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Research on the "Three-Dimensional Empowerment" Training Mode for Cultivating Engineering Practice Ability of Mechanical Engineering Undergraduates

Long Liu[1,a,*], Huan Ren[2,b], Jin Du[1,c], Jinpeng Bi[1,d]

[1]*Faculty of Mechanical Engineering, Qilu University of Technology (Shandong Academy of Sciences), Daxue Road, Jinan, China*
[2]*Faculty of Chemistry and Pharmacy, Qilu University of Technology (Shandong Academy of Sciences), Daxue Road, Jinan, China*
[a]*15269139995@126.com*, [b]*672435669@qq.com*, [c]*dj84105@126.com*, [d]*jinpengtqm@126.com*
**Corresponding author*

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Abstract: The construction of Emerging Engineering Education has raised higher standards for engineering talent cultivation, making the enhancement of undergraduate engineering practice ability a core issue in current higher education reform. Taking the student affairs system of the School of Mechanical Engineering at Qilu University of Technology as an example, this study proposes a "Three-Dimensional Empowerment" training mode from the perspective of university Youth League Committee. Characterized by value guidance, competition-driven development, and industry-university collaboration, the proposed training mode takes the second classroom as the primary field and the School-level Youth League Committee as the main implementing body. Deep integration and systematic linkage across value shaping, competence forging and industry alignment are achieved, thereby constructing a complete educational ecosystem to mutually support and synergize with the first classroom. The mode offers a replicable and scalable systematic solution for improving the engineering practice ability of mechanical engineering undergraduates.

1. Introduction

The world is currently undergoing an accelerated phase of a new round of scientific-technological revolution and industrial transformation. High-end equipment manufacturing industries represented by intelligent manufacturing, additive manufacturing and robotics have become the strategic commanding heights of competition among major powers. In response, China has successively issued landmark policy documents such as Made in China 2025, the Emerging Engineering Education Construction Guide, as well as the "Fudan Consensus," "Tianjin University Action," explicitly calling for the accelerated cultivation of outstanding engineering talents capable of leading future technological and industrial development. As the cornerstone discipline of the manufacturing sector, the quality of undergraduate education in mechanical engineering directly

affects the core competitiveness of national manufacturing. However, traditional engineering education models remain predominantly centered on knowledge delivery in the first classroom. Although effective in constructing systematic theoretical frameworks for students, they exhibit clear shortcomings in stimulating intrinsic motivation, providing training in solving complex engineering problems, and fostering teamwork, engineering ethics, and professional responsibility. The second classroom, as an important extension and functional complement to the first classroom, will fail to generate systematic educational synergy if it remains confined to fragmented activities. Therefore, under the Emerging Engineering Education framework, a critical pathway is to scientifically design and leverage the unique advantages of the second classroom.

In recent years, Chinese scholars have conducted continuous and in-depth explorations into the cultivation of engineering practice ability among mechanical engineering undergraduates, yielding substantial achievements. Hu et al. [1] constructed a school-enterprise collaborative, tiered training system comprising mixed faculty development, progressive platforms, curriculum optimization, capability expansion, layered training, and competition linkage. Han et al. [2] took theoretical teaching, experimental teaching, and the integration of theory and practice as entry points, proposing progressive strategies and concrete measures for enhancing engineering practice ability under the Emerging Engineering paradigm. Deng et al. [3] found that, to cultivate outstanding engineering talents with practical and innovative abilities, a practical teaching reform plan centered on engineering capability cultivation can be implemented, which includes constructing a comprehensive practical teaching system, establishing a co-creation-oriented practical talent training platform, and optimizing the engineering practice teaching team. Based on school-enterprise collaborative theory, Liu [4] deeply analyzed the components of engineering practice ability and designed a comprehensive system integrating curriculum restructuring, diversified practice platforms, and scientific evaluation mechanisms. Zhu et al. [5] have implemented the "three restructurings" initiative for professional development: restructuring the professional training system, restructuring the education and teaching process, and restructuring the practical teaching platform.

Although existing studies have made significant progress in individual or dual dimensions, there is a notable lack of systematic practical summaries and theoretical refinement that take grassroots university Youth League Committees as the primary actor and the second classroom as the main arena. Correspondingly, this study systematically proposes the “Three-Dimensional Empowerment” cultivation mode characterized by value guidance, competition-driven development, and industry-university collaboration, from the frontline perspective of a school-level Youth League Committee. It thoroughly analyses the mode’s theoretical mechanisms, implementation pathways, and educational outcomes, which provides solution for cultivating engineering practice ability among mechanical engineering undergraduates in the context of Emerging Engineering Education.

2. Constructual Logic and Connotation of the “Three-Dimensional Empowerment” Model

The development of practical engineering abilities in mechanical engineering undergraduates encompasses not only technical operational skills but also comprehensive qualities such as engineering thinking, innovation awareness, teamwork, and professional ethics. Based on this understanding, the present study establishes a construction logic of “Ideological Foundation, Practical Empowerment, and Synergistic Support.” The organic integration of these three dimensions facilitates a fundamental shift in students from passive knowledge recipients to active practice explorers. Theoretically, this model aligns with the "Whole-Person Education" philosophy and engineering education accreditation standards, achieving an organic unity of value shaping, ability cultivation, and knowledge imparting. It directly responds to the Emerging Engineering

Education framework's demand for interdisciplinary and innovative talents. Practically, it addresses prevalent issues among mechanical engineering students, such as the theory-practice disconnect, lack of innovation motivation, and unclear professional identity. It systematically establishes a closed-loop educational logic: Value Guidance tackles the motivation question of "Why practice"? Competition Drive addresses the pathway question of "How to practice"? Industry Collaboration answers the orientation question of "For what purpose do we practice"?

3. Implementation Pathways and Strategies of the "Three-Dimensional Empowerment" Mode

With the student affairs system primarily led by the Youth League Committee, systematic and operable pathways are established around three dimensions. Thus, a practical education framework characterized by full participation, whole-process coverage, and comprehensive support is developed.

3.1 Value Guidance Dimension

The value guidance dimension focuses on cultivating students' ideological foundation. Through role-model demonstration, thematic practical activities, and seamless integration of ideological-political education, a multi-level motivation activation system has been established.

3.1.1 Systematic Construction of the Role-Model Demonstration System

The School Youth League Committee has developed the "Stars of Mechanical Engineering" honorary program, which encompasses four selection categories: academic research, scientific and technological innovation, internship practice, and voluntary service. A comprehensive evaluation standard combining quantitative outcomes and process assessment has been formulated. Each year, 10-15 outstanding representatives are selected, and their stories are continuously featured in the "Shining Stars" series on the official WeChat public account "Zhixing Mechanics". These reports not only highlight hard achievements such as competition awards and patents, but also delve into the recipients' perseverance and their commitment to serving industrial development. Regular "Role Model Sharing Sessions" are organized to facilitate face-to-face interaction between senior and junior students, creating a ripple effect whereby "one exemplar inspires many".

3.1.2 In-Depth Development of Thematic Practical Activities

The innovative "Mobile Youth League Class" program has been launched, featuring parallel dual-track routes of "revolutionary education bases + leading industry enterprises". The revolutionary track takes students to sites such as the Yimeng Revolution Memorial Hall and the Jinan Campaign Memorial Hall, enabling them to deeply appreciate the contemporary significance of craftsmanship spirit through historical reflection. The industry arranges visits to flagship enterprises such as China National Heavy Duty Truck Group and Weichai Power, where students observe intelligent production lines and R&D centers to gain firsthand understanding of China's achievements in mechanical manufacturing. Follow-up activities, including reflection essays and themed League Day sharing sessions, are conducted to consolidate learning outcomes.

3.1.3 Full-Process Integration of Ideological-Political Elements

Ideological and political education is organically embedded throughout the second classroom. For instance, dedicated modules on "engineering ethics" are incorporated into competition training, using cases of major national equipment to illustrate engineers' social responsibilities. Pre-

internship training on “professional conduct” emphasizes quality awareness and safety standards. Social value criteria are introduced in the evaluation of practical outcomes to guide students toward broader societal impact. This scenario-based and embedded approach ensures the simultaneous advancement of professional competence and value formation.

3.2 Competition-Driven Dimension

Disciplinary competitions serve as the primary vehicle, enabling the construction of a tiered cultivation mechanism that achieves both broad coverage and targeted excellence.

3.2.1 Construction and Operation of an Inclusive Competition Platform

The School Youth League Committee organizes an annual “Science and Technology Innovation Cultural Festival,” which features multiple school-level events across categories such as mechanical innovative design, intelligent equipment application, and industrial robot operation. A zero-threshold registration and modular training policy is implemented. Foundational courses and specialized lectures delivered by faculty members are provided for lower-grade students, while essential equipment, venue support, and a seamless “online registration-offline training-centralized competition” service process are offered to all teams. This inclusive platform effectively extends practical training opportunities to the vast majority of mechanical engineering undergraduates.

3.2.2 Cultivation and Management of Elite Competition Teams

A three-level progressive mechanism of school-level selection, university-level intensive training and provincial/national competition sprint has been established. Specialized teams are formed for high-level events such as the “Challenge Cup” and the National Undergraduate Mechanical Innovation Design Competition. An expert guidance panel composed of faculty members provides tailored technical coaching. Dedicated laboratories equipped with advanced facilities are allocated, and special funding is secured to cover materials and travel expenses. A structured management system featuring weekly progress meetings and phased assessments is enforced, with Youth League instructors offering full-cycle project management and psychological support, thereby sustaining stable competitiveness in prestigious competitions.

3.2.3 Transformation and Extension of Competition Outcomes

A systematic outcome transformation mechanism has been instituted to encourage students to convert award-winning works into patents and entrepreneurship projects. A dedicated incubation fund provides financial support, and policies linking competition achievements with course credit recognition and postgraduate recommendation bonuses have been jointly formulated with the academic affairs office. This approach has formed a virtuous cycle of competition participation, competence enhancement and innovation output, which maximizes the long-term educational value of competitions.

3.3 Industry-University Collaboration Dimension

With deep school-enterprise cooperation as the core link, industrial resources are transformed into high-quality educational assets to establish an integrated “practice base-resource introduction-collaborative education” framework.

3.3.1 Networked Layout of Tiered Practice Bases

The college Youth League Committee, in collaboration with the career services department and corporate partners, has established a four-tier practical training base network covering cognitive internship, production internship, graduation project and employment and entrepreneurship. Together with 25 renowned enterprises, the college has co-established Communist Youth League Employment and Entrepreneurship Internship Bases, including 9 cognitive internship bases, 10 production internship bases, and 6 graduation project bases. Differentiated practical content is designed for students of different academic years: lower-year students focus on corporate cognition and process understanding; middle and upper-year students participate in production operations and skill training; and graduating students complete their graduation projects based on real-world enterprise topics. In 2024, the participation rate of mechanical engineering undergraduates in practical training reached 100%, with over 60% of students completing their graduation projects at these internship bases. This tiered practical training platform ensures the continuity and effectiveness of practical training.

3.3.2 Systematic Introduction of Industrial Resources

The "Famous Enterprise Tours" activity organizes students to visit enterprise frontline sites each semester. Since 2021, a total of 10 sessions has been conducted, visiting 18 companies including China National Heavy Duty Truck Group and Weichai Power, covering over 1300 student participants and helping students gain firsthand understanding of the industrial landscape. The "Double Hundred Lectures" invite corporate experts to deliver technical talks in the college, covering cutting-edge fields such as intelligent equipment and new energy vehicles, with an average of 18 sessions held annually. Under the "Industrial Mentors" program, 32 enterprise technical experts have been appointed to participate in competition guidance, course teaching, and project evaluation, integrating industrial trends and real-world cases into the talent cultivation process.

3.3.3 Establishment of a Long-Term Collaborative Education Mechanism

A two-way feedback mechanism has been institutionalized through regular school-enterprise symposia, enabling timely adjustment of training programs in line with evolving industry needs. Faculty members are encouraged to conduct joint research projects with partner enterprises, with research outcomes subsequently incorporated into teaching content. Meanwhile, enterprises grant priority employment to outstanding interns, thereby forming a closed-loop pathway from talent cultivation through practical training to seamless employment transition. This sustained collaborative mechanism significantly strengthens graduates' professional competitiveness and rapid workplace adaptability.

4. Innovative Mode Achievements

The sustained implementation of the "Three-Dimensional Empowerment" mode has yielded remarkable results across multiple dimensions. In terms of engineering practice and innovation competence, student engagement in scientific-technological competitions and innovation-entrepreneurship projects has risen sharply. Since the mode was introduced, the student participation rate in science and technology innovation activities increased from 45% in 2021 to 88% in 2025. Students have collectively won 436 national-level and provincial-level awards, 39 College Students' Innovation and Entrepreneurship Training Programs, 47 published academic papers and 17 authorized national invention patents.

Employment quality and workplace adaptability have also reached leading levels. The 2024

cohort achieved an initial employment rate of 96.8%, 12% higher than the provincial average for comparable programs. More than 85% of graduates entered the mechanical manufacturing sector, primarily joining renowned enterprises such as China National Heavy Duty Truck Group, Haomai Group, and Weichai Power. A satisfaction survey of 187 employing organizations revealed that 92% and 89% rated graduates as possessing strong hands-on ability and rapid job adaptation, respectively. While overall satisfaction with training quality and practical innovation competence exceeded 93%.

In addition, further study and social responsibility outcomes are equally encouraging. The college-wide course failure rate dropped from 15% in 2021 to 12% in 2025, while the postgraduate admission rate rose from 30% to 38%. Among those admitted to "Double First-Class" universities, 60% had distinguished themselves through high-level competitions or in-depth enterprise practice.

5. Conclusions

The "Three-Dimensional Empowerment" mode developed by the School of Mechanical Engineering at Qilu University of Technology represents an effective practice of collaborative education between the second classroom and the first classroom under the framework of Emerging Engineering Education. Its core lessons lie in the following: adhering to a student-centered philosophy to achieve precise alignment between educational objectives and student needs; applying systems thinking to construct a multi-dimensional, interconnected educational ecosystem; and emphasizing practice orientation to promote deep integration of educational resources with industry requirements. By employing value guidance to address the issue of practical motivation, competition-driven development to enhance competence, and industry-university collaboration to ensure alignment with real-world demands, the mode has significantly improved both the engineering practice ability and overall quality of mechanical engineering undergraduates.

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