Cultivating Excellent Engineers at Master's and Doctoral Levels in Chinese Universities: Contemporary Context and Practical Pathways

Chen Yang
Shaanxi University of Science & Technology, Graduate Division, Shaanxi Xi'an, China

Abstract: Amidst the global technological revolution and industrial transformation, universities—core institutions for talent development—strategically align with national engineering imperatives. China has established the world's largest engineering education system (with over 9 million students enrolled by 2025). This study proposes three pivotal pathways: (1) establishing a closed-loop industry-university collaboration mechanism; (2) transitioning evaluation systems from academic to competency-oriented frameworks; and (3) developing integrated training models that merge technical expertise with comprehensive literacy. These pathways aim to bolster national industrial upgrading and contribute China's solutions to global engineering education.

Key Words: Excellent Engineers; Master's and Doctoral Levels; Cultivation, Contemporary Context; Practical Pathways

1. Introduction

As the nexus of scientific innovation, talent resources, and transformative dynamism, the primary resource of talent, and the primary driving force of innovation, universities are the primary arena for cultivating excellent engineering talent. Master's and doctoral students are not only the backbone of the echelon of excellent engineering talents but also the key new force driving breakthroughs in engineering science and technology and supporting national industrial upgrading. Unlike the cultivation of basic capabilities at the undergraduate stage, the training of engineering talents at the master's and doctoral levels focuses more on cutting-edge nature, practicality, and innovation. Colleges and universities must anchor on the needs of national major engineering projects and deeply integrate academic research with industrial practices. the quality of such training directly determines the core confidence for China's engineering science and technology field to leap from "following" to "leading" in the global context.

2. Contemporary Context: Global Value and National Mission of the Reform in Engineering Education

On November 9, 2018, Wu Yan, Director of the Ministry of Education's Higher Education Department, at the 13th International Symposium on Science-Education-Industry Development Strategy (November 9, 2018): "Globally, engineering education leads all educational reforms in pace, prominence, scale, and impact. China's engineering education has provided a fundamental support platform for building a moderately prosperous society in all respects, a strategic leading force for building a great modern socialist country, and Chinese experience for the development of a community with a shared future for mankind. "[1] This assertion accurately anchors the core positioning of engineering education in the overall national development, and the master's and doctoral stages serve as the critical focal point for the reform of engineering education. It also highlights the key value of these stages as the "final mile" of engineering education reform — only by consolidating the foundation for cultivating engineering talents at the master's and doctoral levels can the experience of China's engineering education be transformed into tangible scientific and technological competitiveness.

China has established the world's largest and high-quality higher engineering education system. As of 2025, the number of students enrolled in engineering education in China exceeds 9 million. Colleges, universities and enterprises have continuously innovated in practice and explored a new path for cultivating excellent engineering talents. It not only provides solid and strong support for the economic and social development at the national and regional levels, but also offers a reference paradigm with practical guiding significance for the reform and development of global engineering education. [2]

Against the backdrop of the deep integration of the new round of technological revolution and industrial transformation, the innovative development of the global engineering and technological field has entered an unprecedentedly intensive and dynamic phase. From high-end manufacturing to the digital economy, and from new energy technologies to bioengineering, key core technologies in various fields are no longer isolated breakthroughs, but rather show the characteristics of clustered outbreaks featuring multi-technical collaboration and multi-field integration. Among them, emerging technologies and new formats, typically represented by artificial intelligence and life sciences, are in a process of continuous iteration and upgrading, as well as rapid evolution and expansion. These new technologies not only have significantly shortened their own iteration cycles, but also are deeply coupled with traditional engineering fields, spawning new formats such as intelligent manufacturing and biomedical engineering, and continuously reshaping the application boundaries and industrial ecology of engineering technology. Against this background, the development environment of higher engineering education has undergone remarkable changes: on the one hand, it can seize the opportunity of technological innovation, upgrade practical teaching models relying on new technologies, expand interdisciplinary training dimensions, and explore paths for optimizing and upgrading talent training models; on the other hand, it must face up to a series of new challenges brought by the accelerated technological iteration and upgraded industrial demand, such as the lag in updating talent knowledge systems and the shortage of interdisciplinary and compound teachers, forcing engineering education to accelerate its transformation to adapt to the needs of the times.

3. Practical Pathways: Construction of the Master’s and Doctoral Engineering Talent Training System Anchored in National Needs

Against the backdrop of the deep interweaving of the global engineering and technological revolution and industrial transformation, national major engineering tasks have become the core anchor for the cultivation of engineering talents at the master’s and doctoral levels in colleges and universities. Faced with the traditional barrier of "disconnection between academic research and industrial practice", colleges and universities must be guided by strategic needs, promote all-round and in-depth integration of the talent training system with industrial development realities, and construct a high-quality training ecosystem for excellent engineers that meets the requirements of the new era.

University-enterprise collaborative talent cultivation needs to establish a closed-loop mechanism of "demand docking - joint training - achievement transformation". Colleges and universities should take the initiative to cooperate with leading enterprises and key scientific research institutes in critical fields such as high-end equipment manufacturing, new energy, and integrated circuits to co-build joint laboratories and engineering practice bases integrating scientific research, practical teaching, and achievement transformation, thereby providing a solid platform for collaborative training. Master’s and doctoral students should be deeply involved in tackling "bottleneck" technologies, with real enterprise projects serving as the core carrier of graduate training. the "university-enterprise dual-tutor system" should be adopted to achieve seamless connection between theoretical guidance and engineering practice. In the process of participating in project research and development, graduate students should not only complete theoretical modeling and technological innovation in laboratories but also deeply engage in the entire process of technical plan implementation, product prototype development, and market application verification. This promotes the transformation of theoretical achievements such as patented technologies and core algorithms into practical solutions with industrial value. In the first batch of special pilot reforms for engineering master’s and doctoral training, a large number of technological achievements involving graduate students have been applied in industrialization.

The reform of the evaluation system requires a fundamental shift from "academic-oriented" to "competency-oriented", completely abandoning the single evaluation logic of "thesis-only". Currently, China has reconstructed the academic degree evaluation standards for engineering master’s and doctoral students. Legally, the newly implemented Academic Degree Law places practical achievements on an equal footing with academic dissertations, both of which can serve as the basic content for professional master’s and doctoral students to apply for degree defense. Institutionally, the basic requirements for engineering master’s and doctoral students to apply for degrees with practical achievements have been issued. [3] All colleges and universities should actively establish a diversified evaluation system centered on engineering practice contributions, technological innovation breakthroughs, and industrial value transformation. A tripartite evaluation subject of "universities+enterprises+industries" should be constructed, where enterprise tutors deeply participate in the whole-process evaluation of graduate training, focusing on assessing their practical ability to solve complex engineering problems. Through the restructuring of the evaluation "baton", graduate students are guided to consolidate their mathematical and physical foundations and professional theories while taking the initiative to cultivate hard skills such as engineering design, system integration, and team collaboration, avoiding the disconnection between academic research and industrial needs.

The expansion of competency dimensions requires building a composite training model of "technical competence+comprehensive literacy". On the basis of strengthening the cultivation of core technical capabilities, the cultivation of literacy such as engineering ethics, systematic thinking, and international perspective should be organically integrated into the entire training process. Engineering ethics education should be combined with practical issues such as data privacy protection and low-carbon development to cultivate graduate students' professional sense of responsibility. the cultivation of systematic thinking can be achieved by restructuring the curriculum system and offering interdisciplinary modules to train graduate students' ability to solve complex system problems from a holistic perspective. the cultivation of international perspective should rely on carriers such as international joint training programs and international industry standard certifications (e. g., ISO, IEEE standards) to familiarize graduate students with the technical norms and development trends in the global engineering field. Through the collaborative empowerment of comprehensive literacy, it is ensured that master’s and doctoral students not only become "technical experts" mastering key core technologies but also grow into composite engineering talents with industry responsibility, systematic thinking, and international perspective, providing solid support for the implementation of national major projects and the high-quality development of industries.

4. Conclusion

Looking forward to the future, colleges and universities need to take the cultivation of engineering talents at the master’s and doctoral levels as the starting point, continuously deepen the reform of engineering education, and ensure that the cultivated excellent engineering talents can not only meet the needs of national major projects but also lead the upgrading of industrial technologies. Ultimately, a virtuous cycle of "education - science and technology - industry" will be formed, providing a steady stream of talent support for China's transformation from an engineering power to a world-class engineering powerhouse, and contributing more practical Chinese solutions to the development of global engineering education.

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