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Modular Teaching Reform and Talent-Cultivation Pathways for Early-Career Civil Engineering Teachers in Vocational Undergraduate Programmes from the Perspective of New Engineering Education

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Abstract: Vocational undergraduate education, an important component of the modern vocational education system, carries the core mission of cultivating high-level technical and skilled talent. As the construction industry upgrades towards smart construction, green low-carbon practice, and prefabricated applications, the New Engineering Education initiative requires that the talent-cultivation paradigm in civil engineering be reconstructed. Early-career teachers are the driving force behind teaching innovation, curriculum renewal, and the delivery of industry-education collaboration in vocational undergraduate institutions, yet some of them misread the purpose of their teaching role, have limited engineering practice behind them, are weak at developing modular courses, and are ill prepared to design instruction that integrates posts, courses, competitions, and certificates. These shortcomings constrain the substantive development of their programmes. Taking as its premise the positioning of vocational undergraduate education as a distinct type that unites vocational and higher-education attributes, this paper analyses the practical difficulties of civil engineering teaching and builds a reform system that combines four-dimensional modularisation, project-driven learning, and the integration of posts, courses, competitions, and certificates. It then explores pathways for strengthening early-career teachers' overall teaching competence through conceptual renewal, platform building, teaching-research communities, and digital empowerment. The study offers practical reference for raising the quality of civil engineering programmes in vocational undergraduate institutions and for building a tiered faculty of double-qualified early-career teachers, and provides a replicable model for teaching reform in comparable engineering programmes.

Keywords: New Engineering Education; Vocational Undergraduate Education; Civil Engineering; Early-Career Teachers; Modular Teaching; Post-Course-Competition-Certificate Integration.

1. Introduction

After the revised Vocational Education Law came into force, vocational undergraduate education in China entered a stage of standardised development, shifting strategically from expansion of scale to improvement of quality. General undergraduate programmes concentrate on academic research talent and three-year vocational colleges on basic operational skills, whereas vocational undergraduate education prepares high-level technical and skilled talent for the mid-to-high-end posts of industry, combining theoretical depth with engineering practice and the capacity to apply and innovate with technology. Civil engineering is a pillar engineering discipline underpinning new urbanisation, infrastructure renewal, and green urban-rural development, and the construction industry is undergoing profound structural change: BIM modelling, prefabricated building, smart site management, and low-carbon green construction are progressively displacing conventional practice, and industry posts now set new standards for graduates' digital literacy, project coordination and management, and application of green construction technology.

New Engineering Education calls on engineering programmes to respond to industrial change, break with the discipline-oriented teaching paradigm, and move talent cultivation from knowledge transmission towards competence outcomes. In vocational undergraduate

institutions, early-career teachers form the mainstay of curriculum reform, practical training, and competition coaching. Most of them have a solid grounding in their discipline and take readily to digital tools, but many have followed a campus-to-campus route into teaching, with little experience of engineering projects in industry. Their grasp of the internal logic of vocational undergraduate education as a distinct type is often incomplete, so they transpose the teaching paradigm of research-oriented undergraduate programmes, leaving what they teach disconnected from industrial practice and making it hard to meet the goals of high-level technical and skilled talent cultivation.

A review of the literature shows a substantial body of research on civil engineering teaching reform, but most of it addresses general undergraduate or three-year vocational programmes. Systematic studies that target the vocational undergraduate level specifically, focus on the competence development of early-career teachers, and connect with modular teaching reform remain limited, and some stop at the level of experiential summary without a coherent reform framework or a mechanism linking faculty growth to reform. Against this background, and guided by the requirements of New Engineering Education and the type-based positioning of vocational undergraduate education, this paper identifies the practical bottlenecks in civil engineering teaching, constructs a modular and project-based teaching reform framework, and explores pathways for developing the dual competence of early-career teachers, with the aim of offering both theoretical reference and practical lessons for high-quality development of civil engineering programmes at this level.

2. Core Concepts and Theoretical Foundations

2.1 The Type-Based Positioning of Vocational Undergraduate Civil Engineering Programmes

Vocational undergraduate education occupies the higher tier of vocational education, and its defining feature is the dialectical unity of higher-education and vocational attributes. The former means that students must master a systematic theoretical foundation in engineering science and possess a measure of technical analysis and technical improvement capability; the latter requires talent cultivation to be anchored in the demands of industry posts, with an emphasis on applied engineering practice and a supply of talent for first-line technical and management roles[1].

Civil engineering programmes at this level can neither replicate the general undergraduate model built around structural theory and mechanics research, nor be reduced to the operational training offered by three-year colleges. Their goals are directed at mid-to-high-end posts such as smart construction technician, technical supervisor of prefabricated projects, digital cost manager, and green building operation and maintenance engineer. Graduates are expected to combine theoretical analysis, hands-on engineering skills, project coordination and management, and the ability to apply and innovate with new technology[2].

2.2 The Logic of Teaching Change in Civil Engineering under New Engineering Education

New Engineering Education is not a matter of adding a few courses on new technologies; it is a systemic reconstruction of the talent-cultivation paradigm[3]. Conventional civil engineering teaching organises courses around disciplinary knowledge, emphasising mechanical derivation and structural calculation, and responds slowly to the digital, green, and prefabricated technologies emerging in industry. Under New Engineering Education, the logic of teaching has to move from disciplinary knowledge to the competence required by industry posts: BIM, prefabricated construction, low-carbon buildings, and smart site monitoring are integrated into the curriculum, the classroom turns from a place of theoretical instruction into one of competence training in engineering contexts, and educational provision is matched dynamically to industrial demand[4].

2.3 The Competence Profile of Early-Career Double-Qualified Teachers in Vocational Undergraduate Institutions

The competence of double-qualified teachers in vocational undergraduate institutions goes well beyond the simple stacking of certificates; it is a composite of several capabilities. For early-career civil engineering teachers, a complete profile has five elements. The first is subject teaching competence: the ability to deliver disciplinary theory and design teaching activities

soundly. The second is engineering practice competence: familiarity with the full process of building projects and with current technical standards, together with the ability to develop engineering cases and supervise practical training projects[5]. The third is curriculum restructuring and development competence: the ability to reorganise course content into modules on the basis of post competence and to put the integration of posts, courses, competitions, and certificates into effect. The fourth is digital teaching competence: the ability to use virtual simulation and BIM software for contextualised instruction. The fifth is industry-education collaborative research competence: the ability to work with enterprise resources on teaching reform and technical services. Together these capabilities form the foundation on which early-career teachers in vocational undergraduate institutions carry out their duties[6].

3. Practical Difficulties Facing Early-Career Civil Engineering Teachers

3.1 Lagging Conceptual Transformation and an Unclear Grasp of Type-Based Positioning

Many early-career teachers graduated from comprehensive research-oriented universities, where they were trained for years in an academic model, and their habits of thought do not turn quickly after they join a vocational undergraduate institution. They adopt general undergraduate textbooks and syllabi directly, devote teaching time to theoretical derivation, stress the completeness of the disciplinary knowledge system, and squeeze the share of engineering application and project-based practical training[7].

Such teachers have yet to grasp fully the requirement that vocational undergraduate education be oriented to post competence, and they blur the boundary between vocational undergraduate and general undergraduate education, so that what is taught and what the programme sets out to cultivate fall out of step. Students acquire a large body of theory but are ill equipped to analyse and solve problems when confronted with real drawings, construction schemes, and on-site technical issues, leaving a gap between the graduates produced and the posts the construction industry needs[8].

3.2 Missing Engineering Practice Experience and an Inadequate Supply of Contextualised Teaching

Civil engineering depends heavily on engineering practice settings, and high-quality classroom teaching needs a steady supply of real cases, process details, and problem-handling experience from construction sites. Most early-career teachers recruited into vocational undergraduate institutions are recent master's or doctoral graduates. Many have never held a post in an enterprise and lack hands-on exposure to new forms of engineering such as prefabricated projects and smart sites[9].

With thin reserves of first-line experience, these teachers can only rely on textbook cases, which date quickly, and their treatment of common technical difficulties, quality defects, and site management problems stays at the surface. In practical training and course design supervision they struggle to reproduce the complexity of real projects, so practice teaching tends towards formalism and fails to bring the construction site into the classroom[10].

3.3 Weak Curriculum Restructuring Capacity and the Grip of a Discipline-Oriented Curriculum

Existing civil engineering courses follow traditional disciplinary divisions: Engineering Mechanics, Concrete Structures, and Construction Technology stand apart from one another, their knowledge points overlap, and content is arranged by disciplinary logic rather than integrated around the sequence in which a project is delivered. Vocational undergraduate programmes need to break down disciplinary barriers, reorganise content according to post competence, and adopt modular teaching design, all of which place a premium on teachers' capacity for top-level curriculum design[11].

In practice, many early-career teachers are competent at teaching a single course but have no training in designing a curriculum system as a whole, and they find it hard to decompose, reorganise, and update knowledge points. Course content fails to absorb new industrial technologies such as BIM and green construction, curriculum renewal is slow, and the system cannot meet what is expected of high-level technical and skilled talent[12].

3.4 Superficial Integration of Posts, Courses, Competitions, and Certificates

The integration of posts, courses, competitions, and certificates is the signature model that

distinguishes vocational undergraduate from general undergraduate education. It requires post standards to align with course content, competition tasks with practical training, and certificate assessment points with teaching objectives, forming a complete chain of learning, practice, competition, certification, and employment[13].

Observation of current teaching shows that this integration remains superficial. Some teachers simply forward 1+X certificate documents and competition notices to students without unpacking certificate standards and competition tasks into the everyday course modules. Teaching, skills competitions, and vocational certificates stay separate, so preparing for certificates and training for competitions become extra burdens and the model's potential for coordinated talent cultivation goes unrealised[14].

3.5 Limited Capacity for Developing Digital Teaching Resources and Weak Fit with New Engineering Education

Digital construction is the direction in which the industry is moving, and BIM simulation and virtual simulation platforms offer civil engineering teaching entirely new vehicles. Some early-career teachers, however, use only PowerPoint for basic multimedia instruction and are not equipped to develop virtual simulation projects, design BIM teaching cases, or build digital teaching resources. Immersive engineering teaching scenarios are left unexploited, the classroom stays at the level of drawings and verbal explanation, and teaching lags behind the smart civil engineering trend that New Engineering Education implies[15].

4. Building a Modular Teaching Reform System Oriented to New Engineering Education

To address these bottlenecks, and on the basis of the type-based positioning of vocational undergraduate education, the paper constructs an integrated reform system of four-dimensional modularisation, project-driven learning, post–course–competition–certificate integration, and industry-education collaboration. The system is intended both to raise the quality of talent cultivation and to push early-career teachers to upgrade their overall teaching competence[16].

4.1 Building a Four-Dimensional Modular Curriculum Architecture Oriented to Post Competence

Setting aside the constraints of the traditional disciplinary curriculum, the study surveys the competence lists of mid-to-high-end technical posts in construction enterprises and, following the logic of competence formation, reorganises existing courses into four teaching modules. Overly abstruse academic derivation is trimmed, frontier industrial content such as smart construction and green construction is added, and knowledge, skills, and professional conduct are cultivated as a whole[17].

The first module covers foundational civil engineering theory, integrating Engineering Mechanics, Soil Mechanics, Building Materials, and Engineering Drawing. Theory essential to engineering practice is retained while complex derivation is played down, and content from the New Engineering Education agenda such as low-carbon building materials and digital drafting is incorporated, laying a firm theoretical foundation. This module plays to the strength early-career teachers have in theory and offsets the weakness caused by limited engineering experience[18].

The second module covers construction technology, integrating building construction technology, prefabricated construction technology, and site organisation. Organised around the full sequence of a project, teaching units are rebuilt along the lines of foundations, main structure, prefabricated installation, green construction, and finishing works, with real construction schemes, process videos, and site quality cases drawn from enterprises used as teaching materials, so that the content carries a stronger engineering character.

The third module addresses digital and intelligent construction. It follows the direction of industrial change under New Engineering Education and covers BIM modelling and application, construction process simulation, smart site monitoring, and digital cost estimation, giving vocational undergraduate civil engineering programmes a distinctive teaching profile and steering early-career teachers towards digital civil engineering instruction.

The fourth module covers integrated engineering management, combining project management, engineering cost, tendering, bidding and contract management, construction quality and safety control, and green building assessment. It serves technical management posts and trains students

in project coordination, risk control, and communication, in keeping with the high-level positioning of vocational undergraduate education.

The four modules progress in sequence and connect with one another, and each contains theoretical, practical training, and extension units, forming a closed loop that runs from post competence goals, through module content and project tasks, to evaluation of the skills produced.

4.2 Project-Based Contextual Learning and the Renewal of an Engineering-Oriented Classroom

Within this modular framework, teaching is driven by real engineering projects. Deeper school-enterprise cooperation turns the prefabricated building projects and smart site projects of partner enterprises into teaching vehicles, converting drawings, specialised construction schemes, on-site technical problems, and quality acceptance standards into classroom resources.

The classroom no longer follows one-way lecturing. Early-career teachers act as project mentors and organise students into groups to read drawings, build BIM models, draft construction process schemes, estimate costs, and screen safety risks. Real project problems become classroom tasks, so that students internalise knowledge and sharpen skills while completing them, achieving a classroom that works like a construction site and learning that works like practice.

Project-based teaching also gives early-career teachers a vehicle for growth. Drawing on the project resources that enterprises provide, they can compensate for thin engineering experience, accumulate cases through instructional design and project supervision, and strengthen their capacity for engineering-oriented teaching design.

4.3 Deepening the Integration of Posts, Courses, Competitions, and Certificates

Taking the competence standards of mid-to-high-end posts in the construction industry as the guiding framework, the programme implements coordinated cultivation across posts, courses, competitions, and certificates.

Post-course alignment comes first: the content of the four modules is matched to the competence standards for posts such as prefabricated construction technician, BIM application engineer, and civil works technical supervisor, and module tasks are updated as enterprise surveys reveal changes in post requirements.

Course-competition integration follows: the regulations and practical tasks of BIM innovation competitions and prefabricated building skills competitions are broken down and built into practical training units, and competition standards become everyday assessment indicators, so that competition promotes both learning and teaching.

Course-certificate linkage completes the chain: assessment points from vocational skill certificates such as 1+X prefabricated building and BIM engineering technology are decomposed and embedded in the corresponding course modules, so that certificate content is no longer an extracurricular burden and students build certificate competence while completing their courses.

In building this system, early-career teachers must interpret post standards, competition regulations, and certificate syllabi and then translate them into teaching content — a process that quickly develops their curriculum development and instructional design capacity and brings gains both for the quality of the programme and for their own professional growth.

4.4 Using Industry-Education Platforms to Remedy Gaps in Engineering Practice

Industry-education integration is both an important means of talent cultivation and a key platform for developing early-career double-qualified teachers. A two-way mobility mechanism between institutions and enterprises, together with a secondment system for early-career teachers, allows civil engineering teachers to be sent periodically into construction enterprises, prefabricated building industrial parks, and smart sites to take part in projects, experience the full process of construction and technical management, accumulate first-line experience, and gather case material for teaching. At the same time, senior technical personnel from industry are engaged as part-time teachers. The two sides jointly develop modular courses, write new practical training materials, and build a shared repository of virtual simulation teaching resources. Enterprise engineers cover the gaps in early-career teachers' engineering practice, while the teachers contribute their strengths in theory and digital tools, so that the two parties

complement each other in developing teaching resources.

5. Sustainable Growth Pathways for Early-Career Civil Engineering Teachers

The effect of teaching reform ultimately depends on the overall teaching competence of early-career teachers. In line with the requirements of modular teaching reform, this section sets out growth pathways that cover concepts, training systems, digital empowerment, and teaching-research communities.

5.1 Anchoring the Attributes of Type-Based Education and Renewing Teaching Values

Early-career teachers must first transform their teaching concepts, moving away from the discipline-centred thinking of research-oriented undergraduate education and establishing firmly the vocational undergraduate ideals of industry orientation, post competence outcomes, and the primacy of technical skills. Once the positioning of civil engineering talent cultivation is clear, assessment no longer tests the recall of theory alone but focuses on students' ability to analyse engineering problems, apply technical solutions, and handle practical project tasks. Type-based education requirements are then implemented throughout course design, classroom delivery, and assessment, completing the shift from transmitting disciplinary knowledge to cultivating engineering competence.

Institutions can help teachers renew their educational understanding through dedicated teaching-research sessions, close reading of vocational undergraduate policy, and discussion of typical programme cases.

5.2 Building a Tiered Development System for Double-Qualified Growth

A five-part tiered mechanism is established, comprising pre-service study, on-the-job training, enterprise secondment, teaching-research projects, and competition experience. For teachers in their first years, training focuses on vocational undergraduate educational theory, modular curriculum design, and the instructional design of post–course–competition–certificate integration. For those with three to five years of service, secondment to enterprises is implemented, and they are encouraged to apply for teaching reform projects, take part in writing new-form textbooks, and coach students in skills competitions. Incentive mechanisms bring enterprise practice and reform achievements into teacher evaluation, giving early-career teachers an internal drive to develop as double-qualified professionals.

5.3 Strengthening Digital Empowerment for Smart Civil Engineering Teaching

In response to the digital transformation of the industry, early-career teachers are organised to study BIM applications in teaching, the operation of engineering virtual simulation platforms, and the development of digital teaching resources. They are encouraged to turn construction processes, structural behaviour, and site conditions into visual simulation materials, which resolves the difficulty of observing many engineering scenarios on site. Modular practical training built on virtual simulation projects strengthens their capacity for digital teaching innovation and answers the needs of smart civil engineering talent cultivation under New Engineering Education.

5.4 Creating a Mutual-Aid Teaching-Research Community

A teaching innovation team for civil engineering is formed, in which experienced staff mentor newcomers. Double-qualified backbone teachers with rich engineering and teaching experience lead early-career colleagues in restructuring modular courses, designing project-based instruction, improving practical training systems, and developing school-enterprise teaching resources. Collective lesson preparation, teaching salons, and reform seminars are held regularly to sustain the community.

Teamwork eases the difficulties early-career teachers face in practice, such as limited capacity for curriculum restructuring and a thin stock of engineering cases, and lowers the cost of trial and error in reform, producing a faculty ecology in which backbone teachers lead and younger colleagues grow quickly.

6. Conclusion

Against the twin background of New Engineering Education and the high-quality development of vocational undergraduate education, the shift of the construction industry towards intelligence and green practice poses new challenges for civil engineering talent cultivation. Early-career teachers are the backbone of teaching reform in vocational undergraduate institutions, yet they commonly

face slow conceptual transformation, thin reserves of engineering practice, and weak capacity for modular curriculum development.

Taking the type-based positioning of vocational undergraduate education as its premise, this paper builds a four-dimensional modular curriculum system, promotes project-driven teaching, and refines the coordinated cultivation mechanism that links posts, courses, competitions, and certificates, while establishing growth pathways for early-career teachers through conceptual renewal, tiered development, digital empowerment, and teaching-research communities. The reform scheme addresses both the implementation of talent cultivation reform and the building of a faculty echelon, and seeks to resolve the disconnection between theory and practice and the mismatch between teaching and industry in vocational undergraduate civil engineering programmes. It supports the cultivation of high-level civil engineering technical talent and offers a practical reference for teaching reform in comparable engineering programmes.

Teaching reform at this level is an ongoing, iterative process. Further work is needed to track industrial and technological change, adjust module content dynamically, improve evaluation and incentive mechanisms for early-career teachers, deepen industry-education integration, and keep raising the relevance of the talent that programmes produce.

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