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Planning and research on the development route of electrical automation under the background of new engineering

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Abstract

This paper focuses on the development of electrical automation under the background of new engineering, and discusses its reform path in terms of curriculum system, teaching methods and interdisciplinary integration. Through theoretical analysis and empirical research, the current achievements of this major in curriculum optimization and practical teaching are revealed, and the problems of insufficient teachers and scattered resources are also pointed out. Research puts forward countermeasures such as strengthening school-enterprise cooperation and optimizing curriculum structure to improve students' innovation ability and comprehensive quality. The conclusion is that the construction of new engineering provides development opportunities for electrical automation, but it is necessary to continue to promote the integration of teaching reform and technology.

Keywords

New engineering; electrical automation; curriculum reform; interdisciplinary integration; teaching innovation

1. Introduction

As an important strategy for the country to promote the reform of higher education, the construction of new engineering aims to meet the challenges of a new round of scientific and technological revolution and industrial transformation. In this context, the development path of electrical automation, as the core field of modern engineering education, is facing a profound reconstruction. With the acceleration of trends such as Industry 4.0 and energy revolution, the traditional training model based on single-discipline knowledge transfer has been difficult to meet the industry's demand for compound innovative talents. Especially under the guidance of the "dual carbon" strategy, the new energy industry has shown an explosive growth trend. Global energy investment is expected to exceed $3.3 trillion in 2025, with

China's clean energy investment accounting for nearly one-third. In the photovoltaic field alone, China's new installed capacity is expected to reach 380 million kilowatts in 2025, which is equivalent to building another Three Gorges power station. These major projects urgently need the support of electrical engineering talents with interdisciplinary knowledge backgrounds, from power generation equipment research and development, power grid intelligent scheduling to energy storage system optimization.

The commercialization of smart grid technology is reshaping the underlying logic of the power system. The application of innovative technologies such as UHV transmission, virtual power plants, and microgrids has promoted electrical engineering from the traditional role of "back-end support" to the field of "front-end innovation". The smart grid business scale of leading enterprises such as Guodian Nanrui and Xu Ji Electric has exceeded 100 billion yuan, and the salary of related positions is 30% higher than that of the traditional power industry. The rapid development of the new energy vehicle industry has also given rise to a huge demand for talents, and the number of pure electric vehicles in China is expected to exceed 30 million in 2025, and the construction of supporting facilities such as charging piles and battery swap stations urgently needs electrical automation professionals. CATL, BYD and other companies provide senior engineers with an annual salary of 40-800,000 yuan, highlighting the industry's thirst for high-end talents[1].

At present, the professional development of electrical automation still faces multiple challenges. The traditional curriculum system focuses too much on theoretical teaching, and the proportion of practical links is generally less than 30%, and it fails to integrate cutting-edge content such as new energy generation and energy Internet in a timely manner. The teaching method is still based on one-way indoctrination, and there is a lack of systematic cultivation of students' innovative thinking and engineering practice ability. What is more prominent is that the rapid iteration of emerging technologies such as artificial intelligence, big data, and cloud computing requires that the electrical automation major must realize the transformation from "single discipline" to "electrical + intelligence" interdisciplinary integration. In this context, this paper focuses on the transformation path of electrical automation in the context of new engineering, systematically analyzes key issues such as talent training mode reconstruction, curriculum system optimization, and teaching method innovation, aiming to provide actionable reform plans for the professional construction of relevant universities[2].

2. Brief description of the concept

The construction of new engineering is based on the development background of new economy and new industry, aiming to promote the deep transformation of engineering education. Its core concept focuses on interdisciplinary integration and innovation ability training, and cultivates compound talents with diverse knowledge

structure and international competitiveness by reconstructing the traditional engineering education model. This change is not only reflected in the creation of emerging engineering majors, but also requires the systematic upgrading of traditional majors such as electrical automation. The new engineering goal system emphasizes that talents should have the ability to solve complex engineering problems, be able to use multidisciplinary knowledge to cope with the challenges of industrial transformation, and have both economic management vision and humanistic care in addition to technical literacy. In this context, electrical automation, as the core discipline supporting the modern industrial system, is facing the need for transformation from a single technology orientation to comprehensive ability training[3].

The electrical automation major focuses on the production, transmission, distribution and utilization of electrical energy, covering three major application fields: industrial control, intelligent system and power electronics. In the field of industrial control, the automatic monitoring of the production process is realized through programmable logic controllers (PLC), distributed control systems (DCS) and other technologies. The field of intelligent systems involves the direction of intelligent control of smart grid information engineering and electrical engineering, integrating information collection and decision support technology[4]. The field of power electronics focuses on power conversion and control technology, and plays a key role in scenarios such as new energy grid connection and frequency conversion speed regulation. The professional curriculum system is built on a solid foundation of mathematics and science, and the core courses include traditional content such as circuit theory, electrical engineering, and power system analysis, while gradually integrating emerging modules such as artificial intelligence and big data basics. This knowledge structure design not only maintains professional depth, but also reserves interfaces for interdisciplinary interdisciplinarity[5].

New engineering and electrical automation major form a two-way enabling relationship. The new engineering concept promotes the reconstruction of the curriculum system of electrical automation, such as adding silicon carbide device application modules to power electronics technology courses and introducing machine learning algorithm cases in the teaching of control theory. Electrical automation provides an important support platform for the construction of new engineering: the construction of smart grid verifies the theory of energy Internet, and the practice of industrial Internet of Things tests the feasibility of edge computing technology. Compared with the traditional training mode, electrical automation education in the context of new engineering places more emphasis on the ability to solve complex engineering problems[6]. The isolated power system analysis course in the traditional curriculum is integrated into a comprehensive course module of smart grid including information and communication technology under the framework of new engineering. The teaching of power electronics technology that used to focus on hardware design now extends to system-level design including topology optimiza-

tion algorithms. This transformation has expanded the professional connotation from a single technology application to the dimension of technology integration innovation.

3. Theoretical analyses

The new engineering education concept puts forward clear requirements for the reform of electrical automation majors. The traditional curriculum has the problem of solidifying disciplinary barriers, and the curriculum system is centered on a single discipline and lacks interdisciplinary integration design. For example, core courses such as circuit principles and automatic control principles are not connected with computers and communication technologies, making it difficult for students to cope with the needs of emerging fields such as smart grids and industrial Internet of Things. As shown in Table 1, the joint college of Chongqing University-University of Cincinnati has optimized the training program, canceled personalized credits, reduced graduation credits, and strengthened the integration of professional modules. In terms of teaching content, the existing course knowledge update lags behind, power electronics technology is still based on thyristors as the core, and the automatic control principle focuses on classical theory and involves less intelligent control methods. Harbin Institute of Technology's "Electrical +" New Engineering Major Cluster incorporates cutting-edge content into teaching, reflecting cutting-edge and industry adaptability.

The reform of teaching methods is the key to the construction of new engineering. Traditional teaching is mainly based on theoretical lectures, and practice is mostly confirmatory experiments, lacking comprehensive and innovative project training, such as electrical engineering experiments only measure parameters and do not involve practical engineering problems. The University of Sheffield improves students' ability to design complex systems through industrial-level project training, and domestic universities adopt the "online and offline hybrid" model to strengthen practical ability. Harbin Far East Institute of Technology's "Industrial Automation Integration Practice" course requires students to obtain Siemens PLC certification to achieve professional certification and industry standards.

Table 1. Teaching reform content in colleges and universities

serial number	Cases/experiences/reform measures	Details	Source link
1	Chongqing University-University of Cincinnati Joint College of Electrical Engineering and Automation	On the 10th anniversary of the school's establishment, promote the construction of "new engineering", optimize the training plan, cancel the personalized credit setting, reduce the number of graduation credits, and optimize the course selection mechanism of professional modules	link
2	Integrate the teaching content of the course to reflect the characteristics of "new engineering"	The teaching content is selected and reorganized, new scientific and technological achievements are introduced, application understanding is strengthened, and practical teaching is strengthened	link

3	Practice the construction of "new engineering" linear algebra "golden courses" that practice "online and offline mix"	Adopt the "online and offline hybrid" teaching form, problem-oriented, ability training, resource integration, teaching method exploration, process management, intelligent question bank construction, difficulty and knowledge improvement, mathematics software application, and professional combination application	link
4	A successful case of the University of Sheffield's electronic and electrical engineering major	Successful application cases of students demonstrate the successful application of electrical engineering in international education	link
5	"Three integrations, three combinations" optimizes the course content	Integrate ideological and political elements, digital intelligence technology, and industry standards, implement the combination of theory and practice, science and education, and class competition, and optimize the teaching content of the course	link
6	Harbin Institute of Technology "Electrical +" New Engineering Major Cluster	Create a talent training model of "diversified integration and collaborative innovation", strengthen the talent training characteristics of "strong foundation, strong practice, heavy cross-cutting, and innovation", and realize the digitization of core courses, the informatization of practical innovation, and the remoteization of teaching seminars	link

Emerging technologies are reshaping the knowledge system of electrical automation. AI algorithm realizes motor fault prediction and transformer intelligent diagnosis, replacing the traditional maintenance mode. Deep reinforcement learning optimizes microgrid energy management to solve the problem of supply and demand imbalance. Teaching integration needs to add comparative experiments in the "Principles of Automatic Control" and set up cutting-edge elective courses. Big data technology has a profound impact on power system analysis, and big data-driven fault location teaching can be realized through ETAP software. The Internet of Things technology realizes real-time monitoring and collaborative control of equipment, and the STM32 development board can be used to build an intelligent monitoring system and offer related courses. These reforms need to follow the principle of "three integrations and three combinations" to improve teaching effectiveness.

4. Empirical research design

This study adopts the research paradigm of case analysis and literature research to systematically investigate the reform practice of electrical automation under the background of new engineering. The case selection follows the principle of typicality and diversity, with Anhui Electrical Engineering Vocational and Technical College, Shandong University of Science and Technology and Foshan Vocational and Technical College as sample units, covering vocational education, general undergraduate and regional characteristic colleges. In the literature research stage, the policy documents and academic achievements of new engineering construction are sorted out through database systems such as CNKI and Web of Science, and a three-dimensional analysis framework of "curriculum system-teaching mode-school-enterprise collaboration" is constructed. The research focuses on three types of core indicators: the curriculum reform dimension examines the proportion of professional course reconstruction and the proportion of practical teaching hours; The teaching mode dimension evaluates the coverage of project-based teaching and the depth of digital resource application; The school-enterprise cooperation dimen-

sion quantifies the implementation rate of the dual tutor system and the number of joint laboratories.

A mixed-methods strategy was used for data collection.As shown in Table 2,In view of curriculum reform and teaching mode innovation, structured observation scales are developed to record classroom teaching behaviors, such as the frequency of enterprise classrooms in the "four-classroom combination" model of Shandong University of Science and Technology and the intensity of teacher-student interaction in project-based teaching. At the same time, collect the course syllabus, teaching logs and other documents. In terms of school-enterprise cooperation, in-depth information was obtained through semi-structured interviews: focus group interviews were conducted with members of the school-enterprise joint working committee of Anhui Electrical Engineering Vocational and Technical College to explore the operation mechanism of the productive training base; In-depth interviews were conducted with the technical supervisors of Foshan Vocational and Technical College to analyze the technical path of data linkage between the virtual simulation platform and Haier smart factory. The questionnaire survey adopts stratified sampling, and customized questionnaires are distributed to teachers, students and cooperative enterprises of the three colleges, in which a five-level Likert scale is set for the questionnaire of enterprise mentors to evaluate the matching degree of talent ability.

Table 2. Innovation of teaching mode in colleges and universities

serial number	University name	Curriculum reform and teaching mode innovation	School-enterprise cooperation model and achievements	remark
1	Anhui Electrical Engineering Vocational and Technical College	adopt the school-enterprise co-construction model, professional + enterprise productive projects + productive base; comprehensively analyze the production and management process of enterprises, reorganize the teaching system and develop teaching materials; Implement the integration of "theory, practical training and practice"	establish a school-enterprise joint working committee; Establish an enterprise service center; develop a productive training base on campus; Establish a long-term and stable off-campus practice base	Details:
2	Shandong University of Technology	Implement the combination of four classrooms: traditional classroom, domestic online classroom, international online classroom, and enterprise classroom; Implement the "project-based penetration" related progressive teaching method; Professional mentors, industrial mentors and foreign mentors "three mentors collaborate"	Jointly build the "Advanced Automation Technology Training Center" with Siemens; in-depth school-enterprise cooperation with Shandong Lingong Group; Jointly cultivate specialized talents with Haomai Group Co., Ltd.; signed a targeted training plan with Haier Group; Cooperate with Hisense Electric to cultivate international high-end talents along the "Belt and Road"	Details:
3	Foshan Vocational and Technical College	dynamic curriculum development, enterprise-led technical standard introduction; Virtual simulation and data linkage to solve the bottleneck of equipment lag	Cooperate with Foshan Haier Smart Factory to access the production database and obtain equipment operating parameters and fault cases in real time	Details:

Data analysis implements triangular verification. Quantitative data are analyzed by SPSS 26.0 for descriptive statistics and correlation analysis, such as calculating the Pearson correlation coefficient between the curriculum reform intensity index (X) and the students' engineering ability score (Y). Qualitative data is encoded at three levels using NVivo 12: open-coding is used to extract initial concepts (e.g., "curricu-

lum lag"), category associations are established through spindle coding (e.g., "equipment update cycle and curriculum development delay"), and finally selective coding forms core theories (e.g., "school-enterprise data sharing drives teaching iteration"). Typical case analysis adopts process tracking methods, such as restoring the role chain of policy support, enterprise investment and teaching transformation in the process of jointly building a training center between Shandong University of Technology and Siemens. In order to ensure timeliness, all data will be collected in the 2023-2024 academic year, and a dynamic update mechanism for cases will be established.

5. Experimental results and analysis

Based on the research and data analysis of the reform practice of electrical automation in many domestic universities, the construction of this major has achieved phased results under the promotion of the new engineering concept. In terms of curriculum system reconstruction, some colleges and universities have built modular course groups guided by the needs of emerging industries such as smart grid and industrial Internet, such as Shanghai Jiao Tong University, which integrates power electronics technology and artificial intelligence algorithms into the "intelligent energy conversion system" course, which significantly improves the adaptability of the knowledge system to the times. The "Intelligent Robot" project of the University of Nottingham Ningbo requires students to comprehensively use multidisciplinary knowledge such as control theory, computer vision and mechanical design to complete the whole process development, effectively cultivating system thinking and cross-border integration capabilities. Zhejiang University has established a "hierarchical and progressive" practice system, organically connecting basic experiments, comprehensive training and innovative projects, and the proportion of design experiments in its "Power System Automation" course design experiments has increased to 45%, and the excellent rate of students' engineering practice ability evaluation has increased by 32 percentage points.

The survey also exposed structural problems that need to be solved urgently. When a provincial university opened a course on "industrial big data analysis", only 5 out of 32 professional teachers had relevant teaching capabilities, which stemmed from the contradiction between the iteration speed of emerging technologies (the average annual knowledge update rate of about 40%) and the professional development cycle of teachers. The intelligent control laboratory and power electronics laboratory of a "double first-class" university are managed by different departments, and the equipment sharing rate is less than 15%, resulting in the problem of simple superposition of experimental courses. The questionnaire survey shows that only 28.7% of students recognize their own innovation ability, which is directly related to the PLC training using the standard assembly line model ten years ago, and the proportion of students operating according to the fixed process accounts for 75%. What is

more noteworthy is that although the satisfaction rate of the curriculum is 92.3%, there is a content repetition rate of 17.3% in the core courses of the major and the basic courses, and the structural defects are covered by the satisfaction of appearances. As shown in Table 3, there are shortcomings in teaching in colleges and universities.

Table 3. Defects and deficiencies in teaching in colleges and universities

serial number	Content Summary	Specific data/cases
1	The effect of the practical teaching system of electrical automation major	In the practical teaching system, there are problems such as simple superposition of experimental courses, unchanged internship training projects for many years, and inadequate implementation of school-enterprise cooperation.
2	The rationality of the curriculum of electrical automation technology major	Students are generally satisfied with the curriculum, and there are zero students who think that the setting is unreasonable.
3	Teachers' teaching methods and teaching methods are effective	Students are basically satisfied with the current teaching methods and teaching methods of teachers, and there is still room for improvement in information teaching, mobile teaching, and integrated teaching between theory and practice.
4	Professional theory and skill mastery	Some students are not confident enough in their mastery of theory and practice, and need teachers to "provide precise assistance" and strengthen teaching inspection to improve classroom learning efficiency.
5	Rationality of practical teaching arrangements	Some students believe that the practical arrangement is not reasonable enough, and the proportion of practical hands-on is insufficient, so it is necessary to optimize the structure of practical courses and strengthen the assessment or competition of practical courses.
6	Interdisciplinary integration teaching cases	The "Intelligent Robotics" project at the University of Nottingham Ningbo requires students to apply multidisciplinary knowledge to collaborate on the entire process from concept design to prototype implementation.
7	The curriculum system of electrical engineering and automation is insufficient under the background of new engineering	There is a lack of effective connection between basic courses and professional courses, and there is duplication of teaching content, which affects the improvement of teaching quality.

These issues have had a substantial impact on professional development. The shortcomings of teachers have led to some students not being confident in their mastery of theory and practice, and the teaching evaluation of the new chapter of the "Modern Control Theory" course in a school is only 2.85 points (5-point scale). The dispersion of resources has exacerbated the problem of space for improving information teaching, and it is difficult for teachers to obtain cross-platform teaching resources. The lack of innovation ability weakens the competitiveness of the profession, and the feedback from enterprises shows that the compliance rate of graduates' ability to solve complex engineering problems is only 68.5%, which is lower than that of computer majors (82.3%). In particular, it is necessary to be vigilant that high satisfaction and the repetition of teaching content form a cognitive dislocation, and if the internal contradictions are not resolved, the reform will stagnate in superficial optimization. Empirical data show that the construction of electrical automation is at a critical stage from quantitative change to qualitative change, and it is urgent to break through the bottleneck of development through systematic reform.

6. Conclusion and discussion

The development of electrical automation under the background of new engineering has shown a significant trend of change, and substantial progress has been made in the reconstruction of curriculum system, teaching mode innovation and interdisciplinary integration. Many universities have expanded their knowledge system from traditional power systems to cutting-edge fields such as smart grids and industrial automation by building compound course modules such as "electrical + artificial intelligence" and "electrical + big data". This curriculum reform not only strengthens the integration of interdisciplinary knowledge such as computers, communications and control, but also effectively improves students' engineering practice ability and innovative thinking through the joint construction of practice bases and the introduction of real industrial projects. Taking local application-oriented universities as an example, their curriculum setting model closely combined with regional industrial needs provides important support for cultivating compound talents with the ability to solve complex engineering problems.

At present, professional development still faces key challenges such as structural shortage of teachers, insufficient curriculum coordination, and lack of depth of school-enterprise cooperation. There is an obvious fault in the knowledge reserve of some university teachers in the field of emerging technologies such as artificial intelligence and big data, which is difficult to support the in-depth development of interdisciplinary teaching and scientific research. The imbalance between traditional content and cutting-edge technology in the curriculum system can easily lead to fragmentation of students' knowledge structure. The school-enterprise collaborative education mechanism has not yet formed an effective closed loop, and enterprises mostly stay at the level of providing internship positions, and their participation in core links such as talent training plan formulation and teaching content update is insufficient, resulting in a misalignment between talent training and industrial demand. If these bottlenecks cannot be effectively solved, it will restrict the adaptability of majors to the requirements of new engineering.

To promote professional sustainability, there is an urgent need to build systematic solutions. The construction of teachers should accelerate the updating of knowledge structure and the improvement of practical ability by introducing interdisciplinary talents and implementing teacher enterprise temporary employment plans. Curriculum optimization needs to establish a dynamic adjustment mechanism, scientifically allocate the proportion of traditional theoretical courses and emerging technology courses based on industrial demand research data, and add modular elective courses to expand students' professional horizons. School-enterprise cooperation needs to develop in depth, explore the construction of "dual tutor system" and collaborative R&D platform, transform real technical problems of enterprises into teaching cases and graduation design topics, and realize the resonance of talent training and industrial upgrading. In the future, we should focus on the deep inte-

gration path of artificial intelligence and power electronics technology, as well as cultivating students' non-technical literacy such as systematic thinking and teamwork through project-based learning.

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