Construction of Curriculum System for Intelligent Manufacturing Engineering Speciality

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Abstract. The rapid development of the manufacturing industry has led to a significant increase in the demand for talent in the field of modern mechanical manufacturing, particularly in the area of intelligent manufacturing. Intelligent manufacturing represents the profound integration of next-generation information and communication technologies with advanced manufacturing techniques. This paper aims to establish a curriculum system suitable for cultivate intelligent manufacturing professionals who meet the requirements of the engineering field. By combining the needs of industrial development and talent cultivation, the construction of the curriculum system for intelligent manufacturing engineering is explored through the application of engineering professional certification methods and principles. This exploration encompasses aspects such as the theoretical curriculum, practical curriculum and assessment systems.

Keywords: Intelligent manufacturing, Curriculum system, Theoretical course, Practical component, Assessment system.

1 Introduction

The evolution to a digital society implies a revolution in the industry, with the emergence of smart/connected objects, smart factories, the Internet of Things and artificial intelligence, etc [1-2]. As the accelerating penetration and integration of informatization and intelligentization with the manufacturing industry, traditional manufacturing industry is facing a critical period of transformation and upgrading. "Intelligent manufacturing" has become an important development direction of modern advanced manufacturing industry [3-5]. In the face of new situations and requirements, there is a continuous increase in the demand for specialized talent in the field of intelligent manufacturing, particularly in areas such as the application of intelligent production lines, smart factories, system integration, and maintenance skills [6-8]. From the perspective of cultivating industrial talent, it is urgent for higher education institutions to adapt to the trend and carry out talent cultivation in the professional field of intelligent manufacturing engineering. Due to the complexity, integration and diversity of

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intelligent manufacturing talent cultivation, colleges and universities are facing higher challenges in this regard.

The undergraduate speciality of Intelligent Manufacturing Engineering is a newly established discipline approved by the Ministry of Education in 2018. It is a "new engineering" speciality characterized by the interdisciplinary integration of mechanical engineering and intelligent engineering. The development of this speciality is still in its early stages, and the curriculum system is continuously being improved and explored. Studying its knowledge system, competency requirements, and constructing a curriculum system based on these aspects is the foundation for building a good speciality. It also serves as the guarantee and support for cultivating engineering professionals who meet the current needs of the intelligent manufacturing engineering field.

2 Constructing the curriculum system

2.1 Competency-oriented, rational planning of theoretical curriculum system

Based on the architecture of intelligent manufacturing systems and in accordance with engineering professional certification standards, the construction of theoretical curriculum system for the intelligent manufacturing engineering speciality is guided by the ability to "solve complex engineering problems". The courses are logically structured at three levels: foundation, specialization and integration, gradually deepening the coverage of disciplinary content.

Theoretical course content.

Regarding the knowledge points covered in the courses, the construction of the curriculum teaching system is driven by core courses. Course clusters are established around the core courses to establish the intrinsic connection between course content, theory, and practical applications. The curriculum construction adopts a hierarchical approach, appointing course leaders to break down tasks and assign responsibilities to individuals. The course leaders are specifically responsible for the teaching organization, curriculum development, and management of the courses. The focus shifts from pursuing the rigor and completeness of individual courses to improving the course cluster system and teaching system, transforming the overlapping nature of courses within the cluster into complementary relationships and promoting the integration of courses between clusters, thus forming a coherent and complete teaching system.

Theoretical teaching methods.

Professional education accreditation emphasizes student-centered approaches, urging a departure from the traditional teacher-centered and classroom-centered thinking. It is essential to closely integrate modern teaching resources and methods with production practice, introduce case-based and project-based teaching, and emphasize practical application. Starting from basic concepts, fundamental knowledge points, and basic skills, teaching is conducted around projects. Each chapter of the course is introduced through cases and problem-oriented approaches, fully stimulating students' interest in learning. Concrete projects serve as the thread connecting different courses, enabling the integration of knowledge and cultivating students' comprehensive application abilities. Teaching methods such as questioning discussions and interactive exchanges are employed to encourage active thinking, analysis and discussion among students, avoiding a purely "transmissive" approach to knowledge dissemination. Flipped classrooms are utilized to cultivate students' abilities for independent problem analysis and problem-solving, stimulating their interest and initiative in learning. The production of micro-courses, MOOCs, and other teaching resources assists in pre-class preparation and post-class review, significantly enhancing teaching effectiveness and quality.

2.2 Intelligent manufacturing technology-oriented, constructing practical curriculum system

Based on the framework of engineering professional certification, while emphasizing the coherence and relevance of theoretical courses, it is also important to focus on the practical application of knowledge. The practical teaching component should not only be closely related to theoretical knowledge but also emphasize practicality and hierarchical design, incorporating typical projects from actual production.

Design of practical teaching.

Under the background of engineering professional certification, talent cultivation emphasizes the applicability and practicality of content. Therefore, practical teaching should synergize with theoretical knowledge to cultivate students' abilities while emphasizing the application of key intelligent manufacturing technologies. This necessitates defining the goals of practical teaching capabilities and constructing a practical teaching system that aims to continuously develop these capabilities throughout the entire education process.

According to the three-level "foundation-specialization-integration" of theoretical curriculum system, practical components are arranged, aiming to integrate theory and practice closely and cultivate students' practical skills, as shown in Fig.1. The practical teaching system is designed to achieve the core competencies of intelligent manufacturing engineering, using theoretical knowledge as the foundation. It organically connects and integrates practical components in the foundational, specialized, and comprehensive categories, forming a progressive practical system with intelligent manufacturing characteristics. Supplemented by the actual production project, the intelligent manufacturing process of products is the leading and students are the main body when setting up the practical teaching system.

Content of practical teaching.

Traditional practical teaching primarily focuses on its own teaching objectives in terms of content, which is mostly a single experiment such as verifying theoretical knowledge from textbooks or conducting simple instrument operations. It usually lacks comprehensive training in students' abilities and neglects the organic connection with practical production. The individual practical components are often independent of each other, lacking coherence and hierarchy. In the construction of the intelligent manufacturing engineering curriculum system, the practical components focus on key intelligent manufacturing technologies and are project-based. They are designed to be targeted, comprehensive, and expandable, encompassing foundational training, specialized training, and comprehensive training, as shown in Fig.1.

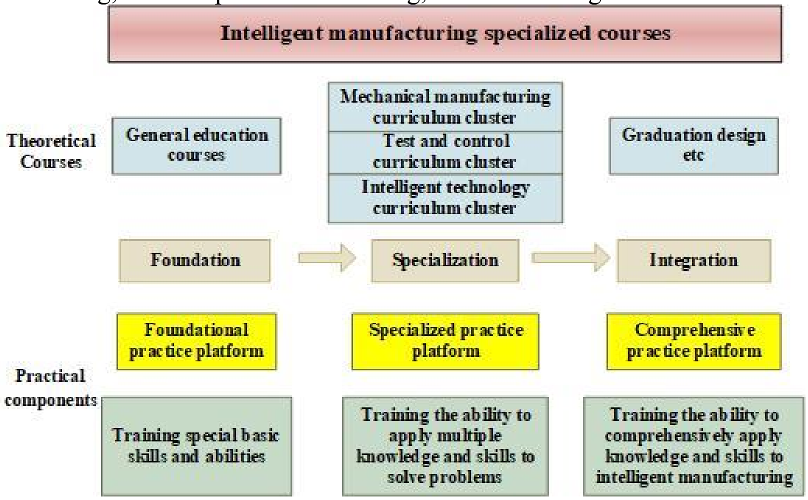

Fig. 1. The practical teaching system

In addition, to further cultivate students' innovative thinking and abilities, the integration of professional education and innovation and entrepreneurship education is pursued. The existing theoretical knowledge is combined with new technologies in practical production. On the basis of compulsory basic experiments, specialized experiments and comprehensive experiments, the practical teaching system of this speciality also develop innovative experiments of different types that are tailored to students' levels. These innovative experiments are based on research projects and technological competitions, fully reflecting the distinctive features of intelligent manufacturing and modern education. This approach establishes a scientific and systematic experimental teaching system with hierarchical and multi-module connections, achieving the organic integration of fundamentals and frontier knowledge, as well as classic and modern approaches.

Implementation of Practical Teaching.

Traditional laboratory sessions are typically conducted in a mechanized manner, with experiment instructors following a prescribed schedule and completing the experiments. Students passively receive instructions, lacking independent thinking time and space. There is limited interaction and discussion between teachers and students, resulting in ineffective training. Therefore, in the implementation of practical components in the intelligent manufacturing engineering speciality, two approaches, centralized and decentralized, are adopted. Foundational practical projects are primarily organized in a centralized manner, with individual completion, aimed at solidifying the fundamental knowledge and developing students' practical skills. Comprehensive practical projects are organized in a decentralized manner, with team-based approaches. Students select the required experimental platforms through online reservations and work in groups to complete project tasks by applying their knowledge and skills. This approach cultivates students' abilities in teamwork, analysis, and problem-solving. Specialized experimental projects combine centralized and decentralized approaches based on the characteristics of the knowledge points, deepening students' understanding of abstract professional concepts.

2.3 Effectiveness-Oriented, Designing a Scientific Assessment System

The construction of the curriculum system for intelligent manufacturing engineering specialty requires a corresponding assessment system to accurately evaluate the teaching effectiveness. This allows for continuous refinement of teaching design and assessment methods, ultimately improving the quality of education.

Establishing a scientific, operationally strong, and outcome-oriented assessment method and evaluation criteria promote students' mastery of knowledge, development of skills, and cultivation of professional qualities. Each course supports the cultivation of different knowledge and abilities within the course cluster. To evaluate these supporting points, diverse forms of assessment must be employed, especially for key knowledge points or skills. Stage-based tests can be used and students who do not pass the assessment cannot proceed to the next stage of learning and training. The assessment should also focus on monitoring students' learning processes and increase the weight of self-directed learning in the course evaluation system. By continuously optimizing the elements of assessment, determining the weights of different assessment methods in course evaluation based on comprehensive evaluation indicators, innovating the final assessment methods, and emphasizing the comprehensive assessment of students' overall qualities, the assessment can objectively and comprehensively reflect students' mastery and application of knowledge. This guides students to improve and enhance themselves in terms of knowledge and abilities.

Additionally, through assessment results, questionnaires and class discussions, students are involved as the evaluators to provide feedback on the effectiveness of curriculum teaching reforms. The feedback is analyzed and summarized to optimize and adjust the measures of curriculum teaching reforms, continuously refine the assessment methods and evaluation criteria, establish a regular evaluation mechanism, and make continuous improvements.

3 Conclusion

Intelligent manufacturing is the main focus of "Made in China 2025." Developing intelligent manufacturing is an important direction and necessary process for the development and transformation of manufacturing industry. The intelligent manufacturing engineering speciality is a new interdisciplinary field. In order to cultivate high-quality professionals who meet the demands of the intelligent manufacturing industry, it is necessary to construct a curriculum system that aligns with the structure of intelligent manufacturing capabilities and supports the training objectives and graduation requirements of the speciality. This paper studied the theoretical curriculum system that supports the knowledge system of intelligent manufacturing engineering, the practical teaching system that supports the development of engineering practical abilities, and explored a curriculum quality assessment and evaluation system suitable for the characteristics of the intelligent manufacturing engineering speciality. This research provides a reference for the construction and development of this young field of study in intelligent manufacturing engineering.

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