Education Reform and Development, 2025, Volume 7, Issue 1
https://ojs.bbwpublisher.com/index.php/ERD
Online ISSN: 2652-5372
Print ISSN: 2652-5364

The Revolutionary Role of Virtual Reality Technology (VR) in Architectural Design Review

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Abstract: Virtual Reality (VR) technology has gradually become an indispensable tool in the field of modern architectural design. This study explores the revolutionary role of virtual reality technology in the architectural design review process. By analyzing the application cases of VR technology and its practical effects in design review, this paper mainly proposes that VR technology can not only enhance the efficiency of communication between designers and clients, but also improve the visualization effect of the design scheme and the comprehension of space. This paper begins with the limitations of the traditional process of architectural design review and reveals the challenges it faces. It then introduces the basic principles of VR technology and its specific applications in architectural design, especially the advantages in the design review stage. Case studies of actual projects are analyzed to discuss in detail how VR technology can help design teams and stakeholders understand and evaluate design solutions more directly, thus accelerating the decision-making process and reducing design modifications and rework in the construction phase. The study summarizes the current status of the application of VR technology in the field of architectural design and looks forward to its future development trend, emphasizing the importance of continuous technological innovation and multidisciplinary cooperation. This paper argues that with the continuous progress and popularization of VR technology, it will play a revolutionary role in architectural design review, completely change the traditional design review method, and promote the overall development of the construction industry.

Keywords: VR; Architectural design; Design review; Technological innovation; Visualization effect

Online publication: February 10, 2025

1. Introduction

The traditional architectural design review process generally consists of preliminary design sketches, the production of computer-aided design (CAD) models, the presentation of design drawings and multiple client-designer meetings [1]. 2D drawings and CAD models often struggle to present the building space and details well, which leads to an inaccurate understanding of the design scheme by the client and may result in some unnecessary misunderstanding and a high cost of modification at a later stage [2]. In addition, inefficient communication during the review process is also a major challenge. A 3D virtual environment is a virtual

reality (VR) technology that can be generated using computer simulation, allowing clients to have an immersive experience of the virtual world. Virtual Reality (VR) technology is widely used in different fields, such as games, medicine, education, military training, etc., which can satisfy the needs of interaction and immersion at the same time, and greatly improve the user's experience and training effect [3]. The purpose of this study is to explore the application of VR technology in architectural design review and its potential changes. The analysis of the specific advantages and application cases of VR technology in the architectural design review stage reveals how VR technology can help the design team to let the client understand the design scheme more intuitively and improve the efficiency and quality of the design review, to reform the traditional review method and achieve the purpose of advancing the development of the architectural design industry.

2. Brief description of virtual reality (VR) technology

Computer-generated 3D realistic virtual environments are the core principle of virtual reality (VR) technology, along with specialized hardware devices such as VR head-mounted displays (HMDs), hand-held controllers, and motion-capture systems to allow users to immerse and interact with them. Key technologies include high-resolution graphics rendering, real-time 3D modeling, motion capture and tracking, stereo sound, and an interactive interface with the user. These technologies work together to create a highly immersive virtual experience that allows the user to feel immersed [4].

The evolution of VR technology can be traced back to the 1960s when American scientist Ivan Sutherland invented the first head-mounted display (HMD) system. Since then, with the continuous progress of computer graphics and hardware technology, VR technology has gradually matured and entered the consumer market [2]. In the 1990s, VR technology began to be used in professional fields such as military training and flight simulation [3]. In the 21st century, especially after 2010, with the introduction of consumer-grade VR devices, such as Oculus Rift and HTC Vive, VR technology has rapidly become popular and widely used in many fields, such as gaming, education, healthcare, film and television [5].

In the field of architecture, the application of VR technology is becoming more widespread. Currently, architectural designers use VR technology for several aspects such as design reviews, client presentations and virtual show homes. Through VR, designers can create immersive 3D models that allow clients to experience the design scheme from a first-person perspective, thus understanding the spatial layout and design details more intuitively [6,7]. This application not only improves the efficiency of design reviews but also significantly enhances customer engagement and satisfaction [8]. Meanwhile, VR technology can help engineering teams better plan the construction process and identify problems and is therefore widely used in building modeling and safety training. The application of VR technology in construction is rapidly expanding and continues to lead the industry in innovation [9].

3. Application of VR technology in architectural design

Specific applications of virtual reality (VR) technology in architectural design review include real-time 3D visualization, interactive exploration of models and virtual presentation of showrooms. Firstly, through real-time 3D visualization, designers can convert 2D drawings and CAD models into realistic 3D virtual environments, allowing clients and other stakeholders to immerse themselves in the design scheme. This approach not only allows for a more intuitive display of architectural space, materials and light effects but also allows for quick feedback and suggestions by dynamically adjusting project details.

Secondly, the interactive exploration of modes is one of the main advantages of VR technology. Users can move, view and interact freely in the virtual space through handheld controllers or gesture operations [10]. This interactive mode allows users to deeply understand the design scheme from different perspectives, levels and details, such as viewing the internal structure of the building, experiencing the real size and layout of the space, and shaping the different use scenarios, and this immersive and interactive experience greatly improves the efficiency and effect of the analysis of the design scheme.

In addition, virtual house model display is another important application of VR technology in architecture. By creating a virtual house model, clients can have a realistic vision of their future living or working space even before the building is completed. This not only helps clients to better understand the design scheme but also enables them to identify potential problems in advance and make changes on time, thus reducing the cost of subsequent modifications and rework [11].

The effectiveness of using VR technology can be demonstrated more clearly through specific examples. For example, in a high-rise project, the design team used VR to create a 3D model of the entire building and invited the client, engineers, and builders to have a virtual experience. The client can "walk" through the future office from a first-person perspective, experiencing the spatial layout and project details [4]. The engineers and construction team used the VR model to gain a clearer understanding of the design intent, plan construction steps in advance, and identify possible technical challenges. In the end, the project achieved significant time and cost savings in both the design and construction phases, as well as improved customer satisfaction.

In another case, the design team used VR technology to conduct multiple design reviews and revisions on a complex urban mixed-use project. With VR, team members can instantly discuss and test different design options in a virtual environment and make quick decisions. This efficient collaboration not only speeds up the design process but also improves design quality and innovation.

In summary, the application of VR technology in architectural design review not only enhances design visualization and client understanding, but also significantly improves the efficiency of team collaboration and decision-making, and promotes innovation in the architectural design and construction process.

4. Advantages and challenges of VR technology

4.1. Main advantages of VR in architectural design review

(1) Higher design accuracy

VR technology enables designers to present architectural designs in an extremely accurate 3D view that goes beyond traditional 2D drawings and static 3D models. Through the immersive experience, designers and clients can have a more intuitive understanding of the architectural space, material texture, and light and shadow effects, thus identifying and eliminating potential design problems and ensuring that the final design is accurate, realistic, and feasible.

(2) Faster decision-making process

Through real-time 3D visualization and interactive model exploration, VR technology enables stakeholders to get quick design feedback, and test and discuss different design options in a virtual environment. This instant interaction and feedback mechanism significantly shortens the design review time, accelerates the decision-making process, and improves the overall efficiency of the project [12].

(3) Higher customer engagement and satisfaction

The immersive experience provided by VR technology allows customers to be more deeply involved in

the design review process so that they can better understand and experience the design solutions. This sense of engagement not only improves customer satisfaction but also reduces the need for subsequent revisions and reworks, thus lowering project costs [13].

(4) Better team collaboration

VR technology enables design teams, engineers, construction teams and other stakeholders to work in the same virtual environment, enhancing communication and understanding between teams. This collaborative approach helps to identify and resolve potential problems at an early stage, ensuring that the project runs smoothly.

4.2. Possible challenges in implementing VR technology

(1) Technical challenges

Although VR technology has made significant progress, its application in architectural design still faces a series of technical challenges. For example, the creation of high-quality 3D models requires significant computational resources and skills, especially when it comes to complex architectural designs. In addition, technical parameters such as the resolution of the VR device, tracking accuracy, and ease of use of the user interface can affect the effectiveness of VR and user perception.

(2) Economic challenges

Implementing VR technology requires a certain amount of economic investment, including the purchase of high-performance hardware devices (e.g., head-mounted VR displays and portable controllers), specialized software, and staff training in these palpable new technologies. For small and medium-sized architectural firms, this may pose a considerable financial burden. In addition, there will be additional costs such as regular equipment maintenance and software updates.

(3) Operational challenges

There are several operational challenges that need to be overcome to implement VR technology. Firstly, design teams need time and resources to learn and adapt to new workflows and tools, which may affect productivity in the short term. Secondly, the design and realization of VR experiences require cross-disciplinary collaboration across several fields, including architectural design, computer graphics and user experience design, which puts a higher demand on the team's overall capabilities.

Despite these challenges, the application of VR technology in architectural design review remains promising. Through continuous technological innovation and multidisciplinary collaboration, many of these challenges can be gradually overcome, thus giving full play to the advantages of VR technology and promoting the continued development and progress of the architectural design industry.

5. Case studies

The "Beijing Chaoyang Cultural Centre" is one of Beijing's urban regeneration projects, a new cultural center in the Chaoyang District of Beijing, designed by MAD Architects. The project involves a wide range of parties, including governmental departments, building departments, design departments, construction departments, etc. The cultural center includes theatres, exhibition halls, libraries and public spaces. The cultural center includes theatres, exhibition halls, libraries and public spaces, and the design is complex [14]. To ensure the accuracy and feasibility of the design, the project design team decided to use VR technology for design review and optimization. During the project, the design team used VR technology to create a 3D model of the building. The

model not only included the exterior of the building, but also presented in detail the interior layout, structure, and materials of the building [6]. The design team and related personnel can wear a VR headset to achieve an "immersive" of the building's interior and truly feel the building's spatial dimensions, lighting environment, and so on.

Compared with VR technology, although the traditional design mode can use 2D drawings and 3D renderings to provide certain visual information, it cannot reflect the real sense of space. With VR technology, the design team can perceive the internal space of the building in an immersive way and better adjust the space. For example, during the design of the cultural center, the designers found that the aisles were too narrow, which could easily cause congestion and increase discomfort. The design team promptly adjusted the width and layout of the aisles to improve the rationality and safety of the design. In the course of the project, several units involved in the project as well as experts from different fields can interact in the same virtual space through VR technology to collaborate and communicate, and put forward opinions and suggestions. Especially in the design presentation and approval process, government officials and investors can intuitively understand the design scheme and propose modifications, through the VR headset. This immersive experience significantly improves communication efficiency and reduces the possibility of design changes and misunderstandings [10]. The design team also used VR technology to combine virtual modeling with site visits. At certain stages of the project, team members wore VR equipment, entered the building site, and superimposed the virtual model on the actual scene through augmented reality (AR) technology. For example, during the foundation construction phase, the team discovered the conflict between certain pipelines and the building foundation through AR technology and adjusted the design program in time to avoid problems during construction. By using VR technology, the design team was able to identify and solve potential problems at an early stage of the design, avoiding the waste of time and cost due to design changes in the traditional design process. In this project, through VR technology, the team identified several design deficiencies in advance and made adjustments before construction. For example, the theatre's seating arrangement and audience sightline issues were optimized through VR simulation, which ultimately enhanced the audience's experience and saved significant renovation costs.

6. Future development trends

In the future, with the enhancement of computer power, improvement of hardware equipment and optimization of software algorithms, VR technology will become more accurate and user-friendly, achieving more realistic images and more natural interactive experiences. With technological innovations and market expansion that can further enhance its application value, virtual reality (VR) technology has great potential for future development in architectural design review. In addition, with the increased demand for university design review tools in the construction industry, as well as normal support and market promotion, the application of VR technology in architectural design will become more widespread. At the same time, the government's policy support for smart cities and digitalization of buildings, as well as the construction industry's high demand for improving the efficiency and quality of design, and with the convergence of 5G networks and artificial intelligence, will further enhance the practicality and intelligence level of VR, which are the main factors driving the application of VR technology [8]. With the joint promotion of many aspects, VR technology can completely change the way traditional design reviews and play an increasingly important role in architectural design review, thus achieving the purpose of promoting the development of the construction industry.

7. Conclusion

The use of virtual reality (VR) technology in architectural design review has brought about a profound change in the industry, dramatically improving design accuracy, communication efficiency and client engagement. Through immersive experiences and real-time interactions, VR technology has enabled design teams and stakeholders to understand and optimize design solutions more intuitively, reducing misunderstandings and modification costs, and facilitating smooth project implementation [15]. However, it is crucial to continue in-depth research and development of VR technologies to overcome existing technical, economic and operational challenges. Through continuous innovation and improvement, VR technology can maximize its potential benefits, further enhance the efficiency and quality of building design and construction, and drive the industry as a whole towards intelligence and digitalization.

Disclosure statement

The author declares no conflict of interest.

References

[1] Shi Y, 2019, Research and Implementation of Virtual Reality Home Decoration Simulation Application Technology Based on UE4, Beijing Institute of Printing, Beijing.

[2] Zheng L, Hua G, 2020, The Application of VR Virtual Reality Technology in Interior Design. Artist, 2020(6): 103–127.

[3] Shang Q, 2024, Research on the Application of Virtual Reality Technology in Interior Design and Decoration of Building Construction Projects. China Architecture Decoration and Renovation, 2024(11): 80–82.

[4] Wu J, Cao Z, Chen P, et al., 2022, User Information Behavior in the Metaverse Perspective: Framework and Prospects. Journal of Information Resource Management, 12(1): 4–20.

[5] Chen X, 2007, Common Problems in the Review of Construction Drawings in the Field of Architecture. Engineering Construction and Design, 2007(3): 30–32.

[6] Zhang J, Zhao L, Cui Y, et al., 2021, Research on Structural Design Review Method Based on BIM Model. Journal of Graphic Science, 42(1): 133–140.

[7] Wang C, 2023, Exploration of the Application of Virtual Reality Technology in Interior Design. Sichuan Building Materials, 49(3): 224–225 + 233.

[8] Yan J, 2024, Research on the Digital Transformation of Construction Project Management Mode. Real Estate World, 2024(16): 94–96.

[9] Li X, 2023, Technical Analysis and Management Strategies for Architectural Design Scheme Review. Architecture, 2023(4): 108–110.

[10] Xu J, 2020, The Latest Development of Green Building Combined with BIM Technology. Western Journal of Human Settlements and Environment, 35(6): 17–23.

[11] Guan B, 2024, Application of Green and Energy-Saving Construction Technology in Housing Construction Engineering. Shihezi Technology, 2024(2): 69–70.

[12] Tian X, Wang W, Wang H, 2009, Discussion on Planning Management of Architectural Design Scheme Review. Liaoning Building Materials, 2009(3): 53–55.

[13] Zhao Y, 2023, Theoretical Research on Urban Construction (Electronic Version). Urban Construction, 2023(23):

59–61.

[14] He J, Wang Y, Li T, et al., 2010, Design and Creation of Regional Cultural Architecture Based on the Concept of "Two Views and Three Characteristics" – Planning and Architectural Design of Yantai Cultural Center. Journal of Architecture, 2010(4): 65–66.

[15] He H, 2016, Related Issues in the Design and Review of Construction Drawings. Construction Technology, 2016(15): 78.