Construction and Practice of School-based Curriculum System for Mechatronics Technology Specialty

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Abstract: With the in-depth integration and development of information technology and manufacturing, enterprises' demand for composite, innovative, and development-oriented mechatronics technology professionals has increased year by year. It was necessary to reconstruct the curriculum system and update the teaching model to meet the enterprise's demand for talents. The advantages and disadvantages of the outcome-oriented and work-process-oriented curriculum development paradigms and their practical experience were analysed. A new path to integrate the two curriculum development paradigms was proposed. Guided by the national vocational education standard system, a modular curriculum system of "5+12(N)" consisting of 12 module courses and several course modules has been constructed for 5 post groups in intelligent manufacturing. It has innovated the path method for the transformation of industrial resources to generate teaching resources in the six steps of "selection, solution, determination, transfer, adjustment and expansion". The modular curriculum teaching project resource library was constructed through school-enterprise cooperation. Based on the comprehensive online education platform and the automated virtual simulation training center, the modular collaborative teaching reform of "dual-teacher collaboration, dual-line mixing, and dual-course complementarity" has been implemented. Through six years of reform and practice, the training ability and level of mechatronics technology professionals has been continuously improved, and the employment satisfaction has reached 99%, and the reform has achieved remarkable results.

1. Reform background

1.1 Manufacturing development

The in-depth integration of information technology and manufacturing industry has triggered the transformation of a new manufacturing system with intelligent, green and innovative development, which has brought new challenges to the cultivation of compound technical and skilled talents. It was urgent to develop the corresponding curriculum system and curriculum resources, and cultivate compound high-quality technical and skilled talents through the reform of corresponding teaching methods.

1.2 Skills teaching and training issues

- The professional curriculum system was not accurate enough to connect intelligent manufacturing job groups, and it was insufficient to support the cultivation of manufacturing compound technical and technical talents.
- The integration of vocational qualification certificate or vocational skill level certificate with the curriculum system was not precise enough.
- The teaching resources for connecting with the production practice projects of enterprises were not rich.
- The teaching method of teamwork and division of labor was insufficient.

2. Reform methods and paths

2.1 A new path of curriculum development integrating outcome-oriented and work-process-

oriented paradigms

In the new manufacturing system, the talent capability structure was highly complex, and the traditional task analysis method suitable for professional capability development of process jobs can no longer be well adapted. Based on the perspective of paradigm integration, the application process-oriented and outcome-oriented curriculum development paradigms were integrated to form new curriculum development ideas [1-2]. On the one hand, according to the systematic development steps based on the work process, firstly, the post work process system and post occupational ability were systematically studied, and several typical work modules of ability classification were summarized. The professional ability grading standard module library was developed, and the professional action field was summarized. Finally, according to the development law of knowledge and skills, the professional learning field courses were summarized, sorted and sequenced. On the other hand, applying the outcome-oriented reverse design, the training objectives were decomposed into graduation requirements, and the graduation requirements were gradually decomposed into course learning outcomes, teaching items, etc., and a curriculum matrix was constructed to clarify the relationship between professional learning outcomes and curriculum architecture. During the implementation process, the curriculum settings were optimized in time, and the teaching content was updated in time. The development path of the curriculum system was shown in figure 1. This kind of curriculum development idea was suitable for curriculum development in complex post work system, which made up for the deficiency of traditional task analysis method.

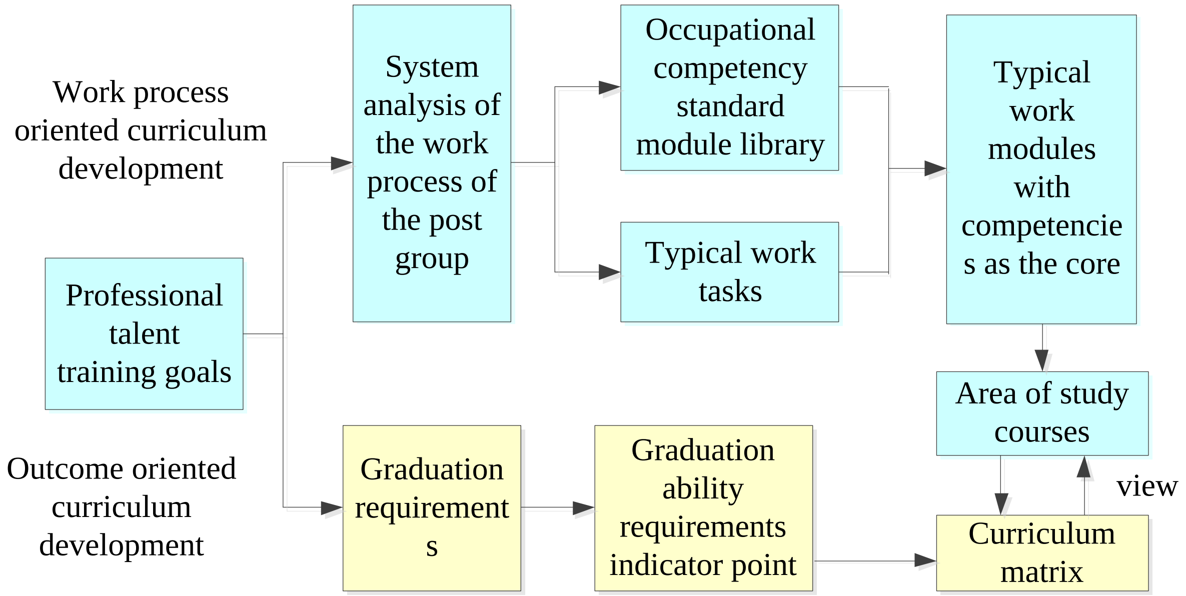

Figure 1 Schematic diagram of curriculum system development

2.2 Developed a standard module library for the grading of professional vocational abilities

Guided by the national professional teaching standards for mechatronics technology, it was oriented to five post groups such as intelligent factory operation and maintenance of intelligent manufacturing enterprises and industrial robot application. According to the complexity level, a standard module library of vocational ability grading including 12 work modules and 166 ability units was constructed in five levels [3]. The professional ability unit and grading table of mechatronics technology major were shown in the table 1. Each competency unit included number, name, grade, competency requirements, assessment samples, etc.

Table 1 Mechatronics technology professional ability units and their Classification

Serial num	Ability / level	One	Two	Three	Four	Five

ber	Competency unit							
1	KA Career-critical competencies			6	8	6	3	3
2	Professional competence	GA Professional general ability		6	5	5	6	2
3		SA Career-specific competencies	SA-1 Recognition and Drawing	5	2	2	0	0
4			SA-2 Typical equipment operation and common tool usage	1	2	2	1	0
5			SA-3 Assembly and commissioning of mechanical systems	1	2	2	5	1
6			SA-4 Assembly and commissioning of electrical systems	5	2	6	1	1
7			SA-5 Installation and commissioning of gas-liquid system	1	2	6	3	2
8			SA-6 Installation and commissioning of automated production lines	1	2	2	2	1
9			SA-7 Inspection, repair and maintenance of mechatronics equipment	6	5	4	2	1
10			SA-8 Electromechanical equipment production site management	0	0	5	3	1
11			SA-9 Design and technical transformation of mechatronics System	0	0	2	3	4
12			SA-10 Sales and technical services of mechatronics equipment	3	4	4	4	2

2.3 Constructed a "5+12(N)" modular curriculum system

By comparing the vocational skills certificate standards with the vocational competency standard module library, a linked list of vocational competencies was established. Vocational skill level certificates such as industrial robot operation and maintenance, industrial robot application programming, and programmable logic controller application were determined to be integrated into the curriculum system. According to the composite model of vertical deepening and horizontal expansion, and the progressive development law of "basic technical skills, single technical skills, composite technical skills, and comprehensive technical skills for positions", the "5+12 (N)" modular curriculum system was constructed. The curriculum system contains 12 modular courses, each of which contains N modules. Curriculum and teaching standards have been formulated. With the development of technology, new course modules can be added in time, and unsuitable course modules can be eliminated in time. Students can also choose different modules according to their personal career development. After completing all the courses, students can obtain both a specialist diploma and a number of vocational qualifications. The problem that the professional curriculum system did not support the cultivation of high-quality compound talents in the manufacturing industry and was not accurate enough to integrate with the vocational skill level certificate has been solved.

2.4 Developed a batch of teaching resources to connect with the productive practice projects of enterprises

The path method of "selection, solution, determination, transfer, adjustment and extension" of industrial resources transformation to generate teaching resources was proposed [4]. The first step was to select enterprise practice projects that meet the standard requirements from the industrial enterprise production practice project database. The second step was to decompose the selected production practice items into work items of independent work process units. The third step was to determine the introduced work items according to the requirements of knowledge and skills and the requirements of the introduction standard. The fourth step was to transform the work items in the work system of the determined occupational field into the teaching items in the vocational education curriculum system. The fifth step was to integrate and sequence the developed teaching projects into modular courses. The sixth step was to expand and develop modular course teaching resources such as loose-leaf teaching materials, micro-course videos, multimedia courseware, and animations with the modular course teaching project as the core. Applying the above path method, 8 enterprise production projects, such as intelligent bar processing and crystal gift intelligent factory, have been transformed into professional core course teaching projects. New contents such as integrated application of industrial robots, industrial Internet, and smart factories were added to the course. The problem of insufficient teaching resources for docking enterprise production practice projects has been solved.

2.5 Implemented modular collaborative teaching reform

Relying on the professional online education comprehensive platform and the automated virtual simulation center, according to the characteristics of courses and teachers, the construction of curriculum resources, teaching design, teaching implementation, teaching diagnosis and improvement were carried out collaboratively. Different full-time teachers and part-time teachers have conducted online and offline collaborative teaching in the training base and production site. The second classroom and the first classroom have cooperated to assist teaching. The problem of insufficient modular teaching methods in teamwork and division of labor has been solved.

3. Implementation Effect

3.1 The results have benefited a wide range, and the competitiveness of graduates has improved

After six years of practical application, the Mechatronics Technology major has benefited more than 3,000 students. The quality of talent training has been improved year by year. The pass rate of vocational qualification certificates has remained at 100%, and the average pass rate of vocational skills grade certificates has reached 95%. The employment rate has exceeded 98% for six consecutive years. The graduates' comprehensive post technical skill level, post adaptability, and sustainable development ability have been significantly enhanced, and employer satisfaction has reached 99.1%.

3.2 Students' innovative awareness and comprehensive practical ability have been

significantly improved

Students participated in the National Vocational College Skills Competition "Industrial Robot Technology Application Competition" and "Photovoltaic Electronic Engineering Design and Implementation" and other projects, and won 2 second prizes and 1 third prize. Students participated in projects such as "Mechatronics Project" and "Modern Electrical System Installation and Commissioning" in the Shandong Vocational College Skills Competition, and won more than 20 awards. Students have also won more than 30 awards in competitions such as the National Higher Vocational College Student Innovation and Entrepreneurship Competition, the Shandong Provincial Science and Technology Innovation Competition, and the Shandong Provincial College Students Extracurricular Academic Science and Technology Works Competition.

3.3 The course construction has achieved fruitful results, and the level of professional construction has been significantly improved

The Mechatronics Technology major has completed 6 provincial-level quality resource sharing courses, developed 6 school-enterprise cooperation textbooks, and was selected as 2 textbooks in the "13th Five-Year Plan" National Vocational Education Planning, and won 1 second prize for national textbook construction. The construction level of mechatronics technology has been continuously improved, and has been rated as a provincial brand professional group, a provincial high-quality school construction major, and a provincial high-level professional group construction major. The teaching team of mechatronics technology has successively won the National Vocational Education Teacher Teaching Innovation Team.

3.4 Achievements are noticed by peers, recognized by experts, and social influence is enhanced

The results have attracted the attention of many schools, such as Shandong Transport Vocational College, Cangzhou Vocational and Technical College, etc., and also received some media reports, such as China Higher Vocational College Network, Zibo TV Station, Dazhong Network, etc. 28 papers published have been cited by teachers from many schools, such as Heilongjiang University of Science and Technology, Weifang University of Science and Technology, Liupanshui Vocational and Technical College, etc. In addition, the online open courses and teaching materials developed by the team have been used by more than 50 universities and more than 100,000 students.

4. Conclusion

A new curriculum development path has been verified, which absorbs the advantages of the work process-oriented and outcome-oriented curriculum development paradigm, and the effect is remarkable. However, the curriculum system is dynamic and still faces many challenges. The relationship between competencies and typical job tasks has not been fully resolved. For example, the basic unit of course organization is job task or vocational ability, and in addition, how to consider the integration of ability training and work task process in the design of specific courses. With the development of technology, there are more and more complex tasks in production positions, and the awakening of people's awareness of all-round development must take ability as the basic unit to organize the course content. The next step will be devoted to the research of vocational ability and the continuous optimization of the standard module library, so as to obtain a more suitable curriculum system.

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