HSLU Hochschule Luzern

Master Design

VR TECHNOLOGY INTEGRATION INTO ARCHITECTURE

"Enhancing Communication and Collaboration between Architects and Stakeholders through Virtual Reality."

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Abstract

The integration of Virtual Reality (VR) into architecture introduces a transformative platform for enhancing communication and collaboration among architects, clients, and various project stakeholders. VR offers immersive, interactive experiences that significantly enhance design visualization and client engagement; however, its adoption in architectural practice remains limited. This research investigates how VR can address prevalent communication challenges, reduce miscommunication, and foster collaborative efficiencies in architectural projects. By identifying the key obstacles to independent VR adoption—such as high costs, insufficient training, and resistance to technological change—this study outlines strategies to facilitate VR integration into both architectural practice and education. Through interviews, case studies, and surveys, the research examines how VR can improve clients' understanding of design concepts and support architects in more effective collaboration with engineers, contractors, and other professionals. Concluding with actionable recommendations, this study emphasizes the importance of educational reforms and awareness initiatives to encourage VR adoption, ultimately advancing both professional practices and architectural curricula.

Keywords: Virtual Reality (VR), Architecture, Communication, Collaboration, Design Visualization, Architectural Practice, VR Adoption Barriers, Client Interaction, Immersive Technology

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Finally, I am grateful to my friends and family for their unwavering support and understanding throughout this journey. Their encouragement has been a constant source of motivation.

I dedicate this thesis to all women striving to achieve their goals and make a place for themselves in a male-dominated society. May their efforts and resilience continue to inspire change.

Figure:Gamze Günes

Affidavit

I, Gamze Güneş, hereby declare that I have independently written this master's thesis titled *"The Adoption of Virtual Reality (VR) in Architecture: Enhancing Communication and Collaboration in Architectural Practice"* for the Master of Digital Ideation program at Lucerne University of Applied Sciences and Arts. All ideas taken directly or indirectly from external sources are clearly marked as such. This thesis has not been submitted to any other examination authority, nor has it been published in the same or similar form.

In writing this thesis, I used the AI-based writing tool ChatGPT by OpenAI to optimize the text. Passages taken verbatim from the tool have been cited in the text as personal communication.

Location, Date : Lucerne, 17.11.2024

Signature:

Gamze Güneş

List of Abbreviations

1. 2D - Two-Dimensional
2. 3D - Three-Dimensional
3. AEC - Architecture, Engineering, and Construction
4. AR - Augmented Reality
5. BIM - Building Information Modelling
6. CAD - Computer-Aided Design
7. HMD - Head-Mounted Display
8. MR - Mixed Reality
9. ROI - Return on Investment
10. SIA - Swiss Society of Engineers and Architects
11. VR - Virtual Reality
12. XR - Extended Reality

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1. INTRODUCTION

> *"Architecture must move beyond buildings; it must become something that transforms human experience in real time, adapting through the possibilities that new technologies offer." (1)*
>
> *Nicholas Negroponte*

Humanity's need for shelter and structured spaces has been a fundamental aspect of life since prehistoric times, when early humans sought refuge in caves and began utilizing natural materials for basic constructions. Over centuries, as civilizations evolved, so did architectural practices, shaping environments that fulfill functional needs while embodying cultural values and artistic expressions. Architecture has always been more than just creating buildings; it involves designing spaces that enhance human experiences, functioning as a bridge between individuals and their physical surroundings (2).

As architectural practices evolved, so too did the tools and methods used to communicate architectural ideas. Initially, architects relied on hand-drawn sketches and simple physical models to convey spatial arrangements and structural details. Although these methods were effective for their time, they were limited in their ability to represent complex three-dimensional forms and spatial relationships accurately. This limitation often led to challenges in communication, particularly when attempting to convey design concepts to clients without a technical background, thus creating a gap in understanding between architects and clients (3, 4).

In contemporary practice, clear communication between architects and clients remains crucial. Architects strive to ensure that design visions are conveyed accurately and comprehensibly to foster trust and alignment throughout a project. Traditionally, two-dimensional (2D) drawings, physical models, and static renders have been the primary tools for representing architectural designs. Renderings, in particular, have been instrumental in providing clients with a visual preview of completed projects, allowing them to understand design concepts more concretely (5). These high-quality images aim to capture material finishes, lighting effects, and spatial qualities, helping clients envision the final product more clearly.

Originally, rendering was a manual process that involved techniques like perspective drawing and shading, allowing for more lifelike depictions of architectural designs. However, digital advancements have transformed rendering into a multi-stage, computer-based process involving sophisticated software, providing even more realistic representations (6).

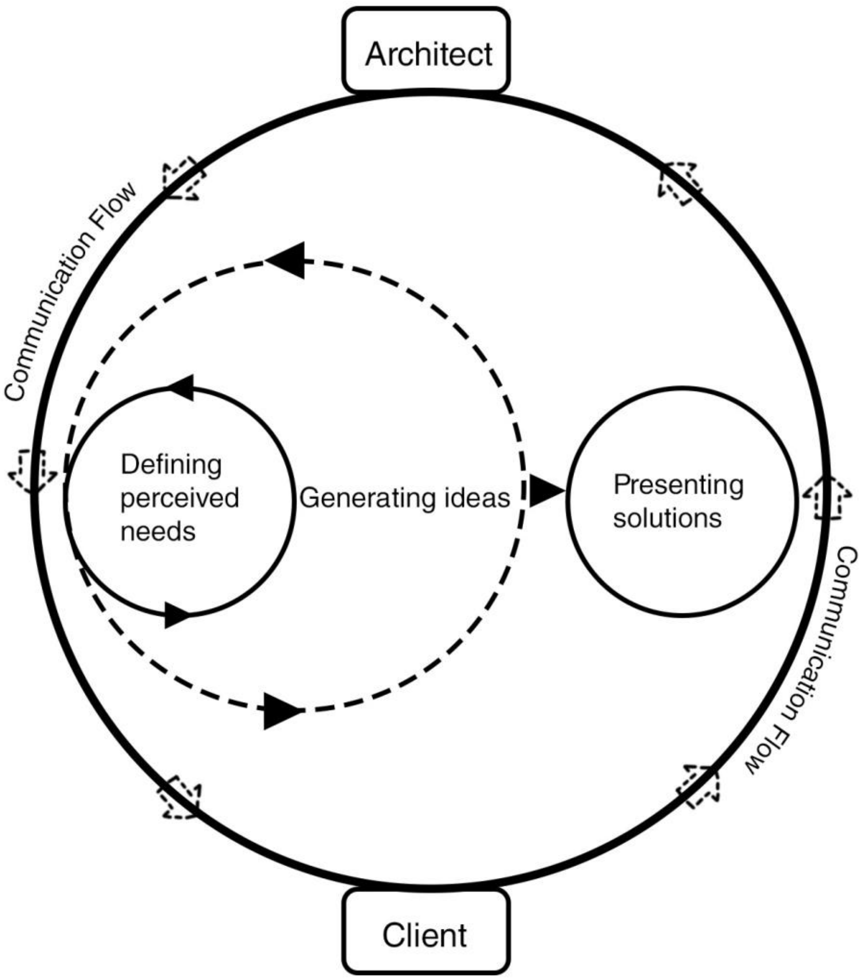

Figure: (1)

The purpose of rendering is to bridge the gap between abstract architectural concepts and realistic visualizations, enabling clients to preview a project before it is physically built. Digital rendering began to take shape in the 1960s with the advent of Computer-Aided Design (CAD) and later evolved with Building Information Modelling (BIM), which provided a more precise framework for three-dimensional modelling and visualization (7).

Despite its advancements, static renderings are inherently limited in fully conveying the depth, scale, and experiential aspects of a space. While they are effective at providing high-detail images of material finishes, lighting, and spatial qualities, they remain bound to screens, leaving clients unable to fully "experience" the design.
Consequently, these limitations have driven the development of more advanced representation tools to better capture architectural intent (8).

From CAD to BIM, each technological advancement aimed to improve accuracy and enhance client comprehension, but even with these tools, traditional architectural communication methods fall short of immersing clients in the spatial experience.

Virtual Reality (VR) offers a promising solution by allowing clients to navigate a space in real time, fostering a sense of presence and engagement that static images cannot provide (9). VR technology has the potential to transform how architects and clients interact with design concepts by creating an immersive experience that allows clients to "walk through" and interact with the virtual environment as though it were a completed space (10). This thesis aims to assess whether VR technology can improve communication better between architects and clients within Switzerland. The research will explore the challenges architects face in adopting VR technology and investigate possible obstacles and solutions to make VR a more accessible tool in architectural communication. By examining architects' willingness to adopt VR in their projects and analysing the factors influencing their reluctance or enthusiasm for this technology, this study will seek to uncover VR’s role in enhancing collaboration, streamlining workflows, and ultimately transforming the architectural design process. Through this exploration, the research will offer insights into how VR can reshape architectural communication, making it more engaging and accessible for clients, thereby fostering a more collaborative and efficient design process.

1.1 Background of Virtual Reality (VR) in Architecture

1.1.1 What is VR?

Virtual Reality (VR) is a computer-generated, immersive experience that fully replaces the user’s real-world environment with a digital one. Using VR headsets, users are transported into a simulated 3D space where they can interact with virtual objects as if they were in a physical environment, allowing for a deeply immersive experience. VR has found significant applications in fields such as gaming, education, architecture, and therapy, providing a controlled environment that can simulate complex real-world scenarios (11).

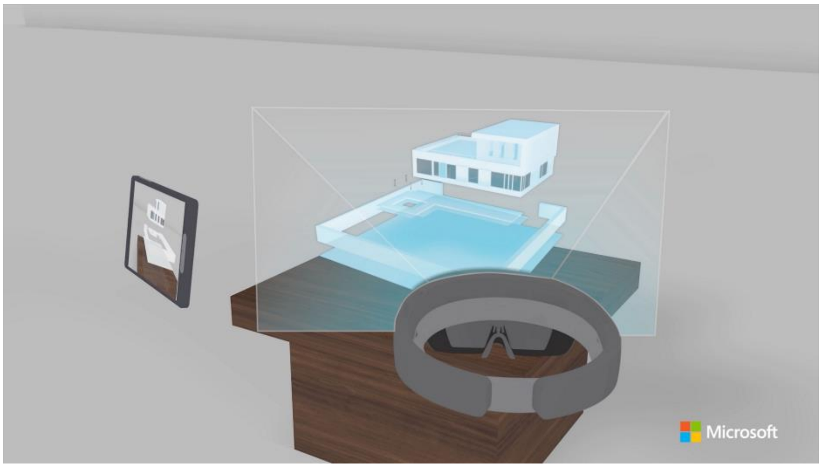

Figure: (2)

As of 2024, a variety of VR headset models and brands are available, each offering unique features and controller types to enhance user interaction. Leading models like the Meta Quest 3, HTC Vive XR Elite, and PlayStation VR2 provide advanced controllers that track hand and finger movements with impressive precision. Some devices, like the Quest 3, also support hand-tracking technology, allowing for controller-free interactions in certain applications, which adds to the flexibility of VR experiences (12).

Resolution and visual clarity are critical to VR immersion, with most premium models now offering between 2K and 4K resolutions per eye. For instance, high-end models like the Varjo Aero can reach resolutions of up to 2880 x 2720 pixels per eye, providing ultra-realistic visuals with minimal screen-door effect (visible pixel grid). Mid-range options, like the Quest 3, offer approximately 2064 x 2208 pixels per eye, balancing clarity and accessibility. These advancements in resolution and tracking capabilities enable VR to support highly detailed, immersive applications in fields such as architectural visualization and simulation-based training, while also providing more accessible options for general use (13).

1.2 Purpose of the Study

The primary purpose of this study is to evaluate the potential of Virtual Reality (VR) technology to revolutionize communication and collaboration in architectural practice. As the architectural profession advances, the complexities of modern design projects grow, with multiple stakeholders requiring clear, precise communication at each stage of the project. Traditionally, architects have relied on tools such as 2D drawings, physical models, and digital renderings to convey design concepts to clients, engineers, contractors, and other project participants.

While these tools have served the industry for decades, they often fall short in providing a comprehensive, immersive experience that allows stakeholders to fully understand and engage with the design intent (14).

This research seeks to address this gap by exploring VR as a tool that enables architects and stakeholders to experience spaces in a simulated, three-dimensional environment, which could fundamentally transform their understanding and decision-making processes. By providing a realistic sense of scale, depth, and spatial relationships, VR has the potential to offer stakeholders an intuitive grasp of architectural designs that static images and traditional models cannot. This immersive quality of VR is especially valuable for clients who may lack a technical background, as it allows them to walk through and interact with a design, helping them make more informed decisions and align more closely with the architect's vision (15).

In addition to improving client communication, this study also examines VR’s role in enhancing interdisciplinary collaboration between architects, engineers, contractors, and other professionals involved in the architectural workflow. Communication challenges are frequent in architectural projects, often due to the specialized language and abstract representations used in architectural documentation (16).

VR could streamline collaboration by enabling all parties to view, discuss, and modify designs in real-time, thereby reducing misunderstandings, minimizing design revisions, and fostering a more cohesive project environment. To achieve these goals, the study will investigate both the opportunities, and the barriers associated with VR adoption. Key questions include identifying the financial, technical, and cultural challenges architects face when integrating VR, as well as assessing how VR technology can be adapted to fit within existing workflows. High hardware and software costs, technical complexity, resistance to change, and usability concerns among clients are among the potential obstacles to widespread VR adoption (17).

This research aims to analyze these factors in depth to understand the practical limitations of VR and propose solutions that can make VR a feasible tool even for smaller architectural firms with limited budgets and resources. Through a combination of qualitative interviews, case studies of firms already using VR, and surveys of architects with and without VR experience, the study will provide a comprehensive view of VR’s current and potential roles in the architectural industry (18).

The findings aim to offer actionable recommendations to architects and firms, emphasizing best practices for VR implementation, cost-effective strategies, and training initiatives that can support both professional practices and architectural education. Ultimately, this study aspires to contribute to a broader understanding of how VR can be harnessed to create more accessible, efficient, and engaging architectural processes. By equipping architects with practical strategies for VR integration, this research seeks to pave the way for an industry-wide shift toward immersive, interactive design experiences, advancing both the effectiveness of architectural communication and the satisfaction of project stakeholders (19).

1.3 Research Questions

This research seeks to address key questions surrounding the role of Virtual Reality (VR) technology in architectural practice. By focusing on communication, interdisciplinary collaboration, and workflow integration, this study aims to explore the full potential of VR in enhancing project efficiency by improving the stakeholder engagement.

1. **How can Virtual Reality (VR) technology enhance communication between architects and clients in architectural design projects?**
   This question investigates VR's capability to bridge communication gaps, offering clients a more immersive understanding of design concepts and enabling architects to convey spatial and design elements with greater clarity.
2. **What are the primary barriers to the widespread adoption of VR technology in architectural practice?**
   Addressing this question will identify the financial, technical, and cultural factors that hinder VR adoption, with insights gathered from literature and interviews with architects who have varying levels of experience with VR.
3. **How can VR technology facilitate interdisciplinary collaboration among architects, engineers, contractors, and other stakeholders?**
   This question focuses on VR's potential to support clearer communication and real-time problem-solving across diverse disciplines involved in architectural projects, from the design phase through construction.
4. **Where is the greatest potential for improvement in architectural processes using VR, specifically in areas with minimal financial and technical challenges?**

   This question focuses on identifying VR applications in architecture that offer substantial benefits with lower barriers to entry, making adoption more feasible for firms regardless of size or budget.

2. Literature Review

The adoption of Virtual Reality (VR) in architecture represents a significant development in how design professionals communicate complex spatial ideas to clients and collaborators. This literature review examines the evolution of traditional architectural communication methods, the introduction and development of VR technology, the benefits of VR in enhancing architectural communication, and the current challenges associated with its widespread adoption.

2.1 Traditional Architectural Communication Methods

Effective communication is essential in architecture, as it ensures that clients, engineers, contractors, and other stakeholders fully understand and align with the design intent. Traditional architectural communication methods have long relied on a combination of drawings, physical models, and digital renderings, each serving to bridge the gap between the architect's vision and the client's understanding. Although these methods have helped convey complex design concepts, they also present certain limitations, particularly in terms of immersive engagement and spatial comprehension.

2.1.1 2D Drawings and Technical Plans

The foundation of architectural communication traditionally begins with 2D drawings, including floor plans, elevations, and sections. These technical drawings convey fundamental details such as spatial organization, structural components, and measurements. However, clients without a technical background may find it challenging to interpret these abstract representations accurately, which can sometimes lead to miscommunication regarding spatial layout and scale (20).

2.1.2 Hand Sketches and Conceptual Drawings

Hand sketches and conceptual drawings allow architects to quickly illustrate design ideas in a flexible, accessible manner. These rough, expressive visuals are often used in the early design stages to communicate initial ideas and explore options with clients. According to Ching, sketches are vital for translating abstract concepts into more tangible forms, giving clients an early visual understanding of the design direction (21).

2.1.3 Physical Scale Models

Physical models offer a tactile, three-dimensional representation of a project, allowing clients and stakeholders to view the design from multiple angles and better understand spatial relationships. Scale models are especially useful in conveying the massing, form, and overall layout of a project. While models help bridge certain gaps in understanding, their production can be time-consuming and costly, and they may still lack the immersive quality needed for clients to feel a full sense of space (22).

2.1.4 Digital 3D Models

With advancements in software, digital 3D models have become a standard tool for architectural visualization. These models provide a more detailed and realistic representation of a project, including material textures, lighting, and structural details. They enable architects to refine specific design elements, making them essential for complex projects. However, without a fully immersive experience, digital models still require clients to interpret a 3D design through a 2D screen, which can limit their spatial comprehension and emotional connection to the project (23).

2.1.5 Photorealistic Renderings

Renderings offer highly realistic images that depict the final appearance of a building, complete with shadows, reflections, and color depth. Advanced software, such as V-Ray and Lumion, generates these photorealistic images by simulating real-world lighting and materials, helping clients visualize the completed project accurately. These renderings set clear expectations by showing how materials, finishes, and lighting will look in the final built environment, although they remain limited in conveying the dynamic experience of moving through a space (24).

2.1.6 Presentations and Client Meetings

Regular presentations allow architects to gather feedback from clients and ensure alignment throughout the design process. Using a combination of 2D drawings, physical models, and renderings, architects present their designs in visually engaging formats. This collaborative process helps address client questions, clarify design choices, and make necessary adjustments. Yet, without interactive or immersive elements, clients may still struggle to fully grasp spatial qualities and the overall experience of the project (25).

While these traditional methods are invaluable, their limitations in providing a fully immersive experience often create gaps in communication and understanding between architects and clients. Emerging technologies, such as Virtual Reality (VR), are now addressing these gaps by allowing clients to “walk through” designs in a virtual space, fostering a clearer understanding and more collaborative decision-making process (26).

2.2 Overview of the Architectural Process from Concept to Completion

The architectural process is a structured progression of phases that guide a project from initial concept to a completed building. Each phase requires the involvement of architects, clients, contractors, and other stakeholders to ensure that the final structure aligns with the vision, meets regulatory standards, and serves its intended purpose. The following overview explores each stage in detail, with examples and insights from celebrated architects who have shaped modern design.

- Pre-Design Phase
- Schematic Design
- Design Development
- Construction Documentation
- Bidding and Negotiation
- Construction Administration
- Project Close-Out

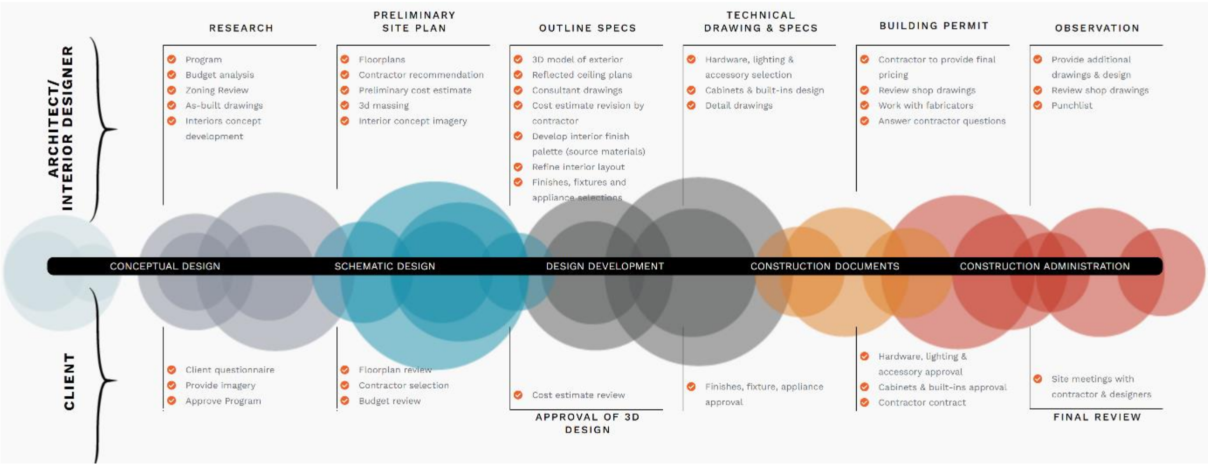

Figure: (3)

2.2.1 Pre-Design Phase

The pre-design phase is the foundational stage where architects and clients work together to outline the project's objectives, budget, and timeline. This phase also includes site analysis, zoning research, and preliminary cost estimates.

Renowned architect Frank Gehry once said, *"Architecture should speak of its time and place, but yearn for timelessness."* This insight reflects the importance of aligning the project with its context and purpose from the very beginning, as considerations like site location and client goals shape the design's direction.

2.2.2 Schematic Design

During the schematic design phase, architects create initial concepts and spatial layouts using sketches, floor plans, and rough models. These initial designs help convey the project's general structure, enabling clients to understand the look and function of the space early on (27). According to Le Corbusier, *"The purpose of construction is to make things hold together; of architecture, to move us."* This phase allows architects to begin creating spaces that not only serve functional needs but also evoke an emotional response from clients and users.

2.2.3 Design Development

In this phase, the schematic design is further refined with detailed drawings, materials, and finishes. Structural and mechanical systems are integrated into the design, ensuring feasibility. 3D models and renderings often accompany these detailed drawings to help clients visualize the project more accurately, facilitating alignment on design decisions (28).

2.2.4 Construction Documentation

Once the design is finalized, architects produce detailed construction documents, including specific instructions, dimensions, and material specifications. These documents serve as the blueprint for construction, guiding contractors through each stage of the build to minimize errors and ensure compliance with design intent (29).

2.2.5 Bidding and Negotiation

In this phase, the architect assists the client in selecting a contractor by reviewing bids and negotiating terms. This process helps ensure that the chosen contractor meets the project's quality standards, budget, and timeline (30).

2.2.6 Construction Administration

Throughout the construction phase, architects oversee progress to verify that the work aligns with the design specifications. They conduct site visits, coordinate with contractors, and resolve any emerging issues, ensuring that the project stays true to its design and adheres to quality standards (31).

2.2.7 Project Close-Out

The final phase involves inspections to ensure compliance with building codes, completing punch lists, and addressing any outstanding issues. The architect confirms that the project meets client expectations and delivers final documentation (32).

2.3 The Swiss Architectural Process: SIA Standards from Concept to Completion

The Swiss Society of Engineers and Architects (SIA) provides a structured process model for architectural and engineering projects, with specific standards like SIA 102, SIA 118, and SIA 142 guiding the planning, design, and construction phases. These standards help streamline communication and clarify responsibilities at each stage, ensuring alignment between architects, clients, and other project stakeholders. The SIA model divides the architectural process into six standardized phases, each tailored to the specific needs of Swiss construction projects. These phases offer a clear, sequential roadmap from project conception to final handover, emphasizing consistent communication and detailed documentation throughout.

2.3.1 Strategic Planning (Phase 1): This initial phase focuses on defining the project's objectives, feasibility, and strategic goals. It includes activities like site analysis, budgeting, and high-level planning. Architects and clients work together to assess project requirements, align on primary objectives, and outline the project's scope and constraints. By involving clients early on, the SIA model aims to ensure that all stakeholders have a unified understanding of project goals from the outset, minimizing potential misalignment later in the process (33).

2.3.2 Preliminary Design (Phase 2): In this phase, architects develop preliminary design options to explore and communicate possible solutions to the client. Initial sketches, rough 3D models, and conceptual layouts are presented for review, allowing clients to visualize key ideas and provide early feedback. This phase often includes discussions around functional requirements, spatial organization, and initial aesthetic considerations. The goal is to establish a shared vision that reflects both architectural intent and client expectations before moving to more detailed planning (34).

2.3.3 Project Design (Phase 3): This phase marks the transition from conceptual design to detailed project planning. Architects create comprehensive architectural drawings, material specifications, and coordinate with consultants across disciplines, such as structural, mechanical, electrical, and plumbing (MEP) engineers. The project design phase involves rigorous collaboration between all involved parties to finalize design elements, establish material standards, and set realistic timelines. By this point, the project's visualizations and technical aspects are well-developed, enabling clients to understand and approve the finalized plans with confidence (35).

2.3.4 Tendering (Phase 4): This phase involves preparing and issuing tender documents to solicit bids from contractors. Detailed specifications, schedules, and cost estimates are provided to ensure transparency and competitive bidding. The architect assists in evaluating bids and selecting contractors, with client input, to confirm that chosen firms meet quality, cost, and timeline requirements. This phase is critical for aligning expectations on both budget and execution standards before construction begins (36).

2.3.5 Execution (Phase 5): During the execution phase, the project moves to construction, with architects providing oversight to ensure that the work aligns with the design specifications. This includes conducting site visits, reviewing construction quality, and coordinating with contractors to address issues as they arise.

Architects play a supervisory role, monitoring progress, verifying material quality, and ensuring that the project timeline is followed. Regular communication between architects, contractors, and clients helps manage expectations and maintains the project's alignment with its intended goals (37).

2.3.6 **Commissioning and Handover (Phase 6)**: The final phase focuses on the commissioning, inspection, and formal handover of the completed project to the client. This includes final inspections to confirm that all work meets regulatory standards and project specifications. Any required adjustments or touch-ups are addressed before the official handover. The project is reviewed in its entirety, including operational testing and final walkthroughs with the client, ensuring that they are fully satisfied with the outcome before assuming ownership (38). The SIA standards, particularly SIA 102, emphasize the importance of clear communication throughout each phase. By defining roles and responsibilities in detail, these standards reduce ambiguity, encourage active client involvement, and promote collaborative decision-making. This structured approach is intended to improve transparency and client satisfaction, addressing common communication challenges by providing clear documentation and frequent checkpoints (39).

For architects in Switzerland, adherence to the SIA model offers a valuable framework for maintaining project alignment and ensuring that clients are consistently informed and involved. The SIA's structured phases can serve as a model for analysing communication gaps within the architectural process and exploring where Virtual Reality (VR) might further enhance client comprehension and engagement (40).

2.4 Introduction to VR Technology

Virtual Reality (VR) technology enables users to experience computer-generated, immersive environments that simulate real-world or imaginative spaces. Unlike Augmented Reality (AR), which overlays digital elements onto the real world, or Mixed Reality (MR), which blends real and digital elements interactively, VR fully immerses the user in a digital environment, blocking out the physical world entirely. Core components of VR include head-mounted displays (HMDs), motion tracking, and 3D virtual environments, which together create an experience that users perceive as real, allowing them to explore and interact within these spaces. According to Whyte and Nikolić (2018), VR provides users with a heightened sense of presence, essential for applications like architectural design where spatial understanding is crucial (41).

VR initially gained traction in gaming, military training, and scientific simulation, where realistic environments were vital for effective learning and experimentation. However, as VR hardware improved with higher resolution displays, better motion tracking, and enhanced processing power, it began expanding into professional fields, including architecture (42).

Modern VR platforms like Unreal Engine and Unity have contributed significantly to VR's adoption in architecture, offering high-quality, real-time rendering that enables architects to create immersive, realistic environments.

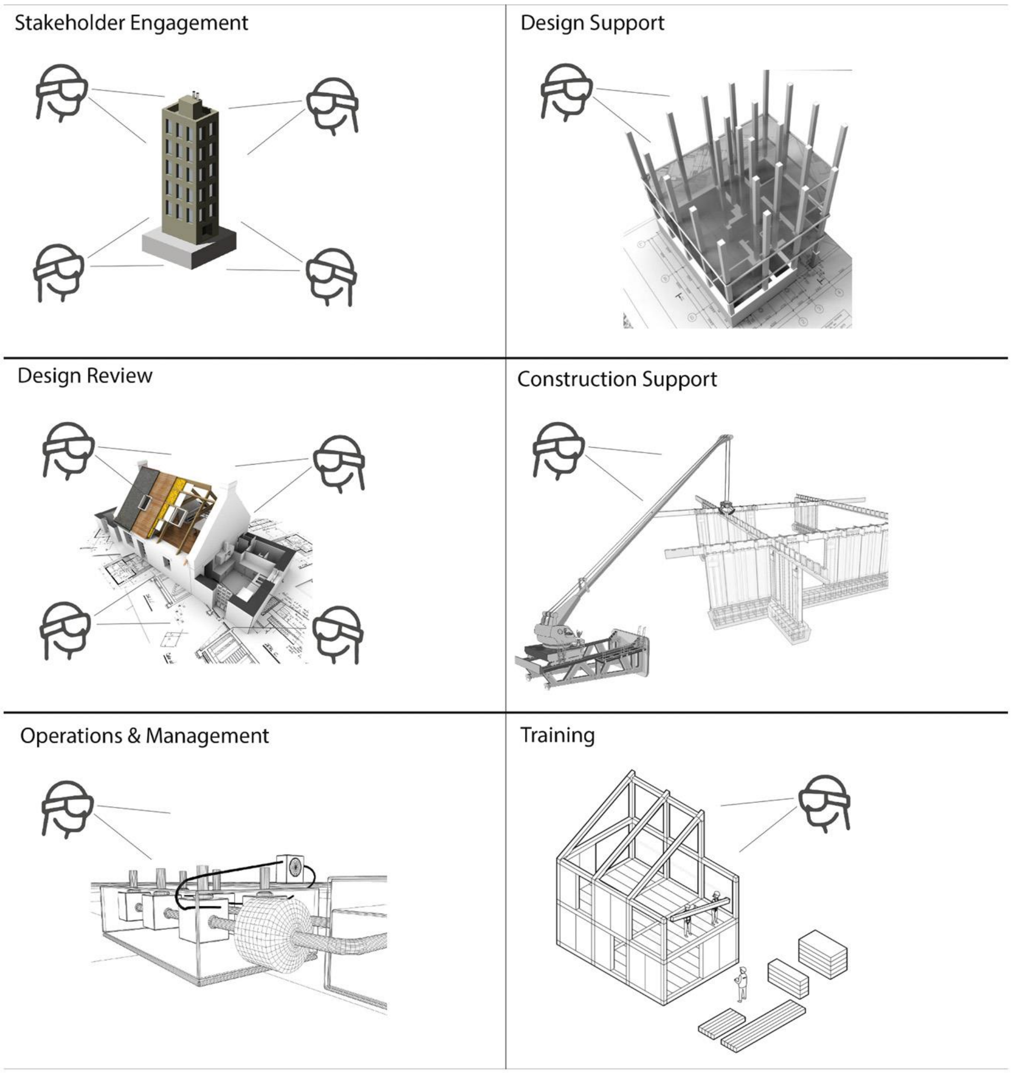

Figure: (3)

In architecture, two primary types of VR systems are used: Desktop VR and Immersive VR. Desktop VR utilizes standard computer screens and input devices, such as a mouse and keyboard, allowing users to view 3D models affordably but with limited immersion (Portman, Natapov, & Fisher-Gewirtzman, 2015) (43). This setup lacks the depth and presence of a fully immersive experience, which can limit spatial perception.

Immersive VR, on the other hand, uses HMDs and motion tracking to place users inside the digital environment, where they can explore the virtual space as if they were physically present, perceiving depth, scale, and lighting in ways similar to real-world experience (44). Although immersive VR requires a greater investment in hardware, its ability to provide a realistic, spatially accurate experience makes it particularly valuable for complex architectural projects.

VR's technical capabilities, such as real-time rendering, spatial audio, and interactivity, provide substantial advantages for architectural applications. Real-time rendering enables users to view realistic lighting, shadow, and texture effects, allowing clients to perceive the atmosphere and spatial qualities of a project. According to Goulding et al. (45), interactive elements like changing materials or adjusting layouts empower architects and clients to explore design options dynamically, enhancing client engagement and aiding in decision-making. Spatial audio also contributes by helping users understand how sound will interact within a space, an important factor in creating environments like auditoriums or open offices (46).

Several software platforms support VR in architecture, with Unreal Engine and Unity being widely used. These platforms allow architects to import 3D models from Building Information Modelling (BIM) or CAD tools, making it easy to transform architectural designs into immersive VR experiences. Tools like Unity Reflect and Unreal's Datasmith facilitate the integration of VR into architectural workflows by allowing smoother synchronization with existing design software, enabling architects to review and present their designs in VR without requiring extensive additional setup (47).

The impact of VR on architectural communication is transformative, as it allows clients and stakeholders to "walk through" designs and experience spatial arrangements directly. According to Whyte (48), VR enhances understanding by enabling clients to interact with spaces at scale, see how lighting affects a room, and understand material textures in ways that traditional methods cannot replicate. This level of immersion promotes more informed client decisions, reduces misunderstandings, and encourages a collaborative approach to project design and revision (49). Furthermore, VR fosters interdisciplinary collaboration, as architects, engineers, and contractors can work within a shared virtual model, facilitating clear communication and smoother project progression (50).

In summary, VR technology has the potential to transform architectural practice by offering a new level of engagement that benefits both clients and project stakeholders. As VR continues to develop, its role in architecture is expected to expand, providing innovative solutions to traditional communication challenges and ultimately enhancing the design process.

2.4.1 Differences Between VR and Other Realities (AR, MR, XR)

2.4.1.1 VR vs. Augmented Reality (AR)

Augmented Reality (AR) enhances the real world by overlaying digital information on top of the user's physical environment. Unlike VR, which entirely immerses users in a virtual environment, AR allows them to see and interact with their actual surroundings, augmented by digital objects or information. AR is often experienced through smartphones or AR glasses, adding a layer of virtual information to enhance physical world contexts, making it useful in fields like navigation, education, and maintenance (51).

2.4.1.2 VR vs. Mixed Reality (MR)

Mixed Reality (MR) combines aspects of VR and AR, allowing digital and real-world objects to coexist and interact within the same environment. MR enables users to interact with virtual and real-world objects simultaneously, making it particularly useful for collaborative design and engineering, where physical and digital elements can be manipulated together (52).

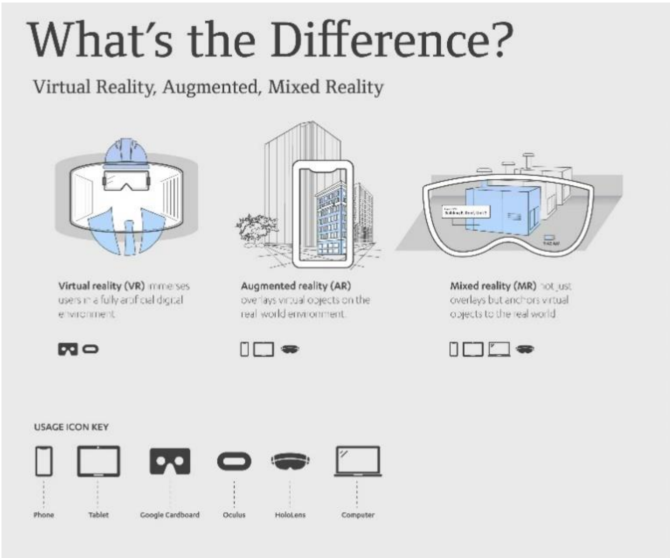

Figure: (4)

2.4.1.3 VR vs. Extended Reality (XR)

Extended Reality (XR) is an umbrella term that encompasses VR, AR, and MR, referring to the entire spectrum of immersive technologies that blend the digital and physical worlds to varying degrees. XR is often used in applications that integrate multiple immersive technologies, dynamically adapting to user interactions with virtual and real elements (53).

2.4.2 What VR Provides?

VR offers unique capabilities across many fields. In architecture, for instance, VR allows clients and stakeholders to "walk through" a virtual model of a building, providing an accurate sense of scale and spatial relationships that are difficult to convey with 2D drawings or static renders (54). By allowing users to interact with and modify elements within the virtual space, VR facilitates more informed decision-making in design and construction (55). VR also enhances training and education by simulating realistic environments that may be difficult to access physically, such as complex industrial sites or historical reconstructions.

Additionally, VR is valuable in therapy and rehabilitation, where controlled virtual environments support treatments for conditions like PTSD, phobias, and motor rehabilitation, providing patients with safe, controlled settings to confront challenges (56).

Additionally, VR can create a feeling of isolation, as users are entirely separated from their physical surroundings. When immersed in VR, users are visually and often audibly cut off from their real-world environment, which can lead to a sense of detachment or disconnection. This isolation can limit social interaction, as users cannot see or communicate with people around them unless the VR environment is specifically designed for social interaction or collaborative experiences (57).

2.5 Understanding Architect-Client Communication and Its Gaps

“A successful building grows from the relationship between client and architect.

Franck & Howard (58)

Effective communication between architects and clients is crucial for aligning design intentions with client expectations. This communication spans the entire design process, from initial discussions to detailed presentations and final approvals. Despite best efforts, several communication gaps commonly emerge, affecting the outcome and potentially compromising client satisfaction. Academic research highlights several sources of these gaps, including specialized architectural language, the abstract nature of traditional architectural representations, the limitations of static renderings, and clients’ evolving preferences (59). One prominent factor contributing to communication challenges is the specialized terminology used in architectural discourse.

Architects use precise terms like “fenestration,” “cantilever,” or “articulation” to discuss aspects such as window arrangements, structural projections, or facade details. Although essential for accuracy, this language can be unfamiliar and confusing for clients without a design background, leading to misunderstandings or an inability to engage fully with the architect’s vision. Studies indicate that clients may focus on minor details that they understand instead of the broader design, potentially leading to delays or decisions based on incomplete comprehension (60). Clients also often face difficulties visualizing architectural designs from traditional two-dimensional (2D) drawings, including floor plans, sections, and elevations.

These representations demand a level of spatial interpretation that may not come intuitively to clients, who must mentally translate these abstract images into three-dimensional spaces. Koutamanis (61) emphasizes that this abstraction in 2D drawings limits the client’s ability to perceive spatial relationships, dimensions, and proportions accurately, which can create a disconnect between the client’s mental image and the architect’s intentions.

Furthermore, even with high-quality digital renderings that present materials, lighting, and textures in detail, clients may struggle to grasp the scale and atmosphere of a space, resulting in an incomplete understanding of the project (62).

The advent of digital renderings and animations has added new tools to the architect's repertoire for communicating design intent. However, even the most realistic renderings have inherent limitations. Rendered images, while visually impressive, remain static and often fail to convey the dynamic aspects of a space, such as its depth and flow. Research by Goulding et al. (63) suggests that these limitations can lead to unrealistic client expectations, particularly when idealized lighting or material finishes in renders create a mental image that may not align with the finished project's real-world conditions. When clients see the completed space and realize it differs from the idealized rendering, disappointment may result, highlighting a gap between visualizations and real-life experiences.

Another source of communication gaps lies in client uncertainty about their own preferences, which can evolve over time. Clients may begin a project with only a vague sense of their needs, which can complicate the architect's task of establishing a design direction. As clients gain clarity on their preferences, this evolving vision can lead to dissatisfaction if the completed project does not align with their refined expectations. In some cases, clients may also lack the vocabulary to articulate their preferences, leaving architects to interpret these needs, which can lead to a design that, while accurate, does not fully satisfy the client's intended vision (64). This lack of clarity, combined with the constraints of traditional visualization tools, can complicate the design process, contributing to misalignments and potential frustration.

Finally, an inherent disparity exists between clients' initial expectations and the realities of architectural projects, particularly in the conceptual stages. Clients often bring an idealized vision to the project, which may be incompatible with practical limitations related to budget, site constraints, or technical feasibility. Studies by Portman, Natapov, and Fisher-Gewirtzman (65) indicate that clients frequently interpret complex 2D plans and static images without fully understanding essential aspects like atmosphere or materiality, resulting in a skewed perception of the design. Without tools to immerse clients in the design's reality, bridging this gap and providing them with a complete understanding of the intended spatial experience can be challenging. These communication gaps underscore a central question for contemporary architectural practice:

-How and where within the architectural design process can alignment between clients and architects be improved?

New approaches that move beyond traditional visualization, such as Virtual Reality (VR), offer potential solutions to bridge these gaps. VR's immersive capabilities allow clients to "experience" the space in a simulated environment, addressing many of the challenges inherent in traditional methods. This study aims to explore whether VR can effectively improve communication, enhance client satisfaction, and provide clear alignment between the architect's design intentions and the client's expectations.

2.6 Overcoming Communication Challenges in Architecture through VR

Virtual Reality (VR) technology may offer innovative solutions to overcome many of the communication barriers traditionally experienced in architect-client interactions. One of VR's primary advantages is its ability to immerse clients in a full-scale, three-dimensional environment that allows them to experience architectural spaces as if they were physically present. This immersive experience can bridge the visualization gap by enabling clients to "walk through" designs, providing a clear and intuitive understanding of spatial relationships, materials, and lighting in a way that two-dimensional (2D) drawings and static renders cannot (66).

Unlike traditional representation methods, VR provides a realistic sense of scale and depth, allowing clients to accurately perceive how a space will feel. This helps address the common issue of clients struggling with the abstract nature of 2D plans and technical drawings, as VR creates an experiential understanding that does not rely on technical knowledge or spatial imagination (67). By giving clients an accurate, life-like preview of the design, VR minimizes misunderstandings and helps align expectations, ultimately reducing the risk of costly revisions and adjustments (68).

Additionally, VR enables real-time interactivity, allowing clients to make instant modifications or explore different design options. For instance, clients can see how changing a wall color, adjusting furniture placements, or modifying lighting would impact the overall feel of the space. This ability to make real-time adjustments within a virtual environment fosters a collaborative process where clients feel more engaged and informed, leading to higher satisfaction and better decision-making (69).

Moreover, VR can facilitate clearer communication by removing the reliance on architectural terminology and abstract concepts.

Clients are able to directly experience design elements, which reduces the need for technical explanations and enables them to give more specific and informed feedback (70). This experiential approach aligns with clients' natural way of interacting with spaces, making the design process more accessible and intuitive.

In summary, VR addresses key communication challenges in architecture by enhancing spatial comprehension, enabling real-time interactivity, and making the design process more intuitive and engaging. These benefits may help to bridge the gap between architects and clients, allowing for more accurate understanding and alignment in project expectations. Interviews conducted with architects in Switzerland who have experience with VR technology also support these findings, indicating similar improvements in client communication and satisfaction. These insights will be discussed in greater detail in later sections of this thesis, alongside specific data gathered from these interviews.

2.7 Understanding Communication Challenges in Each Phase of the Architectural Workflow

Architectural communication involves translating complex design concepts into accessible, understandable information for clients and other stakeholders. However, several key challenges arise throughout the workflow, largely because architectural terminology, visualization methods, and spatial concepts are unfamiliar to many clients. Each phase of the process brings unique communication obstacles, highlighting the need for effective tools and strategies to align expectations, clarify details, and avoid misunderstandings.

In the pre-design phase, communication challenges often stem from clients' unfamiliarity with architectural terminology and abstract concepts. For example, clients without a design background may not understand why architects need to "cut" a building to create sections, leading to confusion about fundamental design concepts (71). According to Cuff (1992), this lack of familiarity with architectural language can create barriers to effective communication, as clients may struggle to visualize or comprehend the spatial relationships that sections and other technical drawings aim to convey (72). Additionally, during this early stage, clients may find it difficult to express their preferences accurately, as the design itself is not yet developed. This often results in frustration or uncertainty, as clients feel unable to engage fully with a concept they cannot yet see. Cross (2001) notes that architects must work to bridge this gap by providing simpler visual aids or examples that help clients understand the foundational ideas behind a project, even when detailed designs are not yet available (73).

Another common issue in the pre-design phase is that clients may have specific visual preferences influenced by other projects they've seen, sometimes online or in other buildings. They might request certain design elements for their project without fully understanding that these choices may not align with the function, scale, or structural requirements of their own building. Emmitt (2001) highlights that clients' tendency to reference other designs can lead to unrealistic expectations, especially if their chosen design elements are incompatible with the unique characteristics of their project (74).

For instance, a client might request a large atrium space similar to one they've seen elsewhere, not realizing that their building's smaller footprint or different structural requirements may prevent such an addition. Architects face the challenge of explaining these limitations without disappointing the client, requiring a sensitive approach to managing expectations (75). In the design development phase, architects present more concrete aspects of the design, such as materials, colours, and finishes. However, because clients often lack the ability to visualize these elements on a larger scale, misunderstandings can arise (76). A client may approve a material based on a small sample but later find it doesn't meet their expectations when applied across an entire room or facade. Research by Gann and Salter (2000) shows that clients frequently struggle with assessing material samples and understanding how these choices will impact the finished space (77). Lighting conditions, textures, and even the scale of application can alter the appearance of materials, and clients may feel dissatisfied if they had anticipated a different result.

While architects may use mock-ups and samples to help convey these details, these tools often lack the full immersive experience needed to give clients a comprehensive sense of how the design will look and feel (78).

As the project moves into the construction documentation phase, the need for precise, technical communication becomes even more critical. Here, architects produce detailed drawings and specifications that define the project’s dimensions, materials, and construction methods. However, the technical nature of these documents can be challenging for clients and even some contractors to interpret correctly, especially in complex projects. Bouchlaghem (2000) points out that clients often find construction documentation overwhelming due to its specialized language and the abstract representations of spatial relationships (79). For instance, clients may have difficulty understanding the positioning of utilities or structural elements in relation to the rest of the building, which can lead to confusion and misaligned expectations (80). Misinterpretations at this stage can have costly consequences, as errors in construction documentation can lead to issues on-site, potentially requiring rework or causing delays (81).

During the construction phase, communication expands to include various contractors, engineers, and subcontractors who are responsible for translating the design into a physical structure. In larger or more complex projects, misunderstandings can easily arise, as each team may have a different interpretation of how certain systems—such as electrical or plumbing—should be integrated with the structural elements. Murtagh (2011) emphasizes that construction sites are highly dynamic, and each participant’s unique expertise and perspective can sometimes lead to conflicting ideas about the design’s execution (82). For example, a structural engineer might prioritize load-bearing concerns, while a contractor focuses on material usage efficiency, leading to discrepancies in understanding the architect’s overall vision (83). When communication between architects and on-site teams lacks clarity, it can lead to deviations from the intended design or compromises in quality, especially if adaptations are made without consulting the original design plans (84).

Another critical challenge during construction is that stakeholders’ “vision” and interpretation of the design can vary significantly, creating conflicts. Each person brings their own imagination and understanding to the project, and without clear, consistent communication, their interpretations of the design intent may diverge. According to Dainty, Moore, and Murray (2006), the diversity of perspectives on-site requires robust communication protocols to ensure that everyone remains aligned with the project’s overall goals (85). Misalignment on-site can be particularly problematic, as it often results in last-minute changes that impact timelines, costs, and quality control (86).

In the project close-out phase, architects conduct final inspections and hand over the completed project to the client. At this point, communication challenges may arise if the client’s understanding of the project has shifted throughout the construction process. Lovell (2014) notes that clients often experience a “reality check” during the close-out phase, where they finally see the completed space and assess whether it meets their expectations (87). If there were misunderstandings in earlier stages—particularly around aesthetics, scale, or spatial relationships—the client may be disappointed with the outcome. This challenge underscores the importance of consistent communication throughout the project to ensure that the client’s evolving expectations are managed effectively (88).

Each stage of the architectural process brings distinct communication challenges, stemming from a combination of technical terminology, differences in visualization ability, and varying perspectives among stakeholders. For example, clients' lack of familiarity with architectural language and their tendency to compare projects with other buildings can hinder effective communication and create unrealistic expectations. The construction phase, in particular, demands clear communication across multiple parties, each with their own priorities and interpretations of the design. These challenges reveal the need for enhanced visualization tools and communication methods that go beyond traditional sketches, models, and static renderings.

3. Types of VR Systems in Architecture

Virtual Reality (VR) has increasingly become a valuable tool in architectural design, with various VR systems offering different levels of immersion and interaction. These systems can be broadly categorized into two types: Desktop VR and Immersive VR. Each type offers distinct advantages and limitations, and their suitability often depends on the specific needs and resources of the architectural practice.

3.1 Desktop VR

Desktop VR refers to virtual environments viewed through a standard computer screen. In this setup, users interact with the virtual space using input devices such as a mouse, keyboard, or joystick. Desktop VR allows users to navigate 3D models in real-time, exploring design elements like spatial layouts, lighting, and materials from a two-dimensional interface. One of the main advantages of Desktop VR is accessibility. It requires relatively low-cost equipment—only a standard computer and display are needed, without the specialized hardware, such as head-mounted displays (HMDs) or motion-tracking systems, required by more immersive options.

For smaller firms or projects with limited budgets, Desktop VR provides a cost-effective solution for visualizing designs in a 3D environment (89). Additionally, Desktop VR can integrate smoothly into existing architectural workflows, particularly those based on BIM or CAD software, allowing for easy transitions between 2D design processes and 3D visualization.

However, Desktop VR's limitations stem from its lack of full immersion. Viewing the virtual environment through a flat screen restricts the user's sense of presence and spatial depth, which can make it harder for clients or stakeholders to fully grasp the scale and atmosphere of a design. Additionally, relying on indirect input devices like a mouse or keyboard reduces interactivity, preventing users from engaging with the virtual environment as naturally as they would in real life (90).

3.2 Immersive VR

In contrast, Immersive VR systems provide a fully immersive experience by utilizing head-mounted displays (HMDs) and motion-tracking systems that enable users to interact with the virtual environment in real-time. Immersive VR creates the sensation of being physically present in a digital space, allowing users to move through the environment, look around, and interact with objects as if they were in the real world. Popular immersive VR platforms in architecture include technologies like Oculus Rift, HTC Vive, and Microsoft HoloLens, which enable architects and clients to explore virtual buildings at full scale and test various design scenarios (91).

The primary benefit of immersive VR is its ability to enhance understanding of spatial relationships and design intent. Clients, who often struggle to interpret 2D drawings or even 3D renders, can experience the design as if they were physically inside the building. This level of immersion bridges the communication gap between architects and clients, making it easier to convey complex spatial concepts and gather more accurate client feedback (92).

However, immersive VR systems are considerably more costly than desktop VR. The hardware required, including high-performance computers, HMDs, and motion-tracking systems, represents a substantial financial investment. Moreover, the setup and maintenance of immersive VR systems often demand specialized technical expertise, which can be a challenge for smaller architectural firms that may lack the necessary resources or personnel (93). Additionally, prolonged use of immersive VR, especially through HMDs, may cause discomfort or fatigue for some users, particularly during extended sessions (94).

3.3 Comparison and Use in Architectural Practice

The choice between Desktop VR and Immersive VR depends largely on the requirements and constraints of the architectural firm or project. For smaller firms with limited budgets, Desktop VR offers a practical solution, providing a 3D visualization tool without the need for costly equipment. This type of VR is especially useful for early-stage design reviews where quick iterations and lower-cost solutions are prioritized. For example, Desktop VR may be used for internal team meetings or to communicate preliminary design concepts to clients who do not require full immersion (95).

On the other hand, larger firms or projects with higher budgets often opt for Immersive VR systems to enhance client presentations and stakeholder collaboration. Immersive VR is especially beneficial for complex or large-scale projects, where experiencing the design in full scale helps clients and stakeholders make more informed decisions. For instance, architectural firms like Foster + Partners have integrated immersive VR into their workflows, enabling clients to walk through virtual models of large-scale developments, which helps reduce design revisions and improve project efficiency (96).

Ultimately, both VR types have their place in architectural practice.

While Desktop VR provides a cost-effective and accessible entry point for architectural visualization, Immersive VR offers a more engaging, interactive experience that can significantly enhance communication and collaboration throughout the project lifecycle.

3.4 Integration with Building Information Modelling (BIM) Building Information

Building Information Modelling (BIM) has become central to architectural practice, allowing for the development of highly detailed, data-rich models that are used throughout the lifecycle of a project. When combined with Virtual Reality (VR), BIM becomes even more powerful, allowing stakeholders to explore, visualize, and interact with building designs in immersive environments. A variety of software platforms are used to integrate BIM with VR, each offering unique strengths and capabilities. Below is an exploration of some of the key platforms and how they contribute to BIM and VR workflows. The integration of BIM and VR enables the creation of immersive experiences where stakeholders can walk through 3D models, visualize construction sequences, and make real-time adjustments to the design. This process enhances collaboration between architects, engineers, and clients, improving understanding and reducing errors throughout the design and construction process (97).

3.4.1 Unity vs. Unreal Engine for Architectural Visualization

Unity vs. Unreal Engine for Architectural Visualization in 2024
Unity and Unreal Engine continue to lead in architectural visualization, each offering distinct benefits. In 2024, both platforms have expanded their features to meet the growing demand for immersive, realistic, and interactive architectural experiences.

3.4.1.1 Visual Quality

- Unity: Unity's High-Definition Render Pipeline (HDRP) has further improved in 2024, allowing for near-photorealistic quality in architectural renderings. HDRP now includes enhanced lighting, shadow details, and material effects, making Unity more competitive with Unreal in realism. However, for ultra-realistic renderings with advanced lighting like ray tracing, Unreal still leads slightly (98).
- Unreal Engine: Unreal Engine 5, with its updated Lumen lighting system and Nanite technology, continues to offer the highest level of visual fidelity. Lumen allows for real-time global illumination, and Nanite optimizes high-polygon assets, creating incredibly detailed and realistic scenes (99).

3.4.1.2 Ease of Use and Learning Curve

- **Unity**: Unity remains a go-to choice for new users in 2024, with improved user interfaces and a streamlined workflow, particularly for those new to 3D software. Unity's extensive learning resources, including updated tutorials and asset packs, help beginners create visually appealing projects quickly. Unity Reflect's 2024 updates also improve integration with BIM models, making it easier to view real-time design changes within Unity (100).
- **Unreal Engine**: Unreal Engine 5 introduced Blueprint visual scripting updates, making it easier for non-programmers to create interactive experiences. However, Unreal's advanced features, such as Nanite and Lumen, still require a more technical understanding. Unreal's learning curve remains steeper than Unity's but is offset by the availability of free resources like Unreal Academy, which offers specialized courses for architectural professionals (101).

3.4.1.3 Integration with BIM and Architectural Tools

- **Unity**: Unity Reflect 2024 offers enhanced real-time collaboration with BIM tools like Revit, ArchiCAD, and SketchUp, making it an excellent choice for real-time architectural visualization. Reflect's improved sync functionality supports frequent design updates, providing a seamless connection to BIM software without requiring complex data conversion. This makes Unity a strong candidate for iterative design processes and team collaboration (102).
- **Unreal Engine**: Unreal Engine's Datasmith tool, updated for 2024, has become more efficient at importing BIM data from Revit, Rhino, and 3ds Max while maintaining details, textures, and metadata. Datasmith's streamlined workflows now include direct synchronization for certain applications, although it still requires a separate step for updates. Unreal's integration is ideal for final presentation quality, but it's less suitable for real-time design updates compared to Unity Reflect (103).

3.4.1.4 Performance and Hardware Requirements

- **Unity**: Unity's continued optimization for mobile and lightweight VR applications makes it suitable for projects that need broader accessibility. The HDRP pipeline, although resource-intensive, can be adjusted to optimize performance on lower-end hardware, making Unity more flexible in terms of device compatibility. Unity's versatility makes it ideal for architectural visualizations on mobile devices, standalone VR headsets, and lower-power computers (104).
- **Unreal Engine**: With Unreal Engine 5's Nanite and Lumen technologies, high-fidelity projects require powerful GPUs and high-performance systems. While Unreal does offer scalable options, projects aiming for the highest visual quality will benefit most from high-end desktops or VR setups. Unreal is preferred for projects focused on desktop VR or installations where high-end hardware can be dedicated to immersive experiences (105).

3.4.1.5 Cost and Licensing

- **Unity**: Unity's flexible licensing options continue with a free personal tier for small-scale use and monthly subscription plans for Unity Pro. Unity's subscription model allows firms to budget effectively, making it accessible to small to medium-sized architectural firms that may require advanced rendering without high upfront costs (106).
- **Unreal Engine**: Unreal Engine's royalty model has become even more advantageous, with no upfront costs and a royalty fee only applied after commercial projects exceed $1 million in revenue. For architectural projects, especially those focusing on high-end visualization, this cost structure allows firms to access Unreal's full features without an initial investment, aligning with project-based billing structures (107).

Both Unity and Unreal Engine have advanced significantly in 2024. Unity offers a user-friendly approach with strong real-time BIM collaboration, while Unreal Engine provides industry-leading realism for immersive, photorealistic architectural experiences. The choice between them depends on the project's scale, budget, and desired level of visual fidelity.

4. How VR Improves Communication in Each Stage of the Architectural Workflow

4.1 Pre-Design Phase

VR in the pre-design phase can help clients visualize the project's site and general context, enabling them to better understand the initial design goals. This immersive experience fosters early alignment on the project's scope and objectives, creating a strong foundation for the project (108).

Figure: (5)

4.2 Design Development

During design development, VR is invaluable for helping clients assess materials, colours, finishes, and other details. By visualizing these choices in a realistic environment, clients can make more informed decisions and provide more precise feedback, minimizing the likelihood of late-stage changes (109).

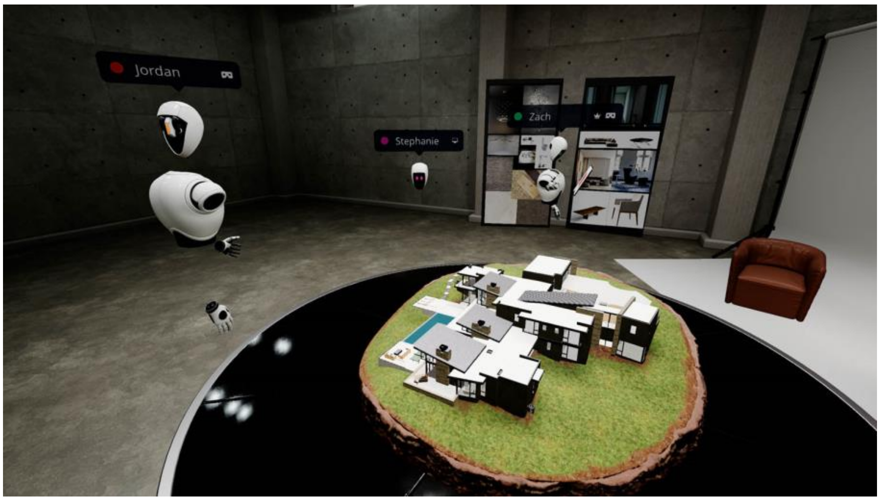

Figure: (6)

4.3 Construction Documentation

At this stage, VR serves as a tool not only for clients but also for engineers, contractors, and other technical experts. Reviewing VR models allows these stakeholders to identify potential structural or technical challenges and verify that construction documents accurately represent the intended design. This enhances coordination among architects, engineers, and contractors, promoting a shared understanding of project details (110).

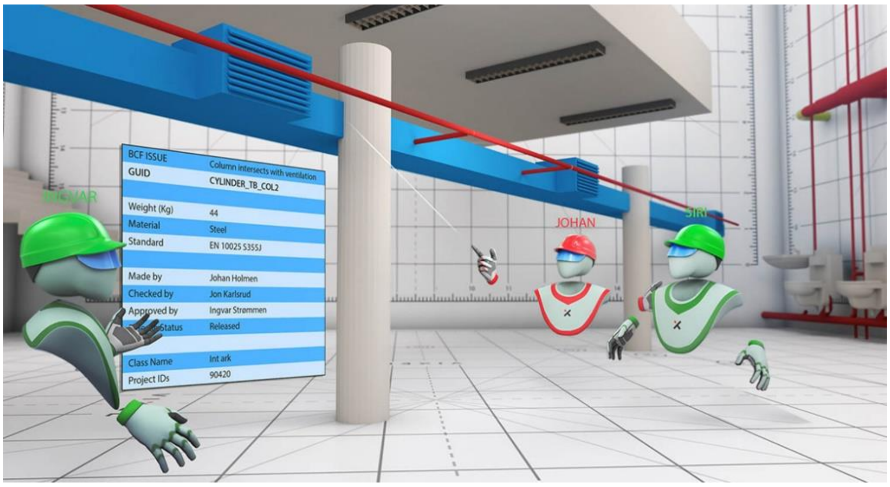

Figure: (7)

4.4 Bidding and Negotiation

In the bidding phase, VR models provide contractors and subcontractors, such as electrical and plumbing teams, with a clearer understanding of the project scope. This enables more accurate estimates and helps avoid discrepancies that could arise from interpreting 2D plans alone. VR can also clarify complex areas, supporting informed discussions and negotiations on project specifics (111).

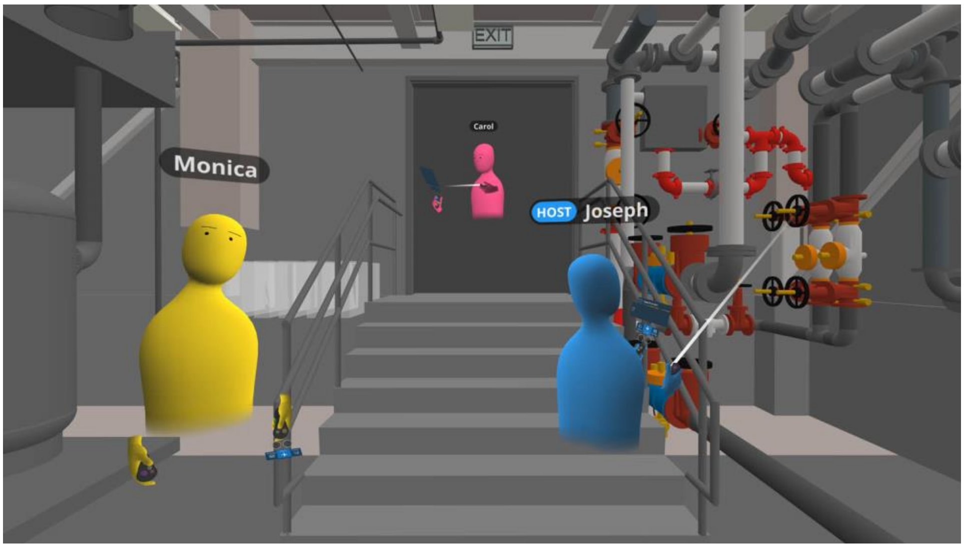

Figure: (8)

4.5 Construction Administration

Throughout the construction phase, VR facilitates ongoing communication among architects, engineers, contractors, and specialty trades. By comparing on-site progress to the VR model, stakeholders can identify deviations or potential issues before they escalate, ensuring a closer alignment with the original design intent. This collaborative use of VR helps maintain quality standards and supports real-time problem-solving (112).

Figure: (9)

4.6 Project Close-Out

In the final phase, VR can be used to conduct virtual walkthroughs for final inspections, assisting engineers and technical teams in verifying that installations match the design specifications. Post-occupancy evaluations can also leverage VR, allowing stakeholders to assess the project's performance and provide valuable insights for future collaborations (113).

5. Barriers to VR Adoption in Architectural Practice

While Virtual Reality (VR) holds great potential to revolutionize architectural communication and visualization, several factors continue to limit its widespread adoption within the field. Understanding these barriers is essential to address the challenges architects face when incorporating VR into their workflows. These barriers have been identified through extensive research and interviews conducted with architects and industry professionals, who highlighted specific challenges in adopting VR within architectural practice. A more detailed analysis of these interviews will be presented in later sections.

5.1 High Costs of Hardware and Software

The cost of VR hardware, such as head-mounted displays (HMDs) and high-performance computers, remains one of the most significant obstacles for architectural practices, particularly smaller firms. Advanced VR setups require substantial financial investment, not only for the initial purchase but also for regular maintenance and upgrades.

However, recent updates in VR technology, such as the Meta Quest 3 and HTC Vive XR Elite, offer more affordable yet high-quality experiences, which may lower the entry barriers for smaller firms. These devices balance accessibility with advanced resolution and tracking, making it easier for architects to incorporate VR without extensive budgets (114). Even so, top-tier immersive systems like Varjo Aero, with its ultra-realistic visuals, still come at a premium, adding to the financial burden on firms with limited budgets.

5.2 Technical Complexity and Learning Curve

VR technology requires specialized technical skills, which can present a barrier for many architects who are more accustomed to traditional software like CAD and BIM. Integrating VR into an existing workflow often requires architects to learn new software or adopt complex visual scripting techniques, such as those in Unreal Engine or Unity (115). In response, VR platforms have introduced more intuitive interfaces and updated tools, such as Unreal Engine's enhanced Blueprints visual scripting system and Unity's Reflect updates, which aim to simplify the learning curve. However, many architectural teams still find they need dedicated VR specialists, which increases operational costs (116).

5.3 Time Constraints in Project Delivery

Architectural projects are typically under tight deadlines, leaving limited time for experimenting with new technologies. Adding VR to a project requires additional steps, such as model preparation, rendering, and VR environment setup, which can extend project timelines. For firms that operate on strict delivery schedules, this added time commitment can make VR seem less practical compared to more familiar methods that are faster to implement (117). Despite recent updates that enhance VR rendering speed, such as real-time global illumination through Unreal Engine's Lumen system, this remains a barrier for many practices with tight deadlines.

5.4 Resistance to Change and Cultural Factors

The architectural field has a strong tradition of using hand sketches, physical models, and 2D drawings. Many architects have developed methods and workflows around these tools and may be resistant to adopting VR, viewing it as a "novelty" rather than an essential tool (118). Additionally, some clients, especially those without a technical background, may be hesitant to use VR, preferring more conventional representation methods. This cultural resistance can slow the integration of VR into standard practice. However, as younger generations become more familiar with VR, this cultural shift is expected to gradually favour VR integration.

5.5 Lack of Standardization and Compatibility

Another challenge in adopting VR is the lack of standardized practices and compatibility with architectural software. Each VR platform often has its unique file formats and compatibility requirements, making it difficult to integrate VR workflows seamlessly with BIM or CAD platforms. Tools like Unity Reflect and Unreal's Datasmith have been updated to improve compatibility with BIM models from Revit, SketchUp, and ArchiCAD, streamlining VR integration. However, converting and optimizing models for VR can still be time-consuming and requires a consistent workflow standard across different software environments (119).

5.6 Concerns Over Client Accessibility and Usability

VR technology may also be seen as inaccessible or impractical for some clients, especially if they do not have the necessary equipment or technical skills to engage with VR environments effectively. New VR headsets in 2024, like the Meta Quest 3, have introduced hand-tracking and controller-free navigation to improve usability, making VR interfaces more accessible for non-technical users. However, not all clients are comfortable using VR headsets, and usability barriers remain a concern that may discourage architects from implementing VR if it risks hindering, rather than enhancing, the client experience (120).

5.7 Physical Discomfort and Usability Limitations

VR headsets, while advanced, can still cause discomfort for some users, including issues such as motion sickness, eye strain, and fatigue during prolonged use. These usability concerns can impact clients' willingness to use VR for long sessions, limiting the effectiveness of VR as a design communication tool. While newer models like the HTC Vive XR Elite and Varjo Aero have introduced ergonomic improvements to reduce discomfort, these issues continue to influence architects' adoption decisions, as uninterrupted immersion is key to VR's effectiveness (121).

5.8 Perceived Lack of Proven ROI

For many firms, the decision to adopt a new technology depends on clear evidence of a return on investment. While VR has shown potential benefits, it is still relatively new in the architectural field, and many firms may hesitate due to a lack of concrete data on its long-term ROI. Without sufficient evidence demonstrating VR's impact on client satisfaction or project efficiency, firms may be reluctant to invest resources in VR. However, in recent years, studies have demonstrated the potential of Virtual Reality (VR) in enhancing client satisfaction and decision-making efficiency within architectural projects, countering concerns about VR's return on investment (122).

Research highlighted by Portman, Natapov, and Fisher-Gewirtzman (2015) has shown that VR allows clients to experience design spaces immersively, bridging the gap between abstract architectural representations and tangible client expectations. By allowing clients to "walk through" a design, VR provides a real-time, interactive experience of architectural spaces that static models or 2D drawings cannot achieve (123).

Empirical data from case studies in Europe and North America, such as projects incorporating VR with immersive VR systems by firms like Foster + Partners, indicate that VR reduces the need for post-completion adjustments by enabling more accurate client feedback early in the design process. These studies reveal measurable improvements in project efficiency and client confidence, as VR helps clients better understand spatial relationships and material impacts. Such immersive experiences reduce misunderstandings and increase satisfaction levels by aligning client expectations more closely with final outcomes (124).

Furthermore, surveys conducted with architecture firms that have implemented VR provide further evidence of the technology's positive impact on collaboration and communication among stakeholders. These surveys, conducted in architectural hubs across Europe and North America, assessed how VR influenced collaboration between architects, engineers, and clients. The findings consistently show that VR's immersive capabilities help streamline the design process by reducing the need for interpretative explanations and by facilitating clearer discussions about design intent and spatial considerations. According to these surveys, the ability to explore and modify designs in real-time allows clients to make more informed decisions, thereby reducing the likelihood of costly changes later in the project. This interactive experience not only enhances client engagement but also supports more cohesive communication between all project participants ((125). One significant outcome reported in these surveys is the improvement in collaborative efficiency between architects and engineers. VR enables technical teams to assess structural and technical challenges within the same virtual environment, which is especially beneficial for complex projects that require interdisciplinary collaboration. For example, stakeholders can view the placement of structural elements or mechanical systems in real-time, helping to prevent potential conflicts that might arise from differing interpretations of 2D plans (126).

Interviews with VR-experienced architects reveal that the technology fosters a more interactive and cohesive process. By immersing clients in a virtual model, architects can visually communicate design choices, allowing clients to explore different options and make modifications on the spot. This process leads to a higher degree of client satisfaction as clients feel more involved and invested in the design process. Furthermore, it promotes confidence in decision-making and encourages quicker consensus on design elements, which can significantly reduce project timelines (127).

These findings suggest that as VR technology continues to mature, it holds the potential to demonstrate a reliable ROI.

Architecture firms increasingly prioritize enhanced client experience, collaboration, and efficiency, and VR's impact on these areas can further justify its adoption. As firms continue to see measurable improvements in client satisfaction and decision-making efficiency, VR may become a standard tool in the architectural industry, providing both qualitative and quantitative returns (128).

These barriers, identified through general research and targeted interviews, provide insight into the current challenges surrounding VR adoption in architecture. The perspectives gathered in these interviews further illustrate the practical realities architects face, offering a comprehensive view of the obstacles VR adoption entails. A more in-depth discussion of these interviews and findings will be provided in later sections.

6. METHODOLOGY

"Innovation in architecture is about breaking boundaries, embracing new tools, and continually reimagining what is possible."
Norman Foster

This chapter outlines the research methodology employed to investigate the adoption of Virtual Reality (VR) in architectural firms. The study is designed to explore the barriers and benefits associated with integrating VR into architectural workflows, with a focus on understanding the practical experiences of architects. Due to challenges in identifying firms actively using VR, the research adopts a qualitative approach, allowing for in-depth exploration while acknowledging limitations to ensure transparency.

6.1 Research Design

The research follows a qualitative design due to difficulties in gathering substantial quantitative data. Initially, a mixed-methods approach was considered to gain both qualitative and quantitative insights. However, it became evident that the limited adoption of VR in architecture made quantitative research challenging, as only a small number of architectural firms currently use VR (129). Therefore, the study focuses solely on qualitative methods, such as interviews and case studies, which offer the flexibility to capture nuanced experiences and insights. This qualitative approach is particularly valuable for emerging technologies like VR, as it captures complexities in real-world architectural practice (130).

Additionally, the research incorporates elements of prototyping, using the researcher's own VR projects as examples within the study.

These projects, which explore VR integration in architectural workflows, were shared with participants to illustrate practical applications and gather feedback on VR's potential impact on communication and collaboration in the design process.

6.2 Qualitative Research

The core of this study relies on qualitative research methods, specifically semi-structured interviews and case studies. Qualitative research is especially useful for exploring emerging topics like VR integration in architecture, where personal experiences and perceptions are crucial for understanding adoption potential and challenges.

6.2.1 Semi-Structured Interviews

Semi-structured interviews form the main method of data collection, with open-ended questions providing flexibility in questioning to gain deeper insights into participants' experiences (131). This approach is valuable for exploring a relatively new field like VR adoption in architecture, where participant perspectives may vary significantly. Architects with VR experience and those without were asked different sets of questions to tailor the discussion to their familiarity with the technology. Participants were briefed on the thesis topic and VR's applications in architecture before beginning the interview.

6.2.1.1 Swiss-Based Interview Context and Participant Selection

For this thesis, interviews were conducted across Switzerland, focusing specifically on small and medium-sized architectural firms to gather insights on their perspectives and challenges regarding VR integration in architectural practice. The choice to focus on smaller firms (often with 1-5 employees) was intentional, as smaller practices typically have fewer resources and may be more cautious about adopting new technologies, such as VR, due to the risks and investments involved (132). While larger firms often have greater flexibility to experiment with emerging technologies, smaller firms face unique constraints that can shape their approach to innovation.

Participants in this study included a mix of solo practitioners and architects from small firms, as their experiences provide a nuanced understanding of the barriers to VR adoption in architecture. On average, over 30 different firms were approached, leading to interviews with 15 architects with no prior VR experience. Most of these firms rely on 2D technical drawings, hand-drawn sketches, and physical models for client communication. Additionally, five more firms with VR experience were interviewed to explore the perspectives of those who have integrated VR. Notably, these VR-experienced firms tended to outsource VR tasks to specialized VR designers rather than developing this capability in-house, reflecting a cautious approach to handling VR projects directly (133).

Interviews were also conducted with solo architects who operate without a formal office, primarily producing project proposals for competitions. Findings from these discussions indicate that individuals from the real estate sector show greater interest in VR technology than traditional architectural firms. Quotes and excerpts from these interviews are shared throughout this section to illustrate the perspectives of participants, particularly in how small-scale practices and solo practitioners attempt to navigate technological advancements in an industry where client expectations and project demands continue to evolve.

6.2.1.2 Interview Questions for Architects Without VR Experience

1. What methods do you currently use to present your designs to clients? (e.g., 2D drawings, 3D renderings, physical models)
2. What are the most common challenges you face when communicating design ideas to clients using traditional methods?
3. How do clients typically react to your design presentations?
4. Do you encounter misunderstandings or misinterpretations frequently?
5. How do you handle feedback from clients who might struggle to visualize the end result from 2D drawings or renderings?
6. When collaborating with other stakeholders (e.g., engineers, contractors), what difficulties arise in sharing and discussing design concepts?
7. Have you explored any new tools or techniques to improve communication with clients during the design process?
8. Have you considered using Virtual Reality (VR) in your design presentations? If not, what are your concerns or hesitations about adopting it?
9. In your opinion, how might VR help clients better understand the design compared to traditional methods?
10. What challenges or barriers do you foresee in integrating VR into your workflow, especially in terms of time and cost?
11. Do you think VR could change the way you collaborate with other stakeholders, such as contractors or engineers, in your projects? If so, how?

6.2.1.3 Architect Perspectives: Communicating Design Without VR

Alesch W.:

(MSc Architect, runs a small architectural firm with a team of three in Zurich, specializing in the design of tiny houses,)

"People who are unused to the architectural process have challenges understanding 2D plans. It's about imagination. I often use a pen to sketch and give a quick idea of how it might look, especially in face-to-face meetings, because it's quick, and people like it. Often, they understand better with this approach."

Dieter H.:

(Dipl. Architekt FH specializing in competition projects in Lucerne with no other team-member)

"Clients often struggle to imagine the end result and may not fully understand the technical terminology. Sometimes, they're unsure of what they want, which means I have to show examples to help clarify their preferences."

Beat J.:

(Dipl. Architekt FH specializing in 2d technical projects in Zurich with no other team-member)

"I generally encounter no issues when presenting designs, as I work with experienced clients like real estate professionals who understand architectural plans. Misunderstandings are rare but may occasionally occur with technical installations (such as electrical or ventilation systems) that I haven't reviewed in detail. When clients have difficulty visualizing a design, I provide extra support, such as cardboard models, or quick pencil sketches. Challenges in collaboration usually stem from planners focusing solely on their tasks, which could be eased with a shared 3D model for better coordination. I'm uncertain about the benefits of VR, as I have yet to explore it."

Natalie T.:

(MSc Architect working at an eight-person firm, where she primarily creates 3D models with 3ds Max in Zug)

"Sometimes, projects are highly complex, and we encounter scale-related issues when communicating with engineers and contractors. To address these challenges, visiting the construction site is essential; face-to-face communication with these stakeholders makes it easier to clarify and align on the design concepts."

Simon M.:

(MA Architect, works at a 20-person firm using Revit and oversees project transitions from 2D to 3D in Lucerne)

“Clients' reactions to design presentations vary throughout the design process. In my experience, the most significant challenges arise at the start of a project, particularly in the Pre-Design phase. At this stage, we often rely on quick sketches and mood boards to communicate ideas, but without a 3D model, clients sometimes struggle to fully understand the concept. While 3D models and renders are always helpful later, it's during the initial phase that clients seem to experience the most difficulty.”

6.2.1.4 Interview Questions for Architects, Designers with VR Experience

1. In what specific ways does VR improve communication between architects, designers, and clients compared to traditional methods like 2D drawings or physical models?
2. How does VR help clients and designers better understand spatial relationships and material choices, and what impact does this have on collaboration and decision-making?
3. What are the key challenges that architects and designers face when adopting VR technology to enhance collaboration with clients, and how can these challenges be addressed?
4. How does VR technology enable more interactive and immersive collaboration between architects, designers, and clients during the design process, and what unique value does it offer?
5. Would you suggest any strategies or solutions to encourage more widespread use of VR in architecture and design to improve client communication and engagement?
6. At which stage of the architectural design process do you believe VR is most beneficial for enhancing communication with clients?

6.2.1.5 Architect Perspectives: Communicating Design With VR

Matt Z.:

(MA Architect works with a four-person team, using Rhino, Unity, and Unreal to create interactive environments in Basel)

" From an architect's perspective, VR may not significantly enhance communication, as existing tools like 2D drawings and 3D models are already effective for professional use. However, for clients, VR provides a crucial improvement by allowing them to experience the design in an immersive way. This helps bridge understanding gaps, enabling clients to grasp spatial relationships and material choices intuitively, which can reduce misinterpretations and revisions."

José A.:

(MSc Architect works at a company with 200-300 employees, using Revit, Unreal, and Unity in Basel, where he primarily creates 2D drawings and 3D models)

"VR and AR are particularly helpful on the construction side, assisting architects in improving project stability and resolving misunderstandings. These tools reduce the need for constant site visits, as they provide a clear, interactive view of the project. Personally, I find them extremely useful for enhancing communication and accuracy in construction."

Sarah S.:

(MA Architect at ETH Zurich, where she leads VR master classes specifically for the Architecture department)

“One of the main challenges in adopting VR for architecture is managing the sheer amount of data you’re producing. Working in game engines, for example, makes it easy to get overly detailed. It’s important to use VR in a way that supports the concept with minimal effort—focusing on key elements rather than trying to model every single detail. For instance, instead of a fully detailed housing project, I might just include the structural elements to discuss with engineers. When VR is overloaded with details, you risk losing the architectural intent. Keeping things simple and intentional is key.”

Based on the insights from the interview with Sarah Schneider, it has been decided to test her approach, particularly in the prototyping phase, to understand the optimal level of detail for effective communication in different process stages. The results of this test will be presented in the prototyping section.

Patrick M.:

(Head of Sales Member of the Board, CEO, He leads a Zurich-based VR company with 1-10 team members)

"VR headsets haven’t penetrated the market yet. Many people either don’t know about them or hold negative views, like associating them with gaming, motion sickness, or high costs. Architects, in particular, tend to be conservative with work habits compared to other industries. There’s also a concern among architects about losing control over design and planning if clients begin to fully understand and experience plans in a 1:1 scale."

Sebastian J.:

(Game Developer and VR Designer based in Aarau, working as part of a 15-person team and specializing in 3Ds Max, Unity, and Unreal Engine.)

"VR remains underutilized primarily because creating realistic 3D experiences demands significant time and expertise. Although hardware costs have dropped, preparing high-quality 3D data remains time-intensive and costly. Large projects, like 200-unit developments, may have the marketing budget for VR, but such projects are rare. High-end, smaller-scale properties might also invest in VR, yet traditional marketing methods—websites, ads, brochures, and animations—often prove sufficient for sales. As a result, VR has yet to become widely adopted in Switzerland."

Peter T.:

(MSc architect, VR designer, and VR lecturer based in New York, USA, working collaboratively with a Swiss architectural firm in Zurich)

"People often hesitate with bold colours, but in VR, they're more open to taking risks. It really helps them confidently make the right decisions. A common issue is that clients misjudge room or furniture sizes with traditional methods, but VR removes much of that guesswork. Many clients even describe a sense of *déjà vu*, as if they've already been in the space because VR lets them experience it immersively.

Engineers also appreciate VR models; it clears up confusion by providing a full view of the structure in advance. No drawing can truly convey how a room feels, but VR bridges that gap. Not everyone sees VR's value yet, but as more VR architects offer free demos, people will need to decide if they're ready to embrace this future. Mistakes in design are expensive, and VR can help prevent them."

6.2.1.6 Interview Questions for Clients

1. What types of materials (e.g., 2D plans, photos, physical models) have architects or developers typically used to help you understand a project's design?
2. Have you encountered difficulties visualizing a design or space based on these materials? If so, could you describe what was challenging?
3. Have you noticed any differences between the final project and the design materials initially presented? What do you think might have contributed to this?
4. What tools or methods do you believe could help you better understand a design before it's constructed?
5. Have you ever used Virtual Reality (VR) to explore a design? If so, how was the experience, and did it improve your understanding?
6. Do you think using VR to navigate a design virtually could enhance your decision-making or help you give feedback more effectively?
7. Would experiencing a design in VR increase your confidence in making design or investment decisions before the project's completion?
8. What concerns, if any, would you have about using VR to explore a design (e.g., usability, access to VR equipment)?

6.2.1.7 Client/Stakeholder Perspectives on Design Visualization and Communication

Renato H.:

(Asset Manager at a prominent real estate company in Zurich and a potential client)

"I think VR will be able to develop further, especially with efficient AI. It will certainly take another 3-5 years to reach an interesting level. We are therefore following developments very closely and if a product proves itself, we will consider further steps."

Alexandra D.:

(A client who is a Dr. med. veterinarian based in Winterthur)

"Last year, we renovated a building for our veterinary office with the help of an architect. Although I'm not familiar with architecture, the architect guided us well, especially in positioning equipment to suit our workflow. We designed separate waiting areas for cats and dogs, each with a custom, single-piece elliptical seating unit where people could sit around the perimeter. Our architect provided both plan views and 3D renderings, which looked great and helped us visualize the space. However, even though the seating was identical in both rooms, it appeared much larger in the cat waiting area because the room was smaller. This wasn't something we anticipated, and it ended up making the seating feel a bit overwhelming in the cat area. Since we had invested so much, we didn't want to replace it, and it's not a major issue, but perhaps with the technology you're describing, we could have avoided this kind of oversight."

João G.:

(Strategic IT Leader at a Zurich-based company and potential client)

"I had the chance to try this technology at a trade fair, and I was really impressed. Looking ahead, I would love to work with this technology both as a client and as an investor. With the new headsets coming out, I believe this technology will become more widespread over time. I haven't commissioned an architectural project before, so I haven't encountered any issues. I've always found animations cool, but this technology goes beyond animations, it allows for interaction. I definitely think it represents a new reality."

Aslihan A.:

(A client who is a beauty specialist based in Lucerne)

"My family and I had a villa built in Hergiswil, and the result turned out beautifully. We were very pleased with our architect. However, we had a lot of disagreements with my mother when it came to choosing the wallpaper. I've never tried the kind of technology you mentioned, but it sounds really cool. If we'd had the chance to use something like that, we definitely would have tried it."

Heidi K.:

(A retired client who was a nurse in Lucerne)

“About 20 years ago, we had our current home designed and built. When we met with the architect, I often couldn’t understand what he was trying to convey. He would bring his own hand-drawn sketches, but I struggled to visualize them. My husband would explain as much as he could from what he understood, but it was still difficult for me. Although we were happy with the final result, the process was stressful for me because I could never feel certain or picture it clearly in my mind. The architect made special sketches for the kitchen and some specific parts of the house, but it was still an uneasy experience. I consider myself lucky that the outcome turned out well in the end."

6.3 Interview Analysis

6.3.1 Perspectives of Architects with No VR Experience

Based on interviews conducted with over 15 architects from different cantons in Switzerland, none of whom have VR experience, key insights emerge regarding current communication challenges in architecture and the potential for Virtual Reality (VR) integration. Architects rely on traditional methods, such as hand sketches, CAD models, mood boards, and 3D renderings, to convey design ideas to clients. While effective for clients with a certain level of architectural familiarity, these tools often fall short with clients who struggle to visualize 2D plans or static 3D models.

A recurring challenge reported by architects is clients’ difficulty in fully understanding static, non-interactive representations. This lack of clarity often results in misunderstandings and iterative changes, slowing the decision-making process. Architects frequently turn to hand-drawn sketches or mood boards to bridge these gaps, but these methods are time-consuming and highly dependent on real-time, face-to-face interaction. Additionally, while 3D renderings generally help, architects pointed out that discrepancies between renderings and the final result, particularly in terms of room depth, spatial perception, and materials, occasionally lead to client dissatisfaction.

In collaboration with other stakeholders, such as engineers and contractors, architects find 2D plans sufficient for simpler projects. However, for more complex designs, they acknowledged that 3D models provide a clearer, more effective means of communication, improving technical discussions. Despite this, face-to-face meetings remain the most reliable method for ensuring alignment and resolving complex issues among stakeholders.

The architects interviewed are cautiously optimistic about VR as a potential solution to these communication challenges.

Although none have direct VR experience, they recognize its potential to offer a more immersive, interactive experience that could improve client understanding and engagement in complex designs. They believe that VR could help clients better understand the design intent by allowing them to explore projects in an immersive 3D environment, potentially reducing the need for repeated explanations. However, they remain somewhat sceptical about its immediate adoption due to the costs and learning curve associated with VR technology.

Cost and the time investment required to adopt VR technology emerged as major concerns, particularly for smaller firms with limited resources. Many architects expressed interest in exploring VR in the future, contingent on advancements that make it more accessible and cost-effective. They see VR as an exciting tool that could eventually enhance their workflow, improve client interactions, and facilitate smoother collaboration with stakeholders.

In summary, the interviews underscore both the strengths and limitations of traditional architectural communication methods and the promising potential of VR. While current tools like renderings and mood boards are somewhat effective, misunderstandings regarding materials and spatial dimensions are still common. VR presents a compelling solution by providing a more accurate, immersive design experience that could minimize client misinterpretations and improve project outcomes. Although architects without VR experience view it as an intriguing new reality, they feel that more widespread adoption and cost reductions will be essential for it to become a valuable asset in architectural workflows.

6.3.2 Perspectives of Architects and Designers with VR Experience

Due to the limited number of architects experienced with VR, interviews also included VR designers, VR-based real estate agents, and VR company owners.

The interviews conducted with several people who have experience with VR, working for different companies in various cantons, highlight several key insights into how VR is transforming communication between architects, designers, and clients. A common theme among the responses is the ability of VR to allow clients to experience an unbuilt environment as if it were already constructed. This immersive technology provides a much clearer and more intuitive way for clients to understand design elements like space, materials, and lighting compared to traditional 2D drawings or physical models. Particularly for clients without technical knowledge, VR becomes a powerful tool for visualizing the final outcome, leading to improved communication and more informed decision-making. One interesting observation made by the architects is that younger individuals, particularly students from various sectors, are increasingly reaching out to their firms, expressing interest in learning about VR or incorporating it into their personal projects. This reflects a growing trend of younger generations being particularly engaged with VR technology, seeing it as an exciting tool to innovate and explore in architecture.

This additional point emphasizes the rising popularity of VR, not only among professionals but also among emerging designers and students who are eager to leverage this technology in their work. The architects also pointed out that VR is particularly effective in helping clients and designers better understand space and materials, which has a direct impact on collaboration and decision-making. By immersing themselves in a virtual environment, clients can experience a project in real scale and context, allowing for more accurate feedback and faster, more effective decision-making. This shared experience between clients and designers promotes a more cohesive collaboration, reducing misunderstandings and the need for revisions later in the process. When asked how more architects and designers could begin using VR, the architects recommended that the key is to experience the technology firsthand. VR is a technology that truly needs to be experienced to be fully appreciated, and architects who are hesitant to adopt it should give it a try. Younger generations, who are already showing a strong interest in VR, are a testament to its potential to shape the future of architecture and design. In conclusion, the responses from the architects with VR experience demonstrate that the technology is playing an increasingly important role in improving communication and collaboration in architecture. While there are still technical challenges to overcome, the growing interest from younger designers and the clear benefits of VR suggest that it will become a more integral part of architectural practice in the future.

6.3.3 Perspectives of Clients

Interviews with clients and potential clients from various backgrounds revealed a common challenge: many clients find it difficult to visualize architectural designs using traditional materials like 2D drawings, technical plans, or static renderings. Clients without technical expertise often struggle with interpreting these materials, finding themselves overwhelmed by lines, measurements, and abstract elements. This can make it challenging for them to fully understand how the design will translate into the final space, especially regarding spatial relationships, material selections, and lighting effects.

Clients frequently expressed frustration with the gap between what was presented and the final outcome. Many noted that the completed project sometimes felt different from what they had envisioned, with spaces appearing smaller or lighting behaving differently than expected. These discrepancies are often due to the inherent limitations of traditional architectural tools, which can be difficult to interpret without a design or construction background.

A strong interest emerged among clients for more immersive and intuitive tools that could provide a clearer understanding of designs before construction. In this regard, Virtual Reality (VR) was widely viewed as a potential game-changer. VR allows clients to "walk through" a design virtually, offering a realistic, full-scale experience that bridges the gap between abstract representations and the real-world project.

Many clients noted that experiencing a design in VR would improve their understanding of dimensions, layouts, and material choices, thereby enhancing their confidence in decision-making and reducing dissatisfaction after project completion.

VR was also seen as a tool that could facilitate more effective communication between clients and architects. By immersing themselves in the virtual design, clients felt they could more easily identify areas they might want to adjust, leading to more constructive feedback, collaboration, and fewer misunderstandings.

However, some clients expressed concerns about the accessibility and ease of use of VR, particularly those who are less familiar with technology. They emphasized that VR must be intuitive and user-friendly to be an effective solution. Additionally, cost and the time required to integrate VR into the project timeline were identified as potential barriers.

Overall, the interviews underscored that for clients from various backgrounds, VR has the potential to greatly improve their understanding of architectural designs, enhance communication, and instil confidence in their design and investment choices. By addressing common visualization challenges, VR could effectively bridge the gap between technical representations and client expectations, leading to more successful project outcomes.

6.4 Case Studies

In addition to interviews, case studies examine real-world examples of firms that have successfully integrated VR into their workflows. These case studies provide practical insights, illustrating both the potential benefits and challenges encountered during VR adoption (134). The combination of interviews and case studies offers a well-rounded view of VR's current role in architecture, combining individual perspectives with applied examples.

Through this qualitative approach, the study aims to provide a comprehensive understanding of VR’s role in architecture, considering both the obstacles and opportunities for wider adoption.

6.4.1 Virtual Exhibitions of the Kirchner Museum Davos by Hegias

Hegias’s digital twin of the Kirchner Museum Davos (135) offers a compelling example of how VR can extend access to architectural and cultural spaces, allowing virtual visitors to experience the museum as if they were physically present. By booking a virtual appointment through Hegias, users can navigate the museum from anywhere, immersing themselves in its spaces and exhibitions. This VR model demonstrates the potential of digital twins not only to replicate the physical structure but also to preserve the character and atmosphere of significant architectural sites.

The images below illustrate the impressive realism achieved: the upper image shows the VR model created by Hegias, while the lower photo captures the actual museum interior, highlighting VR's capacity to maintain fidelity to the original space.

Figure: (10)

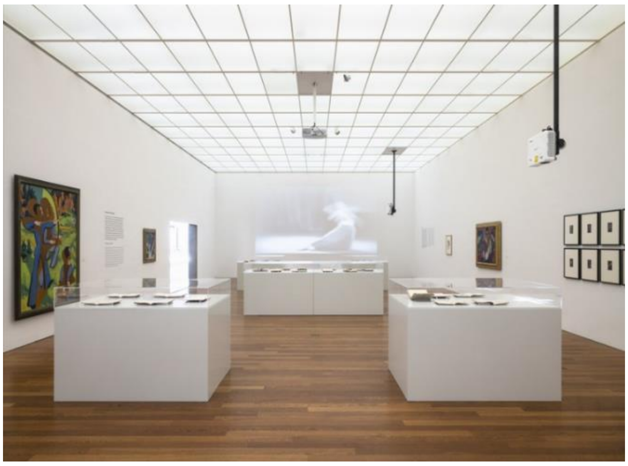

Figure: (11)

Hegias's project with the Kirchner Museum Davos positions this VR application within the post-construction phase of the architectural process, where the primary goal is to enhance accessibility and engagement with an already built space. Unlike VR's common use during design or construction stages to visualize concepts, here VR is used to expand the museum's reach, enabling a global audience to experience the space virtually. This application highlights VR as a powerful post-construction tool, not just for viewing but for immersive, spatial engagement—a benefit that traditional photographs or videos cannot fully achieve. Architect Rem Koolhaas once remarked, "Architecture is a dangerous mix of power and importance," and through VR, Hegias has made that importance accessible across borders, amplifying the museum's presence.

Creating this digital twin presented specific challenges that underscore VR's strengths and limitations in representing physical spaces. The primary challenge was achieving high fidelity and realism, capturing textures, lighting, and spatial relationships accurately enough to make users feel truly "present" in the museum.

Even small discrepancies in these elements can disrupt the immersive experience, underscoring the need for careful detailing and rendering in VR environments. As Tadao Ando noted, “We borrow space and create a place that belongs to us” for VR to succeed, it must effectively convey this sense of place and ownership to the user.

Additionally, replicating the spatial experience within VR posed a challenge, as users must feel the museum’s proportions and layouts as they would in person. VR sometimes alters perceptions of scale or distance, which can impact how users experience architectural spaces, particularly if their VR equipment or resolution is limited. This limitation is significant when considering VR as a tool for architectural preservation and exploration.

Another key challenge was ensuring device compatibility for consistent user experiences. Different VR headsets offer varying levels of resolution, interactivity, and immersion, which can affect how users perceive and navigate the space. To overcome this, the digital twin was optimized to be accessible across various platforms while preserving as much of the original experience as possible. Through this case study, several insights emerge about the potential for VR in post-construction applications. VR allows for an expansion of accessibility, opening cultural and architectural sites like the Kirchner Museum to audiences who may never visit in person. As the technology advances, VR can serve as a form of archival preservation for future generations, enabling cultural and educational experiences beyond geographical limits. Moreover, VR reveals its power not only as a visual medium but as an emotional one, letting users feel connected to spaces in ways that traditional media cannot. As Louis Kahn said, “Architecture is the reaching out for the truth.” (136) With VR, Hegias brings that truth closer to users, preserving and sharing the museum’s essence with a wider world.

This case study illustrates VR’s promise and challenges, highlighting its growing role in architecture and cultural preservation, especially in enhancing engagement and accessibility.

6.4.2 Virtual Exhibition of a Residence by VRQ

VRQ’s virtual exhibition of a residential space showcases VR’s ability to offer clients an immersive, realistic experience of a home design, highlighting how VR can visualize interiors in remarkable detail (137). Through VRQ’s virtual environment, users can explore the residence, observing the room’s layout, depth, and furnishings from different angles. The two images below demonstrate how VR allows viewers to experience changes in design elements, such as swapping furniture or adjusting material colors under varying lighting conditions. In these views, VRQ provides exceptionally high image quality that brings near-photorealistic realism to the experience, making it appear as though one is looking at actual photographs (138).

Figure: (12)

Figure: (13)

VRQ’s virtual exhibition of a residential space demonstrates VR’s potential to create an immersive, realistic experience for clients, allowing them to explore design options in rich detail. In this project, VRQ developed a virtual environment that lets users examine different angles within a room, showing how elements like furniture and materials change based on lighting conditions. For instance, the two images below reveal how a material shifts under natural sunlight compared to lamplight, as well as how the room’s depth and proportions are experienced in VR. The realism is striking, with image quality that gives the impression of looking at actual photographs, bridging the gap between design intent and client understanding.

This case study is located in the design development phase of the architectural process, where VR serves as an essential tool for helping clients visualize the space in near-photorealistic quality. During this phase, clients often struggle to fully grasp how colours, materials, and furniture choices will look and feel in a completed room. Here, VR allows them to experience design options in a much more interactive way, making choices like lighting and furniture placement tangible. As Zaha Hadid once noted, “Architecture is really about well-being”—VRQ’s approach aligns with this vision, as it brings a sense of comfort and confidence to clients by allowing them to interact with the space in a meaningful way (139).

This project also highlighted specific challenges in creating a VR environment that feels authentic and intuitive for clients. Achieving near-photorealism in VR required precise rendering of material textures, lighting effects, and furniture finishes, especially as these elements change under different lighting conditions. Without this level of detail, the immersive experience could falter, leaving clients unable to fully appreciate or understand the design intent.

Another significant challenge was ensuring that clients could interact smoothly with the virtual environment by swapping out furniture or adjusting colours. This level of customization is particularly valuable, as it allows clients to test different looks and choose options that fit their vision. However, it also demands meticulous modelling and rendering to maintain consistency and realism across various design choices.

By offering a high degree of interactivity and a realistic portrayal of materials, VRQ's project underscores VR's value in the architectural design process. VR brings an unparalleled level of engagement, allowing clients not only to see but to feel the space, creating a more confident and informed decision-making experience (140).

6.4.3 Virtual Exhibition of a Residence by SwissInteractive

SwissInteractive's virtual exhibition of a residence highlights the power of VR to create an immersive and interactive material selection experience. In this project, users can explore the residence in VR and interact with the design by pressing the "Boden" button on the left wall to change the floor's color, pattern, and material. This function enables clients to see how different flooring choices affect the room's ambiance, providing an immediate and realistic preview that aids decision-making. The images below show the VR environment from the same angle, demonstrating how the room's look transforms with each floor option. The photorealistic quality of the images gives users the impression of viewing real photographs, enhancing the immersive quality of the VR experience (141).

Figure: (14)

Figure: (15)

This SwissInteractive project situates VR within the design development phase of the architectural process, where it serves as a powerful tool for exploring detailed material choices. In a traditional setting, clients might rely on small samples to choose materials, which often fail to convey how these elements will look across the entire room. VR addresses this gap by allowing clients to visualize material changes in real-time, within the context of the complete space. This ability to see immediate results fosters a sense of confidence and ownership over design decisions, as clients can make choices that align closely with their vision for the room.

Creating this VR environment posed several challenges. First, achieving a high level of realism in the floor materials required detailed rendering of textures and lighting effects. To maintain immersion, each material had to reflect the space's lighting conditions accurately, ensuring that users felt each option was a true representation of the final result. Any inconsistency could disrupt the immersive experience, as clients need to trust the VR visualization as an authentic preview of the finished space (142).

Another challenge lay in creating an intuitive interface for users to engage with. The "Boden" button needed to be easy to find and operate, allowing clients to switch floor options seamlessly. This interactivity adds a unique value, enabling clients not only to visualize but to test their preferences quickly and confidently. As Frank Gehry observed, "Architecture should speak of its time and place, but yearn for timelessness." Through this VR feature, clients can experiment with material options that resonate with them personally while also considering how those choices will stand the test of time (143).

This case study demonstrates VR's capacity to enhance client engagement and decision-making in the design development phase. By letting clients interact with material options directly in the VR environment, SwissInteractive provides a more reliable and holistic way to envision the design. The result is a richer, more intuitive process that reduces uncertainties and supports clients in making informed choices that align with their aesthetic and functional goals. This project highlights VR's potential as a transformative tool in architecture, offering clients an experience that static samples and renderings simply cannot match.

6.5 Design Interventions

“The future has already arrived. It's just not evenly distributed yet.”

William Gibson (144)

In this section, the study explores targeted design interventions aimed at improving communication and collaboration between architects and clients. By integrating Virtual Reality (VR) and other immersive technologies into the architectural workflow, these interventions seek to address common challenges, such as spatial comprehension and material selection, thereby enhancing the overall design experience. Each intervention is designed to be practical, adaptable, and capable of bridging the gap between traditional and modern communication methods in the field of architecture.

6.5.1 VR Solutions to Prevent Misunderstandings and Communication Issues Between Architects and Clients

To improve communication and prevent misunderstandings in architectural projects, Virtual Reality (VR) offers immersive and interactive solutions that help architects convey their designs more effectively to clients. Traditional methods like 2D drawings and static 3D models often fail to fully capture the depth and intent of a design, which can lead to misinterpretations, client dissatisfaction, and costly design revisions. By using VR, architects can provide a more accurate representation of space, structure, and materials, ultimately enhancing the client’s understanding and engagement. Here are some common communication challenges in architecture and how VR can help resolve them, with examples and references where applicable.

6.5.1.1 Enhancing Spatial Understanding in Complex Designs

Problem: Clients often find it difficult to understand spatial relationships and scale from 2D plans or static 3D renderings, leading to misunderstandings about room sizes, flow, and layout.

Solution: VR allows clients to experience a 3D walkthrough of the design, providing a realistic sense of spatial relationships. With VR headsets like the Meta Quest 3 or HTC Vive, clients can navigate the space at their own pace, exploring room connections and flow as if they were inside the finished building. A study by Whyte (2002) shows that immersive walkthroughs significantly improve clients' understanding of space, reducing the need for explanations and revisions (145).

6.5.1.2 Clarifying Structural and Functional Elements for Better Collaboration

Problem: Technical elements like structural supports or ventilation systems can be difficult to convey in traditional formats, causing misunderstandings with clients and other stakeholders.

Solution: In VR, architects can create a simplified model that highlights critical structural components, helping clients and engineers visualize load-bearing walls, ventilation pathways, and electrical layouts. Unreal Engine's Blueprints system, for example, allows for real-time adjustments and labelling, which helps clarify functional elements without overwhelming the viewer with unnecessary detail (146).

6.5.1.3 Supporting Material and Finish Selection to Align Expectations

Problem: Clients often have difficulty visualizing material choices, leading to dissatisfaction when the final build differs from their expectations based on renderings.

Solution: VR allows architects to present material options in a more realistic context. Using Twinmotion, architects can adjust lighting, textures, and finishes in real time, enabling clients to see how materials will appear under different lighting conditions (147).

6.5.1.4 Providing Adaptive Settings to Address Physical Discomfort

Problem: Motion sickness or eye strain in VR can hinder the client's ability to engage with the presentation, leading to shortened sessions and incomplete feedback.

Solution: Advanced VR headsets like the Varjo Aero and HTC Vive XR Elite offer ergonomic features that reduce eye strain and motion discomfort, while teleportation-based navigation can minimize sensory conflict that leads to motion sickness. Adjustments to frame rate, field of view, and gradual exposure to VR environments are also effective in improving user comfort (148).

6.5.1.5 Enhancing Client Accessibility and Usability in VR

Problem: For many clients, VR technology can seem complex and intimidating, especially if they are unfamiliar with the equipment and controls. This lack of familiarity can cause hesitancy, reducing VR's effectiveness as a communication tool in architecture and impacting client engagement.

Solution: New, user-friendly VR devices such as the Meta Quest 3 address these challenges with features like hand-tracking and controller-free navigation, making VR intuitive even for non-technical users (149).

Yet, as Sarah S., a VR educator in architecture, notes, the process of adopting VR goes beyond learning the controls—it requires a shift in how users, particularly practicing architects, approach their work. Sarah S. states, *"VR education should be introduced in schools, and students should learn to adapt this technology to different phases of their design work during their studies. For practicing architects, adopting new software and integrating it into their workflow can be quite challenging. This challenge goes beyond merely learning a new tool, it involves changing the very way they approach their work."*

While Sarah S. emphasizes the difficulty experienced or graduated architects may have in embracing VR, research indicates that a structured, introductory onboarding session can be highly effective in reducing these barriers. Pombo and Marques (2017) highlight that such onboarding sessions make VR more accessible and manageable, helping architects and students integrate VR into their design processes with less friction. According to Portman, Natapov, and Fisher-Gewirtzman (2015), these initial sessions also encourage a positive response to VR, fostering openness to the technology and allowing architects to navigate its features with increased confidence (150). Whyte (2002) supports this by emphasizing that onboarding sessions help architects understand the full benefits of VR without feeling overwhelmed. Furthermore, Sharples et al. (2008) found that even a short onboarding session of 5-10 minutes can significantly improve user confidence and ease, demonstrating that a brief introduction can enhance engagement and usability (151).

For clients specifically, these onboarding sessions are equally valuable. Offering a short, supportive onboarding session early in the design process, ideally in the prototyping phase, helps clients become comfortable with VR's controls and navigation. As research by Sharples et al. (2008) and Portman et al. (2015) indicates, this introduction reduces initial friction, allowing clients to explore VR environments more independently and engage more actively in the design discussions. Companies like Hegias and VRQ support this approach by providing free demo sessions for architects and clients alike. These sessions create a safe, supportive environment where clients can experience VR firsthand, gaining familiarity with the equipment, controls, and capabilities of VR. By demystifying VR through hands-on interaction, clients become more comfortable and confident in using the technology, helping them see VR as a valuable complement to traditional architectural visualization tools.

Example: Hegias and VRQ offer demo sessions that enable architects and clients to engage directly with VR in a hands-on manner. These sessions have proven to be particularly effective in familiarizing clients with VR's potential, leading to a more positive perception of VR's role in architectural communication. In these sessions, clients learn to use the technology independently, fostering an open attitude toward VR and improving engagement in the design process.

Outcome: This approach fosters a welcoming and accessible VR experience, especially during the prototyping phase, which is ideal for refining and reviewing design concepts.

It supports smoother VR adoption in architectural workflows, ultimately enhancing communication, client satisfaction, and engagement in design discussions. Moreover, these onboarding sessions can lead to greater acceptance of VR among both clients and architects, contributing to a more effective and collaborative design process. Research shows that, despite initial challenges, architects and clients alike are increasingly open to VR's potential when supported by structured onboarding, as they become more comfortable with the technology's transformative capabilities.

7. Conclusion and Recommendation

The integration of Virtual Reality (VR) into architectural practice has the potential to transform client communication, improve design comprehension, and streamline collaborative workflows. This study highlights that, while traditional methods such as 2D drawings and static renderings have long served the architectural field, they often fall short of conveying complex spatial relationships and material selections to clients, especially those without a technical background. By enabling clients to experience designs in an immersive, real-time environment, VR bridges this gap, providing an intuitive understanding of architectural spaces, materials, and lighting conditions that 2D representations cannot fully capture.

Interviews conducted during this study underscore both the strengths and challenges associated with VR adoption in architecture. Architects without VR experience generally recognized its potential, particularly in helping clients who struggle to interpret 2D plans, as noted by many participants who frequently encounter visualization challenges in client interactions. However, architects cited high costs, technical complexity, and a steep learning curve as significant barriers to VR adoption, particularly for smaller firms with limited budgets. Those with VR experience emphasized VR's unique advantages, including enhanced client communication, improved spatial comprehension, and a reduction in misunderstandings that typically lead to project revisions. Several architects using VR reported quicker decision-making as clients could visualize and understand designs more effectively. Clients, on their part, expressed a strong preference for more immersive visualization tools, believing that VR would help them feel more engaged and confident in the design process.

Based on these insights, the following recommendations address practical steps that architects and firms can take to integrate VR effectively, as well as directions for future research to expand VR's role in architecture.

7.1 Practical Recommendations for Architects and Firms

Based on the findings of this study, there are several recommendations to support the effective implementation of VR in architectural practice, particularly to enhance communication between architects and clients.

By adopting VR thoughtfully, architecture firms can foster clearer client understanding, mitigate misunderstandings, and support more collaborative design processes. Studies have shown that VR can act as a vital communication tool that bridges understanding between architects and clients, enabling clients to experience designs in an immersive, interactive way (152).

1. Integrate VR Early in the Design Process for Complex Projects VR proves especially valuable in the initial stages of projects with complex spatial relationships or scale challenges, as it provides clients with a comprehensive sense of the space from the outset. Early VR use can minimize client misunderstandings and align expectations before construction begins (153). Alesch W., an architect in Zurich, noted that his clients often struggle with traditional 2D plans and benefit from alternative visualization methods; in such cases, VR can serve as a faster, more accurate tool for bridging this communication gap. Offering VR experiences early in the design phase allows clients to engage more intuitively with the spatial layout, reducing the need for extensive explanations or revisions later on.

2. Adopt Cost-Effective VR Solutions for Smaller Firms Given VR's high costs, smaller firms should consider more affordable, user-friendly VR solutions. Devices like the Meta Quest 3 provide a balance of accessibility and functionality, enabling firms to enhance client engagement affordably. According to feedback from firms already utilizing VR, such as VRQ, accessible VR options allow even small firms to leverage VR's communication benefits without excessive financial strain (154). This approach democratizes VR access, empowering smaller firms to offer high-impact client presentations typically associated with larger firms.

3. Provide Staff Training on VR Tools and Integration Familiarity with VR tools is essential for effective client interactions. Structured training for staff on VR use and integration can help teams adopt VR smoothly and utilize its full potential. Architects with VR experience, such as those interviewed in Basel, noted that training and hands-on experience are vital to maximizing VR's communication benefits in client presentations. Familiarity with VR tools enables staff to lead immersive sessions confidently, allowing for richer, more interactive client experiences (155).

4. Offer Structured Client Onboarding for VR Use Clients unfamiliar with VR may initially feel hesitant, limiting the tool's communication advantages. Short onboarding sessions allow clients to become comfortable with VR controls and navigation, resulting in a more engaged and active participation. Firms like Hegias and VRQ, which offer demo sessions, report that clients find VR more accessible after these hands-on introductions, enhancing engagement in the design process (156). Introducing VR in a supportive, client-focused way further encourages clients to embrace VR as a valuable complement to traditional visualization tools.

5. Combine VR with Traditional Visualization Methods While VR provides an immersive understanding of designs, traditional tools like 2D drawings, physical models, and static renderings still hold value, especially for clients accustomed to these methods. Combining VR with traditional visualization techniques ensures clients can explore the design from multiple perspectives, enhancing overall understanding. Studies indicate that blending VR with familiar methods optimizes client engagement, making VR a supportive, rather than standalone, communication tool (157,158).

By adopting these recommendations, architecture firms can leverage VR's unique communication strengths to foster clearer, more effective interactions with clients. The benefits of VR as a tool for architect-client communication are clear, enabling clients to experience and understand design elements that are often challenging to convey through traditional methods alone. As VR becomes more accessible, implementing supportive practices and training will allow architects to maximize its potential for improved client satisfaction and streamlined project outcomes.

7.2 Focused VR Communication Strategy: Immersive Design Exercises for the Prototyping Phase

Objective: To improve communication during the prototyping phase by engaging clients in immersive VR sessions where they can experience spatial relationships, materials, and lighting firsthand. This focused component leverages VR to create a shared, interactive space where clients and architects can refine design details collaboratively.

7.2.1 Structure of the Immersive Design Exercise:

1. **VR Model Creation**: A detailed VR prototype is built using tools like Unity or Unreal Engine, compatible with accessible VR headsets such as Meta Quest 3. The model is customized to highlight core design elements relevant to the prototyping phase, such as spatial layout and material choices allowing clients to explore and respond to specific features of the design.

2. **Interactive Client Session**: Clients are invited to engage with the VR model, exploring areas such as room flow, material textures, and lighting setups. As they navigate the space, clients can request adjustments or explore options, which architects can demonstrate directly in VR. This interactive process fosters real-time feedback and helps clients visualize changes as they occur, reducing ambiguity and aligning expectations.

3. **Feedback Collection and Analysis**: After the session, structured interviews and feedback forms capture client responses regarding design clarity, spatial comprehension, and material preferences.

By comparing this feedback to that from traditional prototyping methods, the effectiveness of VR in enhancing client understanding and communication can be evaluated.

Anticipated Outcome: Through Immersive Design Exercises, clients gain a tangible, interactive experience of the design that traditional models cannot provide. This deepened understanding is expected to streamline feedback, reduce revisions, and ultimately foster a clearer, more collaborative communication process during the prototyping phase.

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Practical Application: Villa Project Prototype Development

As part of the planning for my master's thesis, I developed several prototypes focusing on enhancing client-architect communication through immersive Virtual Reality (VR) interactions. These prototypes, though preliminary, demonstrate the core idea of using VR as a tool to improve spatial comprehension, facilitate real-time feedback, and provide clients with a more intuitive understanding of architectural designs. By integrating VR as a key component of the design review process, these prototypes aim to bridge common communication gaps, reduce misunderstandings, and create a more collaborative, interactive experience for both clients and architects.

Over the past year, I have applied this immersive VR approach to a specific architectural project a villa. This project includes comprehensive plans, technical drawings, and a fully developed digital model.

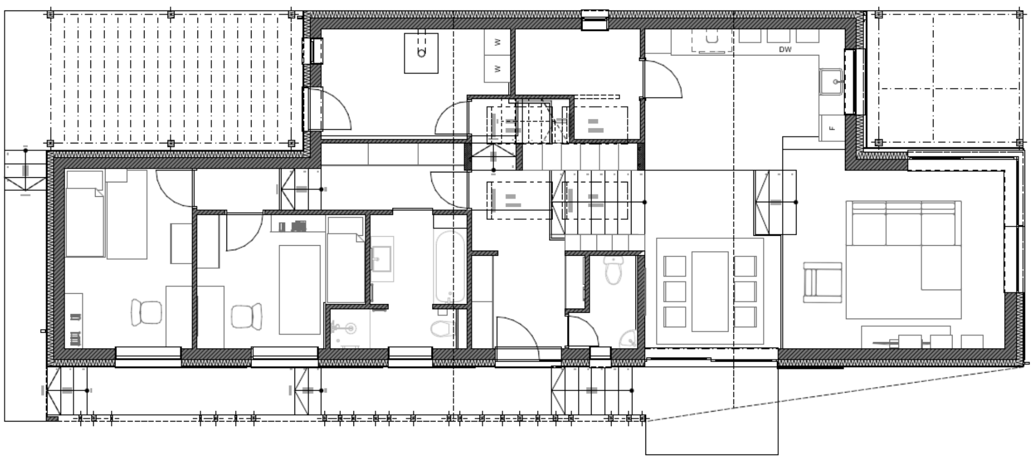

Figure: Gamze Gunes, Ground Plan, ArchiCAD 27

The goal is to import the villa model into Unreal Engine, creating an interactive VR environment that allows for in-depth exploration of spatial arrangements, material selections, and lighting conditions.

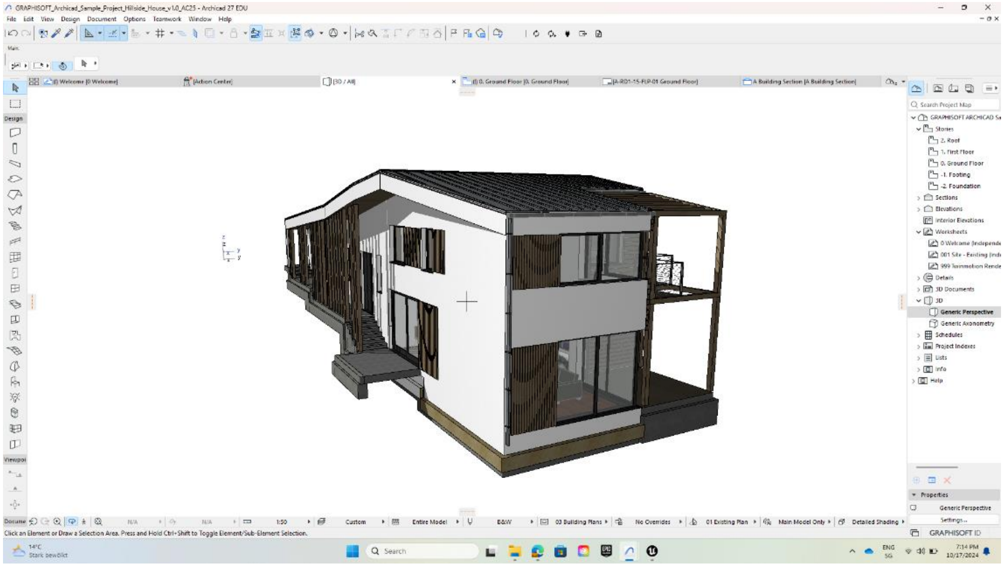

Figure: Gamze Gunes, 3D Model (exterior), ArchiCAD 27

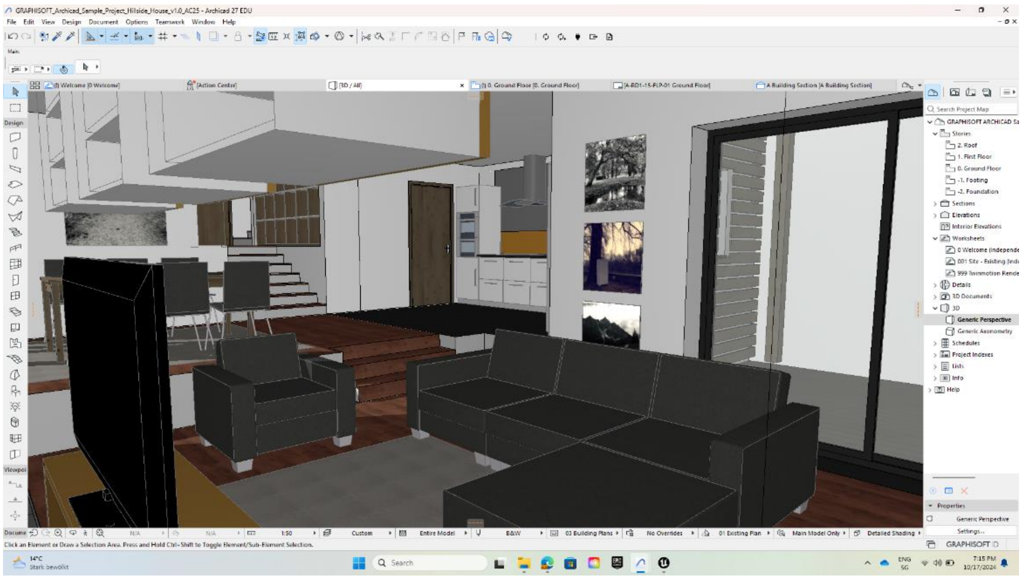

Figure: Gamze Gunes, 3D Model (interior), ArchiCAD 27

The goal is to import the villa model into Unreal Engine, creating an interactive VR environment that allows for in-depth exploration of spatial arrangements, material selections, and lighting conditions.

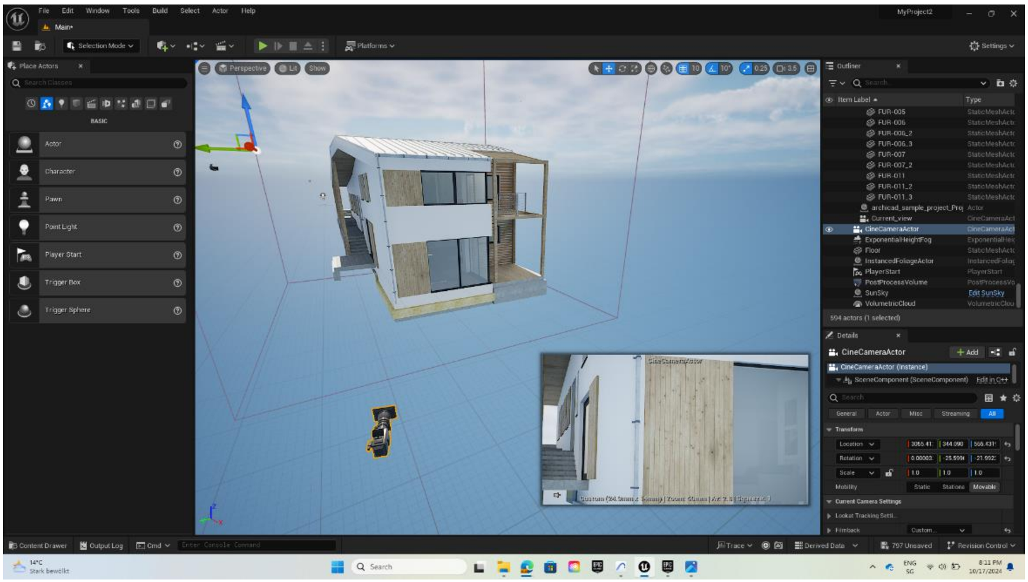

Figure: Gamze Gunes, 3D Model (exterior), Unreal Engine 5

Figure: Gamze Gunes, 3D Model (interior), Unreal Engine 5

Through this VR setup, I plan to present the project to clients, architects, and other stakeholders, enabling them to "walk through" and interact with the virtual space. This hands-on experience will allow users to provide immediate feedback and reactions to design elements, which I will analyse to further refine the communication and engagement strategies. By collecting and evaluating feedback from these sessions, I aim to conclude this thesis with practical insights into how VR can enhance the client-architect communication process in architectural practice.

Practical Application 2: Trade Fair Experience in Berlin

In addition to my thesis work, I had the opportunity to attend a trade fair in Berlin, where I showcased several 3D-modeled environments, each designed with a different functional focus, such as residential and commercial and leisure spaces.

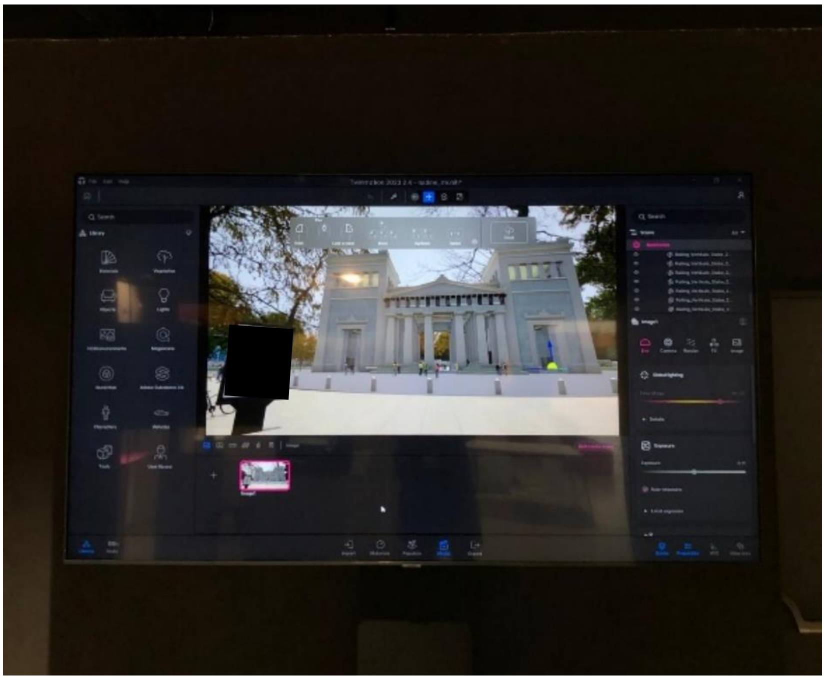

Figure: Gamze Gunes, Immersive Leisure Space, Twinmotion 2023

These models were developed and imported into Twinmotion to create VR experiences for the visitors at the fair. While Twinmotion offers limited interactions compared to Unreal Engine, allowing for features like material switching and weather/season adjustments, it provided enough interactivity to captivate attendees.

Figure: Gamze Gunes, Immersive Residential Space, Twinmotion 2023

Many visitors were notably impressed with the ability to customize materials and visualize spaces in various seasonal settings.

Figure: Gamze Gunes

Although this experience demonstrated VR's potential to engage users effectively, it differs from the main goal of this thesis. Here, my objective is not just to create an immersive experience but to address communication challenges specifically between architects and clients. The thesis aims to use VR as a tool to improve understanding and clarity in design, fostering better collaboration by bridging the communication gaps that traditional methods often leave.