Article

Research on the Talent Training Reform of Civil Engineering and Architecture Majors in Higher Vocational Education under the Background of Existing Building Renovation

Di Wang [1,*], Jiebing Zhu [1], Jiandong Tian [1], Xiaolei Zhu [1] and Mengzhou Chen [1]

[1] Suzhou Vocational Institute of Industrial Technology, Suzhou 215000, China
* Correspondence: Di Wang, Suzhou Vocational Institute of Industrial Technology, Suzhou 215000, China

Abstract: With China's urban development shifting from "incremental expansion" to "stock optimization," the renovation and adaptive reuse of existing buildings have become central to urban construction. This transformation imposes new demands on the knowledge, skills, and competencies of frontline technical and skilled personnel. Currently, the talent training system for civil engineering and architecture majors in higher vocational education remains closely aligned with traditional construction paradigms, characterized by outdated curricula and a disconnect between practical training and real-world requirements, limiting its effectiveness in addressing the growing needs of the building renovation sector. This study analyzes the core competency requirements for technical and skilled personnel in existing building renovation and constructs a systematic talent training pathway for civil engineering and architecture students in higher vocational education. The framework emphasizes five dimensions: redefining educational philosophy, restructuring the curriculum, reforming teaching models, deepening industry-education integration, and enhancing faculty development. By focusing on cultivating composite technical talents who are proficient in construction, knowledgeable in design, skilled in coordination, and capable in management, this study provides theoretical guidance and practical strategies to support the adaptation of vocational education to industry transformation and upgrading.

Keywords: existing building renovation; urban regeneration; higher vocational education; civil engineering and architecture majors; talent training reform

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1. The Industry Transformation and the Reality Gap in Talent Cultivation

Over the past two decades, civil engineering and architecture programs in China's higher vocational education system have cultivated millions of technical and skilled professionals, providing crucial support to the nation's rapid urbanization. Historically, the talent cultivation system has been closely aligned with a construction industry model primarily focused on new building projects, emphasizing competencies in construction techniques, project organization and management, and quality assurance for newly constructed facilities. Students were trained to meet the standardized requirements of new construction projects, with curricula, practical training, and assessment mechanisms heavily oriented toward traditional construction practices [1].

However, recent macro-level policy reforms and shifts in market demands have fundamentally transformed the industry landscape. Policy directives, such as the "Notice on Preventing Large-Scale Demolition and Construction in Urban Renewal Actions," signal a transition toward an urban regeneration paradigm that prioritizes the preservation, renovation, and adaptive reuse of existing structures while selectively integrating new construction. Consequently, the core of future construction activity is

expected to center around aging residential neighborhoods, industrial heritage sites, historic preservation districts, and existing commercial and institutional buildings, which are distributed throughout urban areas. This shift represents a profound change in both technical and managerial requirements, highlighting the need for multi-dimensional expertise that extends beyond traditional construction competencies [2].

The transformation of the industry has generated a set of complex and specialized demands for talent. Renovation and adaptive reuse projects are characterized by challenging site conditions, high integration of modern technologies, multi-disciplinary collaboration, ambiguous or evolving regulatory standards, and intricate coordination requirements across stakeholders. Professionals engaged in such projects must possess not only foundational skills in construction but also advanced competencies in the "diagnosis," "reinforcement," "reactivation," and "enhancement" of existing buildings. In addition, they must demonstrate an ability to integrate contemporary design solutions, sustainable practices, and heritage preservation principles, often under tight project constraints and with limited precedents [3].

In contrast, current talent cultivation practices in higher vocational institutions reveal several critical shortcomings [4]. First, outdated educational concepts persist: training objectives remain predominantly focused on new construction, with limited integration of emerging paradigms such as urban regeneration and building renovation. Second, curricula are disconnected from real-world needs: most teaching content continues to adhere to technical standards designed for new construction, lacking specialized modules in essential renovation technologies, including building inspection and assessment, structural strengthening, historic building restoration, and environmentally responsible retrofitting. Third, practical training is insufficient: on-campus facilities largely replicate components of new construction, failing to simulate the complexities and uncertainties of renovation work, while off-campus internships rarely provide comprehensive exposure to full renovation processes, including planning, execution, and interdisciplinary coordination. Finally, faculty preparedness remains limited: many instructors are trained in research-oriented environments and lack direct hands-on experience in renovation projects, resulting in a shortfall of "dual-qualified" teachers capable of integrating theoretical knowledge with applied renovation practice [5].

The resulting gap between talent supply and market demand has become increasingly conspicuous, highlighting an urgent need for systematic, self-directed reform in civil engineering and architecture education within higher vocational institutions. Addressing this gap requires a comprehensive reevaluation of educational philosophy, curriculum design, practical training strategies, industry-academia collaboration, and faculty development. Against this backdrop, the present study undertakes an in-depth exploration of pathways for talent cultivation reform, aiming to equip future professionals with the integrated technical, managerial, and interdisciplinary capabilities needed to thrive in the evolving landscape of building renovation and urban regeneration.

2. New Core Competency Requirements for Higher Vocational Talents in the Context of Existing Building Renovation

Talent cultivation at the higher vocational level is oriented toward frontline production, construction, management, and service roles [6]. The goal is to develop well-rounded technical and skilled professionals who achieve comprehensive growth across moral, intellectual, physical, aesthetic, and labor education, possess solid foundational and specialized knowledge in civil engineering and architecture, and demonstrate core competencies in building inspection and assessment, structural reinforcement, green retrofitting, information management, and project communication and coordination. These professionals are expected to serve in diverse fields, including building inspection, reinforcement construction, engineering consulting, and property management,

contributing to technical, managerial, and consulting functions in existing building renovation projects.

In the context of existing building renovation, graduates are required to cultivate the following core competencies. Building Diagnostic Capability involves the ability to conduct detailed on-site surveys and mapping using instruments such as theodolites, laser distance meters, and crack monitoring devices, alongside the capacity to interpret inspection and assessment reports and identify structural pathologies related to safety, durability, and performance deterioration. Specialized Technical Application Skills encompass mastery of construction techniques and quality control standards for mainstream structural strengthening methods, such as steel plate bonding, carbon fiber reinforcement, and post-installed rebar systems; proficiency in building envelope energy retrofit methods, including external wall insulation, window and door replacement, and roof refurbishment; and knowledge of specialized materials and techniques for historic building restoration and adaptive reuse [7].

BIM and Information Technology Application Skills require the ability to employ 3D laser scanning for accurate verification of existing conditions, leverage BIM platforms for clash detection, integrated pipeline planning, and construction simulation, and achieve precise and coordinated construction management. Awareness of Green and Sustainable Development involves a deep understanding of green building standards, mastery of energy-saving, water-saving, and material-saving techniques in renovation projects, and a foundational ability to analyze and optimize building energy consumption. Communication, Coordination, and Project Management Skills are essential due to the multi-stakeholder nature of renovation projects, which often involve property owners, residents, government departments, and design teams; professionals must manage scheduling, cost control, safety, and regulatory compliance efficiently. Humanistic Literacy and Craftsmanship Spirit require respect for historic buildings, recognition of cultural and heritage value, pursuit of meticulous construction quality, and cultivated aesthetic sensibilities [8].

At the knowledge level, students are expected to master the structural and material characteristics of existing buildings, methods for structural inspection and assessment, principles of conventional reinforcement techniques, building energy efficiency technologies, fundamentals of BIM modeling and application, basics of historic building conservation, and regulations and management practices specific to renovation projects. At the capability level, these include Professional Skills, such as conducting on-site surveys and data collection, interpreting inspection and assessment reports, preparing conventional reinforcement and energy-efficient renovation plans and guiding their implementation, employing BIM for clash detection and pipeline coordination, and managing quality, safety, and project progress during renovation. Methodological Skills encompass the ability to acquire information, pursue lifelong learning, analyze complex technical problems, and implement practical solutions in renovation scenarios. Social Skills involve strong communication and coordination, team collaboration, and effective interaction with owners, residents, designers, and regulatory authorities [9].

At the level of personal qualities and professional attitudes, students should exhibit a craftsmanship spirit, reverence for historical and cultural heritage, a commitment to green and sustainable development, and robust professional ethics. Collectively, these core competencies define a new paradigm for higher vocational talent in civil engineering and architecture, enabling graduates to navigate the technical, managerial, and social complexities of existing building renovation and to contribute effectively to the ongoing transformation of urban construction practices [10].

3. Reform Pathways for Talent Training in Civil Engineering and Architecture Programs in Higher Vocational Education

To align with the core competencies required for existing building renovation, higher vocational institutions must undertake systematic and profound reforms in their talent training models, encompassing educational philosophy, curriculum design, teaching approaches, industry integration, faculty development, and assessment mechanisms.

3.1. Reshaping the Educational Philosophy: From "New Construction Artisans" to "Urban Regeneration Specialists"

A fundamental shift in mindset must begin with the top-level design of educational programs. The training objective should transition from cultivating "technical and skilled talents serving new construction" to developing "composite technical and skilled talents capable of addressing urban regeneration and existing building renovation." Core competencies-including building inspection and strengthening, green and energy-efficient retrofitting, and historic building conservation and repair-should be embedded explicitly in the talent training program. This approach instills in students the concept of whole-life cycle management of buildings, emphasizing sustainability, heritage protection, and adaptive reuse alongside technical proficiency [11].

3.2. Restructuring the Curriculum System: Building a New "Foundation + Module + Project" Course Structure

The traditional discipline-based curriculum should be transformed into a modular system oriented toward the renovation workflow, integrating general education, professional foundation, core competency modules, and comprehensive practical projects.

1) General Education Platform Courses: Introduce courses such as Green Building, Urban Development History, and Architectural Cultural Heritage to enhance students' humanistic literacy and awareness of sustainable urban regeneration.
2) Professional Foundation Platform Courses: Retain essential subjects such as Architectural Drawing, Construction, Materials, Structures, and Construction Technology, but enhance them with case studies focused on existing buildings. Traditional courses like "Building Construction" can incorporate analyses of structural pathologies and aging building details, while "Building Materials" introduces properties of traditional and compatible new materials.
3) Professional Core Module Courses: Establish specialized modules including "Inspection and Appraisal Technology for Existing Buildings," "Building Structural Strengthening Technology and Construction," "Building Energy-Saving Retrofitting Technology and Application," "BIM Applications in Building Renovation," and "Historic Building Conservation and Repair."

Modules are structured as follows:

1) Module 1: Building Inspection and Appraisal - Courses focus on surveying, crack observation, non-destructive testing, and structural safety and serviceability assessment.
2) Module 2: Structural Strengthening and Retrofitting - Covers design and construction of reinforcement methods such as CFRP wrapping, steel plate bonding, post-installed rebar, and section enlargement.
3) Module 3: Green and Energy-Efficient Retrofitting - Includes envelope insulation, energy-efficient window and door replacement, roof waterproofing and insulation, and upgrading of building equipment systems.
4) Module 4: Information and Project Management - Emphasizes BIM modeling, 3D laser scanning, cost estimation, project scheduling, and communication management.

Comprehensive Practical Project Courses are embedded across the curriculum, using real or simulated renovation projects to provide hands-on experience in inspection, design,

construction organization, cost estimation, material procurement, and project operation. Students progress from cognitive internships in historic districts (Year 1) to specialized practical training in specific modules (Year 2), and finally to comprehensive, full-process projects and practicums (Year 3), ensuring continuity from observation to project execution.

3.3. Reforming the Teaching Model: Implementing a Practical "Site-As-Classroom" Approach

Renovation knowledge requires experiential learning beyond theoretical instruction.

1) Project-Based Learning (PBL): Core modules are structured around real renovation projects, with tasks such as developing reinforcement plans, selecting energy-saving replacement models, and documenting construction key points, enabling students to integrate knowledge through practical application.
2) On-Site Teaching: Classes are conducted at institutional old buildings, ongoing enterprise renovation projects, or historic districts, allowing students to observe, handle materials, and experience construction processes firsthand.
3) Digital Teaching Resources: VR/AR simulations are employed to practice high-risk or high-cost operations, complemented by online case libraries and instructional videos.

A four-level progressive practical teaching system is established: foundation training (basic skills), specialized module training (inspection, strengthening, BIM), comprehensive project training (cross-disciplinary application and teamwork), and practicum (six-month hands-on training at partner enterprises).

Assessment and evaluation are diversified and process-oriented. Written exams are complemented by practical evaluations, project defenses, and simulations. Certification standards, such as BIM and component installation, are integrated into assessments. Industry mentors participate in evaluating professional skills, problem-solving ability, and work attitude during comprehensive practical training and practicums.

3.4. Deepening Industry-Education Integration: Co-Constructing "Teaching Workshops" and "Industry Colleges"

Rapid technological evolution necessitates close collaboration with enterprises.

1) Urban Regeneration Teaching Workshops: On-campus facilities co-constructed with leading firms provide integrated training in inspection, strengthening, energy-efficient retrofitting, and technique demonstration, also serving as R&D and technology promotion centers.
2) Urban Regeneration Industry Colleges: Collaborations with local governments, associations, and enterprises co-develop curricula, teaching materials, and assessment systems while solving practical industry challenges.
3) Real-World Projects: Graduation design and comprehensive training projects are implemented using renovation of institutional buildings or neighborhood micro-regeneration projects under dual guidance from instructors and industry mentors.

3.5. Strengthening Faculty Development: Building "Dual-Qualified & Triple-Competent" Teaching Innovation Teams

Teachers play a central role in reform.

1) Dual-Qualified & Triple-Competent Teams: Faculty are required to combine teaching ability, engineering practice, and technical R&D expertise.
2) Enterprise Practice: Full-time teachers undertake a minimum of six months of practicum in the renovation sector every five years.
3) Industry Mentors: Technical experts and master craftsmen are recruited to support core courses and mentor faculty.

4) Modular Team Organization: Teaching teams, combining in-house and industry experts, are structured around technical modules for collaborative course preparation and instruction.

3.6. Establishing a Diversified Evaluation System: A Closed-Loop Engine for Talent Quality Assurance

A robust, scientific evaluation system ensures continuous improvement in talent training.

1) Evaluation Subjects: Expanded from single-school assessment to collaborative evaluation involving faculty, enterprise instructors, industry experts, peers, and students themselves.
2) Evaluation Content: Broadens from knowledge recall to comprehensive capability assessment, covering BIM application, 3D scanning, renovation design, teamwork, communication, and cultural heritage awareness.
3) Evaluation Methods: Combines process-oriented and developmental assessment, including project portfolios, transformation scheme defenses, on-site operation logs, and virtual simulation data analysis.
4) Continuous Optimization: Data-driven feedback informs curriculum refinement, teaching content updates, and methodological improvements, enabling dynamic adaptation to industry evolution and cultivating professionals equipped to serve as "building doctors" and "smart architects" in urban regeneration.

4. Discussion

The reform of talent training for civil engineering and architecture in higher vocational education represents a strategic response to the evolving landscape of urban construction, particularly the growing emphasis on existing building renovation and adaptive reuse. Unlike conventional curriculum adjustments, this reform entails a multi-dimensional transformation of the educational ecosystem, encompassing philosophy, curriculum design, pedagogical methods, industry collaboration, and faculty capabilities. One notable aspect is the integration of technical, managerial, and humanistic competencies, ensuring that graduates can navigate the complex interplay between structural integrity, sustainability requirements, and socio-cultural considerations in renovation projects.

The discussion of this reform can be framed from several perspectives. First, from an educational perspective, aligning talent cultivation with market demand requires moving beyond discipline-centered teaching to modular, project-based, and practice-oriented learning. Students are expected not only to acquire technical knowledge but also to develop problem-solving skills, adaptability, and interdisciplinary collaboration abilities. This shift encourages higher vocational institutions to rethink the sequencing of courses, the balance between theory and practice, and the incorporation of digital tools such as BIM and virtual simulations into routine instruction.

Second, from an industry perspective, the success of this reform depends on sustained and proactive partnerships with enterprises, government agencies, and professional associations. Embedding students in real-world projects, involving them in cross-functional teams, and providing mentorship from industry experts enhances their readiness for professional practice and fosters a culture of continuous learning. Furthermore, the co-development of teaching content and assessment criteria ensures that graduates' competencies remain aligned with the rapidly evolving technical and regulatory standards in renovation and retrofitting.

Third, from a faculty development perspective, the reform underscores the importance of cultivating instructors who are both technically proficient and pedagogically skilled. Dual-qualified and triple-competent teachers, who combine

engineering practice, research capability, and teaching effectiveness, serve as essential conduits for translating industry knowledge into educational outcomes. Continuous faculty training, enterprise immersion, and collaboration with industry mentors strengthen the teaching workforce and foster innovation in instructional design.

Finally, from a strategic policy perspective, this reform highlights the need for higher vocational institutions to adopt forward-looking planning mechanisms. By systematically integrating knowledge, practice, and evaluation into a closed-loop talent cultivation system, institutions can ensure that graduates not only meet current industry requirements but are also equipped to anticipate and adapt to future challenges, such as urban densification, aging building stocks, and the increasing demand for sustainable construction solutions.

5. Conclusion

In response to the increasing wave of existing building renovation and adaptive reuse, the reform of talent cultivation in civil engineering and architecture programs within higher vocational education extends far beyond the mere addition or removal of courses. It represents a comprehensive and systematic reconstruction of the entire educational ecosystem, encompassing educational philosophy, curriculum design, teaching methodologies, practical training models, industry integration, and faculty development. This reform requires higher vocational institutions to adopt a proactive and forward-looking approach, stepping beyond conventional practices, closely monitoring industry developments, and swiftly adapting to market changes through deep and sustained collaboration with enterprises and professional bodies.

The ultimate objective of this reform is to nurture a new generation of "Urban Regeneration Specialists" who combine technical expertise, practical problem-solving skills, and innovative thinking with an appreciation for cultural heritage and urban sustainability. These professionals are expected to play a pivotal role in promoting high-quality urban development, safeguarding historical and cultural continuity, advancing sustainable construction practices, and contributing to broader environmental and societal goals. By equipping graduates with cross-disciplinary knowledge, hands-on experience, and adaptive competencies, higher vocational education can ensure that its alumni are not only capable of meeting current industry demands but also prepared to drive future innovations in urban regeneration and the adaptive reuse of existing buildings.

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