Research and practice of application-oriented curriculum system construction under the background of engineering education integration -- Taking automation major as an example

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***Abstract*：** *The integration of production and education is becoming more and more important to the cultivation of engineering application talents. Through in-depth analysis of the connotation of complex engineering problems, analysis of the problems existing in the integration of industry and education in the course system of automation major, this paper puts forward some effective measures for the integration of industry, such as increasing cutting-edge content, improving the school enterprise cooperation mechanism and optimizing the design of practical teaching system, and explores the construction of "three docking, four levels and three levels" suitable for the integration of industry and education in application-oriented undergraduate colleges The application-oriented curriculum system of automation specialty of "Duan" provides certain reference and reference for improving the engineering practice ability of college students and strengthening the integration of industry and education of application-oriented undergraduate specialty.*

***Key words*：** *Integration of Engineering and Education；Application Course；Engineering Practice Ability；Automation Major*

Introduction

Industry-education integration is a school-running model characterized by the close connection between education and practical production, as well as mutual cooperation and benefit between universities and enterprises. At present, industry-education integration has been extensively implemented in application-oriented undergraduate institutions and has achieved certain results. The National Conference on Undergraduate Education in Colleges and Universities in the New Era proposed that education should "adhere to the principle of putting undergraduate education at the core and promote the return to four essential elements," emphasizing that undergraduate education must stay informed about disciplinary frontiers and be aligned with social practice. The automation major is characterized by strong applicability in engineering practice and requires students to possess solid engineering capabilities. In order to cultivate automation engineering talents who meet the needs of industry development, it is imperative to construct a well-structured curriculum system based on social demand, training objectives, students' interests, and the needs of application-oriented development. It has become an inevitable trend to reform the professional curriculum system through the path of industry-education integration.

Taizhou Institute of Sci.&Tech.,NJUST. is a local application-oriented undergraduate institution that adheres to the talent cultivation goals of "aligning with industries, reforming disciplines, guiding employment, and encouraging entrepreneurship." Aiming to "build a first-class application-oriented undergraduate university with distinctive characteristics," it actively aligns with the latest development trends of industries and the corresponding talent cultivation needs, explores the construction of an application-oriented curriculum system, and has developed distinctive features in aspects such as industry-education integration, university-enterprise cooperation, and collaborative education.

1. Analyze the current status of professional course offerings in response to the requirements of engineering education accreditation

Solving complex engineering problems is a required graduate competency in engineering education accreditation. The cultivation of engineering talent requires not only a solid foundation of theoretical knowledge but also the accumulation of engineering practice capabilities, fully reflecting the practical, innovative, and systematic nature of engineering education. In response to the competency requirements for addressing complex engineering problems, this paper analyzes several existing issues in the current structure of professional course offerings:

1.1 The concept behind the curriculum system design is relatively outdated.

The curriculum places excessive emphasis on the delivery of control theory knowledge, and the teaching content fails to incorporate engineering cases in a timely manner. Courses offered in the automation major remain limited to traditional foundational subjects such as "Fundamentals of Automatic Control Theory," "Motion Control," and "Electrical Control," without the timely integration of courses that reflect cutting-edge technologies at the forefront of the discipline. As a result, the underlying philosophy of curriculum design is outdated, the knowledge scope is narrow, and the system fails to meet the new demands of the evolving automation industry.

1.2 The course content is not well aligned with industry requirements.

The current course arrangement remains relatively arbitrary and does not follow a logical, progressive sequence, resulting in poor alignment between the curriculum and industry practices. For example, "Automation Engineering Design and Application" is scheduled in the seventh semester, which does not coincide with the timeline for the initiation of graduation project topics, making it difficult to achieve the instructional goal of integrating this practical training course with graduation design projects.

1.3 The level of enterprise participation in course development is insufficient.

During the construction of the curriculum system and the formulation of talent cultivation programs, participation from relevant industry enterprises is minimal, and the process of joint research and discussion between universities and enterprises is largely lacking. Most courses and the selection of teaching materials are determined solely by program leaders, department heads, or a small group of specialized faculty members, without substantive involvement from enterprises. As a result, enterprise participation in course development remains superficial and fails to achieve meaningful impact[1].

1.4 There is a certain disconnect between teachers' capabilities and engineering practice applications.

In application-oriented undergraduate institutions, there is a lack of professional teachers with enterprise backgrounds. Most instructors begin teaching directly after graduating from universities, possessing only theoretical teaching knowledge and lacking experience in social and industrial sectors. Their ability to apply professional knowledge in practical contexts is weak, and participation from enterprise professionals in teaching is insufficient. In terms of overall faculty quality, it is difficult to meet the requirements for cultivating students' engineering competencies.

1.5 The integration between the practical teaching system and industry is insufficient.

The practical teaching components of the automation major mainly include professional course internships, production internships, and graduation projects, but lack a market-oriented, engineering-problem-centered practical teaching environment. Students rarely have opportunities to engage in hands-on practice on the front lines of automation production, resulting in a disconnect from market demands and hindering the development of students' engineering practice skills.

2. Measures for Reforming the Professional Curriculum System in Application-Oriented Undergraduate Institutions Based on Industry-Education Integration

2.1 Increase cutting-edge content to reflect industry development.

With the progress of society and advancements in automation technology, the teaching content and curriculum system of the automation major must keep pace with the development of the discipline and industry by appropriately adding new knowledge. Courses such as "Artificial Intelligence and Robotics," "Intelligent Manufacturing Technology," and "Machine Vision and Sensing Technology" should be incorporated into the teaching plan to ensure the updating of instructional content.

2.2 Improve cooperation mechanisms and strengthen industry participation.

At present, although many local institutions have established cooperation with enterprises through faculty internships in enterprises and student training bases, the benefits primarily favor the schools, resulting in passive participation from enterprises and a lack of effective collaboration. University-enterprise cooperation should be led and coordinated by the government, with close collaboration between schools and enterprises to jointly promote the institutionalization of such cooperation. Relevant regulations should be formulated to encourage and facilitate university-enterprise partnerships, providing enterprises with effective incentive mechanisms to ensure that they genuinely benefit. Only then can enterprise participation in teaching be effectively strengthened, achieving long-term cooperation characterized by complementary advantages and shared benefits[2].

2.3 Optimize the practical teaching system to achieve industry-education integration.

Industry-education integration should fully utilize the practical teaching resources of industry enterprises to supplement and expand the teaching resources of application-oriented undergraduate education. Based on the goal of industry-education integration, emphasis should be placed on combining industry and enterprise practical teaching scenarios with platforms such as MOOCs and SPOCs. The advantages of MOOC and SPOC teaching platforms should be leveraged to design online and offline Q&A discussions, connecting industry-education integration platforms with online teaching platforms. Using MOOC and SPOC instructional video materials to showcase industry and enterprise practical teaching components can enhance the visualization and richness of practical teaching scenario design, thereby promoting the role of industry-education integration in the instructional design of application-oriented undergraduate education.

3. The "Three-Four-Three" Application-Oriented Curriculum System for the Automation Major Based on Industry-Education Integration

By deepening university-enterprise cooperation and implementing multiple reform measures such as increasing cutting-edge content, improving the university-enterprise cooperation mechanism, and optimizing the practical teaching system, the automation industry enterprises can effectively participate in the teaching of the automation major in application-oriented undergraduate institutions. This paper proposes constructing an application-oriented curriculum system for the automation major based on the "Three Alignments, Four Levels, and Three Stages" framework.

3.1 The "Three Alignments" refer to the alignment between professional development and industry demands, the alignment between course content and occupational standards, and the alignment between the teaching process and production processes.

3.1.1 Alignment between professional development and industry demands

Grounded in local conditions and serving regional economic development is a fundamental responsibility of local application-oriented undergraduate institutions. The driving force behind their development is not limited to the essence of education but primarily stems from the needs of local economic growth, especially the talent demands arising from rapidly developing regional economies. Industrial development depends on professional talents, and successful professional programs support industry growth. To cultivate application-oriented skilled talents favored by enterprises and industries, local institutions must closely rely on industries, infuse professional teaching with enterprise characteristics, integrate the teaching environment with enterprises, and ensure that professional teaching closely aligns with industry production.

3.1.2 Alignment between course content and occupational standards

Seamless alignment between students' professional vocational abilities and enterprise job requirements depends critically on how course content aligns with occupational standards. The cultivation of students' vocational skills must meet industry skill standards, which requires both schools and enterprises to jointly develop professional vocational competency system standards. The occupational standard requirements of enterprise positions should be integrated into the school's talent cultivation curriculum system, and course content should be adjusted based on the skills and employment standards demanded by these positions to achieve alignment between curriculum standards and occupational standards.

3.1.3 Alignment between teaching processes and production processes

During the teaching process, institutions combine curriculum instruction with industry production by using university–enterprise cooperation platforms, inviting enterprises onto campus, sending teachers into workshops, and conducting instruction on-site to create a "factory within the school" and a "school within the factory" environment. This close integration of production and teaching provides an effective approach to building a modern engineering education system. Application-oriented undergraduate institutions must fully consider enterprises' profit objectives and talent needs, identify mutually beneficial collaboration points, and form complementary advantage patterns with enterprises in terms of equipment, facilities, technical services, and engineering talent cultivation, thereby establishing a dual-main-body collaborative education mechanism between universities and enterprises.

3.2 The "Four Levels" refer to the practical teaching system consisting of the "Basic Experiment Platform → Professional Experiment Platform → Engineering Innovation Practice Platform → Professional Quality Cultivation Platform."

The design of the practical teaching system is a crucial component in cultivating application-oriented engineering talents. To ensure the achievement of engineering talent cultivation goals, a four-level practical teaching system has been constructed: the Basic Experiment Platform, the Professional Experiment Platform, the Engineering Innovation Practice Platform, and the Professional Quality Cultivation Platform. The Basic Experiment Platform cultivates students' engineering awareness and initially trains their engineering practice abilities; the Professional Experiment Platform enhances students' professional skills and engineering quality, achieving seamless alignment with enterprises; the Engineering Innovation Practice Platform, based on projects, guides students to start from engineering problems, encouraging them to independently conceive, design, and implement solutions, thereby strengthening their comprehensive engineering capabilities and innovative consciousness; the Professional Quality Cultivation Platform improves students' professional abilities and engineering innovation skills through comprehensive practical teaching components such as professional skills training, production internships, and graduation projects[3].

3.3 The "Three Stages" refer to implementing the professional teaching model of "Preliminary Cognition – Enhancement and Deepening – Comprehensive Application."

The development trend of application-oriented undergraduate institutions is to cultivate applied talents who meet industry demands. Therefore, the automation major should align the timing of automation enterprise production with curriculum scheduling, allowing teaching to take place on-site, teachers to enter enterprises, and enterprises to truly engage with campuses. This creates a virtuous cycle of integration between teaching and production. Throughout the entire teaching process, the cultivation of engineering capabilities should be emphasized, exploring a practical teaching model featuring the three stages of "Preliminary Cognition → Enhancement and Deepening → Comprehensive Application" and continuous collaborative education between universities and enterprises as dual main bodies.

3.3.1 Preliminary Cognition Stage of the Major.

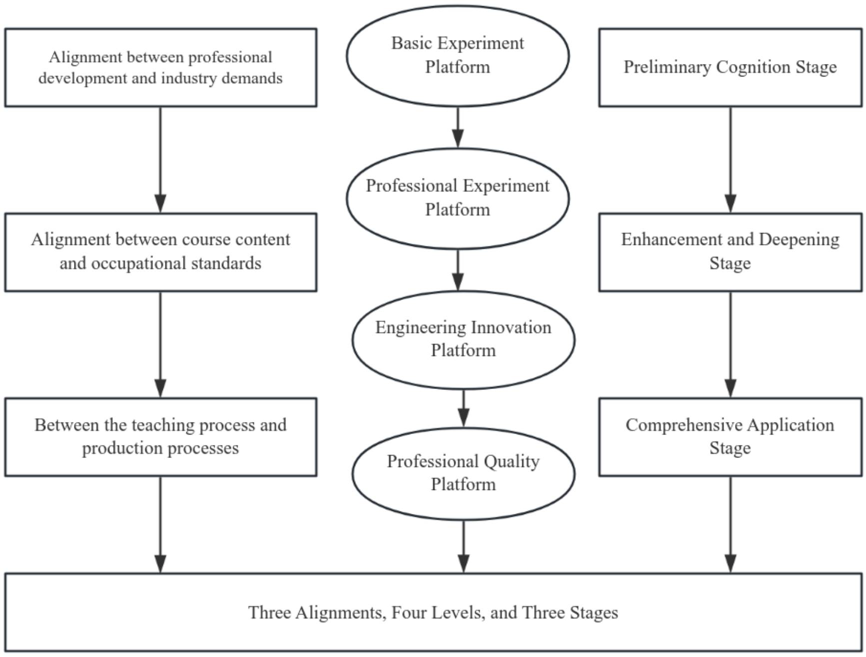
This stage mainly cultivates students' understanding and initial awareness of the automation major by arranging concentrated cognitive internships, professional guidance lectures, visits to the Intelligent Manufacturing Technology Center and the Automation Practical Teaching Center, as well as practical innovation activity bases for university students and cooperative automation industry enterprise internship teaching bases.

3.3.2 Enhancement and Deepening Stage of the Major.

This stage mainly involves the implementation of teaching for fundamental and specialized courses such as "Fundamentals of Control Engineering" and "Robotics Technology and Applications." Characterized by a complete foundational knowledge system and strong theoretical content, the teaching team combines in-house faculty with industry experts. Integrating engineering project cases throughout the course, theoretical knowledge is taught within the context of engineering problems. This approach not only deepens students' intuitive understanding of professional knowledge but also introduces them to deeper thinking about engineering issues.

3.3.3 Comprehensive Application Stage of the Major.

This stage mainly involves category-based teaching processes for professional practical application, such as "Intelligent Manufacturing CNC Machining Practice," "Microcomputer Control Course Design," "Automation Engineering Design and Application," "SCADA System Design and Application," and "Robot Workstation Design and Debugging." Characterized by strong comprehensive practicality, this stage employs teaching methods that include on-site instruction by industry experts and enterprise engineers, model-based teaching, and engineering case video instruction. Practical teaching actively participates in actual engineering projects within automation enterprises, enhancing students' comprehensive professional abilities and practical skills. This approach facilitates the integration of graduation projects with real enterprise projects, achieving seamless alignment between vocational competencies and employment positions.



4. Teaching Practice and Initial Achievements

4.1 The "Dual-Qualified" Teaching Team Has Gradually Taken Shape

The automation program places high demands on the practical teaching abilities of its faculty. To enhance teachers' hands-on capabilities, the school has adopted a dual approach of "going out and bringing in." In 2024, four teachers were selected to study in Germany to explore the talent cultivation model of university-enterprise cooperation. Meanwhile, three enterprise-based engineers were hired as part-time faculty members from partner companies such as Beijing Huasheng Jingshi Co., Ltd. and Shanghai ABB Co., Ltd. As a result, the proportion of teachers with industry backgrounds has increased from 8.5% in 2020 to the current 43.8%. The school has also actively promoted industry-university-research collaboration projects and participated in enterprise-led research initiatives to support the local economy.

4.2 The Application-Oriented Curriculum System Based on Industry-Education Integration Has Been Gradually Improved

In the 2024 talent cultivation program for the automation major, the application-oriented curriculum system and practical teaching system, which embody the concept of engineering education, were adjusted and optimized based on the guiding principle of aligning professional development with industrial demand, aligning course content with occupational standards, and aligning the teaching process with the production process. The integration with industry projects has been significantly strengthened. For example, the course “Sensor and Detection Technology” was revised to “Machine Vision and Sensing Technology,” with a particular focus on the relationship between robotic vision and sensors. The curriculum progresses from theory to integrated application, advancing step by step from basic to advanced levels. Additional enterprise-developed courses, such as “Intelligent Factory Equipment Communication” and “SCADA System Design and Application,” were introduced. These courses are taught by enterprise-based engineers in real production settings, using actual project scenarios to enhance learning[4].

4.3 Students’ Engineering Practice Abilities Have Been Gradually Enhanced

Professional courses have been taught through various approaches, including hiring part-time industry instructors, integrating actual projects into teaching, and encouraging students to participate in engineering projects, which has significantly improved students’ engineering practice and innovation capabilities. For example, with the introduction of industry mentors, student participation in practical teaching components such as “Industrial Robot System Integration Design” and “Robot Workstation Design and Debugging” has reached 100%, resulting in a substantial improvement in both engineering practice and innovation abilities, as well as a noticeable enhancement in system design quality. By involving students in instructors’ real engineering projects, they become familiar with the design process of engineering projects, gain an understanding of new design standards, and acquire exposure to emerging industry skills during their time at school, thereby strengthening their ability to apply theoretical knowledge to practical work.

Fund Projects

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