Construction of an Integrated and Innovative Practical Teaching System for the Engineering Cost Major under the Background of Green Transformation

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Abstract Against the backdrop of China's accelerated comprehensive green transformation of economic and social development, both traditional industries in the market and traditional disciplines in universities are facing transformation and reform to adapt to the changes of The Times. The deep integration of digitalization, intelligence and greenization has made the empowerment of green transformation by digital technology become the main direction. This study explores the impact of the green economy on the engineering cost industry and discipline, reflects on the deficiencies of the practical teaching system of this major, and proposes reform and development countermeasures for discipline construction and talent cultivation from the perspectives of teaching content reconstruction, teaching mode innovation, and cross-disciplinary integration and development. It is planned to establish an integrated and innovative practical teaching system centered on BIM technology and cost management in the full life cycle, thereby providing experience references for the sustainable development of the engineering cost major and the transformation and construction of related disciplines.

Keywords Green, Practical teaching, Engineering cost, Integration

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In the present era, global exchanges and cooperation among countries and regions in the fields of economy, culture, science and technology, climate governance, etc. are becoming increasingly close. Meanwhile, in order to seize the initiative in the new round of technological revolution and industrial transformation, different countries compete in energy and technology more and more fiercely. In a complex and volatile situation, China has put forward goals in a new journey in the new era ("leading people of all ethnic groups in the country to fully build a modern socialist power and achieve the second centenary goal, and promoting the great rejuvenation of the Chinese nation through Chinese-style modernization"), has adopted the new development concepts of "innovation, coordination, green, openness and sharing", emphasizes the two major directions of industrial transformation ("digital intelligence" and "green development"), and give birth to new quality productive forces covering the entire process of design, production, construction, operation and maintenance of "green materials, clean energy, low-carbon processes, intelligent construction, smart buildings, carbon reduction throughout the life cycle, and an environmentally friendly society" during urban and rural construction and management through deep integration and collaborative evolution.

In the *Opinions of the Central Committee of the Communist Party of China and the State Council on Accelerating the Comprehensive Green Transformation of Economic and Social Development* released in July 2024, it is clearly stated that it is necessary to promote the in-depth integration of digital and intelligent industries with green development, deepen the application of artificial intelligence, big data, cloud computing, industrial Internet and other technologies in the power system, industrial and agricultural production, transportation, construction and operation of buildings and other fields, and achieve the empowerment of green transformation by digital technologies. Meanwhile, it is needed to promote the "cloud adoption, data utilization and intelligence empowerment" of all types of users, and support enterprises in transforming and upgrading traditional industries with digital and intelligent technologies as well as green technologies, promote the construction of green, low-carbon and digital infrastructure, advance renovations of existing facilities in energy conservation and carbon reduction, and gradually phase out "old, small and scattered" facilities[1].

1 Impact of green economy on engineering cost

The green economy, with the development connotations of enhancing efficiency, harmonious coexistence and sustainability, emphasizes green intelligence and low-carbon environmental protection throughout the entire life cycle of "design, materials, manufacturing, packaging, transportation and recycling" in all industries. It is mainly composed of industries such as clean energy, green transportation, green buildings, green agriculture, circular economy and green consumption. With the turbulence and transformation in the real estate industry, green buildings, as an important component of green economy, have led various industries in construction industry to carry out in-depth technological innovation and structural adjustment, moving towards sustainable development, intelligence and diversified integration. The industry perspective of construction industry has also paid attention to construction, management, operation and maintenance in the entire life cycle of buildings instead of merely focusing on the early-stage design and construction.

In the transformation and upgrading of green buildings, it is bound to bring about disruptive changes to the design concepts, evaluation standards, technical processes and management models of buildings and landscapes. On October 1, 2024, the *Assessment Standard for Green Buildings* (GB/T 50378−2019) revised and released by the Ministry of Housing and Urban-Rural Development came into effect, in which the evaluation indicators mainly cover the main parts such as heat insulation and

energy conservation, noise control, air pollution, natural lighting, natural ventilation, all-age design, green operation and maintenance. The revised and newly added content places even greater emphasis on the importance of some indicators such as the application ratio of green building materials, carbon emission intensity throughout their life cycle and carbon reduction technologies, the utilization rate of renewable energy, the proportion of permanent irrigation facilities for greening, rainwater and flood management and surface runoff retention, outdoor light pollution control, the inheritance of regional architectural culture, adaptability to climate and sites, and the utilization of abandoned buildings and sites in terms of sponge cities, clean energy, ecological design and greening management[2]. With the popularization of green buildings by the state, the research hotspots and core technologies in the engineering cost industry should also be updated and adjusted in a timely manner in response to market changes. The intelligent management and visualization application of building information modeling (BIM) throughout the entire life cycle of this major, as well as the comprehensive application of new business forms and technologies in cross-disciplinary fields such as new materials and intelligent construction, ecological restoration and smart gardens, Internet of Things and smart buildings should be used as the transformation connotations, and the corresponding practical operation and application capability should be strengthened.

In terms of disciplinary knowledge system, engineering cost major, as an interdisciplinary applied discipline, aims to cultivate talents who are not only proficient in core engineering technology knowledge of engineering graphics, building structures, engineering measurement and valuation, bidding and tendering, but also familiar with relevant economics and management knowledge of project management, construction regulations, and engineering economics. At present, with the changes in market demand and the transformation of green buildings in the new era, the market's demand for digital technology talents has soared. This has put forward high requirements for the intelligent management technology of engineering cost talents in the entire life cycle of buildings and their ability to integrate and apply knowledge of "ecological friendliness, energy conservation and consumption reduction, greening maintenance, and smart buildings" in disciplines such as landscape architecture, ecology, and the Internet of Things. Mastering the construction of BIM,

the operation ability of smart construction site systems, and a multi-disciplinary knowledge structure has become its core competitiveness[3-4]. Due to the high requirements of green building technology for the ecology, coordination, intelligence and humanization of buildings and their affiliated sites, the energy-saving, consumption-reducing and intelligent standards in all aspects of building design, materials, construction, equipment, management, operation and maintenance are constantly improving. The initial cost of construction will increase significantly, but from the overall perspective of the entire life cycle of buildings and the improvement of the human living environment, the cost advantages and social benefits of their operation and maintenance as well as management will become increasingly prominent.

Therefore, gradually shifting the focus of attention in the early and middle stages of building design and construction to the "entire life cycle" and "all-round ecological environment" is the key to upgrading the disciplinary connotation of engineering cost major. The practical application ability of students majoring in this field should be strengthened based on the concept of green economy by relying on the BIM digital management platform and focusing on the application of various modules of building information modeling, the integration of multiple disciplines, and the full life cycle management. Efforts should be made to promote the discipline and major to keep pace with industrial update and upgrading, and eliminate the mismatch between the talent cultivation of colleges and universities and the demands of social positions, and serve regional high-quality development[5-6].

2 Problems and countermeasures of the current practical teaching system

Presently, the practical teaching system of engineering cost major at the College of Science and Technology of China Three Gorges University mainly includes cognitive internship, course design, project simulation, engineering training, graduation design and other major modules. After the proportion of practical training has been further adjusted, the current number of total class hours is 730, and the total number of credits is 45.625, accounting for 44.95% of the total credits of professional courses. The main forms are on-campus computer operation, on-campus project training and local visits and investigations.

Although the current practical teaching system has formed a relatively complete practical education system covering professional cognition, specialized training, production internship and graduation design, there are still obvious problems that restrict the cultivation of students' ability and the development of disciplines and specialties.

2.1 Practical links are relatively independent

Practical courses such as cognitive internship, course design and engineering training are independent and scattered. Comprehensive training is obviously insufficient. The coherence, integrity and systematicness of knowledge are poor, which is difficult to meet the current market's demand for the ability for full-process cost management and control.

2.2 Practice is disconnected from theory

There is a disconnection between the practical links and theoretical teaching in terms of both content and time. The theoretical knowledge that students acquire in class fails to keep pace with the research hotspots in the industry, and cannot be strengthened and deepened in practice in time. This is not only detrimental to students' understanding, memory and mastery of subject knowledge, but also seriously weakens their enthusiasm for learning.

2.3 It does not match industry demands

The current venues and forms of practical teaching are basically concentrated in on-campus laboratories and short-term internships, lacking systematic operation training of projects. The operation of BIM software is relatively simple, and there is a lack of comprehensive training in the integration of project information and multi-module collaborative management. The industry has tended towards the cost management of construction projects in the full life cycle, while universities still focus on stage skills, and students lack the ability of investment decision-making, operation and maintenance.

2.4 Practical teaching resources are insufficient

The construction and operation of a practical teaching system that is in line with the industry and integrates industry and education require corresponding laboratory space, equipment, software and financial support. The current practical teaching resources are difficult to meet the needs of cultivating modern engineering cost talents.

In response to the existing problems, practical teaching should be reformed in accordance with the requirements of national green transformation and market demands. It is needed to supplement

and improve the practical teaching system, and pay attention to the complementarity and extensibility of the three classroom practical education methods of "classroom, campus and society". Besides, it is necessary to strengthen the connection and integration between practical links and theoretical teaching, optimize the proportion of theoretical teaching and practical teaching, enrich the forms and contents of in-class practice, and pay attention to the correlation between theoretical knowledge points and practical operation application. Meanwhile, it is needed to give close attention to industry dynamics and development trends, promptly adjust the content and methods of practical teaching, promote teaching to keep pace with industry demands and standards in real time, and ensure the advanced nature of practical education. Finally, it is necessary to do a good job in the application and construction of laboratories, strengthen the expansion and maintenance of off-campus practice bases, introduce enterprise experts to participate in teaching and discipline construction, and ensure the quality and effect of practical teaching.

3 Construction of a practical teaching system for engineering cost with the connotation of green transformation
3.1 Reconstruction of teaching content
The update and reconstruction of teaching content is the primary task for colleges and universities to adapt to the changes of The Times, lead the transformation of the industry, and move towards connotative development. At present, the transformation of engineering construction industry under the guidance of the green development concept is in full swing. Energy conservation and consumption reduction, ecological and environmental protection, comfort and high efficiency, which run through the entire life process of buildings (including planning, design, construction, operation and maintenance, and demolition), have become new industry standards. This involves multiple technical fields such as intelligent construction, insulation and enclosure, renewable energy, and smart management. New technologies such as prefabricated buildings, additive manufacturing, recycling and regeneration, sponge cities, and smart buildings have been rapidly popularized and promoted. The reconstruction of practical teaching content in colleges and universities not only requires integrating the cutting-edge technologies of the industry into the theoretical knowledge system

and practical operation links, but also needs to update and transform the connotation of the discipline. It is also necessary to sort out the intrinsic connections among each practical link and build a new type of "progressive, full-cycle, innovative and green" practical teaching system for engineering cost[7].

The proposed restructured practical teaching system of professional courses consists of six major parts: in-class practice, computer simulation, course design, cognitive internship, engineering training, and graduation design. In terms of content, new trends and technologies such as "green buildings, sponge cities, intelligent construction, clean energy, and energy-saving operation and maintenance" have been updated in the theoretical and practical teaching of core professional courses like "Building Architecture", "Project Management", and "Installation Engineering Estimation". Logically, the intrinsic progressive relationship of "cognition–skills–innovation–integration" during practical teaching has been clarified, forming a progressive sequu-ence of "cognitive internship–in-class practice–computer simulation–course design–graduation design–engineering training". In terms of focus, students are guided to pay attention to the control of "buildings in the full life cycle" and the integrated design, operation and maintenance of "buildings–equipment–environment–greening" instead of only focusing on cost control and project management during the construction period of engineering projects, and build a knowledge linkage system centered on BIM technology and platforms. Formally, efforts should be made to break through the limitations of classrooms and campuses, and local authorities and enterprises should be relied on to promote the formation of a new model of industry-education integration featuring "interaction between schools and enterprises and alternating inside and outside the classroom" (Fig.1).
3.2 Innovation of teaching modes
In terms of practical teaching models, the limitations of the unchanging on-campus computer room simulation or classroom drawing have been broken through. The logical sequence and internal connections of each practical link have been rationalized, and the connection with the industry has been strengthened in each link. The cognitive internship and in-class practical activities are interspersed with enterprise visits, technical tours, on-site teaching, expert lectures and other links, and closely connect with the industry to broaden students' horizons and enhance their intuitive perception of new

technologies and new potential. In the on-computer simulation session, BIM is taken as the core, and "green development" is as the connotation to build a practical operation system of "digital modeling + cost management in the full life cycle", break the traditional single teaching mode of "quantity calculation and pricing", and comprehensively integrate design, quantity calculation, pricing, construction, operation and maintenance. During course assessment and graduation design phases, it is needed to regularly hold and participate in school-level and provincial-level cost skills competitions, simulate the actual work of cost estimators (such as time-limited quantity calculation and formulation of bidding quotation strategies), integrate the examination content of the first-level cost engineers into the curriculum, set up a certification guidance module, and adopt more diverse and flexible assessment methods and project sources through the linkage of subject competitions and the orientation of professional qualification examinations to enhance students' interest in learning, practical ability and industry recognition[8].
3.3 Cross–disciplinary integration and development
In today's era, interdisciplinary integration has become a prominent feature of technological iteration and disciplinary development. The energy conservation and consumption reduction throughout the entire life cycle of buildings and the eco-friendly urban renewal advocated by "green buildings, smart cities, and environmental friendliness" have become the main direction and important way for the transformation of construction industry. Construction projects can no longer focus solely on buildings themselves. Ecological resources, building environment, site facilities, green building materials, greenery management and maintenance, regional culture and other elements combine with buildings to form a complete system of green buildings that are interrelated and interact with each other[9-10]. This is precisely what The Times require for the cross-integration of the core knowledge and skills of the two disciplines of engineering cost and landscape architecture. Within the profession, emphasis is placed on integrating the cost management and visual operation of engineering projects in the entire process of "planning and design, project construction, operation and maintenance, renovation and demolition". Externally, it is needed to promote the in-depth integration and co-construction of engineering cost with disciplines and specialties such as landscape architecture, environmental
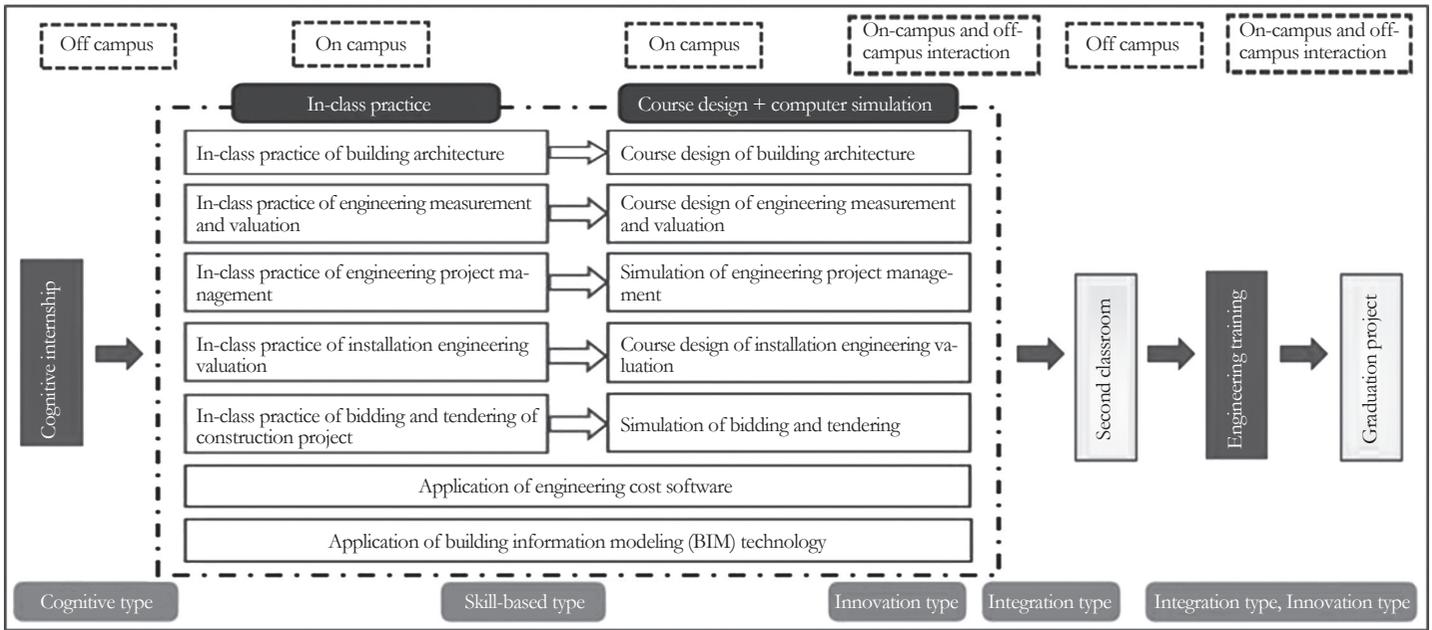
Fig.1 Integrated and innovative practical teaching system for engineering cost

design, and computer science and technology. Through specific forms such as cross-teaching in theoretical classes, joint exercises in practical links, and interactive academic activities, the complementarity and update of knowledge and skills are strengthened in green digital fields such as "intelligent construction, new materials, smart Internet of Things, ecological restoration, recycling and regeneration, landscape greening, and virtual simulation". At the same time, it is necessary to promote in-depth integration of industry and education with enterprises, cooperate with leading cost estimation enterprises to set up "order classes" or jointly build "industry colleges", customize practical content according to enterprise standards, introduce enterprise technical experts as external teachers, and open a "talent cultivation - internship and employment" green channel to enable students to possess comprehensive ability that meets the current job requirements.

4 Summary and prospect

In the current era when China's economy and society are comprehensively transforming towards green development, traditional industries, especially those in the field of civil engineering and architecture, have been greatly impacted. Industrial transformation and technological innovation have become the key to the survival and development of related industries. Relevant disciplines and majors in colleges and universities also shoulder the important responsibility of connotative transformation and talent cultivation reform.

Green and digital are as new quality productive forces, and a comprehensive update and reconstruction should be carried out in aspects such as training objectives, training programs, teaching content and teaching methods. Besides, extensive and in-depth cooperation between schools and local authorities as well as between schools and enterprises should be enhanced to further strengthen students' innovative consciousness and practical ability and then meet the talent demands of China's modernization construction.

With the accelerated iteration of science and technology and the continuous construction of disciplines and specialties, the cross-integration of engineering cost with related disciplines such as landscape architecture and urban and rural planning will be further deepened. In addition to the intersection of professional knowledge centered on "green ecology, energy conservation and consumption reduction, safety and efficiency, comfort and friendliness", the platform bridging and integration innovation of BIM and GIS technology will also bring about more new technological innovations and create new job positions in multiple fields such as highways, municipal works, landscapes, architecture, planning, digital twins, smart cities, and virtual simulation, becoming the fundamental support for the construction, operation and maintenance of smart cities in the future.

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472 trees are of normal growth, 14 show weak growth and 3 are endangered.

The spatial distribution characteristics of ancient trees in Changning City are as follows: There are 5 ancient trees in Baisha Town of Changning City, 10 in Baifang Town, 29 in Banqiao Town, 9 in Dabao Town, 30 in Guanling Town, 7 in Lanjiang Town, 32 in Luoqiao Town, 38 in Miaoqian Town, 2 in Peiyuan Sub-district Office, 15 in Pengtang Town, 4 ancient trees in Quanfeng Sub-district office, 22 in Triangtang Town, 18 in Shengqiao Town, 8 in Shuikoushan Town, 72 in Tashan Township, 6 in Tiantangshan Office, 76 in Xiling Town, 22 in Xinhe Town, 12 in Yanzhou Town and 33 in Yangquan Town., 7 in Yitan District, 4 in Yiyang Sub-district office and 28 in Yintian Town.

The findings of the analysis of the dominant species of ancient trees in the towns of Changning City shows that camphor tree is the dominant species of ancient trees in 18 towns (subdistricts) of Changning City , and the other dominant species of ancient trees are Guizhou Photinia (2) from Lanjiang Township, Chongyang wood (12) from Luoqiao Township, Southern yew (15) from Tashan Township, sweet clover (2) and evergreen chinquain (2) from Tiantanshan District Office, Chinese honey locust (5) from Xinhe Town and Minnan (4) from Yiyang District Office.

4.2 Discussion

This study focuses on the ancient trees in Changning City. Based on the survey of ancient and famous tree resources in Changning City and the need for ArcGIS analysis of the current situation of ancient tree resources in Changning City, we have researched, designed and developed the ancient tree resource database system based on ArcGIS and built the overall framework for the ancient tree resource database system in Changning City on the whole, finally setting up a reasonable logical structure for the database. Using ArcGIS technology for operation and processing, it is essential to specify the technology be applied to each module to achieve the preset functions. Based on these, a meticulous design plan has been formulated with the fundamental goal of developing ancient tree resources and improving the utilization rate of these resources, forming a reasonable development approach. The system is highly operable, preparing for technological upgrades and expansion. It is also robust in terms of maintenance and holds significant reference value for the future protection, development, and utilization of ancient tree resources in Changning City. The integration of database and ArcGIS technology is undoubtedly a major breakthrough in the research field in China, with a strong sense of innovation that will lead to broad prospects for development[15].

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