Academic Education Publishing House

Higher Education and Practice Vol. 3 No. 5, 2026

Research on Talent Training Mode of Mechatronics Technology Major in Higher Vocational Colleges from the Perspective of "Post- Course Competition Certificate"

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Abstract: With the intelligent upgrading and transformation of the manufacturing industry, the training of talents majoring in mechatronics technology in higher vocational colleges faces problems such as rapid iteration of job demand, lagging course content, disconnection between skill competition and teaching, and separation of vocational skill certificates and course evaluation. In view of this current situation, the "Post-Course Competition Certificate" (PCCC) integration proposes to integrate job ability standards, course teaching, skills competitions and vocational skill level certificate systems to provide new ideas for talent training. Based on analyzing the current situation and existing problems, this paper proposes a four-in-one talent training model, a curriculum system reconstruction path, and a teaching model reform plan of "determining courses based on positions, promoting courses and competitions, integrating courses and certificates, and complementing competitions and certificates". It also proposes countermeasures based on the cooperation between schools and enterprises, the construction of a "dual-teacher" teacher team and practical training base, providing theoretical and practical reference for the talent training reform of higher vocational mechatronics majors.

Keywords: PCCC; Mechatronics; Higher Vocational Education; Talent Cultivation Mode; Integration of Courses and Certificates

1. Introduction

China's manufacturing industry is accelerating its strategic transformation from a big manufacturing country to a powerful manufacturing country. Made in China 2025 takes intelligent manufacturing as the core development orientation to boost the in-depth integration of a new generation of information technology and manufacturing technology [1].In 2019, the Implementation Plan for National Vocational Education Reform [2] (dubbed the "20 Articles on Vocational Education") launched the pilot program of the 1+X Certificate System in vocational colleges to realize the organic connection between academic diplomas and multiple vocational skill level certificates. In 2020, the Action Plan for Improving the Quality of Vocational Education (2020-2023) [3] further stressed the comprehensive talent cultivation based on the integration of PCCC. The newly revised Vocational Education Law of the People's Republic of China [4] in 2022 legally established the school-running framework featuring industry-education integration and school-enterprise cooperation. In 2025, the administration of the 1+X Certificate System pilot was formally transferred from the Ministry of Education to the Ministry of Human Resources and Social Security for overall coordination [5], marking a new stage of the vocational skill level certificate system shifting from education-dominated management to the new mechanism of overall planning by the Ministry of Human Resources and Social Security with collaborative support from education authorities.

As a core technical field of manufacturing automation, mechatronics imposes new requirements of compound capability, intelligent literacy and engineering practicality on professionals. Enterprises demand not only practitioners proficient in conventional operational skills, but also interdisciplinary high-skilled talents competent in intelligent production line installation and commissioning, industrial robot operation & maintenance as well as automatic system integration [6]. Nevertheless, dominated by discipline-oriented knowledge framework, the traditional talent training mode for higher vocational mechatronics specialty suffers from delayed

curriculum update. Practical training projects arranged by colleges differ greatly from actual production projects in enterprises [7]. The mismatch between talent cultivation and industrial technological upgrading becomes increasingly prominent, resulting in long post-adaptation period for graduates and unsatisfactory employment feedback from enterprises for a long time.

Based on the integrated philosophy of PCCC, this study puts forward a four-in-one talent training mode that organically integrates post competency standards, curriculum teaching, skill competitions and vocational skill level certificates. The proposed mode dynamically links industrial demands and integrates diversified educational resources, providing new ideas and theoretical foundations for talent cultivation of mechatronics technology major in higher vocational colleges.

2. Analysis on Current Situation of Talent Cultivation for Mechatronics Technology Major

2.1 Delayed Update of Curriculum Structure

At present, most higher vocational colleges adopt a modular curriculum framework consisting of general basic courses, professional basic courses, core professional courses, extended professional courses and centralized practical training, which is standard in form [8]. Nevertheless, formulated mainly based on disciplinary knowledge system rather than actual post competency requirements of enterprises, the curriculum standards fail to cover comprehensive vocational skills. Besides, they cannot timely reflect the application requirements of new technologies, new processes and new approaches arising from industrial upgrading.

2.2 Insufficient Horizontal Connection between Courses

Theoretical courses and practical courses are relatively isolated from each other, lacking coordination in schedule and content between knowledge learning and skill training, which fails to build a progressive continuous skill system. For instance, PLC Programming and Application serves as the theoretical foundation of the practical training course Installation and Commissioning of Automatic Production Line. However, these two courses are generally taught by different teachers, hindering effective knowledge transfer between teaching contents.

2.3 Inadequate Coverage of Practical Teaching

On-campus practical training is dominated by verification experiments and single-skill training, while the proportion of comprehensive project-based training remains low. Practical teaching of some courses becomes perfunctory, which merely relies on pictures and video demonstrations to carry out simple verification experiments with severely insufficient practical hours [9]. Training items are performed following fixed operating procedures without open-ended and challenging problem scenarios, creating a prominent gap with the innovative, comprehensive and stress-resistant training required by skill competitions.

2.4 Restricted Application of Vocational Skill Certificates

On the one hand, the assessment content of certificates partially overlaps yet fails to coincide with curriculum content. Students have to receive extra special training after regular course study to pass certificate examinations, which increases their academic burden. In addition, certificate assessment is separated from curriculum evaluation with no mutual recognition of course scores and certificate results, resulting in redundant learning and examination: students need extra exams after class learning and cannot get course exemption with acquired certificates. On the other hand, some colleges adopt intensive short-term cramming training to raise the certificate passing rate, going against the original intention of curriculum-certificate integration.

3. Connotation of Integrated Four Elements of Post-Course-Competition-Certificate

PCCC is a comprehensive concept composed of four core elements of talent cultivation. The “Post” refers to vocational posts and their competency requirements, representing the industrial demands for knowledge, professional skills and comprehensive literacy of technical talents, and serves as the logical starting point and ultimate goal of talent training [10]. The “Curriculum” stands for the professional curriculum system covering curriculum objectives, teaching contents, teaching methods and curriculum evaluation. As the core carrier to

fulfill talent cultivation goals, courses act as a hub linking posts, competitions and certificates. The "Competition" denotes vocational skill competitions and their derived teaching resource systems. Competitions provide a platform for teachers and students to demonstrate professional capabilities, and their competition criteria, scoring rules and equipment configurations reflect cutting-edge industrial technologies, which can be transformed into conventional teaching resources. The "Certificate" refers to vocational skill level certificates, an objective socialized criterion for evaluating students' vocational proficiency. Under the newly upgraded certificate management system, the standards of X-type certificates are formulated in line with the National Occupational Classification Catalogue and national vocational skill standard system, and colleges shall set up their curriculum systems and teaching contents based on relevant assessment requirements and evaluation specifications.

The integration of PCCC transforms the previously fragmented four elements into a systematically collaborative talent cultivation community: post requirements orient curriculum design, skill competitions boost teaching quality, certificate standards integrate curriculum evaluation, and competition achievements connect with certificate accreditation. Ultimately, a virtuous cycle featuring "posts guiding curriculum reform, courses integrating competitions and certificates, and competitions plus certificates mutually boosting talent training" is established [11].

4. Construction of Talent Training Mode from the Perspective of PCCC Integration

This paper proposes the conceptual framework for constructing a "four-in-one" talent cultivation model featuring "determining courses by job requirements, mutual promotion between courses and competitions, integration of courses and certifications, and complementarity between competitions and certifications". The four principles not only function independently but also support each other to form a closed loop, collectively driving the continuous optimization of the curriculum system.

4.1 Construction Ideas of the Four-in-One Talent Training Mode

4.1.1 Curriculum design driven by post competency standards based on post requirements

Taking the competency requirements of vocational posts as the fundamental basis for the formulation of curriculum system and teaching content, the implementation path can be carried out from three aspects. First, cooperate with representative regional enterprises to sort out the core post groups for mechatronics technology majors in accordance with the three-level ladder of entry-level posts, development-level posts and expansion-level posts, and draw competency maps for each post. Second, connect with the typical work tasks of posts to form a three-dimensional comparison table covering work tasks, competency elements and knowledge support. Third, decompose post competency elements into the teaching objectives of each course, so as to ensure that every course is equipped with clear competency training objectives.

4.1.2 Mutual promotion of courses and competitions: Transformation of competition projects into teaching projects

Skill competition questions are disassembled in a stepwise manner according to difficulty gradients and knowledge coverage. The primary level corresponds to single training of basic skills, the intermediate level matches comprehensive skill project training, and the advanced level targets innovative engineering challenges. The competition projects after teaching-oriented transformation are embedded in practical training courses of different semesters in a progressive difficulty gradient, enabling all students to receive competition level training step by step in conventional teaching processes.

4.1.3 Integration of courses and certificates: Docking of vocational skill level certificates and curriculum system

Following the reform of the 1+X Certificate System pilot program in 2025, the formulation of vocational skill level certificate standards is more closely aligned with the National Occupational Classification Catalogue of the People's Republic of China and the national vocational skill standard system. Therefore, the selection of curriculum content should be based on the vocational skill standards related to mechatronics technology, such as the post standards for electricians, industrial robot system operators, and industrial robot system maintenance personnel. The curriculum modules

incorporate professional functions, work contents, skill requirements and relevant knowledge specified in the standards, so as to realize the homologous and isomorphic development of curriculum standards and certificate standards.

4.1.4 Complementation of competitions and certificates: Two-way empowerment of skill competition achievements and certificate certification

On the one hand, the award results obtained by students in major vocational skill competitions can be connected with the vocational skill level evaluation system. For example, students with outstanding achievements in the "Industrial Robot Technology Application" project of the National Vocational College Skills Competition can apply for corresponding levels of vocational skill certificates with award certificates to avoid repeated assessments. On the other hand, the question design, scoring criteria and technical requirements of competitions can be refined and transformed into practical cases and advanced training projects for certificate-related courses, so as to improve the pertinence and effectiveness of teaching.

4.2 Curriculum System Restructuring Based on the PCCC Concept

4.2.1 Construction of modular curriculum system based on post groups

The curriculum adopts the basic framework of "platform + module + specialization direction". The platform consists of public platform courses and professional group platform courses. Public platform courses cover general competency courses including ideological and political education, English, mathematics, and fundamental computer applications, which are uniformly arranged at the college level. Professional group platform courses involve the core basic courses of the mechatronics discipline, such as Mechanical Drawing and CAD, Electrical and Electronic Technology, Mechanical Foundation, and Sensor and Detection Technology, laying a solid and comprehensive foundation for students' subsequent specialized learning. The module part includes post direction modules and certificate expansion modules. The post direction modules are set according to different post groups, with each module containing 3 to 5 core courses and supporting practical training projects. For instance, the automatic control direction covers courses including PLC Programming and Application, Industrial Robot Operation and Programming, Configuration Software Application, and Design and Commissioning of Automatic Production Lines. The electromechanical equipment maintenance direction includes Fault Diagnosis and Maintenance of Electromechanical Equipment, Installation and Maintenance of CNC Machine Tools, and other related courses.

4.2.2 Design of practical training courses integrated with competition projects

Practical training courses are arranged progressively in four hierarchical levels: basic skills, special skills, comprehensive skills, and innovative skills. The basic skill level focuses on standardized training of individual skills, including basic electrical operation, mechanical disassembly and assembly, and installation of electrical control circuits. The special skill level centers on combined training of skill modules, such as the construction of PLC control systems as well as the installation and commissioning of pneumatic systems. The comprehensive skill level is dominated by comprehensive project training based on complete working processes, including joint commissioning of automated production lines and integration of industrial robot workstations. The innovative skill level focuses on open-ended problem solving and innovative design, encouraging students to participate in the World Skills Competition and organically integrate innovative design with competition preparation.

4.2.3 Curriculum content aligned with vocational skill level certificates

With reference to the assessment standards of core vocational skill level certificates in the field of mechatronics, the curriculum content is reformed and optimized, and a comparison table of curriculum standards and certificate standards is established. This measure ensures full coverage of all teaching points, rationalizes the logical sequence of knowledge points, and avoids redundant and repetitive content. Taking the intermediate certificate for Industrial Robot System Operator as an example, its vocational skill standards cover robot safety operation specifications, teach pendant programming, coordinate system establishment and calibration, handling and palletizing programming, and simple vision-guided positioning. The above contents can be integrated into the teaching content of courses such as Industrial Robot

Operation and Programming, Sensor and Vision Technology, and Comprehensive Practical Training of Automated Production Lines.

4.3 Teaching Mode Reform of the PCCC Four-in-One Model

4.3.1 PCCC four-in-one teaching mode

At the level of teaching methods, the construction of the Post-Course-Competition-Certificate four-in-one teaching mode needs to take the following aspects into consideration. First, authentic teaching scenarios. Teachers preferentially select real enterprise production projects and official skill competition questions as teaching projects in teaching design, which can be appropriately simplified, while avoiding virtual cases divorced from practical production. Second, comprehensive teaching tasks. Teaching tasks cover the complete competency dimensions of knowledge understanding, skill operation, problem-solving, team collaboration and safety specifications. The assessment criteria are formulated in accordance with enterprise post specifications, competition scoring standards and certificate assessment standards, realizing multi-dimensional alignment with unified teaching tasks. Third, progressive teaching process. The teaching procedure of a single course follows the five-stage model of demonstration, imitation, practice, competition and evaluation. Specifically, teachers demonstrate standardized operations in line with enterprise standard operating procedures (SOPs); students master basic skills through imitative practice corresponding to basic certificate assessment requirements; students consolidate professional competencies by completing independent tasks; students finish comprehensive challenging tasks in group competition mode consistent with vocational skill competition standards; and finally, multi-dimensional process and result evaluation is conducted based on the three unified standards of enterprise posts, vocational certificates and skill competitions.

4.3.2 Practical path of project-based teaching and integration of competition and training

Project-based teaching serves as the basic teaching organization form for the integration of posts, courses, competitions and certificates. Teaching projects are selected from typical enterprise work tasks to ensure the professionalism and practicality of teaching content. Different from verification experiments targeting single knowledge points, project-based teaching requires the comprehensive application of knowledge and skills acquired from multiple courses. The implementation procedures and evaluation criteria of projects are designed in reference to skill competition rules and certificate assessment specifications, enabling project training to support students' preparation for skill competitions and vocational certificate assessments simultaneously.

4.4 Deepening the Construction of Industry-Education Integration from the Perspective of PCCC Integration

4.4.1 Deepening school and enterprise collaborative talent cultivation

The effective operation of the PCCC integration mode requires in-depth enterprise participation in collaborative talent cultivation. Firstly, schools and enterprises jointly build industrial colleges, technological innovation and development centers, and industry-education integration communities. Enterprises actively participate in key teaching links including the formulation of talent training programs, curriculum development, practical teaching and guidance, and student assessment and evaluation. Secondly, the multi-collaborative community should optimize top-level design, establish a dynamic update mechanism for post competency standards oriented to actual industrial demands, and form a core team composed of enterprise experts and full-time teachers. Regular review and demonstration shall be carried out in the links of major dynamic adjustment, curriculum restructuring, content optimization and textbook development to ensure that the effectiveness of talent cultivation keeps pace with industrial technological development.

4.4.2 Strengthening the construction of dual-qualified teachers

Colleges should broaden the sources of teachers and strengthen the introduction of high-skilled talents with enterprise work experience, including competition award winners and senior technicians. Meanwhile, it is essential to improve the enterprise practice system for in-service teachers, implement the requirement that vocational college teachers shall complete no less than six months of enterprise practice every five years, and encourage teachers to participate in enterprise technological transformation and process optimization projects. Teachers' enterprise practice experience and

achievements are incorporated into professional title evaluation and performance assessment. In addition, colleges need to enhance teachers' abilities in competition guidance and certificate evaluation, and encourage professional teachers to obtain the qualifications of vocational skill level certificate assessors and skill competition referees.

4.4.3 Optimizing the construction of training bases and teaching resources

The planning and construction of practical training bases should comprehensively consider the compatibility of four core functions, including daily teaching, skill competition training, vocational certificate assessment, and enterprise vocational training. Equipment selection is in accordance with the designated equipment standards for skill competitions and certificate assessments, and the venue layout supports the flexible conversion between teaching stations and competition stations. Without redundant investment, a unified set of training facilities can serve four practical purposes, including daily teaching, competition training, certificate practical assessment, and enterprise skill training. A digital teaching resource platform should be constructed to integrate digital resources such as competition question analyses, certificate examination real questions, and typical enterprise work cases with regular updates, forming a systematic teaching resource library. Furthermore, new loose-leaf textbooks, work-manual textbooks and digital textbooks should be developed. The textbook content fully integrates typical enterprise work tasks and practical cases, and adopts competition scoring criteria and certificate assessment requirements as important references for practical teaching.

5. Conclusion

From the perspective of PCCC integration, the talent training mode of the mechatronics technology major in higher vocational colleges should focus on solving the collaboration problems among the four core elements, namely the organic integration of post requirements, curriculum content, competition resources and certificate assessments. Specifically, a systematic framework should be constructed to closely align curriculum content with post competencies, transform competition achievements into available teaching resources, and realize the linkage between certificate assessment and curriculum evaluation. Following the transfer of the management authority of the 1+X certificate system to the Ministry of Human Resources and Social Security, the authority and social recognition of vocational skill level certificates have been further improved. Vocational colleges should actively adjust curriculum settings in accordance with the national vocational skill

standards issued by the Ministry of Human Resources and Social Security, and open up policy channels for the recognition of competition awards as valid certificate qualifications. Such measures ensure the effective implementation of curriculum -certificate integration and competition -certificate complementation under the background of the new institutional reform.

Acknowledgments

This paper is supported by the General School-level Teaching Reform Project of Chongqing Industry & Trade Polytechnic (No.JG20240249).

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