

Immersive Architectural Experiences: The Integration of VR in Design Processes

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Abstract

Virtual Reality (VR) technology, a computer-simulated innovation, enhanced the architectural design process by offering users an immersive three-dimensional experience. Its integration into 3D architectural design fostered cohesive and realistic spatial environments. This study explored the application of VR in 3D architectural design, combining literature reviews, specific case studies, and practical applications. The findings revealed that VR technology not only streamlined the design process but also enhanced creativity and efficiency, engaging users' visual, auditory, and tactile senses for a comprehensive immersive experience.

The researchers conducted extensive field surveys and design practice using CAD, Photoshop, and 3DMAX. Interviews and questionnaires were carried out using a random sampling method with university teachers, VR practitioners, architects, and clients engaged in architectural design, revealing that 90% of participants favored immersive architectural design as their preferred method. The data suggested that VR's capacity to replicate spatial realities, facilitate dynamic editing, and visualize complex details significantly enhanced user engagement and satisfaction. The study concluded that VR technology offered substantial benefits in refining design processes, improving communication between designers and clients, and creating immersive architectural experiences that closely aligned with user expectations.

Keywords: Virtual Reality (VR), Immersive Experience, Three-dimensional Architectural Design, Spatial Reality Restoration, Design Processes

Introduction

Virtual Reality (VR), also referred to as virtual reality or spiritual realm technology, emerged as a groundbreaking technology in the 20th century. Owing to its robust applicability, its integration into various fields, especially in three-dimensional architectural design, has been expanding. Three-dimensional

architectural models are crafted using advanced computer software, enabling the creation of expansive scenes or high-resolution images. This enhances traditional design concepts and augments the viewer's visual experience. When constructing a 3D building model, the software's inherent animation settings amplify the model's realism and dynamism, bestowing the 3D animation with a distinctive visual flair and emotional ambiance. In conventional architectural design, designers frequently revise and restructure their plans, representing the design's impact through two-dimensional sketches and three-dimensional dioramas (Ling, 2022). However, such traditional methods fall short in portraying the design's effect with precision, nor do they facilitate a profound understanding of the entire design scheme for residents. Hence, employing VR for three-dimensional architectural design has emerged as an optimal solution. Upon finalizing the three-dimensional architectural model, one can utilize a VR device to immerse oneself in the entire architectural design plan. This unrestricted, real-time exploration of the three-dimensional space ensures that residents can make informed decisions promptly.

Both VR technology and 3D architectural design share mutual objectives. VR employs specific software to generate three-dimensional animated visuals, crafting an idyllic realm within the virtual space. Conversely, 3D scenes undergo computerized preprocessing, allowing users to grasp the designer's conveyed message within the scene. Through animation, elements like color, lighting, and camera angles depict a particular spatial environment to viewers. Often, this space possesses an idealized hue. The primary aim for both is to immerse users within a perfect virtual world (Yuan, 2021).

Objectives

To explore the multifaceted advantages of virtual reality (VR) technology in 3D architectural design, emphasizing its capacity to enhance design visualization, foster immersive user experiences, and streamline the design process.

Research Methodology

To gather comprehensive data, the researcher utilized a combination of document analysis, case studies, questionnaires, and interviews throughout the research process. Virtual reality technology, along with CAD software, Photoshop, and 3DMAX, was applied in real-life cases within the field of 3D architectural design to conduct design practice research. These tools allowed the researcher to explore the integration of VR technology in creating immersive and detailed architectural experiences.

A random sampling method was used to conduct interviews and distribute questionnaires among various stakeholders, including university teachers, architectural designers, VR technology practitioners, and clients involved in architectural design. This approach aimed to understand their experiences and perceptions in actual operations and gather their feedback, which was used to evaluate the immersive architectural experience.

The theory and practice of virtual reality technology in practical applications were extensively collected from the Internet and academic literature. This information, combined with the data from interviews and questionnaires, was integrated and analyzed to draw a feasible conclusion, demonstrating the advantages and applications of VR technology in enhancing three-dimensional architectural design.

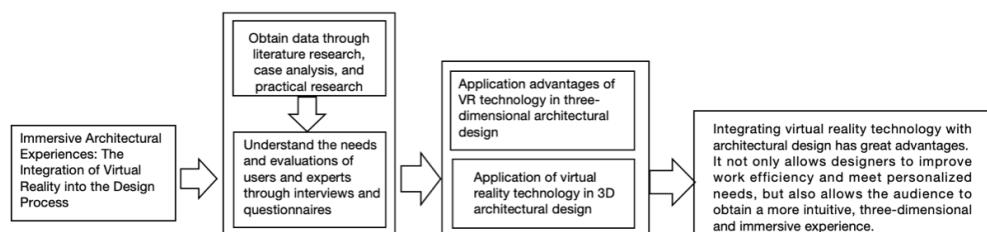


Figure 1 Research Model

Source Author

Literature review

Over the past decade, the exploration and application of virtual reality (VR) technology have garnered significant support in China. The nation has strategically incorporated VR technology into pivotal research initiatives, including the National High-Tech Research and Development Program, the National Natural Science Foundation of China, and the Ninth Five-Year Plan. Both the Ministry of Science and Technology and the Commission of Science, Technology, and Industry for National Defense have prioritized VR technology research as a key project. Numerous domestic research institutions have embarked on VR technology studies, yielding notable outcomes. For instance, the National Optical Disc Engineering Research Center at Tsinghua University successfully created a panoramic virtual reality representation of the Potala Palace. Zhejiang University introduced a desktop virtual real-time roaming system tailored for architectural environments. Furthermore, the Virtual Reality Laboratory at Tongji University's School of Architecture has developed virtual simulations of building structures and landscapes. These advancements have significantly propelled the evolution of VR technology in 3D architectural design within China (Li, 2007).

In contrast, many developed nations have already achieved substantial progress in VR technology, extending its applications beyond indoor or architectural landscape designs. Numerous research institutions and corporations, recognizing the potential of VR, have swiftly ventured into this domain. Their endeavors span a wide range of sectors, including computer-aided design, education, graphics, imaging, machine simulation training, robotics, entertainment, urban planning, real estate, cultural heritage preservation, medical applications, and military training exercises, among others. The fusion of VR technology with three-dimensional holographic projection is anticipated to offer an even more potent sensory experience (Negroponte, 1997).

Research Results

Survey and Analysis of Immersive Architectural Experiences

Interviews and questionnaire surveys were conducted with university teachers, architectural designers, virtual reality technology practitioners, and clients involved in architectural design in China from December 2021 to the present. A total of 300 questionnaires were distributed, and 287 valid responses were received, providing a solid basis for analysis. The survey aimed to gather essential information, including gender ratio, age distribution, design preferences, and experiences with immersive architectural design.

The Crowd Structure Analysis was performed to understand the demographics and preferences of the respondents. The analysis included information on gender ratio, age groups, the respondents' experiences with immersive architecture, and their preferences regarding design requirements. The data collected were summarized and visualized to provide insights into the composition of the sample and the overall perception of immersive architectural design.

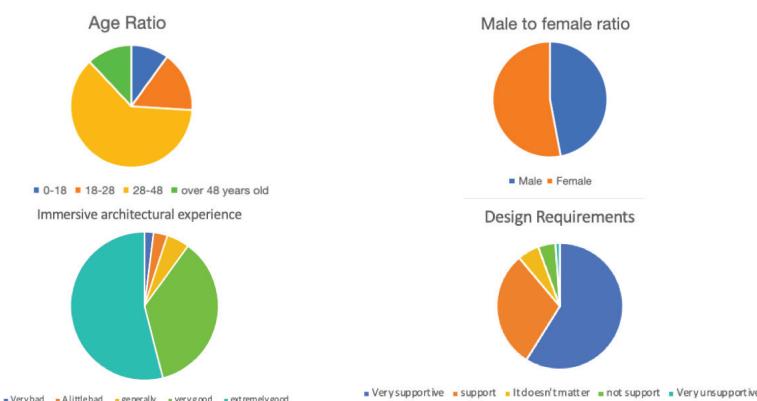


Figure 2 Crowd Structure Analysis

Source Author

The Figure 2 illustrates the findings from the Crowd Structure Analysis, showing the gender ratio (47% male, 53% female), age distribution (62% aged 28-48), and the respondents' ratings of immersive architectural experiences.

It also highlights the preference for immersive design as the primary display method, with 90% of participants favoring this approach. These results emphasize the growing acceptance and demand for VR integration in three-dimensional architectural projects, confirming its effectiveness in enhancing user experience.

Advantages of VR Technology in Three-Dimensional Architectural Design

In the contemporary new media landscape, the integration of VR technology with traditional sectors is a clear trend. The synergy between evolving virtual reality technology and 3D architectural design is progressively becoming the norm. VR technology offers distinct advantages in the architectural design domain, facilitating a seamless exchange between designers and clients.

1. Enhanced Communication of Design Concepts

Virtual reality technology, characterized by its immersive nature, meets clients' desires for a tangible understanding. Beyond simple visualization, clients can navigate indoor spaces and experience various scenarios, such as the ambiance with lights on or off. This immersive experience allows designers to convey design concepts more vividly, fostering effective communication and mitigating potential design issues arising from miscommunication. VR technology involves clients directly in the design process, enabling them to articulate specific design adjustments through VR projections. The technology's ability to vividly depict three-dimensional sections of model rooms allows designers to identify and rectify design shortcomings. VR technology shifts interior design from a passive approach to an intelligent one, fostering creativity through a blend of real and virtual environments (Fu, 2023).

2. Inspiration Catalyst

VR technology's capability to replicate spatial realities can stimulate designers' creativity. By manipulating and juxtaposing various patterns and items in virtual spaces, designers can discover new inspirations. Such playful combinations not only spark design ideas but also alleviate screen-induced fatigue, enhancing work efficiency.

3. User-Friendly and Vivid Design Display

VR technology's direct delivery feature facilitates personalized presentations tailored to clients' preferences. It enables quick modifications based on client feedback, offering a more streamlined communication process compared to traditional methods. Traditional two-dimensional representations

often fail to convey spatial depth, leading to potential discrepancies between design outcomes and client expectations. VR technology bridges this gap by providing clear, three-dimensional, and dynamic architectural visualizations (Quan, 2022).

Application of Virtual Reality Technology in 3D Architectural Design:

1. Architectural Spatial Experience:

The spatial experience focuses on elements like material selection and color coordination. Traditional animation-based architectural displays often struggle with managing spatial details, leading to inconsistencies between the overall design and its components. Moreover, these traditional methods, primarily two-dimensional, fail to offer a genuine spatial experience, causing discrepancies between designers' outputs and clients' expectations. VR technology addresses these challenges by providing a three-dimensional spatial display, coupled with a compelling visual impact.



Figure 3 Three-dimensional Q Version of the Building

Source Author

2. Application in Pre-Decoration Phases

Architectural design is an intricate process, encompassing various facets such as home furnishings, color palettes, lighting configurations, furniture arrangements, and the quality and aesthetic of materials employed in interior design. Moreover, the intricate nature of decoration details demands sophisticated combinations and harmonization techniques. Traditional animated architectural displays often grapple with the three-dimensional representation of these

nuances and struggle to simulate an integrated approach to these details.

In stark contrast, VR technology offers an immersive experience, adeptly replicating the intricacies and items pivotal in the pre-decoration phase. Interior designers, leveraging 3D modeling, can meticulously articulate every spatial detail, thereby instantaneously communicating design concepts to clients within a real-time 3D milieu. Clients, through VR technology, can indulge in a 360-degree exploration, enabling them to refine their preferences and requirements more effectively. This transcends the temporal and spatial constraints inherent in conventional pre-decoration approaches, impeccably mirroring client preferences in simulation exercises.

By facilitating an intuitive spatial representation and offering multiple opportunities for selection during the pre-decoration phase, VR technology adeptly addresses the fragmented nature of traditional pre-decoration. It not only enhances design efficiency but also caters to the bespoke needs of clients, epitomizing a more intelligent and efficient design methodology. It is anticipated that the realm of interior design will evolve towards greater transparency, standardization, and intelligence in the foreseeable future.



Figure 4 Three-dimensional Q Version of the Building

Source Author

3. Application in Dynamic Comparison of Design Elements

A salient challenge in architectural interior design pertains to the dynamic comparison of design elements. Designers are tasked with juxtaposing various architectural nuances through an ever-evolving dynamic display. Traditional animated architectural display methodologies grapple with multiple challenges in

this context. Firstly, they must navigate a plethora of evaluation criteria encompassing practical implications, feasibility assessments, and economic considerations, often failing to deliver a holistic solution. Secondly, their expressive capabilities are somewhat limited, often falling short in delivering a potent dynamic sensory impact spanning visual, auditory, and tactile dimensions. In contrast, VR technology, leveraging its three-dimensional spatial representation, facilitates a seamless dynamic comparison of diverse factors. It enables profound exploration, tangible modifications, and experiential fine-tuning during transitions between varying layouts and stylistic approaches. This modality adeptly amalgamates criteria such as practicality, feasibility, and cost-effectiveness, striving to identify an optimal solution amidst a myriad of constraints. Consequently, VR technology emerges as a formidable tool, offering the most refined adjustment strategies for interior design endeavors.



Figure 5 Three-dimensional Interior Design Drawing

Source Author



Figure 6 Three-dimensional Interior Design Drawing

Source Author

4. Application in Prototype Room Design

The prototype room serves as a pivotal conduit, bridging the designer's conceptual vision with the client's specific requirements. It not only offers clients a glimpse into potential design aesthetics but also facilitates the visualization and refinement of intricate design details. Traditional prototyping methodologies often fall short in delivering an immersive, three-dimensional experience to clients. Consequently, even after iterative consultations and refinements, the finalized prototype often diverges significantly from the client's envisioned outcome.

Virtual Reality (VR) technology, however, transcends these limitations. It materializes client preferences through a vivid three-dimensional display, coupled with real-time photographic documentation, thereby capturing the client's nuanced reactions and specific desires with unparalleled precision. VR encompasses functionalities such as panoramic roaming and interactive decor adjustments. Through the panoramic feature, clients can undertake a comprehensive 360° exploration of the spatial layout. Activating the interactive decor mode empowers clients to customize various elements, ranging from furniture arrangements to floor finishes, curtain styles, ceiling designs, and wallpaper selections, aligning them with their unique tastes. Such bespoke VR capabilities can be tailored to resonate with individual client preferences. Furthermore, armed with insights gleaned from these VR interactions, designers can swiftly recalibrate the prototype room, ensuring it aligns more congruently with client aspirations and presents an optimal spatial configuration.

5. Application in Articulating Design Concepts

Virtual Reality (VR) technology has emerged as a potent tool for the vivid articulation of design concepts. Throughout the architectural design trajectory, designers grapple with the challenge of lucidly conveying their design philosophies, all while navigating the architectural context and aligning with clients' subjective preferences. Traditional representational methodologies often falter in encapsulating the essence of design intentions. VR technology, however, offers a comprehensive solution to this conundrum.

Within the VR paradigm, designers have the latitude to craft alternative

plans resonating with the overarching design philosophy, in addition to the primary virtual design blueprint. This immersive auditory and visual experience aids designers in refining and crystallizing their architectural vision, ensuring its accurate portrayal. For instance, the Haus VR platform seamlessly integrates VR informatics with interior design, enabling the transformation of three-dimensional design elements into interactive videos. When confronted with ambiguities in their design intent, designers can upload their conceptual elements, leveraging the platform's capabilities to generate a visual narrative of the design ethos. Furthermore, this platform facilitates the acquisition of a comprehensive VR video suite, encompassing models, sketches, and other ancillary operations. Such videos offer an unfiltered glimpse into the potential realization of the design, empowering designers to juxtapose it against alternative design paradigms, continually refining the original blueprint to ensure alignment with the foundational design philosophy.

Moreover, Haus VR's panoramic video feature compensates for the intricacies in multifaceted scenes, guiding designers in judiciously modulating their design strategies and philosophies during interior architectural endeavors. This platform not only streamlines the virtual simulation and optimization phases of design but also aids in the seamless transition of subsequent design iterations. Analogous to its utility in prototype room design, VR-associated design concept models can be uploaded via cloud-based platforms, preserving three-dimensional models and optimization data for future reference, facilitating project management, intellectual property transitions, and offering a robust database for prospective architectural endeavors.

6. Application in Dynamic Editing and Refinement

Virtual Reality (VR) technology has proven instrumental in facilitating dynamic adjustments to design plans. This technology empowers designers to iteratively refine designs, addressing potential shortcomings influenced by various architectural parameters. For instance, to augment realism and immersive experience, designers can engage clients directly in the dynamic editing process. By donning VR headsets, clients can actively participate, making informed decisions regarding various design elements such as flooring, tiling, ceiling configurations, furniture selections, and spatial layouts. Additionally, real-time

demonstrations can be rendered accessible to clients through contemporary electronic devices, including iPads and smartphones.

In today's era, characterized by rapid technological advancements, architectural professionals can harness the computational prowess and connectivity offered by modern computers. This facilitates the dynamic archiving of evolving design iterations, culminating in a comprehensive historical database that chronicles each modification. Such a dynamic repository not only serves as a robust foundation for future design endeavors but also enhances the efficacy of information dissemination amongst stakeholders. By meticulously documenting each phase of optimization, subsequent designers and clients are presented with a spectrum of dynamic alternatives, streamlining their decision-making and fine-tuning processes.

Discussion and Conclusion

The integration of Virtual Reality (VR) into three-dimensional architectural design represents a significant shift in contemporary design methodologies. This innovative approach enhances the understanding of design blueprints for both designers and clients, accelerating the design process and improving its overall efficiency. Importantly, it meets the increasing demand for customized designs, thereby improving client satisfaction.

In today's architectural landscape, particularly in large-scale projects, VR serves as an essential tool for fostering seamless communication and creating immersive experiences between designers and clients. This technology enables clients to actively participate in the design process, offering real-time edits and comparisons. The resulting designs are not only more cohesive but also provide a tangible, three-dimensional spatial experience, which enhances client engagement and understanding.

The potential of VR in architectural design is multifaceted, with spatial representation and dynamic visualization as its primary strengths. From a practical perspective, VR is not merely a tool for designers but also an

immersive platform for clients. It transcends traditional two-dimensional blueprints by offering a comprehensive three-dimensional perspective that enriches the information conveyed to clients and enables a more interactive experience.

To fully harness the transformative potential of VR in three-dimensional architectural design, it is crucial for designers to master this technology. By leveraging VR's strengths and addressing its limitations, designers can revolutionize architectural visualization. This not only enhances clients' understanding of spatial arrangements but also ensures that the final design resonates with their vision, leading to higher-quality outcomes and client satisfaction.

Furthermore, immersion in architectural design involves the transition and transformation of mental states, characterized by reducing the observer's distance from the displayed object and increasing emotional engagement in the present moment. Immersive architecture effectively showcases the internal and external details of buildings, allowing individuals to virtually explore spaces and experience architectural environments in a realistic manner through advanced digital display methods.

With the continuous advancement of digital technology, the audience's understanding of and engagement with architectural experiences have expanded beyond physical space, situating architecture within a broader digital and experiential context. However, the rapid production and dissemination of information have also led to a reduced sensitivity among audiences, presenting challenges for designers as they strive to further integrate digital transformation into architectural design. It is essential to balance these advancements to maintain meaningful and engaging architectural experiences for users.

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