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Exploration of Robot Oriented Talent Training Mode for Emerging Engineering Education

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Abstract

This paper discusses the confusions and difficulties to be overcome in the upgrading and transformation of automation majors from the essence and connotation of emerging engineering education development. The talent cultivation concept of "education as the core, foundation as the root, practice as the base, and innovation as the soul" is proposed. Talent training objectives and graduation requirements based on the OBE education concept and emerging engineering education requirements are developed. Curriculum system based on training objectives and graduation requirements is constructed. A collaborative education platform based on university-enterprise cooperation is provided. Then, it explores the innovative talent cultivation model of robotics in the context of emerging engineering education by "constructing a scientific curriculum system, building a diversified practice platform, and promoting the deep integration of industry and education".

Keywords

Emerging Engineering Education, Robotics, Innovative Talents, Cultivation Model

1. Introduction

After Germany proposed Industry 4.0 (Henning, Wolfgang, & Johannes, 2013) in 2013, the United States and Japan also put forward their manufacturing strategy ideas, and China proposed "Made in China 2025" (Chinese State Council, 2015) in 2015. In February and April 2017, the Ministry of Education held seminars at Fudan University and Tianjin University respectively, forming the "Fudan Consensus" and "Tianjin University Initiative" for the development of emerging engineering education. In June 2017, the Ministry of Education in Beijing formulated the "Beijing Guideline" for the development of emerging engi-

neering education. Emerging engineering education is the reform direction of engineering education in China based on the new needs of national strategic development, the new situation of international competition and the new requirements of moral education (Li & Dong, 2019). The connotation of emerging engineering education is to cultivate future diversified and innovative excellent engineering talents with strategic, innovative, systematic and open characteristics, led by moral education, with the construction concept of responding to changes and shaping the future, and using inheritance and innovation, crossover and integration, coordination and sharing as the main ways (Zhong, 2017).

In industrialized production, automation science is widely used and permeates almost all sectors of society. Moreover, the level of automation is considered to be an important measure of a country's modernization. In the process of social and economic development, the cultivation of innovative talents in automation majors will play a significant role in facilitating the development. In the process of improving the quality of personnel training in the new era, it is necessary to further promote the quality of education and training of automation professionals in universities to supply a steady source of talents for the development of new industrialization. Robotics covers a wide range of disciplines, which integrates the methods and theories of engineering and natural sciences, and studies the system design, optimal control of robots, environmental perception of robots, artificial intelligence and other academic issues. At present, China's robotics development is facing a significant historical opportunity. The policies of Made in China 2025 and Robotics Industry Development Plan (2016-2020) have clearly identified robotics as a key development area, and robotics will be a key fulcrum to promote the strategy of manufacturing power, which indicates that the robot industry has ushered in an once-in-a-lifetime development opportunity. In 2016, Southeast University offered the first "Robotics Engineering" undergraduate program in China, marking the beginning of a new phase in robotics education (Li, Wang, & Ji, 2021).

Automation science and technology are widely used in industrial production and social management, penetrating into almost all sectors of society. At the same time, the level of automation is the symbol of modernization of a country, and the cultivation of innovative talents specialized in automation plays a great role in boosting social and economic development. As the main battlefield of higher education, local colleges and universities bear the primary responsibility of cultivating automation talents for regional economy and society, and provide intellectual and talents to guarantee the local economic development. With the rapid development of new technologies and the lag of training programs, the cultivation of automation talents in colleges and universities is not synchronized with the economy and society, and it is difficult to adapt to the dynamic needs of new economic and social development. It is an urgent issue to explore how to promote the professional education of automation to meet the needs of new industrialization development in the new era so as to improve the quality of talent

training.

Robotics is a multi-disciplinary high technology with a wide range of applications and a vast span of technology levels, permeating almost all sectors of society, with systems engineering and automatic control technology at its core. Traditionally, the automation profession mainly applies system theory and control theory to industrial machine systems, focusing on local automatic machine control and operation execution. With the rapid development of artificial intelligence, internet of things, big data, robotics and other new technologies, automation majors in local universities should be combined with informationization, digitalization, networking and intelligent technologies. Talent cultivation should be shifted from the closed type within the discipline to the external demand-oriented of local industry, from the division of specialties to the integration of multiple disciplines, and from the passive adaptation to the service market to the active leadership of local industry development. We should cultivate technical talents with local characteristics to adapt to the future "automation". For this reason, we explore the training mode of robotics talents in this paper.

2. Key Problems to Be Solved of Talent Training Mode

As a training base for high-level innovative talents in the automation industry of Inner Mongolia Autonomous Region, Inner Mongolia University has cultivated a large number of specialized talents who master automation control technology and adapt to the economic development of the Autonomous Region. In order to meet the higher requirements for talent training in new industries such as artificial intelligence, robotics and intelligent manufacturing, the automation major in Inner Mongolia University has explored and practiced the transformation and upgrading of automation programs.

Through the preliminary in-depth research on automation-related enterprises, universities, graduates and current students, the key problems to be solved by the existing robotics engineering program of Inner Mongolia University are:

1) The existing training program still focuses on the traditional industrial automation orientation, the talent cultivation goal lacks the core engineering literacy, and the curriculum system is not sufficient to support the training objectives. The practical links are scattered, not integrated, and lack the top-level design to systematically and effectively cultivate students' ability to solve complex engineering problems, which cannot achieve the effect of applying what they have learned to practice. In the process of talent cultivation, "University-Industry Cooperation and Collaborative Education" has been implemented, but the cooperation with enterprises is not comprehensive and deep enough, and further innovation of the talent cultivation model is needed.

2) The general education curriculum lacks overall planning and design, and is only a simple patchwork of courses from different disciplines, which does not meet the substantive requirements of interdisciplinary learning, making it difficult for students to form an integrated and interdisciplinary knowledge system.

The general education curriculum is still based on knowledge instruction and lacks training for students' general skills, such as language skills, teamwork skills, and design and innovation skills.

3. Solutions to the Problems

On the basis of comparing the certification indexes of engineering education and the requirements of national standards for teaching quality, the automation specialty puts forward the following research methods.

3.1. Developing Talent Training Objectives and Graduation Requirements Based on the Outcome-Based Education (OBE) Concept and Emerging Engineering Education Requirements

In view of the new demands of the automation industry, the new trend of interdisciplinary integration and the new achievements of science and technology development and based on the concept of OBE, we propose the training objectives, graduation requirements, curriculum system and enterprise training program for automation majors geared to "emerging engineering education" on the basis of sufficient investigation. Its training objectives are to cultivate high-quality and multi-disciplinary talents in response to the requirements of industrialization, informatization and intelligence development. They should have solid knowledge of natural science and good humanities, master the basic knowledge, basic principles and cutting-edge application technology of automation and related disciplines, and have strong practical engineering ability and cross-boundary integration capabilities. Moreover, they should be able to use information technology and intelligent technology for engineering design and management, with an international perspective, innovation, team spirit and a sustainable development concept (Hu & Tang, 2019).

From the perspective of adapting to the information and intelligence development, this paper analyzes the quality requirements of future engineering talents with reference to the advanced concepts and ideas of international engineering education accreditation. Moreover, the graduation requirements for automation majors are formulated by combining the university's characteristics, talent training orientation and professional training objectives. They mainly include subject knowledge (mathematics, natural science, cross-discipline, cutting-edge engineering knowledge), professional ability (problem-solving ability in design, application research, tool use, information synthesis, project management based on new technology), non-professional ability (communication, innovation and entrepreneurship, teamwork, etc.), comprehensive quality (engineering ethics, patriotic feelings, cross-border integration, global vision, lifelong learning), and so on.

3.2. Curriculum Development Based on Training Objectives and Graduation Requirements

Given the requirements of new economy, new industry and the industrialized,

informatized and intelligent development, we combine the advanced concept of international engineering education, OBE, to build the curriculum system of automation based on artificial intelligence and robotics. In addition to setting the basic requirements of the curriculum system according to the OBE concept and graduation requirements, we also build modular courses according to engineering logic, and break the boundaries of disciplines. We apply information technology and intelligent technology such as Internet+, Industrial Internet of Things, Artificial Intelligence, Robotics, Intelligent Manufacturing, and Virtual Reality to set up a multi-disciplinary curriculum system and carry out a reconstruction of the result-oriented curriculum system.

We have built a platform for general education in engineering (mathematics, natural science, ideology and politics, information, etc.), a platform for professional education in automation (professional foundation, professional core courses, professional orientation), a module for cross-discipline and new technology (Internet+ technology, artificial intelligence, robotics, etc.) (Hu, Si, & Gu, 2021), a module of innovation and entrepreneurship education (discipline competition, innovation and entrepreneurship competition series, comprehensive practice, professional internship, etc.) and a module of engineering and humanities education (engineering culture, humanities and social science series of courses and activities). Based on this, a new curriculum system of automation majors for new economy and new industry will be constructed based on the concept of emerging engineering education which emphasizes interdiscipline and integration, coordination and sharing (Wang, Wu, Jia, & Wang, 2020).

3.3. Construction of a Collaborative Education Platform Based on University-Enterprise Cooperation

The emerging engineering education has the characteristics of reflecting the characteristics of the times, involving a wide range of disciplines, integrating multiple subjects, and involving multiple subjects. In order to achieve the goal of collaborative education among industry, enterprises, societies and universities, Inner Mongolia University and its partner enterprises signed an agreement to build a collaborative education platform in the mode of "3.5 + 0.5" to promote industry-university cooperation and industry-education integration. Based on the multi-subject collaborative education platform, students spend the first three and a half years learning on campus, and the last six months studying and practicing in the above-mentioned ten enterprises, so as to make personalized selection, receive practical training, perform cutting-edge leadership, and improve their quality cultivation. Through "learning by doing" and "doing by learning", students participate in R&D projects and engineering cases in enterprises to develop comprehensive qualities and engineering capabilities required for becoming future engineers (Yi & Sha, 2020). Industry enterprises and experts are deeply involved in the training of students during their school years, teaching practical and cutting edge courses, and developing teaching materials in cooperation with teachers. During the six months in the enterprise, students will be su-

pervised by both the enterprise supervisors and the school supervisors based on practical engineering projects with interdisciplinary and advanced technology applications, and will complete their graduation designs.

The university encourages teachers to improve their own abilities, actively adapt to the requirements of emerging engineering education development, and strengthen their engineering background. Moreover, the university has set explicit requirements for teachers' engineering experience. In addition, based on the platform, the university allows teachers to participate in engineering projects in enterprises to familiarize themselves with the dynamics and trends of the industry, so as to build a faculty that is compatible with the development of emerging engineering education.

4. Reform Measures of Talent Training Mode

4.1. Promoting the Deep Integration of Industry and Education Oriented by Industrial Needs

The education of robotics will be oriented to serve the development of national strategic emerging industries, and aim to cultivate robotics talents with strong engineering practice capabilities. It will actively meet the needs of the robotics industry for diverse, personalized and dynamic talents, gradually improve the curriculum and optimize and integrate the teaching content in a timely manner. Teaching is the driving force and catalyst of research. Teachers bring new knowledge, technology and methods into the classroom through continuous research activities for the robotics industry, while students develop a passion for science and technology innovation and a sense of innovation through practical research problems, thus promoting the in-depth integration between research and teachers' "teaching" and between research and students' "learning". The university should focus on cultivating high-level talents who can adapt to the needs of economic construction in Inner Mongolia, address practical engineering problems at the front line of production, master the latest technology and track the developments of science and technology, and possess certain innovative capabilities.

4.2. Building a Scientific Curriculum with Engineering Concept as the Main Line

The university should actively explore comprehensive courses, multi-angle courses oriented to practical engineering problems, cross-disciplinary seminar courses, and promote the updating and upgrading of teaching contents with the latest development of cutting-edge disciplines, industries and technologies. In the practical courses, teachers should strengthen the concept of engineering education, take engineering projects as the carrier, and insist on the engineering concept throughout the course. Meanwhile, the graduation design should be carried out in the form of project. Throughout the whole process from field research, design, product development to graduation design defense, the focus

should be on cultivating students' core competencies and qualities such as engineering leadership, communication and cooperation.

4.3. Building a Diversified Practice Platform with Competence Development as the Core

Emerging engineering education requires teaching and learning to be centered on students' personalities, interests and potential. Teachers need to understand students' personal characteristics and teach them according to their abilities, as well as to develop their interests and passions to inspire them to explore the unknown. In addition, teachers need to uncover the potential of students and pave the way for their future development. Only in this way can the university produce outstanding engineering and technological talents who can meet the needs of the new economy with individuality, innovation, and potential.

To this end, the university will continue to expand its innovation and practice platform on campus, increase the number of innovation and entrepreneurship training programs for college students, create a platform for disciplinary competitions, and support students to participate in various innovation and entrepreneurship competitions at all levels. Off-campus, the university will strengthen horizontal cooperation with Shuang Yuan Education Group to build off-campus practice bases for students to better match their employment with the needs of the robotics industry, as well as to enhance their innovative spirit and entrepreneurial awareness.

Through the implementation of the above measures, some progress has been made in the construction of automation specialty, the level of professional teachers and hardware conditions have been significantly improved, and four high-quality practical teaching bases have been added. In 2019, the automation specialty was approved to become a first-class specialty in Inner Mongolia Autonomous Region of China.

5. Conclusion

Guided by the demand for robotics professionals in the economic construction of Inner Mongolia Autonomous Region, the university aims to cultivate high-quality professionals in robotics engineering. Adhering to the characteristics of the university, a complete set of training mode for robotics talents that can serve the needs of regional construction and development has been explored and summarized in order to adapt to the transformation and upgrading of industrial structure, cultivate and strive to form a new professional direction in the general field of intelligent manufacturing.

5.1. "Automation+" Multidisciplinary Talent Training Model Integrating the Concepts of OBE and Emerging Engineering Education

In the process of upgrading automation majors, a new model of talent cultivation for local universities with regional characteristics should be built according

to the concepts of result-oriented engineering education, reverse teaching design, student-oriented teaching and continuous improvement. Such "automation+" professional talent training model can be extended to other local universities in the transformation and upgrading of traditional engineering majors.

5.2. Innovative Talent Cultivation Model Based on Regional Economy with Collaboration of Enterprises, Universities, and Research Institutes

The teaching courses of industry-university-research collaborative education should be offered to emphasize the leading position of students' practical teaching. Moreover, we should establish a joint university-enterprise practice base with the main line of "scientific and technological innovation activities-project research-graduation design" and try the "double tutor system" mode for graduation design. Through the in-depth cooperation between the university and enterprises, the existing education model should be reformed to promote the collaborative development of both the university and enterprises, further promote the rapid, stable and sustainable development of the regional economy and society, and create a new and exemplary model of higher education operation.

5.3. "Interdiscipline + Collaboration + Maker" Intergrated Training System of Practical Capabilities

The term "interdiscipline" refers to the interpenetration of liberal arts and sciences, intersection of disciplines, and combination of theory and practice to introduce the actual production of enterprises into the classroom with the OBE project teaching as a grasp, establish the knowledge connection between different disciplines and different courses, and cultivate interdisciplinary professionals with innovative thinking. The term "collaboration" refers to the collaboration between the university and enterprises to complete the cultivation of talents. The term "maker" refers to "maker space", which provides a platform for students to practice innovation and entrepreneurship, so that students' inspirations can be put into practice to stimulate their entrepreneurial ideals and personality development.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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