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Exploring and Implementing a Cross-Disciplinary Innovation Talent Cultivation Model for Professional Master's Programs in Civil and Hydraulic Engineering

Yaping Ge[1], Guoping Huang[1] & Jing Liu[1]

[1] School of Civil Engineering, Hunan City University, Yiyang, Hunan 413000, China
Correspondence: Yaping Ge, School of Civil Engineering, Hunan City University, Yiyang, Hunan 413000, China.

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Abstract

With the rapid development of social economy, the demand for professionals in civil and hydraulic engineering is increasing daily. The traditional model for cultivating professional master's talents is no longer meet the diverse requirements of the market. This paper explores the implementation of a cross-disciplinary innovation Guidance model in the master's education of civil and hydraulic engineering. By analyzing the current challenges in talent cultivation, the paper outlines objectives for talent development, curriculum design, practical teaching methodologies, and strategies for fostering innovative capabilities within the context of Cross-disciplinary innovation Guidance. Additionally, it provides recommendations for effectively implementing this model, aiming to serve as a reference for nurturing high-quality, innovative talents equipped with practical skills.

Keywords: cross-disciplinary innovation, civil and hydraulic engineering, professional master's, talent cultivation model, practical teaching

1. Introduction

In the context of the new era, the high-quality development of China's economic and social increasingly demands high-level interdisciplinary innovative talents. Traditional master's cultivation models in civil and hydraulic engineering primarily emphasize professional knowledge and skills, often neglecting the cultivation of innovation awareness and cross-disciplinary innovation competencies. As the trend of interdisciplinary integration becomes more prominent, Cross-disciplinary innovation talent cultivation models are emerging as a new approach for developing talent in universities. This paper systematically explores and analyzes the civil and hydraulic engineering master's cultivation model under Cross-disciplinary innovation Guidance, aiming to provide insights for enhancing master's students' innovation capabilities and practical levels.

2. Current Problems in Civil and Hydraulic Engineering Master's Talent Cultivation

2.1 Disconnection Between Theoretical Learning and Practical

In the current training process for master's students in civil and hydraulic engineering, the first-year curriculum predominantly emphasizes theoretical foundation courses. However, the teaching approach often prioritizes knowledge acquisition over the development of practical skills and quality, favoring lecture-based instruction over hands-on training. This results in students gaining knowledge in an abstract manner, which diverges from the objectives of practicality-oriented training. Additionally, the instruction of fundamental professional knowledge lacks integration, systematic organization, and relevance to practical training, real-world industry challenges, and thesis work. Consequently, students struggle to apply theoretical concepts to engineering practice and fail to effectively develop their abilities to identify and solve problems in complex engineering projects (Lin Ke, 2020).

2.2 Misalignment Between Cultivation Objectives and Market Demands

The cultivation objectives in current civil and hydraulic engineering master's programs still emphasize singular professional domains, failing to promote the development of cross-disciplinary innovation competencies. As engineering construction continues to evolve, the demand for interdisciplinary talents is growing rapidly. Traditional cultivation models struggle to adapt to this increasing market demand for high-level, versatile professionals.

2.3 Weak Innovation Awareness and Ability Development

Traditional civil and hydraulic engineering master's cultivation models prioritize knowledge transmission over effective innovation awareness and capability development. The curriculum often lacks modules on innovation and entrepreneurship, while practical segments rarely include innovative practice activities. Consequently, students demonstrate weak innovation awareness and capabilities, which contradicts society's urgent need for high-quality innovative talents.

3. Training Objectives of Master's Degree Students in Civil and Hydraulic Engineering Under the Orientation of Interdisciplinary Innovation

Guided by the principles of cross-disciplinary innovation, the training objectives for master's students in Civil and Hydraulic Engineering emphasize the development of a comprehensive competency framework. This framework is built upon a multidisciplinary knowledge base, with interdisciplinary integration as its core and innovative thinking as the driving force (Song Kezhi & Yuan Hongxian, 2024).

By integrating expertise in Civil and Hydraulic Engineering with related fields such as management, economics, and environmental science, the program fosters an interdisciplinary knowledge system that equips students with the necessary foundation to tackle complex engineering challenges. Building upon this foundation, the program prioritizes the cultivation of students' interdisciplinary integration capabilities, enabling them to systematically apply knowledge from multiple domains to formulate effective engineering solutions.

Moreover, the program places a strong emphasis on fostering innovative thinking. Moving beyond the limitations of traditional training models, it nurtures students' creativity by enhancing their problem-solving skills, refining their analytical thinking, and strengthening their practical competencies. Through targeted training in innovation awareness, cognitive approaches, and hands-on experience, the program stimulates students' intrinsic motivation for proactive innovation in engineering practice. Ultimately, it aims to cultivate high-level professionals with cross-disciplinary expertise and sustained innovative capacity, thereby providing essential talent support for the industry's transformation and advancement.

4. Training Path for Interdisciplinary Innovative Master's Degree Students in Civil and Hydraulic Engineering

4.1 Curriculum System Construction

To cultivate interdisciplinary innovative master's students in Civil and Hydraulic Engineering, a three-tier curriculum framework—Basic Layer, Interdisciplinary Layer, and Frontier Layer—can be established to form a progressive and integrative knowledge system.

The Basic Layer aims to strengthen students' foundational knowledge by integrating fundamental natural science courses with core professional courses. Additionally, interdisciplinary general education courses, such as environmental science, materials science, and information technology, are incorporated to build a dual-dimensional knowledge base of "professional expertise + interdisciplinary expansion."

The Interdisciplinary Layer focuses on the convergence of disciplines, offering specialized courses such as intelligent construction and BIM technology, ecological restoration in hydraulic engineering, and engineering-environment system analysis. Furthermore, management-related courses, including engineering economics and project management, are embedded to cultivate students' multidisciplinary collaborative thinking.

The Frontier Layer aligns with the evolving industry landscape, featuring cutting-edge courses such as "Lifecycle Management of Green Buildings," "Artificial Intelligence in Structural Monitoring," and "Hydraulic Engineering under Dual-Carbon Goals." Elective modules in economics, law, and data science further enrich the curriculum, forming a "core-rigidity + flexible-expansion" course structure.

A dynamic course update mechanism is implemented through a dual optimization approach of "interdisciplinary integration + industry-driven demand." Traditional courses are infused with interdisciplinary elements; for instance, intelligent sensor data analysis is incorporated into mechanics courses, while ecological red-line assessments are embedded in water resources planning. To ensure real-time industry alignment, a "Curriculum Update Committee" is jointly established with enterprises and research institutes. This committee transforms cutting-edge technologies—such as digital twins and low-carbon construction—into teaching resources through annual industry white paper analysis and an evolving engineering case library (e.g., resilient urban sponge systems, nearly zero-energy buildings).

A hybrid teaching model combining "theoretical instruction + project-based discussions" is promoted. Leveraging an intelligent construction virtual simulation platform co-developed with industry partners, interdisciplinary course design is conducted to facilitate the deep integration of knowledge dissemination and competency development.

This structured curriculum system systematically supports the cultivation of composite engineering professionals with systems thinking and innovation capabilities, ensuring a progressive learning pathway from fundamental knowledge reinforcement to interdisciplinary innovation and frontier expansion, all while maintaining a dynamic discipline-industry synergy.

4.2 Practical Teaching Component

The construction of the practical teaching system emphasizes progressive competency development through modular design, platform-based support, and innovative methodologies, establishing a continuous capability-building framework throughout the training process. The system follows a "four-stage progressive" model, advancing from fundamental experimental skills to pioneering innovation (Yu Boting, Yang Nan, Teng Yongfu et al., 2023):

- The Basic Training Layer focuses on standardized experiments such as concrete performance testing and mechanical simulation analysis, consolidating students' proficiency in instrument operation and data interpretation.
- The Professional Application Layer builds upon this foundation, incorporating specialized practices such as structural parametric design and BIM modeling, strengthening students' proficiency in professional software and comprehension of engineering standards.
- The Cross-boundary Integration Layer engages students in interdisciplinary projects, such as collaborative building design and lifecycle management, fostering their ability to integrate knowledge across disciplines and apply systematic thinking.
- The Innovation Breakthrough Layer introduces open-ended topics such as algorithm development and novel material synthesis, driving the transition of innovative concepts into functional prototypes.

A dual-element collaborative structure within the practical training platform provides comprehensive capability development support. On-campus, digital twin laboratories for intelligent construction and virtual simulation centers are established, integrating advanced monitoring and modeling technologies to create high-fidelity engineering simulation environments. Off-campus, "on-site engineering classrooms" are jointly developed with leading enterprises (Luo Yunju, Xie Qiang & Liu Lijuan, 2022), incorporating key project milestones to establish a real-world training mechanism based on "construction cycle tracking + key technology breakthroughs." This setup enables students to refine their decision-making abilities in real engineering scenarios.

Innovative teaching methodologies transcend traditional practice boundaries, forming a multi-dimensional learning enhancement model: Project-based teaching leverages real-world engineering projects, guiding students through the entire process—from requirement analysis and solution selection to construction simulation (Yang Xiujuan, Fan Henghui & Wang Ning, 2021). Case-immersion teaching develops an interdisciplinary case library, allowing students to integrate technical, economic, and legal knowledge through role-playing and scenario-based learning. Virtual-real integration teaching utilizes mixed reality (MR) technology to construct an "intelligent construction site sandbox," enabling students to dynamically validate construction plans through virtual simulation and real-world implementation, overcoming spatial and temporal constraints to enhance learning efficiency.

This practical teaching system effectively integrates modular progression, platform synergy, and iterative methodologies to establish a seamless competency development pathway from basic skills → professional application → system integration → innovation breakthroughs. It fosters deep integration between engineering practice and interdisciplinary learning, providing a systematic training framework that bridges theory and practice for solving complex engineering challenges. Ultimately, it significantly enhances the alignment between talent cultivation and industry demands.

4.3 Innovation Capability Development

The cultivation of innovation capability should be closely integrated with curriculum design and practical training to provide students with a comprehensive and structured learning experience.

5. Curriculum Design

To systematically develop students' innovation and entrepreneurship skills, the curriculum should incorporate the following components:

- Fundamental Courses on Innovation and Entrepreneurship: Courses such as "Innovative Thinking and Methods" and "Fundamentals and Practice of Entrepreneurship" should be offered to equip students with a solid theoretical foundation in innovation and entrepreneurship.
- Specialized Courses for Civil and Hydraulic Engineering: Tailored to the discipline, courses like "Case Studies in Innovation and Entrepreneurship for Civil and Hydraulic Engineering" should be introduced to enhance students' ability to apply innovative solutions in their field.
- Practice-Oriented Innovation Courses: Students should be encouraged to participate in experiential learning activities, such as the "Internet Plus" Innovation and Entrepreneurship Competition, where they can develop practical problem-solving skills and entrepreneurial mindset through hands-on projects.

6. Practical Training

To complement the theoretical curriculum, a robust practical training system should be established:

Innovation and Entrepreneurship Practice Bases: On-campus, universities should set up dedicated innovation and entrepreneurship practice bases, offering structured training, mentoring, and project incubation. Off-campus, collaborations with leading enterprises and research institutions should provide students with real-world exposure and industry-driven learning experiences.

Dual-Mentor System: A mentorship program should be introduced, comprising experienced faculty members, industry experts, and successful entrepreneurs, to offer comprehensive guidance in innovation and entrepreneurship.

Innovation Incentive Mechanisms: Innovation and entrepreneurship scholarships and project funding programs should be established to reward students' achievements and encourage participation. Innovation and entrepreneurship practice should be integrated into the academic credit system, motivating students to actively engage in related activities.

By implementing these measures, students will cultivate innovative thinking and entrepreneurial capabilities, enabling them to address the challenges of modern engineering practices. Ultimately, this approach will foster highly skilled professionals who can drive the sustainable development of the civil and hydraulic engineering industry.

7. Conclusion

The exploration and implementation of an advanced training model for master's students in Civil and Hydraulic Engineering represent a critical educational reform aimed at addressing the increasing complexity of modern engineering challenges. This initiative also aligns with national strategic priorities, including the "Dual-Carbon" strategy and the development of new-type urbanization. By establishing an integrated "three-in-one" training framework—comprising curriculum restructuring, practice-driven learning, and innovation empowerment—a dynamic, interdisciplinary training model is developed, with innovation at its core and industry demand as its guiding principle. This approach effectively bridges the gaps between theoretical knowledge and practical application in engineering education, deep specialization and interdisciplinary integration, as well as technological innovation and industrial implementation. Ultimately, this model ensures that talent cultivation remains aligned with major national strategic objectives, while also providing a sustained impetus for the green, digital, and intelligent transformation of the industry.

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References

Lin Ke. (2020). Research on the Evolution of Central District Street Design Guided by Sharing and Innovation. South China University of Technology. DOI: 10.27151/d.cnki.ghnlu.2020.001314.

Luo Yunju, Xie Qiang, Liu Lijuan. (2022). Research on professional master education based on the unity of professional and academic: Taking the full -time degree program of civil and hydraulic engineering specialty in Chongqing University as an example. *Journal of Architectural Education in Institutions of Higher Learning*, *31*(02), 59-65.

Song Kezhi, Yuan Hongxian. (2024). Research on the construction of case teaching resource database based on university-enterprise cooperation from the perspective of curriculum-based ideological and political education: taking Master's course teaching of civil and hydraulic engineering in Ludong University as an example. *Journal of Architectural Education in Institutions of Higher Learning*, *33*(01), 134-141.

Yang Xiujuan, Fan Henghui, Wang Ning. (2021). The Implementation Path of Innovation and Entrepreneurship Education for Master's Degree Students in Civil and Hydraulic Engineering. *Heilongjiang Education (Research and Evaluation of Higher Education)*, (12), 4-6.

Yu Boting, Yang Nan, Teng Yongfu et al. (2023). Discussion on the Training Model for Civil and Hydraulic Engineering Master's Students Linked to Professional Qualifications. *Anhui Architecture*, *30*(08), 96-98. DOI: 10.16330/j.cnki.1007-7359.2023.09.037.