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Construction and Practice of Blended Online-Offline Courses Based on Smart Technologies: Using the Course "Digital Technology and Architectural Design" as A Case Study

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Abstract: Based on multiple rounds of course development and teaching reforms, the teaching team has updated the teaching content related to digital technology. In response to teaching needs, we have improved the MOOC course resources and refined offline teaching methods to achieve better blended online-offline teaching outcomes. Smart technologies have been adopted to build a smart course, with the completion of knowledge graphs, competency graphs, and problem graphs, all of which have been applied in teaching practice. Through the assistance of teaching agents in instruction, we have observed that students' learning interest has increased, knowledge acquisition speed has improved, technical skill mastery has become significantly better, and overall teaching effectiveness has seen remarkable enhancement.

Keywords: Smart course; AI-assisted teaching; Course reform; AIGC

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1. Introduction

Under the wave of digitalization, architectural design concepts and practices have undergone significant transformations [1]. Digital technology has evolved from a mere tool-assisted aid into a core force that drives design innovation and optimizes construction processes—from the early shift from manual drafting to CAD drawing, to today's breakthroughs in AI-generated design solutions; each technological iteration reshapes the boundaries of architectural design [2]. In architectural education, digital design instruction serves as the core curriculum of "Architectural Design" [3], providing students with richer avenues for creative design through parametric design and AIGC-based design [4].

2. Course development history and student performance analysis

2.1. Course development history

In alignment with the development and reform of specialized programs, this course has been delivered over ten teaching cycles, spanning three distinct phases:

(1) 2016–2019: To support the ongoing development of Zhejiang Province's emerging specialized programs and the green building concentration, the course primarily focused on BIM (Building Information Modeling) instruction and training. It was designated as a university-level key course project.

(2) 2020–2024: In response to the needs of first-class program development, online teaching resources were introduced to enrich course content—including resources from Shanghai University—and VR technology was incorporated into instruction. The course was subsequently approved as a provincial-level first-class blended (online and offline) course project.

(3) 2024–2026: Against the backdrop of rapid advancements in AIGC technology, the course content has been restructured to emphasize parametric design and AIGC-based design, integrated with the core "Architectural Design" curriculum. Concurrently, online course offerings and smart course features are being developed.

2.2. Key issues in the course and corresponding strategies

Based on the talent cultivation needs of the discipline, the course development has identified the following key issues and explores solutions through mechanisms such as course groups, online courses, and phased process control:

(1) Effective support from CAAD (Computer-Aided Architectural Design) courses for the core architectural design studio sequence. By forming course groups with architectural design and building technology courses, we integrate design studio content with CAAD training to create complex, comprehensive learning environments. This approach replaces the outdated model of mere skill proficiency, raises the complexity and difficulty of training, and cultivates students' comprehensive problem-solving and exploratory abilities, thereby meeting the teaching objective of "high-level, innovative, and challenging" content.

(2) Heavy course content and substantial hands-on practice workload. Parametric design and AIGC design demand extensive practice and involve numerous technical troubleshooting issues during operation [5]. Introducing MOOC-based teaching enables a flipped classroom model, allowing for more efficient allocation of teaching time. Meanwhile, the adoption of knowledge graphs and competency graphs helps students better understand the relationships between complex concepts and connect them to specific operational skills [6,7].

(3) Differentiated synergy between online courses and the main course. The MOOC content can be adapted to various courses within related disciplines. By selectively opening specific online chapters and assessments according to the teaching requirements of each course, we can provide customized SPOC (Small Private Online Course) learning spaces for different programs.

3. Course development objectives

3.1. Cultivating innovative design talents for the era of digital intelligence

Through the development of smart courses, we aim to integrate theoretical learning, practical innovation, and

virtual simulation, creating a new model for cultivating innovative talents in engineering disciplines under the context of digital-intelligent technologies [8]. The plan is to build upon the university's existing architectural education and extend coverage to architecture students across the entire Zhejiang Province.

3.2. Restructuring course content based on the knowledge graph system

In line with the requirements of the new-era construction industry, we will incorporate the latest technological and methodological achievements to revamp course content, enhancing its cutting-edge nature and practicality. Supported by a professional knowledge graph that integrates digital and intelligent design, we will explore a diversified knowledge architecture for the architecture discipline [9]. Guided by a competency graph that maps digital applications to professional skills, we will strengthen the cultivation of comprehensive engineering capabilities in architectural design practice. Anchored by a problem graph that aligns digital technologies with industry transformation needs, we will enhance engineering thinking and literacy through problem exploration and project analysis.

3.3. Creating an AI-driven tripartite teaching model

Based on the triadic relationship among AI teaching assistants, instructors, and students, we will carry out innovations and reforms in teaching models, methods, and evaluation systems. In conjunction with digital platforms and the development of virtual teaching and research offices, we will build a "smart + open," "online + offline" dual-track integrated teaching model to promote intercollegiate teaching collaboration and enhance the cultivation of digital-intelligent talents in architecture across Zhejiang Province. Leveraging AI technology, we will explore personalized learning and practice pathways, as well as resource recommendations for students, developing new methods of digital-intelligent, precise, and personalized teaching that combine online self-learning with offline practical interaction. With the help of AI teaching assistants and other intelligent tools, we will enable instructors to provide more timely and accurate teaching feedback and establish more scientific and objective teaching evaluation methods.

4. Course development content

Based on the smart course framework, the arrangements for content organization, digital resources, knowledge graph design, course content structuring, and teaching chapter design for the "Digital Technology and Architectural Design" course are as follows.

4.1. Course content organization

A tripartite curriculum system of "Fundamental Theory + Practical Application + Innovative Expansion" has been established. The fundamental theory component covers foundational knowledge such as function-based design, automated generation, AIGC (Transformer), LoRA, and related topics. The practical application component strengthens students' applied skills through case studies and project-based practice. The innovative expansion component guides students to engage in AI-based extension and innovation practices, applying the outcomes of course-based practical work to the core architectural design studio courses, thereby cultivating their innovative thinking [10]. Through knowledge graphs and problem graphs, the content is structurally organized and presented, enabling intelligent recommendation of learning pathways and resources. Additionally, the low-rank language models trained by students during the learning process

are transformed into teaching cases, creating a virtuous cycle that enriches the teaching resource pool with student-generated materials.

4.2. Teaching resource development

The course objectives align with the university's positioning and the talent cultivation goals of the program. The teaching content closely integrates AI technology with the development of the architectural design industry, emphasizing the consolidation of theoretical knowledge while focusing on developing students' professional competencies and skills.

The course design aligns with the goal of leveraging information technology to support practical ability development. Online instruction covers fundamental knowledge and operational methods, while offline guided project-based practice reinforces competence cultivation, enabling flipped classroom and blended online-offline extended learning. The online course has been completed with all 25 instructional videos (totaling 260 minutes) and has passed the online review process.

In line with the requirements of the "Four New" (New Engineering, New Medical Sciences, New Agricultural Sciences, New Humanities) construction initiative, the online course includes a question bank of 154 items, 17 discussion topics, and outstanding student practical outcomes are incorporated as teaching cases to enrich the course resources. Furthermore, based on the program's talent cultivation objectives and student performance analysis, the course's knowledge, competency, and problem systems have been deconstructed to build three major "graphs": the knowledge graph defines 5 knowledge modules, 72 knowledge points, 135 knowledge nodes, and their corresponding ideological-political education points; the competency graph specifies 9 competency objectives; and the problem graph constructs a framework of 29 problem structures. A total of 135 teaching resources have been developed, along with 5 external resources, including 73 self-developed and externally sourced videos, 42 PPT resources, and 14 related recent research papers.

4.3. Teaching reform

The course adopts a blended online-offline teaching approach. In response to hardware constraints, we explore a classroom organization model that utilizes group-based remote desktop sessions during offline instruction, employing a "shared computing power + collaborative division of labor" strategy to complete complex comprehensive training tasks. Offline practical sessions are supported by instructor-compiled practice guidance handbooks to help students better master relevant technologies, complete complex practical outputs, and develop comprehensive abilities. The course makes full use of AI technology, featuring an AI teaching assistant that includes modules such as AI Q&A, AI interaction, AI resource discovery, AI question generation, AI learning analytics, and AI agents.

5. Course application and features

5.1. Integration with the architectural design studio course

The course is paired with the concurrent architectural design studio course to form a course group. Through alignment in teaching content, course milestones, and assignments with the corresponding "Architectural Design 4" course, students are able to fulfill the learning objectives of both courses through a single project. The LoRA models trained by students in this course can serve as the model foundation for AIGC-based effect design in architectural design, which not only enhances students' motivation for learning this course but also

significantly improves the teaching outcomes of the architectural design studio. Additionally, it provides a solid foundation for students' subsequent learning and training in the next semester's architectural design course.

5.2. Integration of online learning and offline teaching features

The course is structured to serve the overall objectives of the program's training scheme. The online component primarily covers fundamental knowledge and basic operational methods, while classroom instruction emphasizes the integration of specific technologies and methods with real architectural projects, enabling students to learn digital modeling and representation applications. In-class and after-class exercises reinforce comprehensive training that combines digital design with other design and innovation capabilities. The course places a strong emphasis on integrating various digital design technologies with traditional architectural design, allowing students to intuitively perceive the combined role of digital tools in design and representation, thereby boosting their learning motivation.

5.3. Leveraging smart technologies to highlight teaching features

The AI course assistant in the smart course is employed to enrich teaching resources, provide 24/7 online instruction, and reduce the instructor's workload. Integration with large language models assists instructors in deepening course content and helps students understand knowledge points—especially key and difficult topics. AI-assisted question bank construction reduces the workload of creating test items, while each question can be linked to specific knowledge points with explanations and answer justifications. Learning analytics help instructors monitor each student's learning progress and knowledge mastery, enabling more effective personalized instruction.

6. Conclusion

The course will serve as an innovative model for integrating smart education and architectural design instruction, promoting the reform and upgrade of teaching models for architecture programs at universities in Zhejiang Province. By introducing artificial intelligence technologies and optimizing teaching content and methods, the course aims to enhance students' digital technology competencies and literacy, generating replicable experience in smart teaching that can be widely disseminated.

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