Study on the Construction Path of Automation Engineering Program under the Background of "New Engineering"

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Abstract: With the introduction of the "New Engineering Education" and the implementation of national strategies such as "Made in China 2025", universities are facing the urgent task of cultivating interdisciplinary and innovative engineering talents. This paper, using the Automation Program at Tianjin University of Commerce as a case study, analyzes the current challenges in undergraduate engineering education, such as outdated course content, insufficient interdisciplinary integration, and weak practical training. Based on the characteristics of industrial development and technical talent demands of Tianjin, this study explores a construction path for the automation program through 6 major areas: curriculum system optimization, interdisciplinary integration, reform of teaching methods, construction of diversified practical platforms, enhanced industry-education collaboration, and restructured assessment systems. By aligning academic training with regional industrial needs, the program achieves high-quality development and improves talent cultivation outcomes. The results demonstrate that the reform strategies significantly enhance students' engineering practice and innovation capabilities, providing valuable insights for other local universities exploring engineering education reform under the "New Engineering" framework.

Keywords: New Engineering; Automation Program; Curriculum Reform; Industry–Education Integration; Practical Teaching; Educational Innovation

1. Introduction

With the advent of a new round of industrial revolution and the launch of the "Made in China 2025" strategy, China is accelerating the intelligent transformation of its manufacturing sector. As a major economic hub in northern China and a center for advanced manufacturing, research and development, Tianjin has been actively advancing emerging industries in line with its "Manufacturing-Oriented City" strategy. This process calls for a large number of engineering and technical talents equipped with interdisciplinary knowledge and innovative capabilities, posing new challenges to traditional engineering education patterns. As key players in supporting local economic development, universities and colleges are in urgent need of upgrading their academic programs to cultivate innovative and versatile engineering professionals. In 2017, the Ministry of Education (MoE) introduced the concept of "New Engineering" (NE) and issued the "Notice on Launching Research and Practice of New Engineering", which clarified the objectives and direction for NE construction and encouraged universities to explore reforms in engineering education. In 2022, the MoE incorporated NE construction into the "14th Five-Year Plan," emphasizing its importance in the reform of higher education and promoting the high-quality development of engineering education.

This paper explores how to drive reform and development for Automation Engineering Program under the NE framework by improving teaching methods, enhancing interdisciplinary integration, and optimizing the curriculum system. The goal is to provide practical experience and insights into cultivating engineering talent that meets future industry demands. Many domestic universities and educators have already conducted multifaceted explorations of teaching reforms under the NE framework, based on the regional industrial and economic characteristics as well as institutional strengths.

For example, Li and Gao proposed program of curriculum cluster for mathematics to enhance professional teaching and improve talent training quality [1]. Ai et al. introduced a progressive course system as "BIM Design and Modeling-BIM Management and Application-Practical Training" [2]. Zhang and Zhang developed a specialized textbook named as "Introduction to Engineering for New Engineering Disciplines in Electronics and Information" for freshmen students to meet the requirement of NE construction [3]. Qian and Yin proposed a new teaching model for "Data Structures" based on an integrated machine learning framework [4]. Chen et al. focused on top-level design and a comprehensive, diversified NE talent cultivation model, establishing a quality assurance mechanism for talent training [5]. Chen et al. proposed the "Four-Element" instructional design model and the "One Cloud Three Integrations" innovative teaching reform initiative [6]. Hou et al. explored industry-education collaborative talent training models through curriculum restructuring, diversified teaching feedback, and the construction of practical education platforms [7]. Wang and Xue improved the teaching quality of the Intelligent Control course by strengthening practical instruction [8]. Peng et al. realized diversity of teaching models, goal-driven transformation of experimental projects and procedurization of assessment for the course named as "Operating Systems" through reforms [9].

2. Talent Requirements under the "New Engineering" Initiative and Challenges Faced by Education for Automation Engineering Program

The construction of "New Engineering" (NE) aims to address the challenges posed by the new wave of technological revolution and industrial transformation to the cultivation of engineering talent, promoting innovation and development in engineering education. "China Education Modernization 2035" proposes "formulating the diverse and forward-looking quality standards for higher education talent training", clarifying benchmarks for talent cultivation and emphasizing to develop high-quality education [10]. Accordingly, NE emphasizes the following core competencies in talent development:

(1) Interdisciplinary Integration: The ability to apply knowledge across fields such as artificial intelligence, big data, new energy, and bioengineering.

(2) Innovation and Practical Skills: Creative thinking and the ability to propose novel solutions. Emphasis is placed on engineering practice, mastering advanced experimental techniques, engineering tools, and innovative methodologies.

(3) Global Vision and International Competitiveness: Understanding global trends in engineering technology and industry standards, and being able to collaborate and compete in a globalized environment.

(4) Teamwork and Leadership: The ability to collaborate efficiently in multidisciplinary teams, with strong organizational, coordination, and leadership skills to accomplish complex engineering tasks.

(5) Lifelong Learning and Adaptability: The ability to continuously learn and adapt to new technologies in a rapidly evolving technological environment, with the capacity to transform and upgrade the knowledge system.

These competency requirements highlight the integration of theory and practice, and the balanced development of technical and humanistic literacy, aiming to cultivate compound engineering professionals capable of driving future technological innovation and industrial development. At the same time, the limitations of traditional engineering education models and present increasingly severe challenges for education, the key problems include:

(1) Disconnect between Curriculum Content and Technological Development

Traditional automation curricula still center on classical courses and lack deep integration of emerging technologies such as artificial intelligence, industrial internet, machine vision, and edge computing. This results in a mismatch between students' skills and actual industry demands.

(2) Insufficient Interdisciplinary Integration

Automation-related courses remain largely siloed and show weak cross-disciplinary interaction. Course content lacks effective integration across disciplines, making it difficult for students to develop interdisciplinary knowledge synthesis and solve complex engineering problems involving multiple domains.

(3) Weaknesses in Practical Teaching

Experimental teaching still relies heavily on traditional lab kits, with limited interactivity in project design. Overly detailed instructions on experimental steps and result analysis leave little space for independent thinking. University-industry collaborations are often superficial, offering students few opportunities to engage in real projects. The absence of practical training based on real-world projects, real problems, and real data leads to generally weak engineering practice and innovation abilities. Additionally, a shortage of advanced equipment and supporting resources, such as industrial robots, digital twin platforms, and industrial internet systems—hinders course development and talent cultivation.

(4) Misalignment between Evaluation Systems and Enterprise Needs

Current evaluation methods are overly reliant on final written exams and fail to adequately reflect students' engineering practice capabilities and teamwork. This results in a skill gap between graduates and industry needs, weakening their competitiveness in the job market and failing to meet the demand for highly skilled professionals.

(5) Poor Alignment between Curriculum and Industrial Demands

The current curriculum for automation programs lacks sufficient connection to local industry needs and fails to incorporate content tailored to regional industrial characteristics.

In summary, systematic improvements are urgently needed in automation education to better meet the demand of modern industries and enterprises for innovative, interdisciplinary engineering talent.

3. Industrial Characteristics of Tianjin and Talent Demand

When planning talent development directions, determining training pathways and formulating education programs, local universities must align closely with the industrial characteristics of their region, understand local advantages, and accurately identify talent needs to ensure targeted and effective education strategies.

Automation Engineering Program of Tianjin University of Commerce, the talent cultivation approach should begin with a thorough analysis of Tianjin's industrial landscape. According to data from the Tianjin Municipal Bureau of Statistics in 2024, the added value of high-tech manufacturing enterprises increased by 8.9%. The output of emerging products such as industrial robots and service robots grew by 13.0% and 32.7%, respectively. Investment in high-tech industries rose by 12.1%. The output of complete electronic computers increased 2.3 times, and the production of electronic components grew by 16.3%.

These indicators reflect Tianjin's continuous efforts to promote technological innovation and industrial upgrading, with the goal of building a "Smart Port City." The city is focusing on key areas such as intelligent factories and high-end manufacturing, new energy vehicles, and smart port logistics. Automation technologies play a central role in these industries, as illustrated in the Table 1:

Table 1. Industrial Sector and Automation Technology

Industrial Sector	Description of Automation Technology Demand
Smart Factories and High-end Manufacturing	Industrial robot digital twin technology industrial internet machine vision AI algorithms
New Energy Vehicles	Autonomous driving systems intelligent control units V2X communication
Smart Ports	AGVs and unmanned scheduling systems, intelligent warehousing and logistics systems

According to the "14th Five-Year Plan for the High-Quality Development of the Manufacturing Industry in Tianjin", the talent gap in the field of intelligent manufacturing is expected to exceed 100000 skilled professionals by 2025. In response, the "Three-Year Action Plan for the Development of the New Generation Artificial Intelligence Industry in Tianjin" explicitly emphasizes the need to "strengthen the development of disciplines such as artificial intelligence and automation in universities, and promote industry-education integration in talent cultivation."

In light of this, the Automation Program has formulated a talent development direction characterized by "intelligent empowerment and industry-education integration," tailored to the local industrial landscape which is marked by deep technological frameworks, broad deployment, and rapid updates. A New Engineering education framework has been established, adopting a student-centered approach that provides abundant practical resources and flexible teaching models. The program focuses on cultivating talent proficient in key technologies such as the industrial internet, artificial intelligence, and digital twins.

4. Countermeasures and Practices

4.1 Optimizing the Curriculum System

To better align with the talent demands of Tianjin's industrial development, the college has revised the curriculum and training program. Based on core courses such as "Signals and Systems", "Automatic Control Theory", "Sensor Principles and Applications", and "Modern Control Theory", the Automation Engineering Program has been divided into two specialized tracks: "Industrial Automation" and "Intelligent IoT." The Industrial Automation track includes core courses such as "Industrial Robots", "Intelligent Control Technology", "Process Control Systems" and "Fundamentals of Robotics". The Intelligent IoT track focuses on "Intelligent Robotics", "Principles of Artificial Intelligence", "Digital Image Acquisition and Processing", "Pattern Recognition", "IoT Systems", "Machine Learning", "Machine Vision", and "Data Communication and Network Technology". In addition, "Introduction to Artificial Intelligence" has been made a compulsory general course, with supporting tool-based courses such as "Python Programming", "EDA Electronic Design", "Blockchain Technology and Applications", and "Fundamentals of Engineering Graphics".

4.2 Strengthening Interdisciplinary Integration

The college emphasizes interdisciplinary integration by carefully planning the teaching content, tasks, and practical components of relevant courses. Elements from various disciplines are systematically introduced to support targeted practical learning, encouraging students to explore interconnections among different fields. Courses like "Industry 4.0 and Flexible Manufacturing" and "Machine Vision and Autonomous Decision-Making" enhance the integration of intelligent algorithms with engineering applications. During joint teaching, course content is integrated into clusters such as "Industrial Robotics+Digital Image Processing+IoT" to enhance students' practical skills.

4.3 Improving Teaching Methods

The college has transitioned from a traditional fragmented teaching approach to a project-based instructional model. In alignment with the curriculum objectives, engineering case studies rooted in real-world scenarios are integrated throughout the course content. In this model, instructors shift from passive knowledge delivery to actively mentoring students through project completion, facilitating the transformation of theoretical knowledge into practical engineering solutions. This approach enhances students' ability to identify, analyze, and solve complex engineering problems. By engaging students in hands-on, inquiry-driven learning, the model effectively cultivates intrinsic motivation, deepens conceptual understanding, and fosters innovative thinking—thereby advancing a reform of the talent cultivation paradigm. Moreover, the proportion of practical components within the teaching framework has been significantly increased to ensure a stronger integration of theory and practice. During course design and practical sessions, students collaborate in teams, with clearly assigned roles and responsibilities. This not only reinforces a disciplined and systematic work ethic but also strengthens essential soft skills, including teamwork, communication, presentation, and interpersonal competence.

4.4 Diversified Practical Teaching System

In addition to in-class practical training, extracurricular hands-on experience is primarily facilitated through three avenues: innovation and entrepreneurship studios, undergraduate research and innovation projects, and discipline-specific competitions. The innovation and entrepreneurship studios are composed of students with a solid technical foundation and relevant experience, and they carry out professional extracurricular training based on real project tasks. Undergraduate research and innovation projects are initiated annually, typically by second-year students, and span one to two years, offering sustained engagement with technological innovation.

Furthermore, participation in academic competitions at the university, provincial, and national levels plays a critical role in enhancing students' competencies in both software and hardware development. Competitions such as programming contests, artificial intelligence challenges, robotics competitions, "New Engineering" innovation contests, IoT challenges, and the "Internet+" Innovation and Entrepreneurship Competition provide valuable opportunities for students to strengthen their practical skills and apply interdisciplinary knowledge in real-world scenarios.

4.5 Deepening Industry-Education Integration

The college has actively promoted university-enterprise collaboration to enhance the quality of talent cultivation by partnering with industry-leading companies such as Shaanxi Shuoke, Jingkong Gaoke, and Honeywell. Through cooperation with well-known enterprises including Qianfeng Technology, Tiandy Technologies, iFLYTEK, Neusoft Ruidao and Airbus, the college has established internship and training programs for students. These collaborations provide students with the opportunity to participate in industrial transformation projects, such as the "Intelligent Production Line Optimization" project developed with Lishen Battery, and the "Energy Consumption Intelligent Monitoring System for Production Lines" project developed with Tianjin Haier Factory. By leveraging the knowledge and skills gained during internships, students have also led and participated in various high-level innovation projects under national and provincial undergraduate training programs. These include the design and development of a "Cloud+Edge Smart Patrol Robot for Production Safety", "Edge-Computing-Based Platform for Industrial Carbon Footprint Tracking and Energy Efficiency Optimization", research on energy-saving technologies for smart heating systems under the "Dual Carbon" policy, optimization of cold-chain logistics with carbon trading and new energy vehicles, micro-expression recognition for fatigue driving detection, and the design of defect-sorting robots based on machine vision.

In addition, the automation laboratory aligns its equipment upgrades and procurement with real-world industrial environments, incorporating enterprise-grade technologies such as automated production lines, collaborative robots, and wireless sensor networks. Enterprise engineers are invited to co-supervise graduation projects with faculty members, with topics directly sourced from real industry needs—for example, a "Digital Twin-Based Fault Prediction System for Production Lines".

4.6 Restructuring Evaluation Criteria

The college has moved beyond relying solely on final examinations as the primary basis for student assessment and has adopted a "multi-dimensional and dynamic" evaluation system. This system incorporates training projects, participation in academic competitions, and internship performance into course grades. Instructors of specialized courses are actively exploring more comprehensive and effective evaluation methods tailored to the nature and challenges of each course. Reform practices such as the inclusion of "design reports" and "innovation proposal defenses" have been implemented, with an emphasis on assessing students' ability to solve complex engineering problems. Industry engineers are also invited to participate in the evaluation of course design and laboratory instruction. By applying professional standards to assess student performance, their involvement as impartial third parties ensures a more objective and meaningful evaluation process compared to assessments conducted solely by academic faculty.

In 2024, the Automation Laboratory provided hardware and software resources for experimental teaching, course design and project-based training to approximately 410 students across four cohorts, totaling around 20000 student-hours. These comprehensive improvements have significantly enhanced both teaching quality and talent development outcomes. The automation program has been recognized as a “First-Class Program of Tianjin,” with students winning 15 national-level academic competition awards and achieving an enterprise satisfaction rate of nearly 92%. Furthermore, the college has signed strategic cooperation agreements with four enterprises, and over 20 companies have engaged in multifaceted, multilevel, and multidimensional university–enterprise collaborations.

5. Conclusion

In the context of New Engineering, automation programs face structural conflicts between traditional engineering education and emerging industrial needs. There is an urgent need to break away from outdated models through precise positioning, interdisciplinary integration, industry-education synergy, and dynamic optimization. By addressing challenges such as outdated curricula and weak practice platforms, and aligning with regional industrial upgrading, universities can integrate high-quality internal and external resources, innovate talent cultivation mechanisms, and construct a demand-driven, capability-centered, and continuously iterative talent development ecosystem—thus achieving distinctive, high-quality development for automation majors in regional institutions

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References

[1] Li Yanqiu, Gao Bin. Construction of Mathematics Curriculum Cluster for Data Science and Big Data Technology under the Background of New Engineering Education. Journal of Taiyuan Urban Vocational and Technical College, 2025, (01):99-101.

[2] Ai XinYing, Luo Zhenyuan, Li Jiaye, et al. Construction of BIM Technology Curriculum Cluster for Civil Engineering under the Background of New Engineering Education. Journal of Higher Education, 2025, 11(04): 101-104.

[3] Zhang Yingchun, Zhang Tianfei. Textbook Construction and Practice of Engineering Introduction for Electronic Information Majors under the Background of New Engineering Education. Office Automation, 2025, 30(01): 106-109.

[4] Qian Youcheng, Yin Xueyan. Exploration on Teaching Reform of "Data Structures" Course under the Background of New Engineering Education. Technology Wind, 2025, (01): 16-18.

[5] Chen Jia, Wang Shaozhen, Liu Shaodong, et al. Research on the Construction of Guarantee Mechanism for Innovative, Interdisciplinary, and Application-Oriented Talent Cultivation under the Background of New Engineering Education. Theory and Practice of Innovation and Entrepreneurship, 2025, 8(01): 97-100.

[6] Chen Yuefen, Chen Rongqin, Zhang Shiqing, et al. (2025). Teaching Reform of Applied Undergraduate Professional Basic Courses under the Background of New Engineering Education. Computer Education, 2025, (01): 91-95.

[7] Hou Wenhui, Ge Jun, Zhang Dashan, et al. (2025). Exploration on Teaching and Education Model of Introduction to Intelligent Connected Vehicles under the Background of New Engineering Education. Journal of Higher Education, 2025, 11(S1): 153-156.

[8] Wang Congqing, Xue Yali. Teaching Reform and Exploration of Intelligent Control Course under the Background of New Engineering Education. China Modern Educational Equipment, 2025, (01): 62-64.

[9] Peng Caihong, Wang Qin, Hu Longzhi. Teaching Reform and Practice of Operating Systems Course under the Background of New Engineering Education. Fujian Computer, 2025, 41(02): 103-106.

[10] Zhou Wenjing, Huang Baifei, Xin Junliang, et al. Cultivation of Core Competencies for New Engineering Talents from the Perspective of Positive Education. Industry and Science Forum, 2023, 22(23): 274-276.