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Construction and Practice of Practical Education System for Emerging Engineering Education in Local Universities

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Abstract

Aiming at the existing problems in local universities, such as insufficient integration between professional practical education and curriculum-based ideological and political education, the practical teaching system failing to support multidisciplinary integration, and the difficulty of current models to meet the fundamental task of fostering virtue through education and the urgent demands for talent cultivation under Emerging Engineering Education, this paper constructs a new practical education system for Emerging Engineering Education guided by equal emphasis on value and competence, with industry-education collaboration, competition-innovation integration and interdisciplinary integration as implementation paths. By building an immersive education mode of proactive ideological-political education, establishing a multidisciplinary integrated comprehensive practical teaching system, and constructing a trinity training platform for applied innovative talents, this study realizes the deep coupling of value guidance, competence cultivation and industry connection in engineering practical education. Practical results show that the proposed system significantly improves students' engineering practice capability, innovation capacity and professional literacy, and provides a replicable and promotable paradigm for practical education of Emerging Engineering Education in local universities.

Keywords local universities; Emerging Engineering Education; practical education; curriculum-based ideological and political education; multidisciplinary integration

1 Introduction

The Outline for the Construction of a Powerful Country in Education (2024-2035) clearly states that to cultivate new-era talents capable of shouldering the great mission of national rejuvenation, it is essential to promote the in-depth integration of value guidance and practical experience, which puts forward new requirements for the reform and development of higher engineering education[1]. The construction of Emerging Engineering Education has become a key measure for China to respond to scientific-technological revolution and industrial transformation[2]. Nevertheless, there are still prominent gaps between the current practical teaching system for engineering education and the above objectives.

For instance, curriculum-based ideological-political education and practical teaching segments in local application-oriented universities are insufficiently integrated; ideological-political contents remain superficial, leading to shallow understanding and limited critical thinking among students, and value guidance

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stays at a formal level[3]. Although students can develop comprehensive practical competence through subject competitions, practical courses and production internships, effective guidance on values is lacking. Besides, practical teaching contents are updated slowly with outdated teaching approaches. Low interdisciplinary integration makes it difficult to equip students to tackle complex cross-disciplinary engineering problems[4]. Industry-university research cooperation often becomes formalistic. Students cannot deeply participate in on-post tasks in enterprises, and their idealized learning expectations are inconsistent with industrial demands. Consequently, they fail to gain real-world challenges from industrial front-lines[5–6].

Targeting the above practical difficulties faced by local universities, this research takes serving national innovation strategies and the construction of the Chengdu-Chongqing Twin-City Economic Circle as the starting point, focuses on cultivating applied technical talents for local universities. It aims to foster students' patriotism while improving their innovation and practical abilities, and carries out reform exploration on the practical education system.

2 Core Problems and Implementation Paths for Reform

2.1 Insufficient Integration of Ideological-Political Values and Practical Competence

Structural challenges exist in the integration of curriculum-based ideological-political values and practical competence in engineering education of local universities. During practical training, students receive ideological-political contents in a passive and indoctrinating way, lacking active exploration and internalization, which results in subjectivity deficiency. The introduction forms of ideological-political elements in practical teaching are relatively simplistic. Ideological-political contents are mechanically embedded like labeling, without deep integration with non-technical competencies required in engineering practice such as dialectical thinking and ethical judgment. Therefore, educational outcomes remain superficial. Students can memorize knowledge points, yet cannot make accurate value judgments when facing real-world engineering scenarios. This disconnection undermines the actual effect of fostering virtue through education. To address this issue, this paper proposes a design pattern to truly integrate value guidance and competence cultivation, forming an operable talent-training path with promotion value for local universities.

Specific implementation paths are as follows:

First, the concept of proactive ideological-political education is put forward. Traditional ideological-political education mostly adopts one-way indoctrination by teachers with passive acceptance from students, leading to limited effects. In this research, students become protagonists rather than passive listeners while conducting practical projects and participating in subject competitions. Supported by comprehensive practical training platforms (e.g., virtual simulation laboratories, artificial intelligence laboratories, process equipment and control laboratories) and subject competitions (Mechanical Innovation Design Competition, Sichuan Provincial Robot Competition, National 3D Modeling Competition, etc.), students are encouraged to summarize methods and experience when solving real-world problems and actively explore ideological-political elements. For example, red-gene resources in professional laboratories and student associations (historical-culture promotion, lectures for primary and secondary schools, red-themed reports, etc.), ideological-political cases (the development path of China's science-technology power since the founding of People's Republic of China, model workers, etc.), as well as craftsmanship spirit, teamwork and responsibility embedded in practical segments can be perceived and applied by students themselves in practice. In this way, ideological-political education is genuinely integrated with practice.

Second, integrate role-model stories, practical thinking logic and engineering practice methods from perspectives of multidisciplinary integration, diversified practical training, multi-category comprehensive practice and multi-dimensional subject competitions. Cutting-edge technologies such as artificial intelligence, digital twin and intelligent manufacturing are embedded into practical teaching. Based on real-

world engineering cases (university-enterprise cooperation projects, university-industry research projects, college student innovation training programs, order-oriented training programs, etc.), students apply multidisciplinary knowledge collaboratively. Meanwhile, characteristic activities such as "Footprints of Strivers" are organized to strengthen students' patriotism and professional identity, which are further consolidated through real-world engineering practice to improve hands-on capabilities and professional literacy.

Third, deepen university-enterprise cooperation and build R&D practice platforms oriented to real enterprise demands (robot development studio, embedded system development studio, intelligent IoT studio, etc.). Enterprises release research topics and provide financial support, and students carry out design and R&D with shared achievements. On such platforms, students face industrial demands directly and participate in real-world R&D projects. They realize technological innovation and application practice while solving practical problems, so that talent cultivation can keep pace with industrial frontiers and scientific-technological trends, and cultivate talents with outstanding values and practical capabilities.

2.2 Weak Practical Value System Supporting Cross-disciplinary Innovation Capability

The practical teaching of local universities fails to meet the talent-training objectives of Emerging Engineering Education for applied talents. The practical value system lacks systematic planning and progressive competence-training paths. Teaching contents are traditional and dominated by verification-oriented experiments, with few projects for innovation improvement. Barriers exist among different disciplines. Practical segments of mechanical engineering, control science and computer science are isolated from each other, which restricts the cultivation of students' cross-disciplinary capabilities and hinders their adaption to industrial demands after graduation. To solve these problems, this study emphasizes multidisciplinary integration and diversified teaching modes combined with various competitions to enhance students' comprehensive innovation capability step-by-step, and constructs a well-structured practical value system with clear training paths.

Specific implementation paths are as follows:

First, a four-level progressive practical teaching system is established:

1. Basic theory and skill training: Master professional basic knowledge and common software tools.
2. Comprehensive training for Emerging Engineering Education: Deal with typical multi-knowledge-point engineering cases and develop problem-solving capabilities.
3. Cross-disciplinary integrated training: Combine multi-disciplinary knowledge for different application scenarios and cultivate thinking for complex systems.
4. High-level Class-A national subject competitions: Stimulate innovation awareness and teamwork spirit through high-level competitions and realize overall improvement of comprehensive competence.

Second, clarify the correlation between value system and innovation competence. A competence development matrix centered on value guidance is constructed. Teaching objectives and evaluation criteria for each training stage are systematically designed covering core socialist values, patriotism and personal quality, engineering knowledge and technical competence, as well as non-technical engineer competencies including communication & collaboration, project management and ethical judgment, so as to promote the improvement of students' innovation capabilities.

2.3 Conflicts between Fixed Mindsets and Multi-disciplinary Integration Competence

The on-campus practical teaching of local universities generally has deficiencies in docking real industrial demands. Traditional single-course experiments focus on intra-curricular verification and standard tasks, while cross-disciplinary verification experiments are insufficient. Students are expected to develop multi-disciplinary integration competence merely through scattered practical segments. The contradiction between ingrained traditional mindsets and students' demands for multi-disciplinary integration competence becomes prominent. To tackle this problem, this paper builds a trinity applied innovative talent-training platform, with on-campus training, off-campus practical training and competition-innovation integration as main lines. It forms a complete chain covering knowledge construction, competence training and innovation practice, responds to the requirements of cross-disciplinarity, practicality and innovation under Emerging Engineering Education, and mitigates the above contradiction.

Specific implementation paths are as follows:

First, for on-campus training, relying on featured research teams in numerical-control & intelligent manufacturing, virtual simulation and intelligent control, an integration mode of research-teaching integration, project-driven learning and platform-promoted practice is adopted. Frontier research achievements are transformed into innovation-entrepreneurship training projects, transferring research resources into teaching resources effectively. Students enhance systematic thinking and innovative design capabilities in real-world research scenarios and break mindset solidification.

Second, for off-campus practical training, deepen the university-enterprise collaborative education mechanism and jointly build high-level practical training bases. Integrate enterprise practical modes and university teaching models to supplement single-dimension on-campus practice and improve students' multi-disciplinary and multi-industrial practical integration competence.

Third, for competition-innovation integration, take student science & technology associations as organizational carriers to establish a normalized mechanism of promoting innovation and learning via competitions. Organize cross-disciplinary student teams to participate in high-level subject competitions. Students exercise technical problem-solving, teamwork and complex-problem solving capabilities in high-intensity and high-complexity competition tasks. Cross-major team formation breaks reliance on traditional laboratory verification practice, achieves multidisciplinary integration, and stimulates endogenous motivation for independent innovation and continuous exploration.

3 Construction of the Practical Education System

3.1 New Concept of Proactive Ideological-Political Education

The new concept of proactive ideological-political education is proposed based on practical value system theory, and a curriculum-based ideological-political mode matching practical teaching is established. Its core transforms one-way teacher lecturing into teacher-student co-construction. Special emphasis is placed on students' background selection and significance analysis in practical segments such as subject competitions and comprehensive training. When selecting topics, forming teams and tackling technical difficulties, students perceive the spiritual connotation of red-gene culture and understand engineering ethics and professional morality through the intrinsic meaning of projects, and internalize ideological-political contents in real-world practice scenarios. Therefore, value guidance is embedded into the whole process of engineering practice. A four-dimensional ideological-political system including role-model stories, philosophical speculation, logical methods and engineering practice is constructed around the dedication spirit of scientific-technological workers and craftsmanship spirit. This approach solves the disconnection between curriculum-based ideological-political education and practical teaching, and realizes the organic integration of value shaping and engineering competence cultivation.

Case 1: In the course Mechatronic System Innovation Design Practice offered by the Mechatronic Engineering program of School of Mechanical Engineering, Sichuan University of Science & Engineering, specific research directions are set by departments (agricultural machinery, intelligent manufacturing, industrial robots, etc.). With the guidance of class tutors, students analyze the background and significance of selected topics within given scopes and make presentations. They actively explore the impacts of research topics at national, social and individual levels, and tutors offer guidance to naturally introduce ideological-political concepts.

3.2 Multidisciplinary-Integrated Practical Teaching System

Adjustments are made on teaching systems. Multidisciplinary-integrated comprehensive training projects considering practical values and innovation competence are set up, and a multi-disciplinary integrated practical teaching system is designed. Beyond single-major boundaries, it integrates knowledge and capabilities from mechanical engineering, control science, material science, measurement & testing, computer science and other disciplines. A four-level progressive practical curriculum module is formed: basic skills → comprehensive training for Emerging Engineering Education → multidisciplinary integrated training → high-level subject competitions.

Case 2: Students from School of Mechanical Engineering participated in the National Final of the 27th China Robot and Artificial Intelligence Competition with the project "Pipeline-Cleaning Robot Based on Artificial Intelligence". This project integrates mechanical, control and computer disciplines for systematic professional training. Team members are from multiple majors including computer science & control engineering, automation & electrical control engineering, physics & electronic engineering and mechatronic engineering. Task division and interdisciplinary collaboration deepen students' understanding of curriculum systems and improve communication competence. Guided by competition platforms, students recognize national development demands and enhance comprehensive abilities as well as ideological-political literacy in multidisciplinary practice.

3.3 Trinity Talent-training Paradigm Integrating University, Industry and Competition

For application-oriented undergraduate universities, a trinity applied innovative talent-training paradigm is explored. It integrates on-campus research teams, off-campus enterprise resources and student science-technology associations, forming a three-party linkage training framework with differentiated focuses. On-campus research teams adopt research-teaching integration and project-driven modes to instruct students. Off-campus university-enterprise co-constructed practical training bases enable students to gain front-line experience. Student science-technology associations promote innovation via competitions. This paradigm breaks barriers among teaching, research and industry, and realizes the integration of knowledge delivery, competence cultivation and industrial practice, providing a replicable reference for applied innovative talent cultivation.

Case 3: School of Mechanical Engineering of Sichuan University of Science & Engineering carries out joint university-enterprise training with Sichuan Changzheng Machine Tool Co., Ltd. and Sichuan Kexin Mechanical & Electrical Co., Ltd. Leveraging enterprise advantages, enterprises assign research topics. Students integrate curriculum tasks such as Special Comprehensive Course Design, Graduation Design and Mechatronic Transmission Control into enterprise topics. The completed achievements are further applied to subject competitions such as China International College Students' Innovation and Entrepreneurship Competition and "Challenge Cup". Students' practical competence is comprehensively improved. Meanwhile, enterprises obtain qualified talents and shorten internal talent-training cycles.

4 Teaching Feedback and Reflections

Feedback data from students, departments, counselors, schools and enterprises are collected to verify the feasibility and promotability of this approach. From students' perspective, comprehensive practical capabilities are significantly improved, together with better knowledge mastery, team management and professional skills. Counselors report stronger sense of collective honor and higher competitiveness among students. Teaching management becomes more efficient. Majors observe deeper understanding of professional knowledge, improved employment and further-study rates, and better recognition from enterprises. The whole campus benefits from richer student achievements and improved study atmosphere.

Nevertheless, reflections are summarized for further promotion:

Sustained motivation of students needs to be guaranteed. Undergraduates face various new affairs. How to enhance students' autonomous learning capacity is critical for system implementation. The system works well for most students, while some individuals still lack subjective initiative.

Improve the timeliness of multi-party information feedback. Shortening information circulation among students, counselors, departments, university and enterprises is an important breakthrough for future optimization.

5 Conclusions

Targeting the disconnection between value shaping and practical competence cultivation in engineering education, this paper systematically constructs and implements a practical education system for Emerging Engineering Education with equal emphasis on value and competence and diversified integration of university-industry-competition-innovation. Three innovative measures are realized: the innovative proposition of proactive ideological-political education mode to embed value guidance into the whole engineering practice process; the construction of multidisciplinary-integrated practical teaching system to break traditional disciplinary barriers; and the establishment of trinity university-industry-competition platform to realize precise docking between talent cultivation and industrial demands.

The research results demonstrate that the system effectively solves prominent problems including superficial curriculum-based ideological-political education, outdated practical contents and insufficient university-industry integration, and provides practically-tested solutions for Emerging Engineering Education construction in application-oriented universities. Its innovation lies in the organic unification of value shaping and competence cultivation, deep coordination of interdisciplinary and university-industry integration, and positive interaction between theoretical learning and engineering practice.

In future research, continuous iterative optimization will be carried out. Further exploration will focus on digital transformation, engineering education accreditation and cross-disciplinary curriculum group construction, so as to further perfect the practical education mode for Emerging Engineering Education with Chinese characteristics and cultivate outstanding engineering talents for national rejuvenation.

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