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Exploration on the Reform of the Teaching Method of the Plant Configuration and Landscape Architecture Course under Digital Technology

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Abstract: By analyzing the urgent demand for digital talents in the current landscape industry and the challenges faced by the traditional teaching mode, this study aims to explore a set of teaching methodology reform solutions based on digital technology to improve the quality of teaching and enhance the practical innovation ability of students. The study firstly describes the application of digital technologies such as CAD/BIM, 3D modelling and rendering, virtual reality (VR)/augmented reality (AR), and geographic information system (GIS) in the field of landscape architecture. Then, the current teaching status of plant configuration and landscape architecture courses is analyzed, and the advantages and challenges of digital technology applications are identified. On this basis, this study proposes a multi-dimensional reform path and practice plan including the reconstruction of teaching objectives and content, innovation of teaching mode, improvement of teaching strategies and methods, as well as the construction of teaching resources and the reform of teaching evaluation, guided by modern educational theories such as constructivism, collaborative learning and project-based learning (PBL). Finally, this study emphasizes the key roles of faculty construction, optimization of hardware and software environment, and teaching management and institutional guarantee in the reform.

Keywords: Digital technology; Plant configuration; Teaching method; Curriculum reform

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1. Introduction

With the rapid development of a new generation of information technology, such as big data, artificial intelligence (AI), and virtual reality (VR), a profound digital wave is sweeping across the world, reshaping the mode of production and the mode of thinking in all walks of life [1]. As a field deeply involved in the construction of space, ecology, and human habitat, the digital transformation of the landscape architecture industry has also become an irreversible trend of the times [2]. From the whole life cycle management based on Building Information Modelling (BIM), to the use of drones and Geographic Information Systems (GIS) for high-precision site analysis, to the immersive program experience with the help of Virtual Reality (VR/AR) technology, cutting-edge concepts such as “Smart Garden” and “Digital Twin City” are being developed. “Digital Twin City” and other cutting-edge concepts are moving from concept to practice [3]. This change puts forward new and higher requirements on the knowledge structure and core competence of landscape architecture practitioners, and also initiates a direct challenge to the talent cultivation mode of higher education institutions.

“Plant Configuration and Landscape Architecture” is a core course for landscape gardening and related majors, which carries the key tasks of training students to master plant ecological habits, understand the aesthetic value of plants, and create a plant landscape space that integrates science and art. However, for a long time, the traditional teaching mode of this course has had significant limitations. The teaching process is highly dependent on two-dimensional media such as floor plans and elevation drawings, making it difficult for students to establish an intuitive and accurate three-dimensional spatial perception; for the “fourth dimension” dynamic aesthetics of plant communities that change with the seasons and time, it is even more so to rely on limited photographs and imaginations, and the expression and understanding of the course are both insufficient; at the same time, the content of the teaching is often disconnected from the real and complex environmental data of the site. At the same time, the teaching content is often disconnected from the real, complex environmental data of the site, resulting in a lack of scientific and local nature of the students’ design programs. These “pain points” have led to the “gap” between the teaching output and the industry’s cutting-edge needs, and the reform of the course teaching is imperative [4].

In the face of such a dilemma, academics at home and abroad have paid attention to it. Some scholars have taken the lead in exploring the application of single digital technology in teaching. Some studies have explored the use of VR technology to enhance students’ sense of spatial experience, or the application of BIM for plant information management. Some scholars have introduced the potential of parametric design software in assisting the generation of complex plant communities [5–8]. These studies have provided valuable insights into curriculum reform and verified the effectiveness of digital technology interventions. However, most of the existing research focuses on the introduction of specific tools or single-point applications. It lacks a systematic pedagogical methodology that organically integrates multiple technologies and deeply integrates them with teaching concepts, content, and process evaluation [9,10]. How to fundamentally change the teaching paradigm and establish a complete set of digital teaching frameworks oriented to the cultivation of students’ comprehensive core literacy has become an urgent research issue.

Based on this, this study aims to face the challenges of traditional teaching and the opportunities of the digital era, taking the course of Plant Configuration and Landscaping as a specific object, and systematically exploring the reform path of teaching methods under digital technology. The study will endeavor to construct a comprehensive teaching reform framework integrating “concept updating, content reconstruction, method innovation, and evaluation diversity,” and verify its effectiveness through practical cases. It is expected that this study can provide valuable theoretical references and feasible practical solutions for the curriculum reform of landscape architecture under the background of the new era, to more effectively cultivate composite landscape architecture talents with cutting-edge vision, innovative thinking, and solid digital skills.

2. Analysis of the current situation and dilemma of teaching traditional plant configuration and landscape architecture courses

2.1. Overview of digital technology types and their application in the field of landscape architecture

The application of digital technologies in the field of contemporary landscape gardening is becoming more and more widespread, providing unprecedented tools and possibilities for the design, performance, analysis, and management of plant configuration and aquascape. At the pedagogical level, these technologies are gradually penetrating all aspects of the curriculum and include the following main types:

(1) Computer-aided design (CAD) and building information modelling (BIM) technology

CAD technology, as the cornerstone of landscape planning and design, has been popularized in the plan drawing, statistics, and drawing output of plant configuration schemes. Its advantages include improved drawing efficiency and accuracy, and ease of modification and archiving [11]. With the development of the industry, BIM technology, with its parametric, visualization, and information integration features, is gradually applied to the field of landscape architecture. In the teaching of plant configuration and landscaping, BIM technology can achieve the model association of plant species, specifications, quantities, growth habits and other information, support the whole life cycle management from design to construction and maintenance, and help students to carry out more accurate simulation and analysis of plant communities in a three-dimensional environment [12].

(2) 3D modelling and rendering techniques

Three-dimensional modelling software and professional renderers have become the mainstream tools for the expression of plant configuration and landscaping schemes. They can transform a plane design into a highly realistic three-dimensional landscape scene, clearly displaying the morphology, color, texture, and spatial composition of plants, which greatly enhances students' understanding and expression of the design scheme [13]. Teaching by simulating the plant landscape in different seasons and light conditions helps students feel more intuitively the artistic effect and ecological function of plant configuration.

(3) Virtual Reality (VR) and Augmented Reality (AR) technology

VR technology can create a fully immersive virtual environment, allowing learners to feel as if they were in a designed plant landscape, roaming and interacting in the field [14], while AR technology can superimpose virtual plant models onto the real environment, helping students to instantly preview the effects of different plant configurations in the field [15]. These two technologies provide an immersive teaching experience that breaks through the limitations of traditional two-dimensional drawings for plant configuration and landscaping courses, especially in the pre-programmer speculation and post-effect evaluation stages, which significantly improves students' spatial perception ability and design decision-making efficiency.

(4) Geographic Information System (GIS) and Remote Sensing (RS) technology

GIS and RS technologies have been widely used in landscape planning, but they also show great potential in the micro level of plant configuration and landscaping. GIS can be used to analyze environmental factors such as climate, soil, hydrology, and other factors of the site, to assist students in the selection of suitable plants and the construction of communities [16]. Remote sensing data, on the other hand, can provide large-scale vegetation cover information to help students understand the regional ecological context [17]. In teaching, combining GIS to analyze the site in multiple dimensions can guide students to make plant configuration more scientific from the perspective of ecology.

(5) Professional plant database and intelligent analysis software

Various online plant databases provide a wealth of information on plant morphology, habit, ecological function, etc., which is an important reference for students to make plant selection. Some intelligent analysis software, such as algorithm-based plant growth simulation software or landscape assessment tools, has also begun to be applied in teaching. Although it is still in the preliminary stage, it is a sign that the future plant configuration will tend to be more data-driven and intelligent optimization.

2.2. Research on the teaching status of plant configuration and layout courses

Currently, the teaching mode of the plant configuration and landscape architecture course is in the transition period from traditional to digital transformation.

(1) Overview of existing teaching modes and methods

The traditional teaching of plant configuration and landscape architecture mainly relies on theoretical lectures, drawing, hand-drawn performance, and on-site cognitive internship. Teachers explain plant knowledge and design principles through PPT, while students express their design intentions through hand-drawn sketches and ink line drawings. Some institutions will organize field trips to botanical gardens or nurseries for students to enhance their perceptual understanding. This model emphasizes basic drawing skills and intuitive feeling of plant forms, but its limitations are: firstly, it is difficult to fully present complex 3D spatial effects and seasonal changes in 2D drawings; secondly, it lacks real-time interactions and the convenience of iterative solutions; and thirdly, the practical opportunities are limited, and it is difficult for students to repeatedly try and revise their designs in real-life scenarios [18].

(2) Teachers' knowledge and application of digital technology

The research shows that most teachers of landscape architecture have recognized the importance of digital technology and have tried to integrate it into their teaching. The application of CAD and 3D modelling software is more common and has almost become a standard part of teaching. However, there are still differences in the mastery and application of cutting-edge technologies such as VR/AR and GIS, and some teachers' use of these technologies in teaching still remains at a rudimentary stage due to a lack of systematic training or practical experience [19]. In addition, teachers' input and ability in the development of digital teaching resources need to be improved.

2.3. Students' acceptance of digital teaching and learning and the effect of feedback

Generally speaking, students showed a high level of interest and motivation in digital teaching and learning. They believe that digital tools can significantly improve design efficiency and enhance the visualization of solutions, enabling better understanding and expression of design intent. In particular, 3D visualization techniques were considered to have greatly compensated for the lack of spatial understanding of traditional 2D drawings. However, some students also reflect that in the absence of systematic guidance, over-reliance on software may lead to the neglect of plant ontology knowledge and design aesthetics principles, and even the tendency of "designing for software" [20]. At the same time, the difference in the proficiency of software operation skills may also affect the learning experience and outcomes of some students.

3. Advantages and challenges of applying digital technology to teaching and learning

3.1. Analysis of advantages

Digital technology shows significant advantages in plant configuration and aquascape teaching:

(1) Improve design efficiency and accuracy: software automation function reduces repetitive labor, and parametric design, and BIM model can ensure the consistency and accuracy of design data.

(2) Enhance visualization and expressiveness: 3D modeling and rendering technology can present design

solutions as realistic 3D images, and VR/AR technology provides immersive experiences to help students intuitively feel the spatial effects, changes in light and shadow, and seasonal transitions.

(3) Simulate the real scene and interactivity: The virtual simulation environment allows students to make repeated refinements and modifications to the plan at "zero cost", and even simulate the growth process of plants, which enhances the interactivity and practicability of learning.

(4) Stimulate interest in learning and innovative thinking: The fun and intuitive nature of digital tools can stimulate students' enthusiasm for learning and encourage them to explore more diversified ways of design expression and innovative solutions.

(5) Promote collaboration and information sharing: Many digital platforms support multi-person online collaboration, which enables students to work together in teams to complete design projects and realize rapid sharing of knowledge and information.

3.2. Analysis of challenges

Despite the obvious advantages, digital technology also faces many challenges in teaching and learning:

(1) Software operation skill requirements: Teachers and students need to invest a lot of time and energy to learn and master all kinds of professional software; popularization of skills and the speed of updating an important challenges.

(2) High cost of equipment investment: computer hardware, software license fees, and maintenance costs for running high-performance design software and VR/AR equipment are high, which puts pressure on the school's teaching funds.

(3) Enhancement of teachers' professionalism: Teachers not only need to have professional knowledge of gardening, but also need to be skilled in the use of digital tools and integrate them organically into the design of teaching, which requires teachers to continuously learn and update their knowledge and skills.

(4) Insufficient construction of teaching resources: There is a relative lack of high-quality, systematic teaching resources such as a digital plant model library, case library, virtual simulation scenes, etc., and the workload of updating and maintenance is large.

(5) Risk of over-reliance on technology: Some students may over-rely on software and neglect the cultivation of basic botanical knowledge, aesthetic principles, and hand-drawing ability, resulting in a lack of depth and connotation in design.

(6) Lagging teaching evaluation system: The existing teaching evaluation system may not adequately reflect the improvement of students' digital design ability, collaboration ability, and innovative thinking, and needs to be further improved.

In summary, the application of digital technology in the teaching of plant configuration and aquascape courses has taken shape and shown great potential, but still faces multiple challenges in terms of comprehensive promotion and deep integration, which provides room for further exploration and optimization in this study.

4. Theoretical foundations for reforming teaching methods in plant arrangement and landscape design courses under digital technology

The application and reform of digital technology in plant arrangement and landscape design course teaching are not merely about introducing technical tools but are deeply rooted in the foundational theories of modern education. These theories provide a scientific basis for understanding how digital tools can enhance learning and optimize teaching processes, guiding the innovation and implementation of teaching models. This section will primarily discuss the guiding significance of constructivist learning theory, collaborative learning theory, project-based learning (PBL) theory, and cognitive load theory in digital teaching reforms.

4.1. Constructivist Learning Theory

(1) Theoretical core and educational implications: Constructivist learning theory emphasizes that learners are active constructors of knowledge rather than passive recipients of information. The learning process is one in which learners actively construct meaning based on their own experiences, through interaction with the environment, processing, and organizing information. Its core principles include: the individuality and contextuality of knowledge, the social interactivity of learning, and the emphasis on learner-centered instructional design.

(2) Implications for teaching plant arrangement and landscape design courses: In traditional teaching, teachers unilaterally transmit plant knowledge and design principles, while students passively receive information, making it difficult to achieve a deep understanding. Constructivism advocates creating real or realistic scenarios to encourage students to construct their understanding of plants, space, and aesthetics through practical operations and exploration.

(3) Support for constructivist learning through digital technology: Scenario creation and immersive experiences: Virtual reality (VR) and augmented reality (AR) technologies can create highly realistic virtual plant landscape scenes or overlay virtual plant models onto real sites, immersing students in the design context. Students can freely explore the virtual environment, observe the effects of plant combinations from different perspectives, and experience changes in light and shadow, thereby intuitively assessing the merits of design proposals and actively constructing spatial cognition.

(4) Hands-on operation and exploration: Professional plant configuration and landscape design software allows students to quickly draw, modify, and iterate design schemes. Students can immediately see the effects of design modifications, compare and optimize multiple schemes, and deepen their understanding of plant characteristics, community configuration principles, and aesthetic rules through trial and error. This highly operational and interactive learning process aligns with the constructivist emphasis on active learner participation and exploration.

(5) Personalized learning and immediate feedback: Digital platforms can record students' learning paths and design processes, providing personalized learning resource recommendations. Additionally, certain intelligent analysis tools or simulation software can conduct preliminary evaluations of students' plant configuration schemes, providing immediate feedback to help students identify and correct issues promptly, thereby promoting spiral-shaped knowledge advancement.

4.2. Collaborative Learning Theory

(1) Theoretical core and educational implications: Collaborative learning theory emphasizes that learning is a social activity achieved through interaction, communication, and cooperation among learners to solve problems, share knowledge, and achieve common learning objectives. It posits that individuals in a group environment can more effectively construct knowledge and develop higher-order thinking skills through observing others, sharing perspectives, debating, and mutual evaluation. In plant arrangement and landscaping courses, design is often the result of team collaboration. Traditional collaboration is constrained by physical space and time, resulting in low efficiency. Collaborative learning theory

suggests that we should encourage students to divide tasks, learn from one another, and collectively complete complex design tasks.

(2) Online collaboration platforms: Cloud-based design software and project management tools enable student teams to share, modify, annotate, and manage versions of design files across time and space. Members can discuss and refine design proposals synchronously or asynchronously, enhancing collaboration efficiency.

(3) Shared Design Environments: Virtual design studios or shared model environments allow team members to operate simultaneously on the same 3D model, collaboratively refining plant layout details to achieve ‘what you see is what you get’ collaboration. This approach effectively avoids issues such as drawing handoffs and information delays common in traditional design processes.

(4) Real-time communication and feedback: Digital communication tools such as video conferencing, online discussion forums, and instant messaging enable student teams to engage in efficient communication and problem discussions anytime, anywhere. Teachers can also intervene in real time to provide guidance and feedback, promoting peer evaluation and mutual progress among students.

(5) Resource sharing and knowledge construction: The digital platform facilitates the sharing of collected plant data, case analyses, design standards, and other resources among student teams, enabling them to jointly build a project knowledge base and foster the formation of collective wisdom.

4.3. Project-Based Learning (PBL) Theory

(1) Theoretical core and teaching implications: Project-Based Learning (PBL) is a student-centered teaching method that involves learning knowledge and skills through solving real-world problems. It introduces complex real-world problems into the classroom, where students, under the guidance of teachers, solve problems through independent exploration, collaborative discussion, critical thinking, and reflection. PBL emphasizes the authenticity, inquiry-based nature, integration, and outcome-oriented approach of learning. In plant configuration and landscape design courses, the PBL model can effectively bridge the gap between theory and practice, guiding students to apply their knowledge to specific site design tasks.

(2) Simulation and presentation of real-world problem scenarios: Digital tools such as GIS data, drone aerial imagery, and 3D point cloud data provide detailed site information, helping students fully understand the project context and environmental constraints to construct highly realistic ‘problem’ scenarios. Virtual reality technology allows students to immerse themselves in the ‘site,’ deepening their understanding of the problem.

(3) Support for design tools and solutions: Digital design software (CAD, BIM, 3D modelling) is the core tool for students to solve plant configuration and landscape design problems. These tools are not only used for expressing design concepts but, more importantly, assist students in analyzing, optimizing, and iterating their designs. For example, by simulating factors such as lighting, wind direction, and plant growth cycles, students can quantitatively evaluate the advantages and disadvantages of different configuration schemes.

(4) Learning process management and presentation of results: Digital project management platforms can help students plan project schedules, assign tasks, and track progress. Students can present and report on their completed projects in multimedia formats, providing a more intuitive and comprehensive presentation of their design concepts and problem-solving processes.

(5) Data-driven decision-making and reflection: Digital tools can assist students in collecting and analyzing plant data and site data, supporting data-driven design decisions. After the project is completed, students can use digital tools to simulate and evaluate the design scheme and combine actual feedback for reflection, forming a complete learning loop.

4.4. Cognitive Load Theory

(1) Theoretical core and educational implications: Cognitive load theory focuses on the burden placed on a learner's working memory when processing information. It categorizes cognitive load into intrinsic cognitive load, extrinsic cognitive load, and related cognitive load. The theory advocates optimizing instructional design to reduce unnecessary external cognitive load, thereby effectively managing total cognitive load, improving learning efficiency, and promoting the generation of related cognitive load. In plant arrangement and landscaping courses, the abundance of plant forms, characteristics, arrangement rules, and complex three-dimensional spatial relationships can easily lead to excessive cognitive load for learners.

(2) Optimization of cognitive load through digital technology: Visualization and intuitiveness: 3D modelling and rendering technologies can concretize abstract plant configuration concepts and spatial relationships, reducing the external cognitive load on students caused by complex spatial transformations based on two-dimensional drawings. Students can directly observe the combination effects of plant height, crown spread, texture, and color in three-dimensional space.

(3) Modularity and interactivity: Digital teaching materials can break down complex knowledge points into smaller modules and guide students through interactive interfaces to learn step by step, avoiding information overload. For example, an interactive plant database can filter by attributes, reducing the burden of information retrieval for students.

(4) Optimizing internal cognitive load: Multi-sensory presentation: VR/AR technology combines visual and spatial perception with multi-sensory information, helping students to understand the complexity of plant configuration more comprehensively and deeply, and effectively linking new knowledge with existing schemas.

(5) Case library and templates: A digital case library provides a wealth of successful cases, allowing students to modify and learn from them, thereby reducing the internal cognitive load of starting from scratch.

(6) Promoting relevant cognitive load:

Operational learning: The practical operations required by digital design software prompt students to actively think, experiment, and revise, fostering relevant cognitive load and deepening their understanding of knowledge and schema construction.

Problem-driven: Real-world project problems presented through digital tools motivate students to actively analyze, synthesize, and apply knowledge to solve problems, transforming internal cognitive load into a more valuable thinking process.

5. Reform pathways and practices for teaching methods in plant arrangement and landscape design courses under digital technology

Digital technology has provided unprecedented opportunities for teaching reform in plant arrangement and landscape design courses. The reform pathways should focus on multiple dimensions, including the reconstruction of teaching objectives, innovation in teaching models, improvements in teaching strategies and methods, the development of teaching resources, and reforms in teaching evaluation. The aim is to cultivate students' ability to comprehensively utilize digital tools for landscape design, enhance their innovative thinking, and improve their practical skills.

(1) Reconstruction of teaching objectives and content: Teaching reforms driven by digital technology first require a thorough reconstruction of course teaching objectives and content to align with the new demands of industry development and technological progress in talent cultivation.

(2) Updating course teaching objectives with digital technology: Traditional teaching objectives have focused on hand-drawn representation and plant identification. After reform, core objectives should include mastering digital design software operation skills, data-driven design analysis capabilities, virtual visualization expression capabilities, and BIM-based collaborative design capabilities. For example, students should not only learn to draw floor plans but also be able to express the spatial relationships and seasonal changes of plant communities through three-dimensional models.

(3) Introducing digital design standards and norms: Course content should incorporate the latest industry digital design standards and norms, such as landscape BIM standards and plant information model (PIM) construction norms. Students should be taught how to use digital tools for standardized drafting, information coding, and model construction to ensure their outputs meet industry requirements and lay the foundation for future career development.

(4) Expanding teaching content to cover digital design processes and methods: Teaching content should expand from traditional design steps to the entire digital design process, including GIS-based site data acquisition and analysis, 3D modelling and information integration, parametric plant configuration, environmental simulation analysis, virtual reality interactive assessment, and digital construction drawing output and information transmission. Introducing cutting-edge concepts such as ecological simulation and smart maintenance systems enhances students' understanding of future developments in the landscape architecture industry.

6. Innovation in teaching modes

Digital technology has given rise to diverse teaching models, breaking the boundaries of traditional classrooms and achieving flexibility and efficiency in the teaching process.

6.1. Hybrid teaching model based on digital platforms (Online and Offline Integration)

This model combines online and offline learning. The online component can be delivered through high-quality video lectures on plant knowledge, software operation tutorials, expert interviews, etc., which are posted on the Learning Management System (LMS) platform for students to learn independently. Additionally, online quizzes and discussion forums can be used for knowledge reinforcement and Q&A sessions. The offline component focuses on practical exercises, group discussions, design guidance, and project presentations, with teachers acting as facilitators and mentors in the classroom. This model ensures systematic learning of foundational knowledge while providing ample time for practical guidance.

6.2. Immersive teaching combining virtual simulation and real scenes

VR/AR technology can be used to create an immersive learning environment. For example, students can wear VR headsets to 'roam' in a virtual botanical garden, learn about the morphological characteristics and configuration effects of different plants, or repeatedly try different plant configuration schemes in a virtual space. AR technology can overlay virtual plant models in real-time onto real campus landscapes or site photographs, helping students visually assess design outcomes. This teaching model overcomes the issues of lengthy timelines, high costs, and difficulty in modifying real plant configuration experiments, significantly enhancing the visual appeal and engagement of learning.

6.3. Digital-Assisted PBL (Project-Based Learning) teaching

Transform plant configuration and landscape design courses into a series of real or semi-real design projects. Students work in groups to use digital tools to complete the entire process from site analysis, scheme conception, detailed design, to final presentation. For example, when designing a themed plant zone for a city park, students need to use GIS to analyze the site's microclimate, simulate plant growth effects using 3D software, and render the results. Teachers provide guidance and support throughout the process rather than directly lecturing, guiding students to master knowledge and skills through problem-solving.

6.4. Interdisciplinary collaboration and design competition model

Encourage students to collaborate with students from other disciplines, such as architecture, planning, and civil engineering, through digital platforms on interdisciplinary projects, such as a comprehensive design project involving architecture, landscape, and municipal utilities. Through online collaboration platforms, students can understand information exchange and design coordination across disciplines. Additionally, organize plant configuration and landscape design competitions based on digital submissions and reviews to incentivize students to apply digital tools for innovative design, enhancing their comprehensive design capabilities and teamwork spirit.

7. Teaching strategies and method improvements

7.1. Application of digital tools in preliminary analysis and site understanding

(1) GIS Data Analysis: Teach students to use GIS software to obtain and analyze data on topography, climate, soil, hydrology, and vegetation conditions, generating contour maps, slope analysis maps, and line-of-sight analysis maps to provide a scientific basis for plant configuration.

(2) Drone Surveying and 3D Modelling: Utilize drones to obtain high-precision imagery of the site, and use photogrammetry software to generate 3D point cloud models and real-world 3D models, providing students with accurate representations of the actual site environment.

(3) Existing Vegetation Survey and Data Entry: Guide students to use tablets or mobile apps for on-site plant surveys, instantly entering plant information and uploading photos to create a digital archive of on-site data.

7.2. Application of digital modelling and visualization in scheme expression

(1) Parametric Plant Modelling: Introduce parametric design tools to teach students how to define plant morphology, growth patterns, and community distribution through algorithms, enabling rapid scheme generation and iteration.

(2) High-Precision Rendering and Animation Walkthroughs: Teach students to use professional rendering software to create realistic plant renderings and demonstrate the spatial experience of design schemes under different seasons and lighting conditions through animation walkthroughs.

(3) Ecological Simulation and Analysis: Utilizing simulation software to conduct preliminary assessments

of the ecological benefits of plant configuration schemes, such as simulating the regulatory effects of plants on temperature and humidity, and their impact on biodiversity.

7.3. Practical application of virtual tours and interactive experiences in scheme evaluation

(1) VR Design Review: Students can import design models into a VR platform and invite teachers and classmates to take a virtual tour, providing an intuitive assessment and real-time discussion of the visual transparency, spatial enclosure, and changing scenery effects of plant configurations from an internal perspective.

(2) AR On-Site Preview: Using AR devices or mobile apps, students can overlay virtual plant models in real-time at the actual site to intuitively experience the integration of the design scheme with the real environment and make timely adjustments.

7.4. Plant intelligent recommendation and configuration optimization based on big data

(1) Intelligent Database Application: Teach students to use professional plant databases to intelligently screen and recommend suitable plants based on site environmental parameters, design styles, and functional requirements.

(2) Algorithm-Assisted Optimization: Explore the introduction of plant configuration tools based on optimization algorithms to assist students in generating more optimized plant configuration schemes under multiple constraints, such as using genetic algorithms to optimize the ecological or cost-benefit efficiency of plants.

7.5. Digital archive management and portfolio presentation

(1) Cloud-Based Project Management: Encourage students to use cloud storage and version control systems to efficiently manage design files and materials, facilitating team collaboration and teacher feedback.

(2) Online portfolio creation: Guide students to use online portfolio platforms to showcase their digital design works, enhancing their professional competence and employment competitiveness.

8. Teaching resource development

8.1. Establish a digital plant material library and case study database

Develop a professional database containing high-precision 3D plant models, plant texture maps, digital plant encyclopedias, and outstanding domestic and international plant configuration and landscaping case studies. These resources should be easy to search, update, and share.

8.2. Developing interactive teaching software and simulation platforms

Invest in the development or procurement of interactive software tailored to the characteristics of plant arrangement and landscaping education. Examples include plant growth simulators, AI-based plant identification and recommendation systems, or virtual simulation platforms specifically designed for plant community simulation and assessment.

8.3. Produce high-quality instructional videos and online courses

Record a series of software operation tutorials, design case analyses, expert lecture videos, etc., and integrate them into a systematic online course to enable students to learn and review anytime and anywhere, compensating for the limitations of classroom time.

8.4. Reform of instructional evaluation

Instructional evaluation should be synchronized with instructional method reforms, shifting from a results-oriented approach to a balanced emphasis on both process and results, and fully leveraging digital tools.

8.5. Introduction of Digital Evaluation Tools and Standards

Develop evaluation standards tailored to digital teaching characteristics, such as precision of digital models, information completeness, data support for design proposals, artistic and accurate visualization, and standardization of design processes. Software can be used to automatically check model compliance, or assignments can be submitted and graded via online platforms.

8.6. Focus on process-based and multi-dimensional evaluation.

Quantitatively assess the learning process by monitoring students' learning duration on digital platforms, software operation logs, project version iteration records, and participation in online discussions. Additionally, combine end-of-term presentation reviews, virtual tours, expert evaluations, and peer reviews to comprehensively assess students' knowledge mastery, skill application, innovative capabilities, and teamwork skills.

8.7. Enhancing students' self-evaluation and peer evaluation capabilities

Utilize online collaboration platforms and review systems to encourage students to engage in self-reflection and evaluation after completing their designs. Additionally, organize students to use digital tools to conduct anonymous or named peer evaluations of their classmates' work, fostering critical thinking and aesthetic abilities while cultivating a positive learning community atmosphere.

9. Guarantee measures for the reform of plant arrangement and landscape design courses under digital technology

The reform of plant arrangement and landscape design courses under digital technology is a systematic project. Its successful implementation and sustained development rely on comprehensive guarantee measures. These measures encompass teacher development, optimization of software and hardware environments, as well as teaching management and institutional safeguards, collectively providing a solid foundation for the advancement of the reform.

9.1. Teacher development

Teachers are the core driving force behind teaching reform. The effective implementation of digital teaching first requires teachers to possess the necessary digital literacy and teaching capabilities.

9.2. Digital skills training and development for teachers

(1) Systematic Professional Software Training: Regularly organize systematic and progressive training for teachers on software used in plant configuration and landscape design courses, including CAD/BIM software, 3D modelling and rendering software, GIS software, and VR/AR development tools. Training

content should cover basic software operations, advanced application techniques, parametric design principles, and the latest industry trends.

(2) Digital Teaching Methodology Workshops: Conduct specialized workshops on topics such as 'Integrating Digital Tools into Teaching Design,' 'Hybrid Teaching Practices,' and 'Virtual Simulation Teaching Case Analyses' to enhance teachers' ability to deeply integrate technology with teaching methodologies, rather than merely focusing on tool usage.

(3) Encourage teachers to obtain professional certifications: Encourage and support teachers to obtain international certifications for relevant software (e.g., Autodesk certifications) or participate in professional training within the industry to ensure their technical capabilities remain aligned with industry advancements.

9.3. Establish a multidisciplinary teaching team

(1) Internal collaboration and experience sharing: Encourage teachers with digital specializations within the landscape architecture program to establish collaborative mechanisms with experienced traditional teaching faculty. Through mentorship and guidance, they can jointly explore digital teaching pathways and share teaching experiences and resources.

(2) Cross-College Collaboration: Actively collaborate with teachers from colleges such as Computer Science, Information Technology, and Art Design to leverage their expertise in programming, interaction design, data analysis, etc., to jointly develop digital teaching modules or undertake related teaching tasks, forming a multidisciplinary teaching team.

9.4. Encourage teachers to participate in relevant research projects

(1) Research feeding back into teaching: Encourage teachers to actively apply for and participate in national, provincial, and university-level research projects related to digital technology in the fields of landscape architecture, smart cities, and digital education. Through research practice, teachers can gain a deep understanding of cutting-edge digital technologies and incorporate the latest research findings and industry application cases into teaching content, achieving 'research-driven teaching and mutual growth of teaching and research.'

(2) Industry-academia-research collaboration: Encourage faculty members to collaborate with landscape design institutes, technology companies, and other enterprises to bring real-world projects into the classroom, enabling students to apply digital technologies to solve problems in authentic contexts and draw teaching materials from enterprise practices.

10. Teaching software and hardware environment construction

10.1. Purchase of high-performance computers and professional software

(1) Configuration of high-performance workstations: In response to the high requirements of landscape design software for graphics processing capabilities and memory, purchase computer workstations equipped with independent graphics cards, large memory, and high-performance processors to ensure that students can smoothly run complex modelling, rendering, and simulation tasks.

(2) Procurement and maintenance of licensed professional software: Purchase and promptly update mainstream licensed landscape design software and related plugins. Establish a comprehensive software maintenance and update mechanism to ensure the stable operation and full functionality of the

software.

(3) Cloud-based software services: Explore collaborations with software vendors to utilise their cloud-based software services or virtual desktop infrastructure (VDI) to reduce local hardware pressure and enhance software accessibility and flexibility.

10.2. Construction of virtual simulation laboratories and smart classrooms

(1) Virtual reality (VR)/augmented reality (AR) laboratories: Construct immersive laboratories equipped with VR headsets, AR devices, motion capture systems, and other hardware to provide students with experiential learning environments such as virtual tours, immersive scheme reviews, and virtual plant recognition.

(2) Smart Classroom Renovation: Renovate ordinary classrooms into smart classrooms equipped with interactive whiteboards, high-resolution projectors, multimedia touchscreens, and wireless screen-sharing systems to support blended learning, group discussions, and digital presentation of learning outcomes.

(3) Green Computing and Energy Conservation: Incorporate green computing principles into hardware configuration and laboratory design, select energy-efficient equipment, and create a low-carbon, environmentally friendly teaching environment.

10.3. Improve campus network and cloud computing platform

(1) High-Speed, Stable Campus Network: Build a high-speed, stable wired and wireless network covering the entire campus to ensure smooth data transmission for faculty and students during online learning, file sharing, cloud rendering, and other digital activities.

(2) Establish or lease a cloud computing platform: Establish a university-level or professionally leased cloud computing platform to provide faculty and students with services such as cloud storage, cloud rendering, and high-performance computing, addressing needs that local devices cannot meet, such as storing large design files or performing complex simulation calculations, thereby enhancing teaching efficiency and research capabilities.

(3) Data Security and Privacy Protection: Establish a comprehensive data management and security system to ensure the security of faculty and students' design data, learning records, and other information, while complying with relevant laws and regulations.

11. Teaching management and institutional guarantees

11.1. Formulate management standards related to digital teaching

(1) Revision of course outlines: Timely revise course outlines and teaching plans to clarify the objectives, content, methods, and evaluation standards of digital teaching.

(2) Standards for the construction of digital teaching resources: Establish standards for the construction of digital teaching resources, quality requirements, copyright management, and update and maintenance mechanisms.

(3) Digital Teaching Ethics and Standards: Guide faculty and students to use digital tools appropriately, prevent plagiarism and data misuse, and emphasize design originality and academic integrity.

11.2. Establish a teaching achievement incentive mechanism

(1) Establish Special Awards: Create awards such as the 'Digital Teaching Innovation Award' and 'Outstanding Digital Course Award' to recognize and reward faculty and teams that have made significant contributions and achieved notable results in digital teaching reforms.

(2) Incorporate into title evaluation and performance appraisal: Use teachers' achievements in digital teaching investment, teaching resource development, and teaching effectiveness improvement as important criteria for title evaluation, position promotion, and performance appraisal to stimulate teachers' intrinsic motivation to participate in reforms.

(3) Funding support: Establish a special fund for digital teaching reforms to support teacher training, software and hardware procurement, teaching resource development, etc., ensuring the smooth implementation of reforms.

11.3. Strengthen university-industry collaboration and introduce industry resources

(1) Co-build practical bases and laboratories: Collaborate with renowned landscape design companies, software firms, nursery bases, etc., to establish digital practical teaching bases or joint laboratories, providing students with authentic internship environments and project training opportunities.

(2) Invite industry experts to participate in teaching: Invite senior digital design experts, project managers, etc., from the industry to serve as part-time teachers, visiting professors, or deliver specialized lectures, introducing cutting-edge industry technologies, the latest design concepts, and practical experience into the classroom to bridge the gap between school teaching and industry demands.

(3) Jointly developing courses and textbooks with industry partners: Collaborate with industry partners to develop digital plant arrangement and landscaping courses and case-based textbooks that align with industry needs, ensuring the practicality and cutting-edge nature of the curriculum.

(4) Providing internship and employment opportunities: Establish a regularized talent recruitment mechanism with industry partners to offer students more internship and employment opportunities that leverage digital skills, thereby enhancing the competitiveness of graduates.

12. Conclusion

12.1. Key research findings

This study delves into the application of digital technology in reforming teaching methods for plant arrangement and landscape design courses, systematically analyzing its impact on and opportunities for traditional teaching models, and proposing specific reform pathways and practical solutions. The research indicates that digital technology is not merely an auxiliary tool but a key driver for reshaping teaching philosophies, innovating teaching models, and enhancing teaching effectiveness.

Digital technologies provide unprecedented visualization and interactivity capabilities for plant arrangement and landscape design education. The application of technologies such as CAD/BIM, 3D modelling and rendering, VR/AR, GIS, and professional plant databases can concretize abstract design concepts, simulate real-world scenarios, and significantly enhance students' intuitive understanding and perception of plant spatial composition, ecological adaptability, and aesthetic effects, effectively addressing the limitations of traditional two-dimensional drawings.

Digital technology supports the innovation of student-centered, practice-oriented teaching models. Hybrid teaching, immersive teaching that combines virtual simulation with real-world scenarios, and project-based learning (PBL) supported by digital tools effectively stimulate students' interest and initiative in learning. Through collaborative learning platforms, students can better engage in teamwork and knowledge sharing, cultivating their ability to solve complex design problems.

Digital teaching reforms help optimize cognitive load. By leveraging the intuitive presentation and interactive operations of digital tools, unnecessary external cognitive load can be reduced, allowing students to focus more on core knowledge related to plant configuration and landscape design, as well as the construction of design thinking, thereby enhancing learning efficiency.

Successful digital teaching reforms require comprehensive support. Enhancing the digital literacy of the teaching staff, establishing high-performance software and hardware environments, and implementing scientific teaching management and institutional safeguards are key to ensuring the smooth implementation and sustainable development of reforms. Among these, the transformation of teachers' concepts and the enhancement of their skills are particularly important.

12.2. Shortcomings

Although this study has conducted a relatively comprehensive exploration of teaching reforms in plant arrangement and landscape design under digital technology, certain limitations still exist.

(1) Sample limitations of the study: This study primarily relies on theoretical analysis and the summarization of existing cases, lacking large-scale, multi-school participatory empirical data support. Quantitative assessments of the effectiveness of digital teaching reforms require further strengthening.

(2) Depth and breadth of technological application: The depth and breadth of digital technology application in plant arrangement and landscape design education remain limited in practice. Some cutting-edge technologies (such as the deep application of artificial intelligence and big data in plant arrangement) have not yet been widely adopted in educational practice, and this study has limited practical case accumulation.

(3) Improvement of the educational evaluation system: How to establish a comprehensive, scientific, effective, and fully reflective evaluation system that captures the characteristics of digital education remains a challenge requiring ongoing exploration and refinement.

12.3. Research outlook

Based on the above conclusions and shortcomings, this study proposes the following outlook for the future development of plant configuration and landscape design course teaching under digital technology:

(1) Deeply explore the application of artificial intelligence (AI) in plant configuration and landscape design teaching: Future research can focus on AI-assisted design, intelligent plant recognition, and big data-based intelligent plant recommendation systems, exploring how AI can further optimize the generation, evaluation, and learning process of plant configuration schemes to achieve personalized and intelligent teaching.

(2) Establish an interdisciplinary, integrated teaching system: With the widespread adoption of BIM and CIM (City Information Modelling), landscape design will increasingly emphasize collaboration with architecture, planning, and municipal engineering disciplines. Future teaching reforms should strengthen the integration of interdisciplinary courses and collaborative projects to cultivate students' comprehensive design and coordination skills in complex systems.

(3) Strengthening the quantitative assessment and feedback mechanisms for digital teaching effectiveness:

Conducting larger-scale empirical research, using big data analysis to examine students' learning behaviors, design process data, and outcomes, and establishing more scientific evaluation models to provide data support for the continuous improvement of teaching methods.

(4) Promote the development of open-source, shared digital teaching resources: Encourage institutions and organizations to jointly establish high-quality, open-access digital plant model libraries, case study repositories, and virtual teaching platforms to reduce the cost of developing teaching resources and facilitate the dissemination and sharing of knowledge.

(5) Deepening the integration of virtual and real-world teaching practices: In addition to virtual simulation, greater emphasis should be placed on combining digital tools with real-world field investigations and experiments. For example, mobile AR devices can be used for on-site plant identification and real-time simulation of design schemes, truly achieving deep integration between online and offline learning to cultivate students' practical skills and ability to solve real-world problems.

(6) Digital technology offers vast potential for reforming teaching in plant configuration and landscape design courses. We believe that under the joint impetus of theoretical guidance and practical exploration, future landscape education will become more intelligent, personalized, and efficient, cultivating more innovative landscape professionals who meet the needs of the times and contribute to the construction of a beautiful China.

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