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Construction of Engineering Creativity and Craftsmanship Training Model for Applied Undergraduate Engineering Talents

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Abstract: In the process of achieving "Made in China 2025," the cultivation and building of engineering professionals is an important competitive advantage and plays a core role. Therefore, Chinese universities should accelerate the cultivation of innovative talents in engineering majors and narrow the gap with other manufacturing powerhouses. This article studies the cultivation mode of engineering creativity for applied engineering talents from the perspective of exploring new engineering disciplines, analyzes the shortcomings of the current talent cultivation mode, constructs an innovative education and cultivation system for applied talents and a craftsman spirit cultivation mode, and proposes specific measures and methods to improve students' innovation and entrepreneurship abilities and craftsman spirit from different perspectives. The research results are of great significance for the cultivation of composite talents who can adapt to the new normal of advanced manufacturing economic development and technical skills.

Keywords: Application-oriented undergraduate program; Engineering creativity; Craftsmanship spirit; Training mode

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1. Introduction

After decades of continuous investment and relentless efforts, significant achievements have been made in the field of engineering and technology in China. Milestones such as the "Chang'e" lunar exploration, the "Jiaolong" deep-sea submersible, the full operation of the Hong Kong-Zhuhai-Macao Bridge, and the leading position of the Fuxing high-speed train in the global market demonstrate substantial progress in China's capabilities for "independent innovation" as well as "absorption, adaptation, and re-innovation" in engineering and technology. The foundation of a lasting enterprise lies in its talent. Upholding and advancing the strategy of strengthening the country through talent has become a national consensus following the 19th National Congress of the Communist Party of China. In the current context of rapid technological development, the essence of international competition remains a talent contest. However, the long-term tendency to follow and imitate developed countries has resulted in a general lack of the ability among Chinese engineering talents to "creatively solve problems

[1,2].” Whether in the fierce competition for dominance in high-end manufacturing on the international stage or in promoting the transformation and upgrading of traditional manufacturing at the domestic level, there is an increasingly clear and urgent need for a continuous supply of high-quality engineers to support human resources. The cultivation of creativity among engineering talents is becoming increasingly essential. In the pursuit of “Made in China 2025,” the training and development of engineering professionals represent a significant competitive advantage and play a central role. Therefore, Chinese higher education institutions must accelerate the cultivation of innovative talents in engineering disciplines to narrow the gap with other manufacturing powerhouses. However, as the main body responsible for talent training, applied undergraduate institutions still require further reform in their talent cultivation models [3,4].

2. Issues in the current training model

2.1. Weak engineering creativity among engineering graduates from application-oriented undergraduate institutions

As the number of students enrolled in engineering programs at application-oriented undergraduate institutions continues to grow, the number of graduates has also increased. However, in recent years, a stark contrast has emerged between the rising number of graduates and the challenges they face in securing employment, alongside the difficulties that employers encounter in recruitment. From the student’s perspective, this indicates a lack of competitive advantage in the job market and limited adaptability to the needs of enterprises and the market. Application-oriented graduates exhibit deficiencies in problem-solving and communication skills, as well as insufficient professional skills training. This situation severely hampers the development potential of students in their careers, necessitating urgent reforms and innovations in the training model. The pronounced imbalance between the supply and demand of talent underscores the need for local universities to reform traditional training models, focusing on enhancing practical skills in application-oriented talent to improve students’ employability while meeting societal expectations regarding both the quantity and quality of talent with economic development [5,6].

2.2. Insufficient emphasis on craftsmanship spirit in talent development

In recent years, General Secretary Xi Jinping has repeatedly emphasized the importance of cultivating a craftsmanship spirit at various conferences, and this concept was also highlighted in the report of the 19th National Congress of the Communist Party of China. Since 2016, the cultivation of craftsmanship spirit has been included in government work reports for four consecutive years, elevating its significance to a national level. Despite growing calls from all sectors of society for a resurgence of the craftsmanship spirit, the cultivation process in application-oriented undergraduate institutions faces several challenges due to both subjective and objective factors, hindering its development among university students. Currently, while the knowledge structure of engineering students is relatively comprehensive, their understanding of the humanities is lacking, making it difficult to foster enthusiasm and identification with their studies and work, which is detrimental to the holistic development of engineering students. Moreover, the responsibility for cultivating students’ craftsmanship spirit primarily falls on educators in ideological and political courses. However, the construction of this academic discipline is currently facing severe challenges, including inadequate curriculum design and ineffective improvements in teaching attractiveness and relevance. As a result, the practical effects of cultivating the craftsmanship spirit among students are adversely affected [7,8]. Universities lack relevant curriculum activities that promote the craftsmanship spirit within their talent development plans and course structures, and educators

in theoretical courses seldom mention the craftsmanship spirit in class, leading to a lack of guidance on this educational theme.

Future engineers will confront not only simple routine problems in industrial production but also increasingly complex real-world engineering issues that require interdisciplinary collaboration for resolution. As existing conventional solutions and internal professional knowledge fail to meet new demands, engineers must seek unprecedented and innovative approaches to problem-solving, which is reflected in their "engineering creativity." Human history has long demonstrated that breakthroughs driven by engineering creativity can profoundly alter the trajectory of technological and engineering development. Seizing historical opportunities and aligning with the pulse of the times to occupy the high ground of scientific innovation is crucially dependent on talent. In the face of technological blockades from developed countries and the relentless pursuit by emerging nations, China's engineering talent needs to possess the ability to creatively address a series of significant technological challenges. Thus, the cultivation of engineering talent creativity is a vital response to the urgent demands posed by the advancement of the times and technological development. The cultivation of craftsmanship spirit in the context of new engineering primarily refers to the role of universities in educating engineering students, who represent a group of future engineers and world changers. Embracing a craftsmanship spirit will significantly aid them in achieving their goals and ideals. One of the primary responsibilities of universities is to cultivate talent by imparting essential knowledge and skills for global engineering careers, while also providing cultural and spiritual education. This education helps students understand their position in a new historical stage, grasp the new trends in industrial development, and develop the ability to respond to and create new directions for development. They must foster dedication, pursuit of excellence, teamwork, and adherence to their ideals and beliefs, internalizing this craftsmanship spirit into their personal qualities and habits. Therefore, establishing a training model that fosters engineering creativity and craftsmanship spirit among engineering talent in application-oriented undergraduate institutions holds practical significance for enhancing the engineering creativity of application-oriented engineering talent and improving the integrated training model of professional education and ideological and political education, ultimately raising the quality of new engineering talent cultivated in local contexts.

3. Construction and practice of talent cultivation model

3.1. Construction of talent cultivation model

This study focuses on constructing a model for fostering engineering creativity and the spirit of craftsmanship among engineering students in application-oriented undergraduate institutions. It aims to explore high-quality, innovative, and interdisciplinary talent cultivation models for engineering majors, establish a new educational system, enhance the quality management of the entire teaching process, and cultivate students' awareness and abilities in innovation and entrepreneurship. This is of significant importance for the future development of advanced manufacturing industries in China.

3.1.1. Cultivation system for engineering creativity in application-oriented undergraduate education

In the context of emerging engineering disciplines, it is essential to comprehensively reconsider the essence of engineering education, establishing a student-centered educational philosophy. By actively reforming teaching methods focused on enhancing students' engineering capabilities, a creativity cultivation model will

be constructed based on Project-Based Learning (PjBL) and the "Learn, Design, Create, Achieve" (LDCA) framework. This model will explore the roles of research-based teaching, project-based teaching, and group teaching in stimulating students' innovative consciousness and fostering diverse thinking skills, including critical thinking, systematic thinking, and human-centered thinking. Furthermore, a practical teaching platform for engineering education will be established to improve the engineering practice system and enhance students' innovative skills [9,10].

3.1.2. Cultivation model of craftsmanship spirit for engineering students

As specialized institutions for talent cultivation, universities have a responsibility to foster the spirit of craftsmanship among application-oriented engineering students, which is also one of their educational goals. Efforts will be made to integrate the cultivation of craftsmanship spirit into the entire process of higher education, including the formulation of talent cultivation programs and teaching plans that incorporate this spirit. The structure of professional course offerings will be optimized to transform fewer engaging courses into high-quality ones, while research will be conducted to identify teaching methods related to the content of craftsmanship in specialized courses. A cultivation model utilizing activities as a medium for educating students on craftsmanship spirit will be established, along with a systematic, multi-level talent cultivation framework that broadens the knowledge base of engineering students and enhances their spiritual qualities in their respective fields. Additionally, a comprehensive evaluation system that integrates professional knowledge, engineering creativity, and craftsmanship spirit for new engineering students will be developed.

3.1.3. "Diverse System" collaborative education model

The cultivation of craftsmanship spirit cannot be achieved without practical education. Enterprises are the primary battlefield for training "excellent craftsmen" with a "craftsmanship spirit." By leveraging the synergy between universities, enterprises, and research institutions, a "diverse system" collaborative education model will be explored. This model will facilitate the alternation between theoretical learning in academic settings and practical learning in enterprises, ensuring the integration of theoretical knowledge with students' practical activities. It will fully utilize the geographical advantages of application-oriented undergraduate institutions, relying on manufacturing bases and production internship sites of enterprises, and enhancing students' utilization of educational resources through collaborative training bases [11,12]. The effective integration of practical activities and craftsmanship spirit within this "diverse system" model will jointly cultivate high-quality, interdisciplinary engineering and technical talents imbued with craftsmanship spirit.

3.2. Specific implementation of the talent cultivation model

Based on the characteristics of various engineering majors, course outlines will be dynamically revised according to teaching quality assessments and the developmental features of disciplines. Resources necessary for teaching, such as lesson plans, teaching slides, and micro-videos, will be constructed, while also expanding available resources that support course instruction and the learning process. Guided by the core concept of outcomes-based education from engineering education professional accreditation, and aligning with the graduation requirements outlined in the "Engineering Education Accreditation Standards," specific course objectives will be formulated. The teaching content, requirements, and methods will be clearly defined around the professional cultivation program, course objectives, and ideological and political education requirements, establishing connections between teaching knowledge points and ideological indicators.

A practical teaching platform for engineering education will be constructed to create a mechanism for cultivating innovative talents and fostering an atmosphere conducive to their development. A comprehensive platform for cultivating innovative talents will be established based on the principles of "joint faculty hiring, shared resources, co-constructed courses, and joint student education." This initiative aims to reorganize teaching resources, promote interdisciplinary collaboration, and enhance teachers' capabilities in engineering practice, innovation and entrepreneurship education, and integration of industry and education. It will explore the establishment of a new mechanism for cross-disciplinary, cross-departmental, and cross-professional talent cultivation, facilitating a seamless integration of teaching resources and creating an interconnected talent cultivation system. Reforms in the goals, resources, systems, monitoring, processes, and organizational guarantees for cultivating innovative capabilities in new engineering talents will be undertaken, constructing a quality assurance mechanism that includes process monitoring, dynamic assessment, and developmental evaluation interactions.

The fundamental task of fostering virtue and character will be thoroughly implemented. The ideological and political education resources embedded in various courses and teaching methods will be deeply explored, integrating value formation, knowledge transmission, and capability cultivation into each course. Leveraging the engineering advantages of the School of Mechanical and Electrical Engineering, the elements of ideological education and related indicators will be systematically identified, forming a comprehensive system of ideological education work that covers all courses, is diverse in types, layered in progression, and mutually supportive. The teaching staff will be identified as the "main force," course construction as the "main battlefield," and classroom instruction as the "main channel," thereby establishing an innovative ideological education system that is comprehensive, continuous, and multifaceted [13,14].

Centered around the modular project teaching requirements, the application of the PjBL model in practical teaching settings, including projects, competitions, and activities, will be explored. PjBL courses will be integrated into the general education curriculum, and small project design and production courses will be offered to enhance students' creative thinking abilities [15,16]. Large-scale practical projects such as project design and product design will be included in professional courses to foster students' innovative thinking. Connections between post-graduate industrial education and undergraduate education will be established, collaborating with industry to undertake innovation projects or simulated innovation project education, thereby enhancing students' teamwork, hands-on practical abilities, and project development capabilities. Through the engagement of enterprise mentors, collaborative training within institutions, and joint cultivation with enterprises, a project-based practical teaching cultivation system for innovative talents will be formed through project implementation, iteration, error correction, and continuous improvement, ultimately improving the training effectiveness of new engineering talents.

4. Reform outcomes and conclusions

The establishment of a training model for engineering creativity and craftsmanship spirit tailored for applied undergraduate engineering talents focuses on the Mechanical Design, Manufacturing, and Automation program and the Automation and Electrical Engineering program at the College of Mechanical and Electrical Engineering, Zhoukou Normal University. This initiative follows the principle of "coordinated development, highlighting key areas, refining characteristics, and advancing step-by-step," thereby accelerating curriculum development and enhancing the curriculum construction system.

By strengthening both in-class and extracurricular practices, the program aims to cultivate students' practical abilities as a breakthrough point. It emphasizes the integration of mechanical and materials science, information science, life sciences, and energy science while reinforcing general education and innovation education. Additionally, it focuses on the development of curriculum standards and the cross-disciplinary integration and comprehensive innovative abilities of new engineering talents. Personalized development for students is prioritized by formulating a flexible professional curriculum system and training scheme.

The project establishes a diversified innovative practical teaching platform to support students' creative activities. Furthermore, it enhances the construction of laboratories for new engineering disciplines, fully utilizing their role in fostering students' innovative capabilities. The research outcomes of this project are gradually being promoted to corresponding programs and grades in other colleges at Zhoukou Normal University, such as Physics and Telecommunication Engineering, and Computer Science and Technology. This outreach benefits over 4,000 students across relevant undergraduate programs and those transitioning from associate degrees to bachelor's degrees within the new engineering fields, demonstrating significant positive outcomes.

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Disclosure statement

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