Journal of Education and Educational Research
ISSN: 2957-9465 | Vol. 18, No. 2, 2026

Reconstruction and Practice of Vocational Undergraduate Course Content Under the Background of Industry-Education Integration

-- A Case Study of *Distributed Control System Application Technology*

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Abstract: Industry-education integration serves as the core approach for vocational undergraduate education to cultivate high-level technical and skilled talents, and curriculum content reconstruction is a key link to promote the implementation of industry-education integration. Taking the course *Distributed Control System Application Technology* as an example, based on theories such as competency-based education and work process orientation, this paper targets the current problems of the course including disconnection from industrial demands and insufficient school-enterprise collaboration, and puts forward a reconstruction idea of "taking industrial demands as the orientation and post competency as the core". It constructs a curriculum content system featuring "adequate theories, prominent practices, industrial connection and literacy integration", and proposes specific implementation paths from the aspects of teaching mode, practical system, faculty construction and evaluation mechanism. Practice shows that the reconstructed course effectively improves students' ability to solve complex engineering problems and can provide a reference for the construction of similar vocational undergraduate courses.

Keywords: Industry-education Integration; Vocational Undergraduate Education; Curriculum Reconstruction; Distributed Control System (DCS); Post Competency.

1. Introduction

Against the background of the national vigorous development of vocational education, vocational undergraduate education, as an important educational type connecting higher vocational colleges and regular undergraduate education, has the core mission of cultivating high-level technical and skilled talents with profound theoretical knowledge and strong practical abilities. As a critical path to achieve this goal, industry-education integration has received high policy attention. The *National Vocational Education Reform Implementation Plan* clearly puts forward "deepening industry-education integration and school-enterprise cooperation" [1-2], and the *Action Plan for Enhancing Industry-Education Integration in Vocational Education (2023–2025)* further emphasizes "promoting the effective connection of the education chain, talent chain, industrial chain and innovation chain". However, many vocational undergraduate courses still adopt the traditional teaching mode at present, which is difficult to meet the industrial demand for high-level technical and skilled talents.

Distributed Control System Application Technology is a core course for majors such as automation and intelligent manufacturing. It is characterized by strong interdisciplinary nature, high practical requirements and close integration with industries such as chemical engineering and intelligent manufacturing. In chemical production, the distributed control system (DCS) can realize precise control of parameters such as reactor temperature and pressure; in intelligent factories, it can efficiently schedule the entire production line. The quality of this course directly affects students' ability to apply and innovate DCS in the field of industrial control. Nevertheless, current problems exist such as outdated course content lagging behind industrial technologies and practical scenarios detached from real production. For instance, the integrated application of industrial Internet and DCS has been popularized in many enterprises, but relevant content is rarely covered in the course. Therefore, reconstructing course content oriented by industry-education integration is of great practical significance.

2. Theoretical Basis of Curriculum Content Reconstruction

2.1. Connotation and Requirements of Industry-Education Integration

The core of industry-education integration is to realize the deep coupling of education and industry through school-enterprise collaborative education, resource sharing and win-win benefits. It is not a simple school-enterprise cooperation, but a long-term, stable and mutually beneficial cooperation mechanism [3]. Under this mechanism, schools can timely obtain industrial development trends, and enterprises can participate in the talent training process to ensure that the trained talents meet their own needs.

For vocational undergraduate courses, it is necessary to take real industrial demands as the orientation, strengthen the cultivation of practical abilities, and highlight the integration of "post-course-competition-certificate". "Post" refers to professional posts, and course content needs to be closely connected with post requirements; "course" refers to curriculum teaching, which should integrate the knowledge and skills required by posts into the whole process of teaching;

"competition" means skill competitions, which improve students' practical abilities through competitions; "certificate" stands for vocational certificates, and course content needs to cover the key assessment points of certificates. For example, the Material Forming and Control Engineering major of Hebei Petroleum University of Technology integrates the assessment content of the "Non-destructive Testing" vocational skill level certificate into relevant courses. After completing the course, students can not only master professional knowledge but also obtain vocational certificates to enhance their employment competitiveness [4]. Through the integration of "post-course-competition-certificate", an integrated education closed loop of "learning-practicing-competing-certifying" is formed to comprehensively improve students' professional literacy and skill levels.

2.2. Curriculum Characteristics of Vocational Undergraduate Education

Vocational undergraduate courses have the "double helix characteristic" of attaching equal importance to theory and practice. Different from higher vocational colleges, vocational undergraduate courses involve theoretical knowledge with both breadth and depth, and the corresponding technical complexity is higher. For example, in the Electrical Control Technology course, higher vocational colleges only require students to master typical circuit connection, fault troubleshooting and simple PLC programming, while vocational undergraduates need to be competent in device selection, schematic design, stepping and servo motor control, analog processing, etc. Compared with regular undergraduate education, vocational undergraduate education pays more attention to the ability to transform theoretical knowledge into practical application and solve on-site complex problems.

The theoretical knowledge and practical skills of vocational undergraduate courses are interpenetrated and mutually promoted. Theory provides support for practice, and practice in turn promotes the deepening of theory. For example, when students majoring in Mechanical Design, Manufacturing and Automation study *Single Chip Microcomputer Application Technology*, they first master the theoretical knowledge of single chip microcomputers, including hardware structure and basic C51 language, and then deepen their understanding and absorption of theoretical knowledge through multi-task practices such as the design and implementation of lighting control systems and interrupt control systems.

2.3. Theoretical Support for Curriculum Content Reconstruction

The educational attribute of vocational undergraduate determines that its curriculum content reconstruction must adhere to the principle of "learning for practice" and always take "practical demand" as the core orientation. Competency-Based Education (CBE) theory organizes course content starting from professional core competencies. This theory first decomposes professional competencies into several competency units, and then designs course content around these units. The work process orientation theory designs learning modules according to the actual work process of posts, transforming knowledge into specific work tasks. Its core lies in emphasizing the consistency between the learning process and the work process, aiming to enable students to learn in simulated real work scenarios. Project-Based Learning (PBL) theory drives the teaching process through real projects to cultivate students' problem-solving ability and engineering thinking. Under this teaching mode, students learn around real projects and independently integrate knowledge and skills in the process of solving project problems.

Vocational undergraduate curriculum reconstruction uses CBE theory to anchor competency goals, relies on work process orientation theory to build a content framework, and activates practical carriers with PBL theory. Finally, it achieves the goals of "connecting course content with post demand, synchronizing learning process with work process, and adapting ability training to career development", thus truly practicing the educational concept of "learning for practice".

3. Analysis of the Current Situation of *Distributed Control System Application Technology*

3.1. Course Orientation and Existing Content Framework

Distributed Control System Application Technology is a core course for majors such as automation and intelligent manufacturing. Its purpose is to enable students to master the basic principles, hardware composition, configuration programming and other knowledge and skills of DCS, cultivate students' ability to apply and innovate complex systems in the field of industrial control, and lay a solid foundation for students to engage in automation control-related work in the future.

The existing content is divided into theoretical and practical modules. The theoretical module includes DCS principles, hardware composition, communication protocols, system configuration, etc., accounting for about 70% of the total class hours, and the selected textbook is *Distributed Control System Application (Second Edition)* published by Chemical Industry Press in 2025. The practical module mainly includes experiments such as control station configuration and operator station configuration, accounting for about 30% of the total class hours.

The teaching process adopts the form of "classroom theoretical teaching + laboratory configuration operation". Students' performance is composed of written examination and experimental operation assessment. The written examination mainly examines students' mastery of theoretical knowledge, accounting for 70% of the total score; the experimental operation assessment mainly examines students' configuration operation skills, accounting for 30% of the total score.

3.2. Course Diagnosis from the Perspective of Industry-Education Integration

By comparing industrial demands with the current course situation, the problems found are shown in Table 1. These problems are caused by many factors, among which the disconnection between course content and industrial reality is particularly prominent. The reason is that teachers lack sufficient industrial practice experience and fail to timely grasp new technologies and trends in industrial development, resulting in obvious lag in course content update; furthermore, it is difficult to integrate real enterprise engineering cases into school teaching in a timely manner. Meanwhile, school-

enterprise collaboration fails to meet expectations, and enterprise engineering and technical personnel have low enthusiasm for participating in curriculum standard formulation and teaching. One-sided ability cultivation is because the traditional teaching mode focuses more on knowledge imparting and basic skill training, ignoring the cultivation of students' engineering thinking and innovative ability. At the same time, the setting of practical teaching links is unreasonable, lacking the cultivation of complex abilities such as system design and debugging, system integration and fault diagnosis. The single evaluation system is reflected in that the traditional evaluation method is difficult to comprehensively and objectively reflect students' comprehensive abilities, ignoring the cultivation of students' professional literacy.

Table 1. Problems and Manifestations of Distributed Control System Application Technology

Problem Type	Specific Manifestations
Disconnection between content and industry	New technologies such as integration of industrial Internet and DCS and digital twin are not included; practical cases lack support from real enterprise projects
Insufficient school-enterprise collaboration	Low enterprise participation in curriculum design, "two separate sheets" between teaching and production practice
One-sided ability cultivation	Focus on basic operations, ignoring complex abilities such as system design and debugging, system integration and fault diagnosis
Single evaluation system	Mainly outcome-based evaluation, without comprehensive consideration of professional literacy

4. Design of Curriculum Content Reconstruction Under the Background of Industry-Education Integration

4.1. Reconstruction Objectives and Principles

The reconstruction objective is to build a content system of "adequate theories, prominent practices, industrial connection and literacy integration" to cultivate talents capable of solving complex engineering problems in the DCS field. "Adequate theories" means that the depth and breadth of theoretical knowledge meet practical needs to avoid excessive theorization; "prominent practices" emphasize increasing the proportion of practical teaching to enable students to master knowledge and skills in practice; "industrial connection" requires course content to keep pace with industrial development and integrate new industrial technologies and specifications; "literacy integration" means integrating the cultivation of professional literacy into the whole process of course teaching to cultivate students' teamwork, communication, innovative thinking and other abilities.

Course reconstruction needs to follow four core principles: first, the principle of industry-education collaboration, emphasizing that enterprises deeply participate in the whole process of curriculum construction, including key links such as content design, teaching organization and quality evaluation, so as to ensure the precise connection between the curriculum system and actual industrial demands; second, the principle of competency-based, advocating the reconstruction of teaching content with the cultivation of core post competencies as the logical main line, so that students can gradually improve post adaptability in systematic learning; third, the principle of integration of theory and practice, highlighting the supporting role of theoretical knowledge in practical application, and deepening students' understanding and transformation of theoretical connotation through practical links; fourth, the principle of dynamic update, requiring course content to iterate synchronously with industrial and technological development, and ensuring the advancement and practical value of the course by timely adjusting teaching elements.

4.2. Curriculum Content Reconstruction Based on Professional Post Competencies

Through investigations in more than 10 enterprises (including central enterprises and large and medium-sized private enterprises) in chemical engineering, intelligent manufacturing and other fields, combined with the standards of vocational skill level certificates such as "Industrial Automation Instrument Assembly and Adjustment Worker", DCS-related post competencies are divided into a three-level system:

Basic competency level: Covers the composition, working principles, communication networks and other contents of DCS software and hardware systems, as the essential literacy for DCS-related work. Students are required to master the basic concepts and operation mechanisms of the system and be familiar with the technical characteristics and application scenarios of DCS.

Core competency level: Focuses on key skills such as hardware selection and configuration, system configuration programming (such as SUPCON WebField and other mainstream platforms), system debugging and optimization, as the core post requirements. Students should be able to complete hardware configuration according to actual needs, proficiently use configuration software for system configuration, and debug and optimize the system to ensure stable operation.

Expanded competency level: Includes system integration of DCS and upper computer platforms, fault early warning and diagnosis, small engineering project management and other contents.

The reconstructed course modules follow the progressive logic of "cognition–practice–comprehensive", as shown in Table 2. Module 1 focuses on DCS system cognition, helping students establish an overall understanding of DCS application scenarios in different industries through analyzing real cases; Module 2 focuses on the cultivation of hardware operation ability, relying on the training room to build a simulated chemical production line hardware environment to train students' practical skills in hardware selection, configuration and debugging; Module 3 focuses on improving programming ability, carrying out programming training based on real projects to strengthen students' practical application ability; Module 4 focuses on cultivating the ability

of DCS integration with other systems and operation and maintenance, enabling students to master the application methods of new technologies in the DCS field; Module 5 guides students to integrate the knowledge and skills of the first four modules through comprehensive project practice, focusing on cultivating engineering thinking and project management ability.

Table 2. Reconstructed Course Modules of Distributed Control System Application Technology

Module No.	Module Name	Core Content	Industry-Education Integration Elements
1	DCS Cognition and Typical Application Scenarios	Analyze real cases of chemical plants, intelligent factories, etc.	Enterprise on-site videos, case base
2	DCS Hardware System Construction and Debugging	Build simulated chemical production line hardware in the training center	School-enterprise co-built training platform, industrial specifications
3	DCS Configuration and Control Logic Programming	Programming based on real projects such as beer production lines	Guidance from enterprise engineers, skill competition test points
4	DCS System Integration and Operation & Maintenance	Complete integration of DCS and virtual simulation platform	Digital twin technology, remote monitoring cases
5	Comprehensive Project Practice	Design "Small Sewage Treatment DCS Control System"	School-enterprise jointly developed projects, post standards

Deep coupling is realized through the "three-dimensional integration model":

Standard dimension: Embed industrial standards such as *Code for Construction Quality Acceptance of Petrochemical Automation Instrument Engineering*. In Module 2 (hardware system construction and debugging), students are required to operate in strict accordance with industrial standards, such as wiring specifications and equipment installation accuracy, so as to develop the habit of abiding by industrial standards in the learning process.

Case dimension: Disassemble enterprise DCS renovation projects into teaching tasks. For example, a DCS system renovation project of a chemical plant is disassembled into teaching tasks such as hardware selection, system configuration, debugging and optimization, and integrated into corresponding course modules, allowing students to contact real enterprise projects in the learning process.

Certificate dimension: Connect with the assessment content of the "Industrial Automation Instrument Assembly and Adjustment Worker" certificate. Integrate the key and difficult points of certificate assessment into course content, such as configuration software programming and system debugging, so that students can successfully pass the certificate examination after completing the course and improve their employment competitiveness.

5. Implementation Paths and Guarantees for Curriculum Reconstruction

5.1. Teaching Mode Innovation

A collaborative teaching mode of "school-enterprise dual teachers + project-driven + mixed teaching" is adopted. In the "school-enterprise dual teachers" mechanism, the responsibilities of both schools and enterprises are clearly defined: in-school teachers are mainly responsible for imparting theoretical knowledge, guiding learning methods and designing the overall curriculum framework; enterprise engineers focus on practical skill training, enterprise case analysis and project result review. To ensure the dynamic adaptation of teaching content to industrial demands, schools and enterprises regularly hold joint lesson preparation meetings to jointly discuss teaching content update, teaching method optimization and teaching schedule adjustment.

Project carriers are selected in strict accordance with the principles of authenticity, typicality and feasibility in the project-driven teaching link, and real enterprise projects or high-simulation cases are selected as teaching materials. The teaching implementation process is divided into six progressive stages: project situation introduction, task module decomposition, implementation plan formulation, project practice execution, result display and exchange, and comprehensive evaluation and summary. Students carry out project practice in groups, and school-enterprise tutors provide targeted guidance and real-time Q&A throughout the process.

5.2. Construction of a "Three-Level Progressive" Practical System

Basic level: Rely on the on-campus industry-education integrated DCS training center to complete the confirmatory experimental teaching of Modules 2 and 3. The training center is equipped with DCS software and hardware systems synchronized with mainstream industrial technologies (SUPCON WebField), enabling students to master basic DCS operation skills through standardized operation training.

Improvement level: Enhance students' engineering practical ability through comprehensive project training in Module 5. On the basis of solid basic skills, students are guided to deeply participate in the whole process of comprehensive project implementation, including demand analysis, scheme design, system construction, debugging and optimization, focusing on cultivating students' comprehensive application ability and engineering thinking literacy.

Practical level: Participate in real DCS projects (system maintenance, small-scale renovation) in enterprise practice bases. The school has established long-term cooperative relations with 3 automation enterprises and built internship bases. Students enter enterprises for internships in the 7th semester, guided by enterprise tutors throughout the process, apply the knowledge and skills they have learned to practical work, and improve professional literacy and practical ability.

5.3. Construction of "Dual-Qualified" Teaching Staff

A long-term mechanism for teachers' enterprise practice is established, requiring professional teachers to accumulate no less than 6 months of practice in DCS-related project development in cooperative enterprises every 5 years. The school formulates the *Measures for the Management of Teachers' Enterprise Practice* and constructs a quantitative assessment system from the aspects of practice duration, content dimension and achievement output. During enterprise practice, teachers deeply participate in the whole process of projects, including demand analysis, system design and on-site debugging, and transform technical documents and solutions formed in the practice process into teaching cases and curriculum resources to realize the effective transformation of practical achievements into teaching content.

Enterprise engineers participate in the teaching process through a part-time teacher selection and employment mechanism, specifically undertaking teaching tasks such as curriculum system design, practical teaching guidance and comprehensive student evaluation. Relying on rich industrial practical experience, part-time teachers integrate cutting-edge enterprise technologies, latest industrial specifications and real engineering cases into teaching links through diversified forms such as classroom teaching, practical operation guidance and special technical lectures, effectively broadening students' professional vision and industrial cognition.

5.4. Reform of Evaluation System

A comprehensive evaluation system of "multiple subjects + multiple dimensions" is constructed, as shown in Table 3. To ensure the fairness and impartiality of the evaluation process, a refined evaluation index system and quantitative scoring standards are formulated to ensure an open and transparent evaluation process. At the same time, a closed-loop evaluation feedback mechanism is established to timely feed back evaluation results to students, clarify their strengths and areas to be improved in the learning process, and provide targeted guidance for subsequent learning.

Table 3. Course Evaluation System

Evaluation Subject	Evaluation Content (Proportion)	Evaluation Method
School Teachers	Knowledge application (40%), skill operation (30%)	Module task report, practical operation record
Enterprise Tutors	Engineering specifications (15%), project management (5%)	On-site performance, project acceptance opinions
Student Peer Evaluation	Teamwork (10%)	Intra-group scoring, achievement display mutual evaluation

6. Conclusion

Taking the course *Distributed Control System Application Technology* as an example, this paper constructs a "four-step path" for vocational undergraduate curriculum reconstruction under the background of industry-education integration, namely post competency decomposition → modular content reorganization → integration of industry-education elements → whole-process guarantee. Among them, post competency decomposition provides accurate positioning for curriculum training objectives; modular content reorganization realizes the scientific optimization of the curriculum knowledge system; the integration of industry-education elements enhances the practical orientation and industrial pertinence of course content; and the whole-process guarantee provides systematic support for the smooth progress of curriculum reconstruction.

Practice verification shows that this path can effectively solve the problem of disconnection between course teaching and industrial development demands, significantly improve students' engineering practical ability and professional literacy, and provide strong support for the cultivation of high-level technical and skilled talents. In addition, this reconstruction path has important reference value for similar engineering courses in vocational undergraduate education. For example, courses such as *Electrical Control Technology* and *Industrial Robot Application Technology* can refer to this method to continuously improve course quality and cultivate high-level technical and skilled talents meeting industrial development demands through post competency analysis, modular content design, integration of industry-education elements and construction of whole-process guarantee mechanisms.

Acknowledgments

Special Project on Vocational Undergraduate Education of Hebei Petroleum University of Technology in 2025: *Research and Practice on Teaching Content and Textbook Improvement of "Distributed Control System Application Technology" Integrating Teaching, Learning and Doing Under the Background of Industry-Education Integration* (Project No. 202501008).

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