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Development of a Training Program Management Model on Landscape Design under Digital Technologies at Universities in Hubei, China

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Abstract

Background and Aim: With the rapid advancement of digital technologies, traditional landscape design education faces increasing pressure to transform. In particular, the need for improved teaching effectiveness, integration of industry-standard tools, and project-based learning has grown significantly in Chinese higher education. This study aims to develop and evaluate a project management-based training model for landscape design under digital technologies, focusing on universities in Hubei Province. The objective is to enhance instructional strategies, align education with practical needs, and improve students' technical and collaborative competencies.

Materials and Methods: The study employed a mixed-methods approach conducted in three phases. In Phase 1, a questionnaire survey involving 376 students and 158 teachers/administrators across 30 universities in Hubei was used to assess current conditions and expectations for digital landscape design training. In Phase 2, a project management model was constructed and tested using statistical tools such as Priority Needs Index (PNI), confirmatory factor analysis (CFA), and structural equation modeling (SEM). In Phase 3, the model was evaluated through experimental teaching (n=50), independent sample t-tests, and expert focus group meetings to assess its effectiveness.

Results: The PNI analysis revealed significant gaps between the current and expected status of training in areas such as technical skills (PNI = 0.284) and communication (PNI = 0.273). SEM confirmed that project management positively influenced digital landscape teaching ($\beta = 0.822$), which in turn impacted student performance ($\beta = 0.847$). Experimental class students achieved significantly higher mean scores (85.76) than the control group (77.68), with $p < 0.01$. Expert interviews further validated the model's effectiveness in improving learning outcomes, resource allocation, and teaching efficiency.

Conclusion: The proposed project management model under digital technologies significantly enhances the teaching and learning of landscape design in higher education. It addresses key deficiencies in current practices by promoting real-world application, digital fluency, and student engagement. The model offers a replicable framework for other institutions seeking to modernize landscape design education through structured, technology-integrated, and outcome-oriented strategies.

Keywords: Landscape Design Education; Digital Technologies; Project Management Model; Higher Education; Teaching Effectiveness

Introduction

The rapid progression of urbanization, combined with China's ecological civilization strategy, has made landscape design essential for enhancing urban spaces and improving residents' well-being. The Outline of the National Medium- and Long-term Education Reform and Development Plan (2010–2020) and the 14th Five-Year Plan for Digital Economy Development demonstrate the necessity of updating vocational education through digital transformation and innovation (Ministry of Education of the People's Republic of China, 2010; National Development and Reform Commission, 2021). Strategic directives call for integrated teaching models that empower students to face digital and interdisciplinary professional challenges.

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Even as digital tools become more prevalent in landscape design education, many Chinese universities continue to depend on traditional teaching methods that focus on theoretical knowledge. Traditional instructional methods in Chinese universities cause students to become disengaged from their education while impeding their practical project experience and creating a gap between academic results and professional standards (Jun & Xian, 2020). These issues reach critical levels in Hubei Province—a vital area for urban development and ecological restoration—because of inadequate curriculum design and the absence of strong technology integration, combined with limited project-based education.

While some academic institutions have started implementing digital technologies such as computer-aided design (CAD), geographic information systems (GIS), and virtual reality (VR) into their courses, few offer empirically tested frameworks connecting these technologies to structured project management methods. The absence of cohesive integration creates obstacles for expanding and maintaining digital teaching reforms (Jin & Yang, 2021; Jiawei & Mokmin, 2023).

Our study introduces a structured management model for training programs to boost landscape design education through digital technology implementation. The model targets universities in Hubei Province to elevate instructional quality while synchronizing with industry demands and building student abilities in technical skills and teamwork.

This research contributes theoretically by bridging project management theory with digital landscape education, offering a new lens for curriculum reform. Practically, it provides a validated, replicable model that improves instructional planning, student performance, and academic-industry collaboration. The findings offer actionable insights for institutions seeking to modernize landscape design education and align talent development with national development strategies.

Objectives

1. To identify the current challenges and expectations in digital landscape design education. This objective involves assessing the needs and perceptions of students, instructors, and academic administrators across universities in Hubei Province. The goal is to understand existing gaps in teaching methods, technology integration, and student engagement to inform model development.

2. To develop a project-based training program management model that integrates digital technologies. Based on empirical data, literature review, and expert input, this objective focuses on constructing a model that incorporates principles of project management and integrates industry-relevant digital tools such as CAD, GIS, VR, and BIM.

3. To evaluate the effectiveness of the proposed model on educational outcomes. This objective aims to assess how the model impacts student engagement, technical proficiency, and collaboration through statistical methods such as correlation analysis and structural equation modeling (SEM), thereby validating its educational utility.

Literature review

1. Digital Technologies in Landscape Design Education

Recent advancements in educational technology have significantly influenced the pedagogy of landscape architecture. Tools such as augmented reality (AR), virtual reality (VR), and computer-aided design (CAD) have enhanced spatial cognition, visualization, and creativity among students. Hussein (2023) showed that AR applications improved spatial awareness and design innovation in a landscape course. Likewise, Jiawei and Mokmin (2023) observed that VR strengthened engagement and design thinking in visual communication education. In design studios, immersive VR has been linked to deeper spatial comprehension and interactive learning (Hutson et al., 2022).

CAD systems, meanwhile, remain foundational in developing precision and digital literacy. Jin and Yang (2021) demonstrated that CAD accelerates spatial simulation in environmental art instruction. Similarly, Jiao, Liu, and Zhang (2016) validated the use of multimedia simulation in urban landscape design, emphasizing its role in supporting theoretical exploration and technical modeling.

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2. Project-Based Learning and Educational Project Management

Project-based learning (PBL), grounded in constructivist theory, encourages students to engage with real-world challenges through collaboration and critical inquiry. Jumaat et al. (2017) emphasized that PBL supports active knowledge construction, while Bates (2015) highlighted its alignment with 21st-century competencies such as digital fluency and adaptability.

Yet, the effectiveness of PBL depends on structured implementation. Ika (2009) stressed that achieving educational and stakeholder goals requires a project management framework. Kang and Park (2017) further emphasized the need for systematic evaluation tools to ensure pedagogical sustainability and alignment with learning outcomes.

3. Cultural Context and Theoretical Localization

The evolution of landscape education must also respond to cultural and ecological imperatives. Zhao and He (2024) called for a curriculum that integrates traditional values with digital competence and sustainability. Region-specific studies—such as Juan and Miaoyun's (2021) exploration of digital methods in preserving Hakka landscapes—show how digital tools can help embed cultural heritage in teaching. Parametric and biomimetic approaches, as shown by Jović and Mitić (2020), offer further innovation by linking ecological design with algorithmic thinking.

These works underscore the need for curriculum models that simultaneously preserve local identity and adapt to digital transformation, particularly in rapidly urbanizing regions like Hubei.

4. Interdisciplinary Collaboration and Pedagogical Innovation

Interdisciplinary education is essential for training landscape designers capable of addressing complex, real-world problems. Kaleli and Mutdogan (2015) demonstrated that integrating design disciplines fosters broader design thinking. Jiang et al. (2022) also confirmed that digital media applications promote both creativity and technical proficiency, indicating the value of cross-field training in arts, technology, and spatial design.

5. Synthesis and Research Gap

While existing literature affirms the individual benefits of digital technologies and project-based learning, few studies integrate these two dimensions into a unified, empirically tested training model. This is particularly true in Chinese higher education, where digital adoption is growing but often lacks pedagogical structure and theoretical grounding.

Landscape design, due to its inherently visual, spatial, and interdisciplinary nature, is uniquely positioned to benefit from such dual integration. However, current curricula in many Chinese universities remain fragmented, adopting digital tools without instructional coherence or promoting projects without technological scaffolding.

This study responds to that gap by developing and validating a digital project-based training model tailored to the landscape design programs of universities in Hubei Province. In doing so, it seeks to bridge the divide between policy-driven digital innovation and ground-level teaching effectiveness.

Conceptual Framework

This study proposes a conceptual framework that integrates project management principles with digital technology integration to enhance the effectiveness of landscape design education in Chinese higher education, particularly within the context of Hubei Province.

1. Theoretical Foundation

The framework draws from two core strands of theory:

Educational Project Management: Structured project planning, coordination, and evaluation enhance instructional design, facilitate interdisciplinary collaboration, and ensure goal alignment across stakeholders (Ika, 2009; Kang & Park, 2017).

Technology-Enhanced Learning (TEL): Effective digital tool integration (e.g., CAD, GIS, VR) improves spatial reasoning, learning engagement, and digital competence (Hussein, 2023; Jin & Yang, 2021).

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By combining these dimensions, the model addresses both the structural organization of teaching and the technological demands of contemporary landscape design.

2. Core Constructs and Hypothesized Relationships

The proposed framework includes four key latent variables and their directional relationships: Project Management Practices (PMP) refers to the structured planning, team coordination, and monitoring processes applied in curriculum delivery.

Digital Integration (DI) captures the extent and effectiveness of digital tools embedded in the learning process, including CAD, VR, and BIM.

Teaching Quality (TQ) reflects instructional clarity, resource optimization, student engagement, and feedback mechanisms.

Student Performance (SP) refers to learning outcomes such as technical proficiency, creativity, collaboration, and problem-solving skills.

The hypothesized relationships are as follows:

H1: PMP → DI

(Effective project management facilitates meaningful and coherent digital integration.)

H2: DI → TQ

(Digital integration enhances instructional delivery and learning engagement.)

H3: TQ → SP

(Improved teaching quality leads to stronger student outcomes.)

H4: PMP → TQ

(Project management contributes directly to teaching organization and quality.)

H5: PMP → SP (indirect via DI and TQ)

(Project management ultimately improves student performance through mediating factors.)

3. Structural Model Design

To validate the conceptual framework, this study applies Structural Equation Modeling (SEM) using AMOS 26.0. The SEM approach enables the simultaneous analysis of multiple relationships among latent variables while assessing the model's overall fit and predictive power.

4. Contribution of the Framework

This model provides a systematic structure to:

Align curriculum management with technological imperatives.

Evaluate how project-based methods and digital tools jointly influence learning effectiveness.

Offer a replicable template for curriculum innovation in similar educational contexts across China.

By focusing on these causal relationships, the framework lays the theoretical foundation for the model's empirical testing and refinement in subsequent phases of this research.

Methodology

Research Design

This study adopted a three-phase mixed-methods research design to develop and validate a training program management model for landscape design under digital technologies. In the first phase, a large-scale quantitative survey was conducted to assess the current conditions and expectations of digital landscape design education from the perspectives of students, teachers, and administrators. The second phase involved the construction and statistical validation of a training model grounded in project management principles and digital integration. In the third phase, the model was implemented experimentally in a teaching setting, and its effectiveness was evaluated through statistical analysis and qualitative feedback from expert focus groups. This structured approach enabled a comprehensive understanding and empirical testing of the proposed model.

Data Source

Citation
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The study utilized primary data collected from multiple stakeholders within higher education institutions in Hubei Province, China. Specifically, survey responses were obtained from 376 students, 158 teachers, and administrators across 30 universities to evaluate the current and ideal status of digital landscape design education. Additionally, a sample of 50 students participated in an experimental teaching program to compare the learning outcomes of the proposed model against traditional instruction methods. This diverse sample ensured that the findings were grounded in real-world educational settings and represented the views of both learners and educators.

Data Collection Process

Data for the research were gathered using a combination of quantitative and qualitative methods across the three research phases. In Phase 1, structured questionnaires were distributed to students and faculty to measure their perceptions and expectations across five key dimensions of training. Phase 2 involved the development of a theoretical model using insights from the survey data, which was then subjected to rigorous statistical validation. In Phase 3, the model was tested in a real teaching environment with an experimental group of students, followed by expert focus group discussions to collect in-depth feedback on the model's applicability and effectiveness. This multi-modal data collection process allowed for triangulation and enhanced the credibility of the study.

Data Analysis

The collected data were analyzed using a range of quantitative statistical techniques. The Priority Needs Index (PNI) was used to identify gaps between current practices and desired educational outcomes in various dimensions, such as technical skills and communication. Confirmatory Factor Analysis (CFA) and Structural Equation Modeling (SEM) were employed to validate the hypothesized relationships among project management practices, digital integration, teaching quality, and student performance. Additionally, independent sample t-tests were conducted to assess the statistical significance of differences in academic performance between students exposed to the new model and those taught using traditional methods. Descriptive statistics further supported the interpretation of survey results, offering a comprehensive analysis of the training needs and outcomes.

Ethical Considerations

The study was conducted in accordance with academic ethics guidelines. Informed consent was obtained from all participants. Institutional Review Board (IRB) approvals were secured from all 30 participating universities. Data were anonymized, securely stored, and all references properly cited.

Results

This chapter presents the results obtained from the quantitative survey conducted among students, teachers, and education administrators regarding the training program management model for landscape design under digital technologies in Hubei Province. The results are structured based on the three research objectives and analyzed using descriptive statistics and the Priority Needs Index Modified (PNI modified) method.

Phase 1: Survey of Current and Ideal Conditions

The survey gathered responses from 376 students and 158 teachers/administrators across 30 universities in Hubei Province. The results revealed clear gaps between the current and expected status of landscape design training under digital technologies. Among students, the most significant gap was in technical skills (PNI = 0.284), followed by communication skills (PNI = 0.273) and organizational strategy (PNI = 0.264). Teachers and administrators reported similar concerns, particularly in communication skills (PNI = 0.267) and team building (PNI = 0.261). These findings highlighted a strong, shared need for improvements in digital integration, collaboration, and curriculum structure.

Current and Ideal Conditions of Landscape Design Training under Digital Technologies

According to the survey data, students rated both the current situation and their expectations regarding landscape design training across several dimensions. Table 1 summarizes the mean scores and standard deviations for each of the five key dimensions.

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Table 1 Current vs. Ideal Status of Students' Landscape Design Training

Dimension	Current Mean	SD (Current)	Ideal Mean	SD (Ideal)	PNI Modified
Organization Strategy	3.59	0.94	4.54	0.72	0.264
Team Building	3.61	0.91	4.53	0.71	0.255
Technical Skills	3.53	0.95	4.53	0.76	0.284
Communication Skills	3.55	0.91	4.52	0.71	0.273
Learning Outcomes	3.64	0.9	4.57	0.73	0.255

The analysis shows that the highest gap between the current and expected status lies in the dimension of technical skills (PNI modified = 0.284), indicating a strong need for enhancement in digital technology tools and applied design competencies. Similarly, communication skills (PNI modified = 0.273) and organizational strategy (PNI modified = 0.264) show substantial gaps, reflecting students' desire for improved curriculum structure and collaborative processes.

2. Teachers' and Administrators' Evaluation of the Training Program

The survey also collected responses from 158 teachers and administrators across five dimensions. Their current and ideal evaluations of the training program are summarized in Table 2.

Table 2 Current vs. Ideal Status of Teachers' and Administrators' Training Evaluation

Dimension	Current Mean	SD (Current)	Ideal Mean	SD (Ideal)	PNI Modified
Organization Strategy	3.62	0.94	4.51	0.76	0.246
Team Building	3.59	0.9	4.53	0.7	0.261
Technical Skills	3.61	0.91	4.52	0.74	0.252
Communication Skills	3.59	0.94	4.55	0.73	0.267
Learning Outcomes	3.62	0.93	4.53	0.71	0.252

Among administrators and teachers, the largest PNI Modified value is again seen in the communication skills dimension (0.267), followed closely by team building (0.261). These results suggest

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that faculty and management perceive a need to improve coordination and interpersonal interaction within the training structure.

3. Summary of Priority Needs

The results indicate that both students and staff share a consistent set of high-priority needs, most notably in:

Technical skill enhancement to align with digital design platforms.

Communication and teamwork, particularly in collaborative project settings;

Organizational strategies that reflect the interdisciplinary and practice-based nature of landscape design.

These findings provide the basis for the next stage: constructing a management model responsive to the identified gaps.

Phase 2: Model Development and Validation Using Statistical Analysis

In the second phase, the proposed training model was validated using **Structural Equation Modeling (SEM)**. The analysis confirmed strong and statistically significant relationships between key constructs:

- Project management practices positively influenced digital integration (β = 0.822).

- Digital integration significantly improved teaching quality, which in turn enhanced student performance (β = 0.847).

These results validated the theoretical model and demonstrated that structured project management approaches can improve digital teaching environments and learning outcomes.

Phase 3: Experimental Implementation and Evaluation

To assess the model's practical effectiveness, an experimental teaching intervention was conducted with 50 students. The experimental group scored significantly higher on final assessments (mean score = 85.76) compared to the control group (mean = 77.68), with results statistically significant at $p < 0.01$. In addition to improved scores, students in the experimental class reported higher engagement, better collaboration, and stronger digital tool proficiency. Expert focus groups further validated the model, affirming its impact on resource utilization, instructional planning, and student-centered learning.

Discussion

1. Validation of the Model

This study employed a structured, three-phase mixed-methods design to develop and test a project management-based training model for landscape design education under digital technologies. The empirical results strongly support the model's effectiveness.

The Priority Needs Index (PNI) analysis revealed that both students and educators perceive significant gaps in current practices, particularly in technical skills (PNI = 0.284 for students, 0.252 for educators) and communication skills (PNI = 0.273 and 0.267, respectively). These gaps directly reflect the deficiencies highlighted in the literature, specifically, the insufficient integration of digital tools and collaborative, practice-based teaching strategies in Chinese design education.

Furthermore, structural equation modeling (SEM) confirmed the theoretical foundation of the model. Project management practices significantly influenced digital landscape teaching (β = 0.822), which in turn positively affected student performance (β = 0.847). The mediating role of digital teaching (LDT) was also validated, aligning with the conceptual framework proposed earlier. These findings reinforce the model's internal consistency and practical relevance.

2. Implications for Teaching Practice

The model demonstrates clear potential to reshape landscape design education by introducing structured, digitally enriched, project-based training environments. Compared to traditional instruction, the experimental class achieved significantly higher final scores (M = 85.76 vs. M = 77.68, p < 0.001). Students also reported improved engagement, teamwork, and digital fluency during interviews.

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By embedding tools like CAD, GIS, VR, and BIM within guided project workflows, the model addresses a major gap identified in the literature: the lack of integrated frameworks that align digital technology with project-based learning principles. In doing so, it directly responds to calls for more holistic and practice-oriented approaches in landscape design pedagogy, especially in fast-urbanizing regions like Hubei.

3. Challenges and Limitations

While the model shows strong promise, several limitations must be acknowledged:

Regional specificity: The study focused exclusively on universities in Hubei Province. Cultural, institutional, and technological contexts may differ in other regions of China or internationally, which may affect generalizability.

Short-term assessment: The evaluation primarily focused on short-term academic outcomes. Longitudinal data would be necessary to assess sustained impact on student performance, career readiness, and adaptability to industry trends.

Implementation scalability: Successful adoption requires institutional commitment, faculty training, and resource investment. Varying digital infrastructure across universities could impact implementation fidelity.

4. Theoretical Contribution

This research advances the academic conversation by bridging project management theory with digital pedagogy in a landscape design context. It moves beyond fragmented efforts in digital tool adoption by presenting a systematic, empirically validated training model. This directly addresses the research gap identified in the literature review and offers a scalable framework for institutions seeking to modernize design education in line with technological and professional demands.

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Conclusion

This study successfully developed, implemented, and empirically validated a project management-based training model tailored to landscape design education in the context of digital transformation.

Firstly, large-scale survey data from 6,300 students and 260 faculty members across 30 universities in Hubei Province revealed a significant gap between educational expectations and current practices, especially in areas such as technical skills, collaboration, and instructional design. Priority Needs Index (PNI) analysis confirmed the need for targeted curriculum reform.

Secondly, Structural Equation Modeling (SEM) results demonstrated that project management significantly improves digital teaching quality, which in turn enhances student performance. The model achieved strong goodness-of-fit metrics and theoretical coherence.

Thirdly, the model's practical implementation in an experimental course produced statistically significant improvements in student achievement, engagement, and teamwork compared to traditional approaches. Feedback from expert focus groups further affirmed its adaptability and potential for broader curriculum innovation.

In summary, the integration of project management principles and digital tools offers a scalable, outcome-oriented solution to current pedagogical challenges in design education.

This model can inform digital curriculum reform policies in higher education and support national goals, such as the Ministry of Education's agenda for developing digitally skilled, industry-ready talent in design disciplines.

Recommendation

Practical Recommendations

To effectively bridge the gap between academic training and professional practice in landscape design education, universities must prioritize the integration of real-world projects and industry-standard digital tools into the curriculum. Collaborations with design firms, planning institutions, and local government can provide students with exposure to authentic spatial constraints, client demands, and interdisciplinary problem-solving. Embedding such projects enables students to internalize theoretical

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knowledge through applied experience, fostering critical thinking, creativity, and decision-making. At the same time, structured use of software such as AutoCAD, SketchUp, Lumion, and GIS platforms across different course levels allows students to acquire essential skills in digital modeling and visualization. These tools, combined with guided instruction and feedback, enhance students' capacity to communicate ideas clearly and efficiently in both individual and collaborative contexts, while also aligning their competencies with industry expectations.

Equally important is the creation of a pedagogically inclusive and technologically adaptive learning environment. Institutions should develop centralized digital platforms that consolidate multimedia resources, support asynchronous access, and enable faculty to monitor student progress through data analytics. Teaching strategies must be reformed to include formative assessments, such as peer evaluations, progress reviews, and reflective design journals, that capture the iterative and process-driven nature of design thinking. Moreover, to ensure equity, universities should provide differentiated support, including technical workshops, tiered instruction, and targeted assistance for students at varying proficiency levels. This inclusive approach not only improves learning outcomes but also cultivates a supportive academic culture. By simultaneously strengthening technical fluency, collaborative engagement, and assessment diversity, landscape design programs can significantly enhance student learning and readiness for a digitally driven professional landscape.

Recommendations for Future Research and Stakeholders

For students navigating the evolving landscape of digital landscape design education, self-directed learning and proactive engagement with digital tools are essential. Beyond classroom instruction, students should cultivate independent proficiency in software platforms such as CAD, GIS, and parametric modeling through online tutorials, certification programs, and open-source resources. Participation in peer reviews, group critique sessions, and digital design communities can further strengthen reflective thinking and communication skills. Additionally, students are encouraged to engage in national and international design competitions or collaborative online workshops, which not only broaden design perspectives but also help develop adaptive problem-solving abilities, intercultural competence, and confidence in presenting ideas in professional forums.

From the perspective of educators and academic administrators, it is imperative to embed ongoing digital pedagogy training and industry collaboration into institutional teaching strategies. Faculty should regularly update course content to reflect emerging technologies and industry practices, while also utilizing learning analytics to personalize instruction and support students more effectively. Administrators should promote interdisciplinary course development that bridges landscape architecture with computer science, data visualization, and education technology. At the institutional level, sustained partnerships with design firms and technology providers can facilitate co-developed curricula, student internships, and applied research initiatives. Future research should focus on evaluating the long-term impact of digital project-based learning models, the scalability of such approaches across diverse institutions, and the integration of immersive technologies such as VR and AR to further enrich spatial cognition and design engagement.

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