Exploration and Practice of the Digital Transformation and Upgrading Paths for Civil Engineering Majors

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Abstract: This article examines the pathway to digital transformation and upgrading in undergraduate institutions, using the civil engineering program at Chongqing Three Gorges University as a case study, focusing on six key areas: developing a high-quality digital talent training program for civil engineering; assembling diverse resources to create a digital, multi-scenario open learning environment that encompasses teaching, research, and practical training for civil engineering undergraduates; piloting innovative digital teaching models for civil engineering undergraduates; crafting a new model for digital resource provision, utilizing self-developed and specialized resources; devising assessment methods and ongoing improvement strategies based on the achievement of students' digital competencies; and devising a new, three-dimensional, multi-modal teaching evaluation system through intelligent data capture and analysis.

Keywords: Digital transformation; Civil engineering; Local undergraduate institutions

1. Introduction

In April 2018, China's Ministry of Education unveiled the "Education Informatization 2.0 Action Plan," setting forth objectives and initiatives for the digital transformation of higher education [1]. The plan underscores the advancement of online learning, smart campus development, and the utilization of big data in education. In August 2018, the "Guiding Opinions on Accelerating the Construction of 'Double First-Class' Universities and Colleges" was officially issued [2-4]; in February 2019, "China Education Modernization 2035" was released, calling for an acceleration of educational reforms in the information age, the establishment of intelligent campuses, and the creation of an integrated intelligent platform for teaching, management, and services [5,6].

In March 2022, China's Ministry of Education, along with three other departments, jointly issued the "2022 Work Guidelines for Enhancing Digital Literacy and Skills Across the Population," which aimed to holistically elevate the digital education and teaching standards in schools and foster lifelong digital learning for all [7,8]. In July, the "Summer Teacher Research" initiative was made available online. In November, the Ministry of

Education convened a symposium on digital education, inaugurated the 2022 National Lifelong Learning Week, and organized open courses centered on the digital transformation of lifelong learning. In December, the International Conference on Artificial Intelligence and Education was held virtually, centered on the theme "Guiding AI to Empower Teachers and Lead the Upgrade of Intelligent Teaching." The World MOOC and Online Education Conference was also held virtually, with the theme "Digitalization of Education: Shaping the Future." In February 2023, the World Digital Education Conference addressed pivotal digital education themes, including digital transformation and the future of education, specifically delving into digital education transformation, digital learning, resource development and application, and enhancing the digital literacy of teachers and students. In February 2023, China unveiled the "Overall Layout Plan for Building a Digital China" and founded a new National Data Bureau. The issuance and implementation of these significant digital education strategic guidelines in China have illuminated the trajectory for the advancement of digital education and defined a clear action plan for its future growth.

In recent years, experts and scholars at home and abroad have conducted research on the digital transformation of higher education. This article explores and conducts practical research on the digital transformation and upgrading paths of undergraduate university education.

Scholars [9-11] have pointed out that the digital transformation of higher education refers to the use of digital technology and information means to improve the process and effect of higher education teaching, in order to enhance the quality and efficiency of higher education.

Facing the advent of the digital era, education must adapt to social changes and accelerate transformation. The digitalization of higher education aims to form a new educational ecosystem characterized by data-driven, human-technology integration, and cross-sector openness through comprehensive digital transformation. Currently, digital transformation is driving comprehensive social changes, and digital transformation in the field of higher education is reshaping the modes and paths of educational development, promoting a paradigm shift in education [12,13].

With the rapid development of technology, the informatization, digitalization, intelligence, and ecological transformation of education are profoundly influencing all aspects of teaching, research, management, and education in the industry [6]. However, compared with the rapidly developing digital industry, there is a severe shortage of interdisciplinary talents in civil engineering majors in China's applied undergraduate universities, who possess front-line professional skills, digital technology, management skills, and innovative research capabilities. According to the author's preliminary research and analysis, the main reasons for the above problems are the lack of theoretical research on the digital transformation of civil engineering education, the lack of overall planning and top-level design, and the low level of digital application.

At present, the level of digital application in higher education in China is relatively backward. The application of digital technology in civil engineering majors of undergraduate colleges is still in its infancy. Currently, the teaching used is mostly ordinary multimedia classrooms, advances such as civil engineering computer laboratories, learning online teaching platforms, and virtual reality laboratories are still under construction, while civil engineering virtual simulation laboratories, digital engineering case libraries, and virtual teaching and research offices have not yet been established. It is urgent to improve the construction of a teaching system based on the concept of intelligent civil engineering digital transformation and upgrading, which is led by the concept of conceptual design and engineering thinking training [14].

2. Exploration of the path and practical research content and methods for the digital transformation and upgrading of civil engineering education in undergraduate universities

2.1. Constructing a digital high-quality talent training program

Undergraduate civil engineering institutions have achieved digital transformation in education and teaching. The talent training program should add core courses in computer science, scientific research training, and practical innovation to the traditional curriculum, shifting the way of thinking of the trained talents from industrial thinking to digital thinking. To achieve the digital transformation of civil engineering education, the talent training program can be constructed in four levels, as shown in **Figure 1**. The first level is to systematically construct digital ideological and political courses. The second level is to add core courses such as computer science foundation and programming theory. The third level is to construct scientific research and engineering training. The fourth level is to offer innovative practice courses.
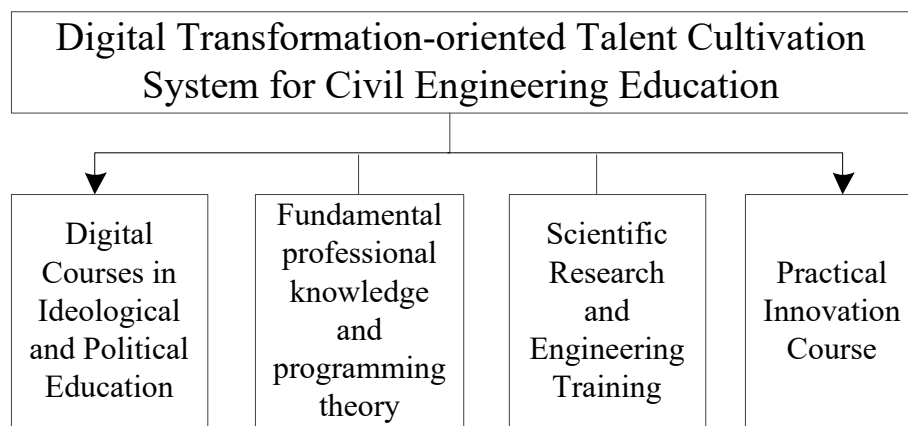
Figure 1. Digital transformation of civil engineering education and talent cultivation

2.2. Gathering various resources to build a digital open multi-scenario educational environment that simulates teaching, research, and engineering training

Gathering various resources and platforms such as the national resource platform, school resource platform, cloud-based integrated smart classroom, intelligent library, engineering construction standardization information network, and the National Center for Education Big Data, we have integrated and constructed a multi-scenario digital new teaching, research, and engineering training environment that is connected, open, shared, perceptible, and analyzable, simulating the civil engineering major in undergraduate universities.

2.3. Constructing a new digital teaching model

According to the outcome-based education concept, we break the boundaries of disciplines, integrate emerging technologies, and build a new digital professional cluster curriculum system. Based on the learning process, we face the complete task, practice step by step, and build a new digital teaching platform, combining the digital twin principle to build a new digital teaching system.

2.4. Constructing a new type of resource supply mode based on digitalization by self-made resources, introducing characteristic resources, and building new types of resources

The construction of digital resources for civil engineering majors in undergraduate universities involves introducing collaborative resources from schools and enterprises, as well as national resource platforms, or

encouraging course teachers to independently develop and entrusting companies or professional multimedia technicians to develop. This promotes the transformation of teaching methods from single classroom teaching to blended teaching, the synchronous construction of paper textbooks and digital teaching resources, the integration of virtual simulation in internship and training teaching, and the application of finite element numerical analysis technology. Through joint construction and sharing, an artificial intelligence-enabled digital teaching resource construction and application ecosystem for online, cloud, and end-to-end courses is created, encompassing self-made resources, introduced resources, collaborative resources from schools, and new resources.

2.5. Research on constructing evaluation methods and continuous improvement strategies based on the achievement of students' digital assets

Constructing research on evaluation methods and continuous improvement strategies based on the achievement of students' digital assets mainly includes four aspects: research on evaluation indicators, design of evaluation tools, construction of digital literacy teaching, and professional digital literacy teacher training.

2.6. Establishing a new three-dimensional multimodal teaching evaluation system through intelligent data collection and analysis

An intelligent data collection and management platform is developed to obtain various data on students' learning, conduct multimodal assessments of students' learning, and implement intelligent evaluations that combine human and technological elements, thereby implementing precision education.

3. Conclusion

Taking the civil engineering program at Chongqing Three Gorges University as an example, and considering the demand for interdisciplinary talents in civil engineering and digital technology among enterprises and institutions in the Chengdu-Chongqing economic circle, we will explore and practice the paths of digital transformation in undergraduate education. We will fully integrate emerging information and computer technologies such as artificial intelligence, and propose a research approach that includes a "digital talent training program + open multi-scenario teaching environment + interdisciplinary digital teaching model + artificial intelligence-enabled resource supply model + student digital asset achievement evaluation method + big data-supported intelligent teaching evaluation system" for the establishment of a digital transformation path for undergraduate education in civil engineering. This approach will help us reconstruct digital talent training programs, teaching and educational environments, digital teaching models, resource supply models, student digital asset achievement evaluation methods, and new teaching evaluation systems based on digitalization. The goal is to form a hierarchical, autonomous teaching system with intelligent, digital, and innovative features. By promoting the digital transformation of undergraduate education and serving the transformation and upgrading of the local civil engineering industry, we aim to contribute to the advancement of digital education in universities.

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(4) Chongqing Three Gorges University First-Class Undergraduate Course "Principles of Steel Structures"

(5) Chongqing Three Gorges University Course Ideological and Political Demonstration Course "Principles of Steel Structures"

(6) Chongqing First-Class Undergraduate Course "Principles of Steel Structures"

Disclosure statement

The authors declare no conflict of interest.

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