects such as the need for enhanced detail and accuracy in the virtual environment, improvements in responsiveness, and a desire for more intuitive movement controls. A few respondents noted that users may require further understanding to fully benefit from the VR experience, suggesting a potential need for additional training or guidance in utilizing Meta Quest 3 effectively for design reviews. While there were some suggestions for improvement, the challenges identified were generally minor, indicating a positive perception of this VR system's capabilities for architecture design reviews while also highlighting opportunities for refinement and optimization to enhance the overall user experience

Additional Comments and Suggestions

Based on the open-ended responses from 213 participants, the feedback provided after the survey reflects a generally positive sentiment toward the experience of using this VR system in design reviews. Participants expressed gratitude for the opportunity to contribute to the research and conveyed well wishes for its success. Some participants commented on the comfort and ease of use of this VR system, highlighting its high-quality visuals and immersive experience. Respondents also recognized the potential of VR technology to revolutionize design processes, with several expressing optimism about its future impact across various fields. The feedback conveyed, appreciated for the innovative approach to design reviews facilitated by the VR system developed by this study, and indicates a strong belief in its transformative potential and the value it brings to the architectural industry.

CHAPTER V

Discussion

This chapter presents the findings based on the research questions and hypothesis, as well as the overall ideas and discussion of the research and the logical conclusions.

The integration of Meta Quest 3 and Unreal Engine 5 in architecture design reviews represents a significant advancement in the field, offering a transformative user experience that has the potential to revolutionize traditional design review methods. Through the combination of cutting-edge VR technology and advanced software development techniques, this study aimed to assess the impact of Meta Quest 3 on user experience in architecture design reviews and explore avenues for optimization. Using Unreal Engine 5 allowed for the creation of a highly immersive VR environment, optimized for the Meta Quest 3, with features such as nanite, dynamic lighting, and high-quality materials from the Quixel Megascans library. This environment was then packaged for Windows, leveraging the powerful hardware of the host PC, and accessed via Quest Link to ensure optimal performance and fidelity.

The results of the usability testing and questionnaire revealed overwhelmingly positive feedback regarding the user experience with Meta Quest 3 in architecture design reviews. Participants expressed high levels of satisfaction with the visual quality, comfort, and responsiveness of the VR environment, highlighting effectiveness in enhancing spatial understanding, design visualization, and overall immersion. Participants also noted the ease of use and ergonomic design of the Meta Quest 3 headset, emphasizing its suitability for prolonged use during design reviews. These findings suggest that Meta Quest 3, when coupled with Unreal Engine 5, offers a compelling platform for conducting architecture design reviews, enabling users to engage with designs in a more intuitive, immersive, and efficient manner compared to traditional and other VR alternatives.

One of the key research questions addressed in this study was the impact of Meta Quest 3 and Unreal Engine on architectural design preferences and decision-making processes. The results indicated that the adoption of these technologies led to a shift in design practices, with participants expressing a preference for the immersive and interactive nature of VR design reviews. Compared to traditional methods, Meta Quest 3 facilitated better spatial awareness, enabling users to assess design elements more effectively and make informed decisions. The integration of Unreal Engine allowed for real-time adjustments and modifications, streamlining the design process and fostering collaboration between architects and clients.

Through the exploration of design guidelines and best practices, this study aimed to provide insights into optimizing the use of Meta Quest 3 and Unreal Engine in architecture design reviews. The findings highlighted the importance of prioritizing visual quality, comfort, and responsiveness in the VR environment, as well as ensuring intuitive navigation and interaction mechanisms. Leveraging the capabilities of Unreal Engine, such as dynamic lighting, and high-quality materials, can further enhance the realism and immersion of VR design reviews.

Table 15

Guidelines for implementing Meta Quest 3 and Unreal Engine in Architecture Design Reviews

STEP	GUIDELINE
1.Start with Autodesk Revit for initial design	Begin your architectural design in Autodesk Revit using the metric architectural template, only if you use metric measurements. Revit is ideal for initial design phase due to its integration with other software and global usage. It’s also preferred for its ease of use in advancing design processes. After completing the model in Revit, export the file as an AutoCAD file for further optimization in SketchUp.
2. Use SketchUp for furniture and model enhancement.	Import the AutoCAD file into SketchUp to add furniture and optimize the model. SketchUp offers a broader variety and more detailed furniture options, along with superior texture mapping capabilities compared to Revit. Organize your model in SketchUp by creating individual groups for components and parts of the models like the floors, which simplifies editing in Unreal Engine. Apply consistent materials to desired faces within SketchUp, and group all

	glass surfaces for easier material application in Unreal Engine.
3. Unreal engine optimization.	Export the SketchUp model as an Unreal Datasmith file using the Datasmith extension from the Epic Games website. In Unreal Engine, select the virtual reality default template and prepare your workspace by organizing the content drawer. Import the Datasmith file and enable Nanite for all meshes except glass, which improves performance and allows for working with larger models. This optimization is crucial for maintaining smooth interactions and a high level of detail in VR.
4. Enhance visual realism with Quixel Megascans and dynamic lighting.	Use high-quality materials from the Quixel Megascans library to enhance the visual realism of the model. Incorporate dynamic lighting instead of baked lighting to achieve more accurate and realistic light behaviour within the VR environment. This step is essential for creating an immersive experience where users can interact with light changes, shadows and materials in real-time.
5. Package the project for optimal performance on Meta Quest 3	Configure the project for windows, ensuring you use DirectX 12, SM6 shader format, and Lumen for optimal lighting and reflections. Package the project for Windows to utilize the graphics power of your PC, (my PC for this study had this specifications: Intel(R) Core(TM) i7-8750H CPU, 64GB RAM, 8GB GTX 1080 VRAM, 2TB SSD). Connect Meta Quest 3 to the PC via quest link using a USB 3 cable for better experience. Once set up, launch the packaged project and explore the VR environment, ensuring smooth and responsive interactions.

(Author’s Work, 2024).

By following these guidelines, you can effectively implement Meta Quest 3 and Unreal Engine in architecture design reviews, optimizing user experience, enhancing spatial understanding and delivering high quality, immersive design visualizations.

The study also sought to investigate the broader impacts of implementing Meta Quest 3 and Unreal Engine in architecture design reviews, particularly in terms of design quality, efficiency, and client satisfaction. The results demonstrated improvements in design quality and efficiency, with participants noting the ability to visualize and experience designs in full detail before construction. The immersive nature of VR design reviews contributed to higher levels of client satisfaction, as clients were able to better understand and engage with proposed designs. Overall, the integration of Meta Quest 3 and Unreal engine holds significant promise for enhancing the architecture design process, leading to better outcomes for architects, stakeholders, and clients alike.

CHAPTER VI

Conclusion

The conclusion chapter summarizes key findings on the effectiveness of Meta Quest 3 and Unreal Engine 5 for enhancing user experience and spatial understanding in architectural design reviews. It highlights the value of VR in improving design comprehension and client engagement while identifying future opportunities for further integration of VR technology in architecture.

In conclusion, the integration of Meta Quest 3 and Unreal Engine 5 has demonstrated immense potential in revolutionizing architecture design reviews. Through the exploration of user experiences and feedback gathered from usability testing and questionnaires, this study has provided valuable insights into the impact and optimization of VR technology in architectural workflows. The findings show the effectiveness of Meta Quest 3 in enhancing spatial understanding, design visualization, and overall immersion, thereby facilitating more intuitive and efficient design reviews compared to traditional methods and other VR alternatives.

The utilization of Unreal Engine 5 has played a crucial role in optimizing the VR experience, enabling the creation of highly immersive environments with advanced features such as Nanite, dynamic lighting, and high-quality materials. By leveraging the power of Unreal Engine, architects and stakeholders can benefit from real-time adjustments and modifications, streamlined design processes, and enhanced collaboration opportunities. These advancements not only improve the quality and efficiency of design reviews but also contribute to higher levels of client satisfaction by providing a more realistic and nagging representation of proposed designs.

Moving forward, the key design guidelines and best practices identified in this study serve as valuable recommendations for architects and stakeholders seeking to integrate Meta Quest 3 and Unreal Engine into their design workflows. Prioritizing factors such as visual quality, comfort, responsiveness, and intuitive interaction mechanisms can further enhance the user experience and optimize the effectiveness of VR design reviews. Ongoing research and development efforts should focus on addressing any identified challenges or areas for improvement.

Overall, the integration of Meta Quest 3 and Unreal Engine 5 holds tremendous promise for the future of architecture design reviews. By embracing innovative technologies and methodologies, architects can unlock new possibilities for creativity, collaboration, and decision-making, ultimately leading to more informed design outcomes and greater client satisfaction. As VR technology continues to evolve and become more accessible, its integration into architectural workflows will undoubtedly shape the future of the industry, driving innovation and excellence in design practice.

Recommendations

As we conclude our exploration of the integration of Meta Quest 3 and Unreal Engine 5 in architecture design reviews, it is imperative to consider the recommendations that emerge from our findings. These recommendations aim to guide architects, stakeholders, and VR technology enthusiasts in optimizing the use of VR technology in architectural workflows.

i. Continuous Improvement of VR Technology: Given the rapid pace of technological advancement, it is recommended to stay abreast of developments in VR technology and regularly update hardware and software to ensure optimal performance and user experience. This includes incorporating the latest features and enhancements offered by platforms such as Meta Quest 3 and Unreal Engine 5, as well as exploring emerging technologies that may further enhance the capabilities of VR design reviews.

ii. User Training and Support: Providing comprehensive training and support to users is essential for maximizing the benefits of VR technology in architecture design reviews. This includes offering tutorials, workshops, and user guides to familiarize users with VR hardware and software, as well as ongoing technical support to address any issues or challenges encountered during the design process. By investing in user training and support, architects can ensure that tea members are proficient in utilizing VR technology effectively and efficiently.

iii. AI for Natural Language Processing in Feedback: AI Powered natural language processing (NLP) tools could assist in gathering and organizing feedback from multiple users in a VR session. By analysing verbal feedback from clients or stakeholders during the VR review, AI could provide summaries, categorize suggestions and highlight key concerns, making it easier for architects to incorporate feedback into the final design.

iv. Customization and Personalization: Recognize the diverse needs and preferences of users and tailor VR environments and experiences to accommodate individual preferences and requirements. This includes allowing users to customize settings such as comfort options, interaction mechanisms, and visual preferences to suit their specific needs. Additionally, consider incorporating features such as multi-user support and real-time annotations to facilitate personalized and interactive design reviews that cater to the unique preferences of each user.

v. Feedback and Modification: Establish a feedback loop to gather insights and suggestions from users on an ongoing basis and incorporate feedback into iterative improvements to VR design processes. Encourage users to provide feedback through surveys, focus groups, and direct communication channels to prioritize implementing suggested enhancements and address identified issues. By continuously soliciting and acting upon user feedback, architects can ensure that VR design views evolve in alignment with user needs and preferences, driving continuous improvement and innovation in architectural practice.

vi. AI for Virtual Client Interaction: AI powered virtual assistants could guide clients through the VR environment, explaining design features, answering questions or offering suggestions based on the client’s previous preferences or design objectives. This would enhance client engagement and provide a more interactive and personalized review experience, even in remote settings.

The recommendations outlined in this chapter serve as a roadmap for leveraging VR technology effectively in architecture design reviews. By embracing continuous improvement, prioritizing user training and support, fostering collaborative workflows, customizing experiences, and embracing feedback-driven modifications, architects can unlock new possibilities for creativity, efficiency, and client satisfaction. As VR technology continues to evolve, it is imperative to remain adaptable and responsive to emerging trends and technologies, ensuring that architectural practice remains at the forefront of innovation and excellence.

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APPENDICES

Appendix A

NEAR EAST UNIVERSITY

SCIENTIFIC RESEARCH ETHICS COMMITTEE

02.07.2024

Dear Abdulmumini Mustapha

Your application titled **"Enhancing User Experience in Architecture through Virtual Reality Design Reviews"** with the application number NEU/AS/2024/211 has been evaluated by the Scientific Research Ethics Committee and granted approval. You can start your research on the condition that you will abide by the information provided in your application form.

Prof. Dr. Aşkın KİRAZ

The Coordinator of the Scientific Research Ethics Committee

Appendix B

Turnitin Similarity Report

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Appendix C

Interview (Usability test) form for Virtual Reality Design Review User Experience.

This survey was conducted to provide data for my master's thesis titled "Enhancing User Experience Architecture through Virtual Reality Design Reviews" This survey is completely voluntary and your identity will remain anonymous. The questionnaire will be for all the members of the building industry including the clients and the usability tests/ interviews will be for the clients in the building industry. Any feedback you provide will be kept confidential and only the summarized results will be included in the written report of the dissertation.

Dear Participant,

Your feedback is crucial for enhancing our understanding of the user experience in architecture design reviews using Meta's Meta Quest 3 in virtual reality.

Thank you in advance,

Department of Architecture, Faculty of Architecture, Near East University

The study will be open ended, and the areas we will observe and document during the usability tests are:

Ease of Navigation

Spatial Understanding

Visual Clarity

Interactivity

User Engagement

Task Completion Efficiency

Comfort and Ergonomics

User Satisfaction

Technical Issues.

Survey form for Virtual Reality Design Review User Experience.

This survey was conducted to provide data for my master's thesis titled "Enhancing User Experience in Architecture through Virtual Reality Design Reviews" This survey is completely voluntary and your identity will remain anonymous. The questionnaire will be for all the members of the building industry including the clients and the usability tests/ interviews will be for the clients in the building industry. Any feedback you provide will be kept confidential and only the summarized results will be included in the written report of the dissertation.

Dear Participant,

We hope you will take all questions into full consideration. Your feedback is crucial for enhancing our understanding of the user experience in architecture design reviews using Meta's Meta Quest 3 in virtual reality. Please take a few minutes to answer the following questions

Department of Architecture, Faculty of Architecture, Near East University.

Section 1: Demographic Information

1.1. Role:

Architect

□ Engineer

□ Builder

□ Client

□ Other (please specify): ....

1.2. Years of experience in the field:

□ Less than 1 year

□ 1-5 years

□ 6-10 years

□ More than 10 years

Section 2: Virtual Reality Experience

2.1. How familiar are you with virtual reality technology?

□ Very familiar

□ Somewhat familiar

□ Neutral

□ Somewhat unfamiliar

□ Very unfamiliar

2.2. Have you previously used virtual reality for architecture design reviews?

□ Yes

□ No

2.3. If yes, please specify the VR systems or headsets you have previously used:

....

Section 3: Meta Quest 3 Experience

3.1. Please rate your overall satisfaction with the Meta Quest 3 for architecture design reviews.

□ Very satisfied

□ Satisfied

□ Neutral

□ Dissatisfied

□ Very dissatisfied

3.2. How would you rate the visual quality and clarity of the virtual environment in Meta Quest 3?

□ Excellent

□ Good

□ Fair

□ Poor

□ Very poor

3.3. Rate the comfort level of wearing Meta Quest 3 during the design review.

□ Very Uncomfortable

□ Uncomfortable

□ Neutral

□ Comfortable

□ Very Comfortable

3.3. Rate the responsiveness and accuracy of interactions with the virtual environment using Meta Quest 3.

□ Excellent

□ Good

□ Fair

□ Poor

□ Very poor

3.4. To what extent did Meta Quest 3 enhance your spatial understanding of the design compared to traditional methods?

□ Significantly enhanced

□ Moderately enhanced

□ Neutral

□ Slightly enhanced

□ Not enhanced at all

3.5. Did you encounter any technical issues or discomfort while using Meta Quest 3 for design reviews?

□ Yes (please specify): ....

□ No

Section 4: Comparative Analysis

4.1. Compare your experience using Meta Quest 3 for design reviews with traditional methods and other VR experiences. (e.g., physical models, 2D drawings).

□ Meta Quest 3 was superior

□ Meta Quest 3 was comparable

□ Traditional methods were superior

Section 5: Open-Ended Questions

5.1. Please share any specific positive experiences or benefits you gained from using Meta Quest 3 in design reviews.

....

5.2. Are there any challenges or areas of improvement you identified while using Meta Quest 3?

....

Thank you for completing the questionnaire. Your insights are invaluable to our research. If you have any additional comments or suggestions, please feel free to share them in the space provided below.

Additional Comments:

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