

Multi-dimensional Application of Virtual Reality Technology in Environmental Art Design Teaching

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Abstract: As digital technology develops rapidly, virtual reality technology has provided a brand-new pathway for the innovation in environmental art design teaching with its core features of immersion, interactivity and visualization. This paper starts from the coupling relationship between technology adaptation and instructional needs, focuses on the multi-dimensional application of virtual reality technology in environmental art design teaching, deeply analyzes its specific application models and implementation pathways in spatial cognition development, visualization of schemes, interdisciplinary collaborative design, reconstruction of practice teaching scenarios, and other aspects, demonstrates the key role of this technology in breaking through the limitations of time and space in conventional teaching and enhancing students' design thinking and practical ability in combination with teaching cases, and proposes corresponding optimization strategies in response to the problems, such as technical cost, teacher quality, and content adaptation, in its current application, aiming to provide theoretical and practical reference for the digital transformation of environmental art design teaching.

Keywords: Virtual Reality (VR) Technology; Environmental Art Design Teaching; Immersive Teaching; Spatial Cognition

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1.Introduction

As an interdisciplinary field that integrates spatial aesthetics, engineering technology and humanistic ethics, teaching core of environmental art design lies in developing students' perceptual ability of spatial forms, innovation ability in scheme design and the ability to implement and transform design results. The conventional teaching model mostly relies on two-dimensional drawings, solid models and on-site view, and has problems such as abstract spatial cognition, high cost of scheme modification and great limitations of practice scenarios, making it difficult for it to meet the demand of the modern design industry for compound talents. With its core advantage of "virtual simulation and reality", VR technology can transform abstract design concepts into perceivable and interactive three-dimensional spatial scenes, breaking down the space-time barriers and cognitive disorder in teaching.

2.Compatibility Between VR Technology and Environmental Art Design Teaching

2.1 Embodied Adaptation of Spatial Cognition

The core of environmental art design is "spatial design", and students need to have the ability to precisely perceive the scale, proportion, light and shadow, and materials of three-dimensional space. In conventional teaching, when teachers explain spatial relationships through two-dimensional drawings, students need to rely on abstract thinking to carry out the cognitive transformation from two-dimensional to three-dimensional, which is prone to problems such as deviations in spatial scale and mess of spatial logic. VR technology can transform design schemes into 1:1 virtual space. After students enter the virtual scenes through VR devices, they can experience the width, height, and brightness changes of the space from the first-person perspective, and even touch the wall materials and turn on and off the lights through gesture interaction to intuitively understand the impact of different design elements on the atmosphere of the space.

2.2 Dynamic Adaptation of Scheme Design

The optimization of environmental art design schemes is a dynamic iterative process. In conventional teaching, when students modify their schemes, they need to redraw the drawings or adjust the solid models, which not only takes a lot of time and effort but also makes it difficult to visually present the effect comparison before and after the modification. VR technology supports real-time modification and dynamic deduction of design schemes. Students can directly adjust the spatial layout, color matching, and furniture display in virtual scenes. The modification results are presented immediately without waiting for rendering or model reconstruction. Taking the *Commercial Space Design* course as an example, when students are designing the atrium scheme for a shopping mall, they can adjust the height of the atrium, the location of the escalators, and the layout of green plants in real time through VR software, and observe the impact of this adjustment on the flow direction of people and the transparency of the space.

2.3 Scenario-Based Adaptation of Practice Teaching

Environmental art design is highly practical. Students need to understand the actual links such as material construction, cost accounting, and on-site coordination. However, conventional practice teaching is limited by site, cost, safety, and other factors, which makes it difficult for students to deeply participate in the whole process of actual projects. VR technology can create simulation construction practice scenarios to simulate the operation procedures and risk points of different construction procedures, and allow students to conduct “risk-free” practice in virtual environment. For instance, in the *Interior Decoration Construction Technology* course, teachers can use VR technology to build a virtual scene of “wall plastering”. Students can simulate the whole process from “basic level processing-hanging net-plastering-leveling-sanding” through VR devices. The system will provide real-time prompts for operation specifications and early warnings for operate miss and correct this miss. Meanwhile, the scenes can also present the cost differences of different materials and the comparison of construction effect to help students understand the correlation between “design schemes and construction cost”. This scenario-based practice teaching effectively makes up for the deficiencies of conventional practice teaching, and allows students to accumulate “practical experience” in virtual environment and enhance their ability to solve practical problems.

3.The Multi-Dimensional Application Pathways of VR Technology in Environmental Art Design Teaching

3.1 Cognitive Teaching Dimension: Constructing an Immersive Spatial Cognitive System

In the basic courses of environmental art design, VR technology can be used to build an “immersive spatial cognitive system”, and help students establish the grounded cognition of spatial forms and aesthetic laws. Teachers can transform classic environmental art design cases at home and abroad into VR scenes. Through immersive experience, students can directly perceive the design techniques of “spatial sequence”, “the use of light and shadow”, and “material comparison” in the masterpieces. For instance, when analyzing the “Rock Slice Landscapes” in the Suzhou Museum, teachers can enable students to observe the spatial relationship between the rockery and the building as well as the courtyard from different angles in virtual scenes, and understand the garden-making concept of “replacing the real with the false”. This experience is far superior to the conventional way of viewing pictures or videos. In the *Spatial Composition* course, teachers can use VR software to build a “Spatial Composition Experimental Platform”. Students can freely combine basic elements, such as point, line, surface, and body, to construct spatial structures of different forms, and feel the spatial mental feelings brought by different structures through immersive experience. Meanwhile, the platform can record students’ operation processes and spatial schemes. Teachers can understand students’ spatial cognitive characteristics through data analysis and achieve personalized pedagogical guidance.

3.2 Design Teaching Dimension: Building a Dynamic Platform for Scheme Deduction

In core courses of design, VR technology can create a “dynamic scheme deduction platform” to support the

whole-process design of students from scheme conception to scheme optimization. During the stage of scheme conception, students can import sketches or mind maps into VR software to quickly generate an initial virtual space model and verify the feasibility of the conception through immersive experience. For instance, in the *Landscape Design* course, when students are conceiving the entrance landscapes of a park, they can first draw a simple sketch for the functional zones, and then use VR software to generate a virtual scene to intuitively judge the issues, such as “whether the size of the entrance square is reasonable” and “whether the plant configuration affects the line of sight”, and avoid extensive modifications to the subsequent scheme due to conceptual deviations. During the scheme optimization stage, students can use VR technology to generate virtual scenes of multiple schemes and conduct multi-dimensional comparisons through the “scene switching” function.

3.3 Collaborative Teaching Dimension: Building Interdisciplinary Collaborative Design Scenarios

Environmental art design often involves multiple disciplines such as architecture, structure, water and electricity, and soft decoration. In conventional teaching, interdisciplinary collaborative design is mostly carried out through the method of “group discussion + summary of paper-based schemes”, which is prone to problems such as information asymmetry and poor alignment of schemes. VR technology can create “interdisciplinary collaborative design scenarios” to enable real-time interaction and scheme synergy among students of different majors. In the “*Integrated Design*” course, students majoring in Environmental Art Design are responsible for spatial aesthetic design, those majoring in Civil Engineering are responsible for structural safety design, and those majoring in Water Supply and Drainage Science and Engineering are responsible for water and electricity layout design. Those students enter the same virtual scenes through VR collaborative platforms and mark their design schemes and technical requirements in real time. During the presentation of design schemes, VR technology can serve as a “visual bridge” for communication between students and clients. In conventional presentation, due to the lack of professional knowledge, clients find it difficult to understand the design schemes through the drawings. However, through virtual scenes, clients can experience the design effect in an immersive way, directly put forward modification suggestions, and students can modify the schemes in real time on site and present the effect, improving communication efficiency and client satisfaction. This “visual communication” model not only cultivates students’ communication skills but also enables them to understand the core principle that “design must meet user need”.

3.4 Practice Teaching Dimension: Reconstructing the Scenario-Based Training System

In practice courses, VR technology can reconstruct the “scenario-based training system”, simulate the construction, materials, cost and other procedures in actual projects, and enhance students’ practical ability. VR technology can be used to build a “construction technology simulation platform” to simulate the operation procedures and technical essentials of different construction procedures. For instance, in the training on “Floor Decoration Construction”, students can simulate the whole process of “base layer cleanup-marking lines-laying bricks-grouting” through VR devices. The system will score according to the operation specifications and provide prompts and explanations for incorrect operations. Meanwhile, the platform can simulate the impact of different construction environment on construction quality, and help students understand the correlation between “construction environment and technology selection”. In the *Decoration Materials and Budget* course, students can choose different types of decoration materials in a VR scene. The system will display the unit price, dosage and total cost of the materials in real time, and compare the cost performance and environmental protection performance of different materials.

4.Existing Problems in the Application of VR Technology in Environmental Art Design Teaching and the Optimization Strategies

4.1 Existing Problems

4.1.1 The Problem of Technical Cost and Equipment Maintenance

The application of VR technology requires professional hardware equipment and software systems. A complete

set of VR teaching devices is relatively expensive, which poses significant barriers to large-scale deployment in many colleges and universities, particularly those with limited budget. Meanwhile, the daily maintenance and software upgrading of VR devices also require additional financial and technical support, which increases the teaching cost.

4.1.2 The Problem of Teacher Quality and Teaching Competence

The application of VR technology has set a high requirement for the comprehensive quality of teachers. Teachers need not only to have professional knowledge of environmental art design, but also to master the operation methods of VR devices, the use skills of VR software and the teaching design ability of “VR+ teaching”. However, at present, most teachers in environmental art design lack relevant training and practical experience in VR technology, and they find it difficult to deeply integrate VR technology with instructional content, which leads to poor teaching results.

4.1.3 The Problem of Content Adaptation and Integration into Teaching

At present, most of the VR instructional resources on the market are general content (such as basic spatial cognition and simple construction simulation), and lack personalized content that is compatible with the specialized courses of environmental art design. Meanwhile, when using VR technology, some teachers merely regard it as a “display tool”, and do not systematically integrate it with learning objectives, teaching processes, and instructional assessment. This leads to a divorce between VR technology and instructional content, and makes it difficult to fully exert its due instructional value.

4.2 Optimization Strategies

4.2.1 Reducing Technical Cost Through Multiple Channels and Improving the Equipment Maintenance System

On the one hand, colleges and universities can employ the “school-enterprise cooperative” model to jointly build VR teaching laboratories with the manufacturers of VR devices and design enterprises. The enterprises provide equipment support and technical maintenance, while colleges and universities offer teaching venues and faculty, achieving resource sharing and cost sharing. On the other hand, “lightweight VR devices” can be chosen to replace high-performance PC-driven VR devices to reduce hardware cost. At the same time, open-source VR software can be used to replace commercial software to reduce software expenses. In addition, colleges and universities can establish “VR device maintenance teams” composed of technical experts and student volunteers who are jointly responsible for the daily maintenance and management of the devices to reduce maintenance cost.

4.2.2 Strengthening Teacher Training and Enhancing the Ability to Integrate Teaching

Colleges and universities can make “VR Teacher Training Programs”, and enhance teachers’ VR technology application ability through the approach of “on-campus training + off-campus research and studies + enterprise practice”. For instance, they can invite VR technology experts to conduct on-campus training, explain the operation of VR software and teaching design methods, organize teachers to conduct research and studies at advanced colleges and universities in VR education and application to learn mature teaching models, and arrange for teachers to participate in VR design project practice in design enterprises to accumulate practical experience. Meanwhile, colleges and universities can establish “VR instructional resource libraries”, encourage teachers to jointly develop VR instructional content that is compatible with specialized courses, and hold “VR Teaching case sharing sessions” to promote experience exchange and cooperation among teachers.

4.2.3 Developing Personalized VR Instructional Content and Building a Systematic Teaching System

In response to the issue of poor adaption of VR instructional content, colleges and universities can collaborate with VR technology enterprises and design companies to jointly develop a “VR Instructional Resource Package for Environmental Art Design Majors”, which covers multiple aspects such as basic cognition, scheme design, collaborative optimization, and training, and is in line with the curriculum system. For instance, for the *Dwelling*

Space Design course, they can develop personalized content such as “VR Module for House Type Renovation”, “VR Module for Soft Furnishings”, and “VR Module for Construction Simulation”. For the *Landscape Design* course, they can develop “VR module for Plant Configuration”, “VR Module for Water Feature Design”, “VR Module for Lighting Simulation”, and other content.

5. Conclusion

As an important tool for promoting the innovation in environmental art design teaching, multi-dimensional application of VR technology not only realizes the transformation of teaching models from “abstract” to “concrete”, from “static” to “dynamic”, and from “monolithic” to “collaborative”, but also effectively enhances students’ spatial cognition ability, scheme design ability and practical ability. However, this technology still faces challenges in terms of cost, teaching staff, and content during its application, which need to be addressed through school-enterprise cooperation, teacher training, content development, and other strategies. In the future, with the continuous development of VR technology, its application will become deeper in environmental art design teaching, and it is expected to build a new teaching system of “virtual-real integration, holistic collaboration and precision teaching” to provide stronger support for cultivating high-quality talents that meet the demand of the modern design industry.

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