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Application of PLC in the Teaching Reform of Construction Engineering Courses

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Abstract: With the continuous upgrading of intelligent technologies in the construction industry, the education of construction engineering majors in colleges and universities should actively adapt to the changing trend of market demand for talents and integrate automatic control technology into teaching content. As a key core device of industrial automation, the programmable logic controller (PLC) has become increasingly prominent in its position. This research focuses on the integration of the construction engineering curriculum system and the PLC technology system, and actively constructs a teaching plan for the in-depth integration of mechanical automation and construction engineering. By optimizing teaching content, innovating practical platforms, improving feedback systems, and continuously upgrading the new form of industry-university-research integration, it aims to cultivate compound talents proficient in automation technology and provide a stable talent impetus for the sustainable development of the construction industry.

Keywords: PLC; Construction engineering courses; Teaching reform

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1. Introduction

With the gradual popularization of industrial automation technology, the intelligent application of the construction industry has been widely promoted. Different from the flexible response speed of the construction market, the teaching curriculum system of the construction engineering major in colleges and universities has lagging feedback sensitivity, with teaching content still focusing on civil engineering structure knowledge and a low proportion of intelligent automation content. This traditional teaching model restricts students' industrial vision and knowledge reserve to the thinking of a traditional civil engineering major, leading to their lack of in-depth understanding of the new integrated and automated system model of the modern construction industry. Programmable logic controller (PLC) plays an important role in the intelligent control of mechanical equipment, and the guarantee of system reliability, and the stability of its control system makes it the most mature control center in the field of industrial automation [1].

In view of its irreplaceable advantages, colleges and universities should actively study the relationship between PLC technology and the teaching of the construction engineering major. This not only realizes the organic integration of construction engineering and mechanical automation, but also is an important measure to conform to the development trend of industrial intelligent technology, which is conducive to promoting the in-depth reform of construction engineering teaching and meeting the practical demand for efficiently cultivating students' engineering literacy. This paper focuses on exploring more effective directions for teaching reform, making PLC knowledge an effective carrier and practical teaching tool to drive the intelligent transformation of the construction engineering industry [2].

2. Teaching value of the integration of PLC technology and construction engineering intelligence

2.1. The core link for constructing an interdisciplinary knowledge system

At present, the teaching content of the construction engineering curriculum system still remains in an independent disciplinary status, long separated from the professional knowledge of mechanical automation. This traditional teaching model results in a single structure of students' knowledge system and fails to foster a multi-level and multi-dimensional thinking mode, which is not conducive to solving practical industrial problems nor adapting to the new centralized and intelligent requirements of modern construction multi-systems [3]. The advantages of PLC technology can effectively integrate these two fields.

Based on this integration thinking, in actual teaching, the teaching of construction engineering major redefines the technical role of PLC, whose learning content is no longer exclusive to the mechanical manufacturing major, but positioned at how to better serve modern architecture and realize solutions for modern building environment control, building automation control, security prevention control and intelligent construction in architecture [4]. Integrating PLC knowledge into the construction engineering professional curriculum system can help students break through the professional thinking of construction engineering, and enable them to understand and master the operation principles and control programs of large mechanical equipment, such as construction hoists, suspended platforms, tower cranes, and concrete mixing equipment in the construction engineering industry more intuitively and in-depth.

The integration of this new professional knowledge enables students to understand the matching degree and correlation logic between the executive mechanisms, detection components of mechanical equipment, and construction processes on the basis of civil engineering knowledge, and equip them with a multidisciplinary knowledge framework of mechanical control technology, intelligent control technology, and information technology in addition to their major. This interdisciplinary knowledge system provides resources for students' diversified thinking and lays a solid foundation for them to design and solve intelligent engineering problems [5].

2.2. Deepening the understanding of efficiency optimization in the whole process of construction engineering

Improving the efficiency of construction engineering projects is not just a simple upgrade and transformation of the original construction technology and processes, but an in-depth optimization from the perspective of more centralized and intelligent automated systems. PLC technology is an effective tool to achieve this goal and also provides the best practical opportunity for PLC teaching [6]. In the teaching of designing specific program control for mechanical equipment in the construction process, in-depth research is conducted on

the characteristics of PLC's time and program control and the design characteristics of logical relationships, simulating material transmission, control programming of building environment, and how to optimize the design. Through targeted systematic learning, students can understand the basic characteristics of PLC, master how to arrange time sequences and optimize system control programs, effectively improve equipment utilization rate and the rationality of process implementation, and ultimately realize the effective control of key construction periods [7]. In addition, through the teaching and analysis of practical cases of PLC in building energy consumption management systems and the explanation of automatic control of lighting systems and time-sharing and zoning control of air conditioning temperature and wind speed, students can fully experience and understand how PLC technology realizes the optimized management of building energy consumption [8]. This teaching model breaks through the traditional teaching concept, presents the concept of energy efficiency management in a more direct and concrete way and demonstrates its operability, which not only makes students deeply perceive the significance of automation technology for the intelligent control of construction projects, but also makes them recognize the important position of automation technology in the whole life cycle of construction projects [9].

2.3. Cultivating engineering thinking and problem-solving ability for intelligent construction

With the wide application of intelligent technology, future architectural designers and practitioners need to not only have solid theoretical professional knowledge, but also possess engineering and technical capabilities to effectively control practical problems through technical means. How to cultivate students' basic concept of intelligent construction in architecture has become the core task of teaching reform, and the PLC teaching content is exactly in line with this basic requirement [10]. Taking practical industrial problems and projects as examples, teachers can inspire students to design an intelligent centralized control system for construction, such as guiding the design of an elevator group control scheme. First of all, teachers should help students sort out the design ideas, that is, comprehensively consider the practical problems in the use process, specifically starting from the analysis of basic demand points, to the design of system control architecture, the setting of control points, the programming of control graphics, and finally, the debugging stage. By allowing students to participate in the whole process, their systematic thinking is cultivated. To realize the predetermined scheme in this project, it is necessary to combine the mechanical characteristics of the equipment, the feedback signals of control components, the safety logic of control programs, and the overall operability. In a word, through project-based teaching, students are guided to decompose system problems and adjust logical relationships, cultivate their practical ability to find the optimal solution, and help them establish the concept of intelligent building management.

3. Specific implementation paths and model construction of teaching reform

3.1. Restructuring and modular integration of curriculum content

The restructuring and modular integration of curriculum content is the core task of teaching reform, in which the primary step is to sort out the traditional teaching content and reshape it through systematic combination to realize the in-depth integration of curriculum content. The overall guiding idea of the reform is to adopt the modular integration thinking and perfectly integrate PLC technology with relevant construction engineering courses according to the curriculum characteristics of PLC technology [11]. For example, in the Building

Equipment course, the basic module knowledge of PLC control for mechanical equipment is integrated and explained, and the combined control principles and the logical relationships of start-stop and speed control are expounded in combination with water pumps, air conditioners, water towers, and elevators involved in the construction engineering major [12]. For the knowledge of building energy consumption management, the Intelligent Building System course is introduced, which systematically interprets the combined application and system control logical relationships of PLC in building automation, security prevention, energy consumption management, and other systems according to the market's intelligent demand. This systematic modular combination design efficiently integrates PLC knowledge with professional knowledge, presents the characteristics of interdisciplinary integration in a more intuitive and vivid form, enables students to have a cross-professional knowledge system, and deeply understand the practical significance and realization methods of intelligent control [13].

3.2. Innovation of practical teaching platform and project-driven teaching

The foundation for the in-depth application of systematic theoretical knowledge lies in a reliable practical teaching platform. The teaching reform model should be based on practical problems and future needs, and adopt various forms of PLC technology practical platforms [14]. First of all, in terms of hardware facilities, colleges and universities should actively build representative construction machinery models, monitoring modules, sensors, and PLC simulation experiment systems with a high market share in practical applications, such as intelligent building lighting control systems and automatic air conditioning control systems. Secondly, in terms of software facilities, advanced programming software, building information modeling (BIM) platforms, and configuration monitoring software are set up, and the interaction between BIM and PLC simulation data is gradually studied and analyzed through the intensification of software platforms. To avoid the abstraction of teaching, teaching should take actual projects as cases and guide students to independently design a set of comprehensive practical training projects from simple to complex [15]. For example, the theme of a simple project can be designed as "PLC-based automatic control of construction water pumps", and a complex project can be designed as "fan group control and BIM information linkage system". Through a series of project cases based on practical problems, students gradually understand the overall thinking from demand, control diagrams, programming design to simulation debugging, and full participation helps them personally experience the engineering practical skills from abstract control logical thinking to the final realization of product results in the project, enabling students to truly master the operation ability and realization methods of improving building energy efficiency by using PLC technology.

3.3. Reform of the teaching evaluation system and competency-oriented assessment

An effective tool to test the results of teaching reform is to establish a teaching evaluation system aimed at enabling students to effectively master practical operation skills. The current teaching evaluation system has many drawbacks and is in urgent need of reform. In practical work, the reform of the teaching evaluation system should be competency-oriented, break the traditional assessment method focusing on the memory of theoretical knowledge, and build a comprehensive evaluation system focusing on the assessment of practical operation, logical thinking, and innovative application. The reformed evaluation system should mainly include the following points: First, assess students' understanding of basic theoretical knowledge through closed-book written examinations, focusing on testing their understanding of the basic principles of PLC technology and

its practical application cases in architecture; Second, focus on assessing students' practical operation skills, evaluating the correctness and standardization of their operation behavior through assessing their wiring, programming and system simulation abilities on the experimental platform; Third, assess the comprehensive quality of students' project completion, focusing on their logical thinking ability and innovative ability in the process of independent scheme design, program design and system simulation in project design; Fourth, focus on assessing students' team cooperation ability and communication ability, and evaluate their actual performance in the cooperation process. Through a comprehensive and whole-process evaluation, students can have a deeper understanding of the competency-oriented training objectives, and through guiding students to carry out targeted learning, achieve the goal of applying what they have learned, with competency orientation as the ultimate goal.

3.4. Strengthening the industry-university-research collaborative mechanism and introducing resources

The industry-university-research collaborative mechanism can effectively promote the continuous optimization and in-depth teaching reform. Colleges and universities should take the initiative to carry out various forms of school-enterprise cooperation models, go out actively, and embrace advanced construction enterprises, automation product manufacturers, and excellent scientific research institutions with a more positive and open attitude. For example, jointly develop teaching courses with enterprises, jointly develop products and solutions meeting the actual needs of the project site according to the actual production situation of enterprises, invite industry experts to teach in the university or guide graduation design, and jointly build simulation practical training bases with scientific research institutions. This two-way cooperation mechanism not only provides rich real project resources and practical scenarios for PLC teaching, but also broadens students' horizons, enriches teachers' engineering practical experience, and at the same time promotes schools to actively adjust the training direction, improve students' employment rate, enable them to take up jobs immediately after graduation, and provide high-quality professional talents for enterprises.

4. Conclusion

In summary, the in-depth integration of PLC technology and the construction engineering curriculum system in colleges and universities is an effective path for future teaching reform to adapt to the intelligent trend of the construction industry. This model effectively changes the traditional single-disciplinary teaching method, constructs an interdisciplinary knowledge system, optimizes the disciplinary integration system, and cultivates students' concept of intelligent construction. The implementation paths centered on curriculum content restructuring, practical platform innovation, and evaluation system reform ensure the operability and effectiveness of teaching reform, cultivate students' systematic and integrated intelligent construction engineering thinking, and provide new impetus for the innovation and upgrading of the construction industry.

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