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Research and Practice on Practical Teaching Reform of Electrical Engineering and Automation Major Under the Background of Industry-Education Integration

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Abstract: With the accelerated pace of intelligent and digital transformation of the global electrical industry, China's demand for high-quality applied electrical talents keeps rising. Promoting the practical teaching reform of the Electrical Engineering and Automation major through industry-education integration has become an inevitable trend. Universities must adjust talent training models to keep up with industrial transformation and economic development. However, the current curriculum setup of the Electrical Engineering and Automation major is unreasonable, and defects exist in the practical content and training environment design, which makes graduates hard to adapt to the workplace and fail to meet the demands of modern electrical enterprises for technically skilled personnel. Therefore, exploring the reform strategies of practical teaching for the Electrical Engineering and Automation major in universities bears far-reaching significance and can provide references for frontline educators.

Keywords: Industry-education integration; Electrical Engineering and Automation major; Practical teaching; Current situation; Reform strategies

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1. Industry-education integration and practical teaching reform of Electrical Engineering and Automation major

Industry-education integration is a strategic school-running mode featuring in-depth integration of industry and education. It realizes precise docking of school-enterprise cooperation in talent cultivation, scientific research services and industrial development demands. Since it was written into the report to the 19th National Congress of the Communist Party of China in 2017, national authorities have continuously promoted relevant work. From the Eight Departments, including the National Development and Reform Commission, issuing the Implementation Plan for Empowering and Upgrading Industry-Education Integration in Vocational Education to clear arrangements in the State Council government work reports, the core status of industry-education integration in building a modern education system has been fully reflected [1-3]. It serves as a bond

that organically connects the education chain, talent chain, industrial chain, and innovation chain, and is an inevitable path to building a strong country in education, science and technology, and human resources. For the technology-intensive electrical engineering field, deepening industry-education integration means breaking the barriers of traditional closed education and integrating frontline industrial demands, real engineering problems and solutions into the whole talent training process. After establishing normalized and long-term collaborative mechanisms, universities can accurately grasp industrial trends and cultivate talents with the ability to solve complex engineering problems, thus effectively solving the problem of superficial industry-education cooperation and providing strong talent support for new industrialization and digital transformation.

In accordance with the characteristics of the Electrical Engineering and Automation major, practical teaching reform should be student-centered and competency-oriented to build a full-process, multi-form closed-loop deep integration model. Relying on industry-education integration communities, universities transform real enterprise projects into teaching resources and reconstruct application-oriented curriculum systems and training platforms [4]. This requires universities to jointly build and share high-level internship and training bases with leading enterprises in the industry, introduce digital and intelligent experimental equipment, and simulate real industrial sites so that students can learn through practice and practice while learning. In addition, innovation of training mechanisms shall be encouraged. Forms such as school-enterprise dual tutors and modern apprenticeships can be adopted to incorporate enterprise technical standards and professional quality requirements into key links, including graduation internships and curriculum design. Besides, a dynamic adjustment mechanism shall be established to update teaching contents in a timely manner in accordance with industrial technological upgrading, so that students' skills can match market demands [5]. Supported by such in-depth collaborative education mechanisms, students' engineering practice and innovation abilities can be greatly improved, scientific research achievements can be industrialized, and precise alignment and synchronized development between educational supply and industrial demand can be realized.

2. Current problems in practical teaching of Electrical Engineering and Automation major in universities

2.1. Insufficient attention to experimental teaching and backward design of practical contents & environment

Practical teaching of the Electrical Engineering and Automation major relies excessively on basic and verification experiments, while comprehensive, design-based, and innovative experiments account for a small proportion. The model prioritizing basics over innovation keeps students in a state of passive operation, unable to access complex engineering problems reflecting cutting-edge industrial technologies. Most experimental content is attached to a single theoretical course without systematic interdisciplinary integration, leading to fragmented knowledge systems and failing to cultivate students' ability to solve practical engineering problems and innovative thinking.

2.2. Outdated teaching resources and hardware equipment detached from industrial frontiers

Laboratory equipment in many universities is updated slowly, with old devices and insufficient sets. Most existing experimental devices only adopt traditional relay contact control or outdated power electronic components, while intelligent control, Internet of Things, artificial intelligence algorithms, and other cutting-edge technologies widely applied in industrial sites are rarely covered in experiments [5]. Backward hardware

directly disconnects teaching content from actual social demands, forming a huge gap between what students learn in school and enterprise requirements.

2.3. Superficial school-enterprise collaborative education and formalized internships

Although most universities have off-campus internship bases, students can hardly participate in core production links due to enterprise production safety requirements, commercial confidentiality restrictions, and high management costs. Most internships are merely visiting and observing activities without hands-on opportunities. Students can only have a superficial understanding of production processes and fail to truly grasp the actual operation of power systems and equipment maintenance, resulting in ineffective transformation of theoretical knowledge into practical capabilities.

3. Practical teaching reform strategies under the background of industry-education integration

3.1. Build a collaborative education mechanism with in-depth industry-education integration

Under the background of industry-education integration, the practical teaching reform of the Electrical Engineering and Automation major shall start from top-level design to build an in-depth collaborative education mechanism. Traditional school-enterprise cooperation only stays at the level of visiting internships and simple project sponsorship without substantial co-construction of teaching contents and joint talent cultivation. Real reform requires universities to break the shackles of closed school-running and build a school-enterprise community of destiny together with leading industrial enterprises and local pillar industries [6-7]. Universities and enterprises shall jointly establish a major construction steering committee to formulate talent training plans and practical teaching syllabi in accordance with dynamic industrial development and technological innovation trends. Supported by enterprise production standards and technical specifications, real enterprise projects are transformed into teaching resources to align teaching contents with industrial demands. A long-term mutual employment system shall also be established: university teachers take temporary posts in enterprises to improve engineering practice capabilities, while senior enterprise engineers and technical backbones are hired as part-time teachers to undertake core practical courses. Moreover, a scientific evaluation system shall be built that incorporates enterprise employment feedback as one of the teaching quality evaluation indicators, forming a closed-loop management of “training – practice – feedback – improvement” to solve the disconnection between talent cultivation and social demands fundamentally.

3.2. Reconstruct modular and progressive practical teaching system

To address the fragmentation and unclear hierarchy of the current practical teaching system, universities shall reconstruct a modular, progressive practical teaching system. Covering strong electricity, weak electricity, hardware, software, components, and systems, the Electrical Engineering and Automation major cannot simply stack experimental courses. Systematic planning shall be carried out in accordance with cognitive rules and competency training logic. The new system breaks the strict boundary between theoretical and experimental courses and divides practical teaching into four progressive levels: basic skill training, professional comprehensive training, engineering innovation practice, and post-internship. At the basic level, training on the fundamental operation of electrical engineering and electronics, as well as electrical machinery drives, shall be strengthened. At the professional level, comprehensive curriculum design such as PLC

control systems and power electronic device debugging shall be offered to improve students' comprehensive engineering capabilities. At the innovation level, university innovation laboratories and discipline competitions are taken as carriers to guide students to participate in scientific research and technological innovation. At the internship level, students enter the real workplace through internships. This system can adapt to students' learning status at all levels, integrate on-campus and off-campus experimental training resources, avoid redundant construction and resource waste, and make practical teaching more systematic and standardized to comprehensively improve students' engineering literacy [8-10].

3.3. Build an intelligent practical teaching platform combining virtual and physical scenarios

With the rapid development of Industry 4.0 and intelligent manufacturing, traditional physical laboratories cannot meet the teaching demands of high-precision equipment operation and complex system simulation for the Electrical Engineering and Automation major. Therefore, building an intelligent practical teaching platform integrating virtual and physical scenarios becomes a key reform measure. Universities shall introduce new-generation information technologies, including virtual simulation, digital twin, and augmented reality, to build an intelligent virtual simulation experimental teaching center. Virtual scenes of high-voltage, large-current, high-risk power system operation and fault handling can be constructed, allowing students to conduct repeated risk-free operations and gain an in-depth understanding of abstract electromagnetic field theories and complex transient processes [11]. The virtual simulation platform shall realize data interconnection and linkage control with existing physical experimental equipment to form a complementary virtual-physical teaching mode. In relay protection experiments, students can both wire and debug physical devices and simulate power grid faults on virtual platforms to observe the action characteristics of protection devices. On the one hand, the intelligent platform breaks time-space restrictions and expands the scope and depth of practical teaching. On the other hand, it keeps students updated with the latest digital industrial technologies during their school years and lays a solid technical foundation for their future career development [12].

3.4. Improve diversified and comprehensive quality evaluation mechanisms

Traditional closed on-campus academic assessment cannot comprehensively and objectively evaluate students' engineering literacy and professional competence of the Electrical Engineering and Automation major. A diversified evaluation system covering the whole training process that meets industrial demands must be established. The single paper-only evaluation model shall be abandoned, and a competency-oriented, process-focused evaluation concept shall be formed. Industrial technical standards and vocational qualification requirements shall be integrated into curriculum assessment standards to realize precise alignment between academic evaluation and post-competency [13]. In specific implementation, a multi-evaluation group consisting of university teachers, enterprise engineers, and industrial experts shall be established. Enterprise actual operation and performance indicators are incorporated into key links, including curriculum design, comprehensive training, and graduation projects, adopting diversified evaluation modes of "on-campus scores + enterprise internship appraisal + vocational skill certification". Meanwhile, a quantitative and qualitative evaluation indicator system covering knowledge mastery, skill proficiency, engineering innovation thinking and teamwork shall be built. Information platforms are used to collect and feed back students' practical data in real time. Regular school-enterprise joint evaluation meetings are held to conduct diagnostic and formative assessment of teaching effects, ensuring evaluation results truly reflect talent training quality and finally forming a closed-loop quality guarantee system of "evaluation – feedback – improvement" to improve graduates' engineering practice and employment competitiveness effectively.

3.5. Optimize construction path of dual-qualified teaching staff

The quality of practical teaching is ultimately determined by teachers' engineering practice capabilities. Against the background of industry-education integration, universities shall optimize the construction path of dual-qualified teachers and resolve the structural contradiction that teachers prioritize theory over practice. For a long time, most university teachers have only studied in schools without frontline enterprise engineering experience, making practical guidance merely textbook-based. Therefore, universities shall establish a long-term mechanism for teachers' engineering competency training and formulate special incentive policies. Enterprise practice experience shall be taken as an important criterion for professional title evaluation and post-appointment. Young and middle-aged teachers shall be encouraged to take part-time posts in enterprises during winter and summer vacations or one-year full-time leave to participate in technological transformation, product R&D and engineering project management, and accumulate real engineering cases and practical experience [14-15]. Besides, a two-way mobility mechanism between schools and enterprises shall be built with special industry professor posts to introduce senior technical personnel with rich practical experience into teaching teams. Internal school teaching and research mechanisms of senior-junior mentoring shall also be established to organize regular engineering skill training and teaching exchanges, so as to improve all teachers' practical teaching capabilities. Only with high-quality teaching staff proficient in both theory and engineering guidance can the practical teaching reform of industry-education integration be fully implemented and high-quality applied electrical engineering talents meeting the demands of the times be cultivated.

4. Conclusion

In summary, in-depth research on practical teaching reform of the Electrical Engineering and Automation major under industry-education integration proves that building a government-industry-university-research-user collaborative education mechanism is crucial. It can effectively integrate internal and external teaching resources and greatly improve students' engineering practice and professional quality. School-enterprise co-built internship bases and joint laboratories also serve as important platforms for technological innovation and achievement transformation. Nevertheless, the in-depth advancement of industry-education integration still faces challenges, including long-term mechanism construction and teaching staff transformation. In the future, interest-sharing and risk-sharing mechanisms shall be further improved, talent training programs shall be continuously optimized, and major construction shall always keep pace with industrial technological development to deliver more high-quality engineering technical talents for regional economic development.

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Disclosure statement

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