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Research on the Collaborative Training Path for Outstanding Engineering Talents in Mechanical Engineering between Universities and Enterprises

Ailing Song*

School of Mechanical and Power Engineering, East China University of Science and Technology, Shanghai, China

**Corresponding Author*

Abstract: Outstanding engineers are the key strategic force supporting the transformation and upgrading of the national manufacturing industry. This paper focuses on the field of mechanical engineering and systematically analyzes the structural problems such as insufficient goal coordination, lack of driving force, and weak resource integration existing in the current collaborative training model between universities and enterprises. Based on this, taking East China University of Science and Technology as an example, innovative paths such as optimizing the training plan, implementing the dual-mentor collaboration mechanism, and constructing a mutually beneficial cooperation ecosystem are proposed. The aim is to bridge the gap between academic training and industrial demands, and provide theoretical basis and practical reference for improving the quality of independent training of outstanding engineers in mechanical engineering.

Keywords: Outstanding Engineers; Mechanical Engineering; Collaborative Training; Universities and Enterprises

1. Introduction

In the context of the deep evolution of the global new round of technological revolution and industrial transformation, engineering technology talents have become the core component of the national strategic scientific and technological strength. As the foundation of the manufacturing industry, the mechanical engineering field has an especially urgent need for outstanding engineers with outstanding innovation capabilities and the ability to solve complex engineering problems[1]. East China University of Science and Technology, as the first research-oriented university in China renowned for its chemical engineering specialties, has accumulated profound educational and training experience in engineering technology during its long-term service in the construction of national pillar industries. However, in response to the new economic forms such as "intelligent +" and "carbon neutrality" that have brought entirely new requirements for the knowledge structure of talents, the traditional training system based on disciplinary logic is facing severe challenges[2].

Since the Ministry of Education launched the "Outstanding Engineer Education and Training Program" in 2010, promoting deep collaboration between universities and enterprises and strengthening the cultivation of engineering practice and innovation capabilities has become a national strategic consensus for improving the quality of engineering education. This discussion profoundly reveals the core essence of the collaborative education between universities and enterprises: Universities possess irreplaceable academic advantages in imparting basic theories and exploring cutting-edge disciplines, while enterprises have inherent advantages in tackling major engineering challenges, applying real scenarios, and transforming technological innovations. The complementary advantages of the two are not only the inevitable path to improving the quality of engineering master's and doctoral students' training, but also a key measure to respond to the urgent demand for top-notch innovative talents from the country[3].

However, current collaborative efforts between universities and enterprises mostly remain at the shallow level of resource connection, and have not yet formed a deeply integrated mechanism that runs through the entire cycle of talent cultivation. How to break through disciplinary and industry barriers and construct a path for cultivating outstanding mechanical engineering engineers that meets the needs of the new era has become the core issue that needs to be broken through in the reform of higher engineering education. Based on this, this article, based on national strategic needs and the characteristics of our university's disciplines, deeply examines the practical predicaments of the traditional mechanical engineering talent training model, and explores the construction of a new paradigm for cultivating outstanding mechanical engineering engineers with a core of collaborative education and a focus on capability attainment. It aims to provide a reform sample that can be learned from for similar institutions.

2. Research Status of Collaborative Training for Outstanding Engineers in Universities and Enterprises

To accurately identify the key bottlenecks in the current process of cultivating outstanding engineers in the mechanical engineering major, this study adopts a mixed research method combining quantitative and qualitative approaches. Through systematic literature review and questionnaire surveys of graduate students in the mechanical engineering disciplines of multiple "Double First-Class" construction universities, data were collected on core dimensions such as learning commitment, course satisfaction, mentor guidance, research training, internship experience, and assessment evaluation. Combined with descriptive statistics and correlation analysis, it reveals the threefold structural mismatch issues in the current collaborative training system.

2.1 Insufficient Alignment of Goals between the School and the Enterprise

The primary obstacle to collaborative education lies in the inherent tension of organizational goals. Universities, as academic institutions for knowledge transmission and innovation, focus on the completeness of the disciplinary knowledge system, the cultivation of students' theoretical literacy, and the exploration of their long-term development potential; while enterprises, as market entities, highly focus on the job competence, i.e., combat effectiveness, and the contribution to short-term production efficiency of the talents they recruit. This fundamental difference between "academic orientation" and "market orientation" directly leads to difficulties in reaching a deep consensus on key aspects such as training standards and ability assessment between the two parties. Specifically, the update of the curriculum system in the mechanical engineering major of universities often lags behind the industrialization process of emerging technologies such as intelligent manufacturing and industrial internet, resulting in a significant time gap and structural mismatch between the knowledge and skills students have acquired and the actual job requirements of enterprises. At the same time, enterprises, fearing the long-term investment in collaborative education carrying the risk of technology leakage and the long return cycle, their participation is mostly limited to providing visiting and internship or basic operation positions, with little motivation to touch upon the deep collaborative links such as the design of the training plan and the development of core courses. The two parties have not yet established a long-term binding contract mechanism with strong constraints, and their cooperation is mostly characterized by short-termization and projectization, unable to generate institutionalized collaborative effects.

2.2 Lack of Collaborative Motivation for Training Model between Schools and Enterprises

The traditional engineering education training model has formed an inertial path dependence, resulting in a lack of a common vision between the university and the enterprise in the innovation collaborative goals. On one hand, the internal evaluation system of universities still focuses on academic papers and vertical projects, and teachers' motivation to engage in teaching reform and the iteration of engineering practice capabilities is insufficient, with widespread phenomenon of the disconnection between course teaching content and the cutting-edge technologies in the industry. On the other hand, enterprises view participation in education as an additional cost expenditure rather than strategic human resource investment, lacking the intrinsic motivation to deeply intervene in the early stage of talent cultivation. This conceptual mismatch has led to the cultivation of outstanding engineers falling into an inefficient cycle of "emphasizing knowledge transmission, neglecting ability forging". The deeper problem lies in the insufficiency of the effectiveness of the collaborative platform. At the technical transformation level, universities' research aims for theoretical originality, while the core process technology of enterprises is difficult to be transformed into teaching cases due to confidentiality requirements, forming a barrier of "frontier technology cannot enter the classroom". At the faculty allocation level, university teachers generally lack rich engineering field experience, while the hired enterprise experts, although highly skilled, often due to limitations in teaching ability and experience, cannot effectively transform practical experience into teaching resources, resulting in the awkward situation of "understanding technology but not good at teaching, and good at teaching but unable to practice". Due to the lack of effective cost sharing, risk sharing, and benefit sharing mechanisms, the resource investment of the two parties cannot generate synergistic benefits, and the innovation ability cultivation is stagnant at the primary level.

2.3 Inadequate Integration of Practical Teaching Resources

Practical teaching is the core part of cultivating the capabilities of outstanding engineers, but its effectiveness is highly dependent on the access and transformation of high-quality industrial resources. Currently, the lack of smooth connection between university and enterprise technical resources constitutes the primary barrier: The experimental teaching in universities mainly focuses on verifying principles, while the complex process parameters and system optimization logic involved in actual production in enterprises, due to the constraints of commercial confidentiality agreements, are difficult to be effectively transformed into teaching materials. Even during the internship period, students are often assigned to non-core operational positions and are unable to participate in the complete technical research or process improvement procedures, resulting in the lack of a real "training ground" for developing the system thinking and innovative decision-making skills required to solve complex engineering problems.

Furthermore, the joint laboratories or training bases jointly established by universities and enterprises face challenges in operational efficiency. Enterprises, in order to ensure normal production order and the safety of core equipment, usually have a conservative attitude towards granting access to equipment, causing some jointly-built platforms to function abnormally and the utilization rate to be far below expectations. The root cause of this lack of resource integration lies in the deep differences in organizational operation logic between the two parties: Universities pursue the breadth of knowledge dissemination and the depth of academic exploration, while enterprises are driven by profits and efficiency. The two have not yet established a value co-creation and resource connection mechanism that can accommodate both parties' core demands. The absence of top-down design and continuous policy guidance makes resource collaboration dependent on the temporary promotion of individual projects, making it difficult to form a stable, efficient, and regular integrated development pattern.

3. Innovation in the Collaborative Training Pathway

In response to the structural problems such as target deviation, lack of motivation, and resource barriers existing in the collaborative education between schools and enterprises, the reform of the mechanical engineering excellence engineer training model should shift from scattered "point-based cooperation" to a systematic "ecological construction". The innovative path should focus on the reconfiguration of the training plan, the upgrading of the guidance model, and the reengineering of the cooperative relationship, forming a new paradigm of collaborative education with common goals, shared processes, and shared outcomes.

3.1 Establishing an "Outcome-Based Education" Modular Curriculum System

The talent training plan is the core carrier for translating educational concepts into practical training outcomes. In response to the rapid evolution of the mechanical engineering field towards intelligence and greenness, the curriculum system reform needs to break free from the traditional "subject-centered" constraints and establish the "Outcome-Based Education" (OBE) concept centered on ability attainment[4]. First, the modular design of the knowledge structure should be reformed. The rigid barriers between basic courses, professional courses, and elective courses should be broken. Based on core ability dimensions such as mechanical design, manufacturing technology, measurement and control technology, and robot application, a hierarchical and closely-connected curriculum group should be constructed. In the curriculum setting, in addition to strengthening the foundation of mathematics and mechanics, cutting-edge cross-disciplinary modules such as intelligent manufacturing, industrial big data, and digital twin should be proactively implanted to expand students' technical horizons. At the same time, courses such as engineering introduction and project-based learning that run through the undergraduate and postgraduate stages should be set up to guide students to establish an engineering system view and creative thinking from the very beginning of their enrollment. Secondly, deepening the course development mechanism for industry-academia integration. Enterprises should move from being the "terminal users" of talents to the "co-designers" of the training plan. Both the university and the enterprise should jointly establish a curriculum construction committee, and deeply integrate actual engineering cases, technical standards, and job ability requirements into the teaching syllabus and textbook compilation. By introducing enterprise mentors to teach "real-world" engineering examples, theoretical teaching should be closely linked to industrial practice, fundamentally eliminating the "time gap" between teaching content and technological development in enterprises. Finally, promoting the practical orientation of teaching methods. The "project-based" teaching method should be promoted in experiments, practical training, and course design. Teachers can rely on simplified or adapted cases from the production frontlines of enterprises to guide students to internalize theoretical knowledge in solving realistic problems. At the school level, systematic organizing of science and technology competitions, academic salons, and interdisciplinary innovation workshops should be carried out, along with dedicated funds and teacher guidance, to serve as a powerful extension of the curriculum system, and to build a three-dimensional training space of "foundation building in class, ability training outside class".

3.2 Improve the "Equivalent Rights and Responsibilities" Dual-Mentor Collaborative Mechanism

The dual-mentor system is a key institutional design for achieving the deep integration of theory and practice, but its effective operation relies on the precise positioning of both mentors' roles and the collaborative efforts of incentive and restraint mechanisms. On one hand, the responsibilities and ability complementarity paths of the dual mentors should be clearly defined. The internal school mentors should focus on the solidification of students' academic foundation, the construction of theoretical frameworks, and systematic training of methodological skills; the enterprise mentors should focus on the guidance of engineering practice, the imparting of industry norms, and the cultivation of strategies for solving complex on-site problems. To enhance the cross-border guidance capabilities of both mentors, institutional channels should be established: encourage young teachers to take up positions in the cooperating enterprises for on-the-job training or engage in postdoctoral research, and use engineering practice experience as an important reference for career advancement; at the same time, provide systematic education and teaching method training for enterprise mentors and explore the inclusion of the educational contributions of senior enterprise experts in the social evaluation system of their respective enterprises. On the other hand, a collaborative guidance model spanning the entire training process should be constructed based on real research projects. Enterprises can propose research topics based on their own technological breakthrough needs, and the school and enterprise sides can jointly assess their academic value and engineering feasibility before converting them into thesis topics for graduate students or team graduation design tasks. The two mentors will jointly guide the students throughout the entire cycle from proposal, mid-term to defense, requiring students to conduct necessary research and verification work at the enterprise site[5].

3.3 Build a Strategic Cooperation Platform for "Value Symbiosis"

The large-scale and high-quality training of outstanding engineers ultimately relies on the establishment of a new type of strategic partnership between universities and enterprises that goes beyond specific projects and has a broad strategic depth. This requires both parties to shift from "resource exchange" to "value symbiosis". First, a strategic cooperation framework with hierarchical alignment should be constructed. The cooperation should not be limited to the student internship stage but should extend to the entire chain of technological research and development, achievement transformation, and talent reserve. Universities should actively align with national strategic demands and regional industrial planning, leveraging the advantages of mechanical engineering disciplines, and sign strategic cooperation agreements with industry leaders to clearly define long-term investment and responsibilities in platform construction, technological breakthroughs and talent cultivation. The cooperation should set clear phased goals and quantitative assessment indicators, covering the construction of joint laboratories, the number of cooperative courses developed, student patent outputs and the benefits of joint technology transformation, etc., to ensure that the collaborative process is monitorable and assessable. Secondly, jointly build high-level collaborative innovation and education platforms. The school should jointly apply for or establish provincial and ministerial-level or higher-level engineering technology research centers and joint graduate student training bases for industry-academia integration. Such platforms should have dual attributes of technological research and talent cultivation, and in their operation mechanisms, break through the physical barriers between enterprise production and school teaching. By setting up "open projects" and "challenge-and-solution" projects, attract enterprise engineers and graduate students on campus to collaborate on platform-level research, which not only directly serves the product iteration and technological innovation of enterprises but also enables students to achieve a substantive leap in innovation ability in high-level scientific research practice. Finally, create a two-way enabling industry-university integration culture. The school should fully utilize its alumni network and industry influence, through regular events such as technology summits and industry development forums, introduce advanced corporate culture and technological frontiers to the campus. At the same time, the school's academic resources and basic research results should also be made available through the platform to the cooperating enterprises, helping them grasp the medium- and long-term technological evolution direction. Through this two-way interaction, ultimately form a joint enterprise-university integration community that shares benefits, bears risks and jointly educates talents, achieving a win-win situation for the improvement of school educational quality, the enhancement of enterprises' core competitiveness and the all-round development of students[6].

4. Conclusion

Based on the analysis of the current situation and the reconfiguration of the path for the collaborative training model of outstanding engineers in the mechanical engineering discipline, the following conclusions can be drawn: The core to resolving the current dilemma of collaborative education between universities and enterprises lies in promoting the transformation of the relationship between the two parties from scattered project-based cooperation to a systematic industrial-education integration ecosystem. This requires universities and enterprises to reach a consensus on "value symbiosis", by constructing an output-oriented modular curriculum system to bridge the structural mismatch between knowledge transmission and industrial demands, by improving the dual-mentor collaborative mechanism with equal rights and responsibilities to break through the gap between theoretical and practical ability cultivation, and by creating a high-level strategic cooperation platform to achieve resource sharing and common goals, so as to, in the institutional design, transform the enterprise's employment needs into training standards, and externalize the academic resources of universities into innovative momentum. Ultimately, in the continuous two-way empowerment, effectively enhance the innovative ability and comprehensive quality of outstanding mechanical engineers in solving complex engineering problems, and truly respond to the urgent needs of national strategies and industrial upgrading for top-notch engineering talents.

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