



AI-Oriented Curriculum Reform in Architectural Education at Universities

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Abstract. This paper discusses the potential and application of artificial intelligence technology in the teaching of traditional architectural design courses. By analyzing the overall relationship between artificial intelligence and architectural design teaching and the current situation of teaching practice at home and abroad, this paper proposes a 'three-dimensional integration' teaching model system based on artificial intelligence (knowledge dimension : AI technology + architectural ontology knowledge ; spatial dimension : physical space + digital twin space ; evaluation dimension : traditional assessment + AI-assisted assessment). Through the strategies of AI technology embedding, intelligent knowledge integration and teaching system reconstruction, a "progressive" curriculum reform model is constructed to provide theoretical support and practical reference for the transformation of architectural education in the intelligent era.

Keywords: Artificial intelligence; architectural design; curriculum reform; knowledge fusion; teaching system.

1 Introduction

With the increasing impact of artificial intelligence technology on the construction industry, the extensive application of parametric design tools, generative algorithms, and digital twin technology is reconstructing the core structure of architectural design—from experience-driven 'form and function' to algorithm-driven data creation. From the perspective of industry demand, the demand for compound talents in the fields of intelligent construction and smart cities has surged, and the role of traditional architects needs to be transformed. As the core course of architecture specialty in traditional colleges and universities, the education system of architectural design course is facing unprecedented challenges. Relevant reports show that by 2030, 30 % of jobs in the global construction industry will be at risk of being replaced by artificial intelligence automation, and the talent gap with AI algorithm thinking and design innovation ability will reach 600,000. In this context, the reform of architectural design courses in colleges and universities is not only an inevitable requirement of technological iteration, but also a strategic choice for talent training.

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2 The Relationship Between Artificial Intelligence Technology and Traditional Architectural Design Teaching

2.1 Technology-Driven Interdisciplinary

The impact of artificial intelligence technology on traditional architectural design education can be summarized into three practical paths. These paths promote the transformation of architectural teaching to intelligent and integrated direction by reconstructing knowledge transfer mechanism, teaching method system and subject organization form. The specific implementation path of the core course of architectural design is :

(1) Innovation of design methodology : from " experience inheritance " to " algorithm driven "

Traditional architectural design teaching takes ' form-function ' as the core teaching content, emphasizing the teaching of empirical knowledge such as designer 's hand-painted techniques and spatial perception ability of scale specification ^[4]. AI technology can reconstruct the design method system in the following ways: 1. Under the influence of artificial intelligence technology, the teaching of architectural design courses should break through the traditional manual modeling software rhinoceros or sketchup, introduce more innovative design software such as Rhino and other teaching tools, combined with Grasshopper (GH) plug-in^[6], realize the parametric design of program algorithms, deeply integrate mathematical algorithms with design logic, help students clarify their ideas, build modeling logic and generate models. At present, the Department of Architecture of Tongji University has incorporated parametric design into the compulsory course of grade three, requiring students to realize the adaptive optimization of building skin through GH. 2. Teaching digital transformation, using online platforms (such as smart teaching platform Rain Classroom, Autodesk Fusion 360) to achieve remote collaboration between extracurricular teaching and classroom teaching, and flipping the classroom model to enable students to change from passive acceptance to active exploration. The data show that the innovative traditional teaching mode of student programs in universities (such as Southeast University) using blended teaching has increased by 37 %^[1].

(2) Transformation of knowledge production mode: from " artificial dominance " to "human-machine collaboration "

AI technology promotes fundamental changes in the subject, process and carrier of architectural design classroom teaching: the diversification of teaching subjects: students ' knowledge acquisition no longer depends only on the experience of the teacher team, but through the interaction with the AI model to obtain diversified knowledge. The informatization of construction process: a large number of colleges and universities across the country have built BIM training centers to realize the intelligentization of building information models, integrate the whole chain data of scheme design, construction and project management, and students use BIM data in curriculum design to realize the digital connection from conceptual design to construction drawing generation. Digitization of knowledge carriers: the building knowledge base has shifted from paper textbooks uniformly stipulated by the Ministry of Education to dynamic databases. The development of digital intelligent software can help students automatically

grasp the matching normative provisions and engineering cases in the architectural design course, provide students with real-time query and comparison functions, and improve the efficiency of knowledge acquisition by more than 5 times.

(3) Disciplinary boundary ablation: from "single discipline" to "cross integration"

The emergence of artificial intelligence technology has accelerated the penetration of knowledge between architecture and other disciplines, and promoted the reconstruction of the curriculum system of architectural design in colleges and universities. With the introduction and deepening of the concepts of green building, sustainable building and zero-carbon building, architectural design teaching can no longer focus on the design and specification of architectural schemes. It is necessary to integrate the three disciplines of environmental science (carbon emission calculation), computer science (machine learning) and architecture (space design) to cultivate students' systematic thinking of comprehensive design. For the existing practical teaching links such as site visit practice and training, through the establishment of 'digital twin laboratory', the existing practice platform can be combined with virtual reality to support students to simulate building performance in a virtual environment. At the same time, the real environmental data is collected through the Internet of Things sensor to form a two-way verification mechanism of 'digital simulation-physical verification'. In order to make up for the knowledge shortcomings of traditional college architecture teachers in the fields of algorithm and big data analysis, other colleges or social data engineers can be hired to assist the course teaching in combination with the industry-university-research and "double-teacher" teaching teams.

2.2 Characteristics and Bottlenecks of AI Architectural Design Teaching in China

Currently, the teaching of AI architectural design in domestic colleges and universities presents significant stage characteristics, but there are still deep contradictions at the level of technology landing and the integration of educational concepts.

(1) Tool-oriented features are prominent and technology applications are superficial.

The intervention of artificial intelligence technology in architectural design education is characterized by an obvious "tool substitution". Taking BIM (Building Information Modeling) technology as an example, according to the data, only less than 10% of the courses involve the in-depth application of BIM data in life cycle management, low-carbon design optimization and other scenarios, and the actual application of the software by the design teams of most colleges and universities still remains at the level of software operation.

(2) Heavy reliance on practice platforms and widespread disconnect between reality and reality

Relying on virtual simulation technology to build the digital twin platform greatly improves the design efficiency, students through the VR equipment can quickly complete the component assembly simulation, but also lead to students mistakenly believe that learning the operation of the software can complete the structural design, while the real material properties, construction nodes and other physical construction knowledge mastery is weak.

(3) Highly uneven regional development and unequal distribution of resources

Eastern coastal universities have formed a crushing advantage in the field of AI architectural design teaching by virtue of their financial and location advantages. 2023 Ministry of Education Industry-University Cooperation data show that 67% of the total number of AI architectural design-related projects were approved for universities in Beijing and Shanghai, which means that the head university has already carried out "generative AI urban design" frontier exploration. This means that the head universities have already carried out "generative AI urban design" frontier exploration^[5], but most local universities are still stuck in the basic training of AI tools, especially in the central and western universities, which faces the risk of aggravating the "technology gap".

(4) Faculty structure and lack of interdisciplinary skills

Very few of the existing university faculties are fully equipped with interdisciplinary research capabilities, which is particularly evident in the teaching of parametric design: teachers can often only copy the original parameters of the case base, and are unable to guide students to explore the spatial logic and aesthetic laws behind the algorithms, and to develop their own updated parameters. This phenomenon reflects the dilemma of single-discipline teachers' knowledge reserve.

3 Methods of Architectural Design Course Reform in the Context of Artificial Intelligence

3.1 Hierarchical Construction of Intelligent Teaching System: A Synergistic Mechanism Based on the Double Helix of Technology and Humanities

Artificial intelligence technology promotes the reconstruction of architectural design teaching system in the direction of "three-dimensional integration", forms a three-dimensional teaching framework covering the knowledge dimension, spatial dimension and evaluation dimension, and provides a practical carrier for the balance between technological empowerment and humanistic perseverance.

(1) Knowledge Dimensions: Building a Three-Level Knowledge Map of Technology-Design-ethics

Teaching content needs to break through the traditional disciplinary barriers and establish a progressive knowledge system of "foundation layer - core layer - extension layer": focusing on the underlying logic of AI technology tools, helping students understand the limits of the application of technology tools through the construction of a case library (e.g. The integration of AI and architectural design methodology helps students to complete the whole process of "algorithm deduction - form optimization - performance simulation" in the design class; embedded in the content of technology ethics and social criticism, and through the reflection of "technology neutrality", we cultivate students' ability to judge humanistic values.

(2) Spatial dimension: creating a "symbiosis of reality and reality" in the classroom

The deep integration of physical space and digital space reconfigures the teaching scene: the traditional drafting table design classroom is transformed into an "intelligent design studio" equipped with interactive whiteboards and VR/AR terminals to support

the immersive display and evaluation of design solutions; a "virtual architecture design platform" is built. The "virtual architectural design platform" is set up so that students can conduct VR field research through the cloud and collaborate to solve cross-regional design tasks; the "online MOOC resources + offline workshop" linking mechanism is adopted to allow students to carry out parametric design practice through the teaching of local BIM training room after learning AI architecture courses online.

(3) Dimensions of evaluation: Establish a multi-dimensional "process-competence-ethics" assessment system.

Breaking through the traditional "drawing + model" single evaluation mode, we build a dynamic evaluation system: through the AI learning management system to record students' program iteration trajectory and teamwork data, we quantitatively analyze the degree of students' dual mastery of design knowledge and intelligent technology and their innovation ability in this design task; we adopt the "AI competence radar map" to evaluate students' comprehensive performance in parametric design, algorithmic thinking, ethical judgment and other dimensions. The "AI competence radar map" will be used to assess the comprehensive performance of students in parametric design, algorithmic thinking, ethical judgment and other dimensions in the course design; the "Ethical Review Committee for Technical Solutions" will be set up by the teachers of the subject group in collaboration with multidisciplinary teachers. To assist students in the design process, design proposals involving AI algorithms must pass the compliance review in the dimensions of fairness, territoriality and social environmental impact.

3.2 Hierarchical Embedding Model: Grade-Module-Scene 3D Mapping

In order to solve the compatibility problem between AI technology knowledge and traditional architectural knowledge system, this paper proposes a "3D mapping" hierarchical embedding model, which realizes the organic integration of external disciplinary knowledge and architectural ontology through the 3D synergy of grade gradient, knowledge module and teaching scenario.

(1) Grade Level Gradient: Gradual Penetration from Tool Enlightenment to Thought Reconstruction

According to the law of students' cognitive development, AI-related knowledge is configured in layers by grade:

Lower grades (grades 1-2): Combined with traditional teaching, focusing on tool enlightenment and spatial scale cognition, the traditional first-grade "Preliminary Architectural Design" course is added to the AI basics to build the "AI Basics and Preliminary Architectural Design" course, so that students can establish perceptual cognition of the AI technology tools, initially understand the basic programming and data processing, and complete the basic training of spatial design; second-grade students complete the design of the relaxation bar. When completing the design of a leisure tea bar, second-year students learn to use natural language control AI to generate a spatial intention map for the tea room through AI tools, and understand the correlation between "functional needs and spatial form".

Middle Years (Year 3-4): Focusing on the integration of technology and design innovation, combined with the traditional design courses, in the museum design course,

the teaching of multiple flow relationships, which is the key point, can be embedded in the Grasshopper parametric modelling and Python data linkage, which can be used to analyse the heat map of the base flow, automatically generate the flow layout of the exhibition halls and optimize the spatial efficiency through parameterized adjustment^[3]. In the third-year key design course Mountain Hotel Design, GANs are introduced to generate terrain-adapted building forms, and students learn different mountainous terrain features through a large amount of data and model training AI to generate a mountainous building design scheme that conforms to the geological conditions, which is verified through BIM simulation.

(2) Knowledge Module: From Single Tool to Complex Competency System Building

AI-related knowledge is broken down into modular units that can be spliced together and embedded into the design course system of each architecture class as needed: According to the needs of different grades, programming languages, algorithmic frameworks and data analysis tools are learned and applied in a shallow and deep way as "technical support"; parametric design, generative design, and performance simulation are covered in the 12 course designs for grades 2-4 as "methodological innovation layer"; and parametric design, generative design, and performance simulation are covered in the internships of senior grades." The 12 course designs for grades 2-4 cover parametric design, generative design, performance simulation, etc. as the "methodological innovation layer"; the internship and graduation design for senior years focus on intelligent construction, smart city, heritage protection, and other issues. The internship training and graduation design in the senior year focus on the cutting-edge fields of intelligent construction, smart city, heritage protection, and so on, as the "practice expansion layer".

(3) Teaching scenarios: multidimensional linkage from virtual simulation to physical verification

Strengthen the application of interdisciplinary knowledge in the field by combining virtual and real scenario design: Using the artificial intelligence technology platform to build a digital twin building, students can experience the AI-generated scenarios through the VR training room and test the spatial performance in the virtual environment; through comparison, students can transform the AI-optimized scenarios into scenario design drawings in the BIM training room and produce them through laser cutting, 3D printing and other technologies. Physical models to verify the feasibility of the design; Practicum courses can organize students to participate in real projects such as rural revitalization and transformation of old communities, and use AI tools to conduct demand research, scheme generation and impact prediction.

4 Challenges and Future of Teaching Reform in Artificial Intelligence-enabled Architectural Design Courses

4.1 Challenges and Responses

With the deeper integration of AI technology into architectural design curricula, there are multiple challenges for traditional architectural educators on the front lines of the profession

(1) The paradox of disconnecting technology tools from design thinking

A large number of parametric design tools have been reduced to "form generators" in the course application, but the existing generative AI outputs lack functional rationality, and students are obsessed with the AI effect and ignore the spatial scale; a "Design Intent Justification Report" can be added to the course.

(2) Lack of humanistic and ethical education

Under the teaching orientation of "technology first", humanities and ethics are forced to be marginalized, and most AI architectural design courses do not deal with ethical issues, and there is a lack of reflection on the deeper logic of technological ethics, leading to the formation of "technocentric" cognitive biases among students who will have to face algorithms in the future. Students can regularly organize a debate on the consistency between AI design solutions and regional cultural heritage⁵, and invite anthropologists or non-geneticists to participate in the evaluation.

(3) Lagging nature of the evaluation system

The evaluation system of traditional design courses is unable to quantify the innovation and ethical rationality of AI design, and is prone to "technology-stacked programs" with inflated scores, which ultimately leads to students worshipping AI technology and ignoring the spatial scale and humanistic care of design. In this regard, the "AI Intelligent Evaluation System for Architectural Design" can be developed, which integrates multi-dimensional evaluation indexes and weighted parametric design evaluation to effectively improve the phenomenon of unreasonable evaluation.

4.2 Future Outlook

Integration of Artificial Intelligence and Architectural Education in Colleges and Universities. With the iteration of large models such as GPT-5 and Claude 3, generative AI is on the verge of realizing the automation of the entire process of "concept generation - spatial projection - performance simulation". According to MIT's prediction, by 2030, 80% of the initial concepts of architectural programs will be completed by AI^[7], and the role of designers will be shifted to "intent inputter" and "result arbiter"; the meta-universe platform will reconfigure the teaching scenario, and students will be able to learn through digital twins. The platform will reconfigure the teaching scene, students will simulate the performance of buildings in real time through digital twin technology, and virtual reality meetings will achieve cross-border collaborative design. At present, Tsinghua University's "Meta-universe Architecture Workshop" has already achieved permanent certification of students' virtual identities and design works, opening up a new model of decentralized education^[2].

The iteration of AI technology is transforming architectural education into "lifelong learning", and platforms such as Coursera and Udacity have launched the "AI architect micro-certificate" program, which allows students to obtain certification through micro-courses, project practice and peer review. The "AI architect certification system" of Tongji University in China, in cooperation with Aliyun, has covered 12 countries, marking the convergence of globalization of technical competence evaluation standards. Driven by the dual drive of "localization + internationalization", Chinese universities are exploring AI architectural design courses with regional cultural characteristics, combining generative AI with traditional Chinese architectural construction techniques and gardening methods, and highlighting the cultural subjectivity empowered by technology.

5 Conclusion

Artificial intelligence (AI) technology is reshaping the underlying logic of traditional architecture curriculum design, but over-reliance on AI algorithms can easily lead to students' weak sense of cultural subjectivity and over-reliance on data for design thinking. Therefore, future architecture education should build a dynamic balance between "technology empowerment" and "humanistic perseverance", embed the ethical review mechanism in the curriculum system, compensate for the dilemma of teacher fault lines through the "dual-teacher system", and use the meta-universe platform to realize the reality of the world. Embedding an ethical review mechanism in the curriculum system, compensating for the dilemma of teacher shortage through the "dual-teacher system," and using the meta-universe platform to realize the connection of virtual and real scenes. With the iteration of generative AI and large-scale models, architectural education will enter the era of "lifelong learning", and Chinese colleges and universities must be based on the characteristics of local culture, explore the integration path of "AI+traditional construction", and cultivate architectural design talents with algorithmic thinking and humanistic care. Chinese universities need to explore the integration path of "AI+traditional construction" based on the characteristics of local culture, and cultivate architectural design talents with both algorithmic thinking and humanistic care, so as to promote the discipline to leap from "technology following" to "independent innovation".

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