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Deepening Practice and Innovation, Empowering Intelligent Control: A Teaching Innovation and Practice Report on the Programmable Logic Controller Course

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Abstract: The Programmable Logic Controller (PLC), a key carrier of intelligent manufacturing technology, is one of the most important courses that bridges theory and practice in engineering fields of mechanical engineering and intelligent manufacturing. The challenges facing current course teaching are noticeable such as archaic teaching philosophies, lack of resource support, superficial theory/practice integration, and monolithic evaluation, which lead to underdevelopment of the practical capability and innovative thinking and leaves students unable to meet the needs of Industry 4.0 development. Based on the talent development orientation of engineering education, this course follows a teaching philosophy of student-centered learning and OBE-directed teaching and creatively develops a blended teaching framework of one competition as the driver, three lines running through, and three steps in progression. By redesigning the teaching material of the triadic concept of knowledge-project-ideology, by incorporating inquiry-based and digital teaching methods and developing an all-encompassing multi-dimensional evaluation system, the course achieves a comprehensive transformation from knowledge transmission to competence development and quality shaping. In the wake of the reform, the applied and innovative skills of students have significantly improved, and the quality of teaching has been widely recognized.

Keywords: Programmable Logic Controller; OBE; Blended Teaching; Multi-Dimensional Assessment; Transformation

1. Introduction

The *Programmable Logic Controller* course is a fundamental course in mechanical engineering and intelligent manufacturing, with 48 class hours and 3 credits. The students are third-year engineering undergraduates, who have some theoretical background, are active-minded and have a strong desire to learn. They have already taken courses like Electrical and Electronic Technology, C Language Programming and therefore have basic knowledge in electrical engineering. The *Programmable Logic Controller* course is very practical with strong practical requirements, which are challenging to students. The course is student-centered and based on an innovative approach to teaching; the online-offline blended model is used, which allows students to master the working principles of PLCs, hardware and software resources, the instruction set, the methods of programming and the development of a configuration monitoring system and master the skills in the design of the PLC control system, its installation, commissioning, and maintenance and acquire such qualities as the safety-first mindset, scientific rigor, collaboration, and an innovative spirit [1-4].

2. Learning Situation and Pain Point Analysis

2.1 Learning Situation Analysis

The students already have some background in electrical engineering and programming theory and are active-minded and have a great desire to learn. But they are not acquainted with the industrial application situations of PLC technology, and have a low level of awareness of the translation of abstract reasoning into concrete operational competence. They are used to receiving knowledge passively and do not have the ability to actively inquire and work as a team to solve complex engineering problems.

2.2 Pain Points

Pain Point 1: Rigid teaching model, absence of student-centeredness [5]. Traditional teaching is characterized by lectures by teachers, and monotonous teaching styles. Students listen

passively which limits their proactive questioning and creative thinking, making it hard for students to adjust to the requirements of the industrial field in terms of problem solving as required by the complex situations.

Pain Point 2: Fragmented teaching resources, lack of connection between theory and practice [6]. The resources available on-line are limited and disorganized; theoretical teaching, practical functioning, and ideological-political factors are not intertwined with each other. There is no properly graded range of practice projects or enough development of non-technical skills (including spirit of craftsmanship), which makes it hard for students to convert their theoretical knowledge into industrial practice.

Pain Point 3: Inadequate practical teaching, weak alignment with real-world application. The hours spent in the laboratory are few, and the combination of laboratory and theory is shallow and asynchronous, so students find it challenging to put the studied theories into practice and acquire deeper insights into theory based on practice.

Pain Point 4: Monolithic evaluation system, biased evaluation orientation [7]. Examination based assessment techniques continue to prevail and the focus is more on theory than practice. Real-life problem-solving skills and innovativeness of the students are not nurtured systematically.

3. Teaching Innovation Philosophy and Overall Approach

The course responds to the teaching pain points and problems by adopting a student-focused approach to change the traditional model of knowledge transmission to knowledge inquiry and competence cultivation instead of knowledge reception. A blended teaching model, called “one competition, three lines, three steps” has been built: the three major threads are: knowledge line, project line, and ideology line. Advocate for students' active participation in learning, fostering a positive learning style characterized by proactive exploration of knowledge and emphasis on solving practical problems, while focusing on cultivating students' habits of autonomous learning. Meanwhile, online teaching materials and the Chaoxing Learning Platform serve as the cornerstone for building an efficient classroom, and the three steps (pre-class, in-class, post-class) are designed to complete the teaching process.; students with strong performance are invited to the CIMC Siemens Cup China Intelligent Manufacturing Challenge, allowing these students to have higher level training through the principle of promoting learning through competition.

4. Innovative Measures

4.1 Innovative Teaching Design

The old lesson plans have been replaced by information-based instruction design. Conventional lesson plans start with textbook content, have knowledge points as their organizing factor, focus on important and challenging points of the lecture, and emphasize a teaching-based pedagogy. Information-based instructional design, in contrast, focuses on a learning system composed of multiple elements, and focuses on the aspects of integrating teaching materials and resources, and emphasizes an orientation towards a learning-centered pedagogy.

Chaoxing Learning Platform resources support online instruction, whereas multimedia instruction is used in the offline classroom teaching. QQ groups, WeChat groups, and the Chaoxing Learning Platform help teachers to communicate with students in real time and answer questions and clear up doubts.

4.2 Restructuring Course Teaching Content

A three-line system of teaching- the knowledge line, project line and ideology line- has been established. These three lines have broken down the content of the course into 23 project cases, with particular examples as shown in Figure 1 and Figure 2. The system of reorganized course content is complete and is organically formed by combining theoretical knowledge with the development of virtue through education and subtly and imperceptibly guiding students' values and enhancing the ideological aspect of the course.

4.3 Integrating Innovative Teaching Methods

Based on the online materials of the course as well as the Chaoxing Learning Platform, a distinctive three-step teaching method is innovatively developed [8-9]. Problems are always the focus of PLC teaching, which combines participatory, inquiry-based, and project-based teaching methods. The three-step method is applied through the Chaoxing

Learning Platform to develop positive learning habits, awaken the interest to learn and build an effective classroom.

The three-step teaching method based on Chaoxing Learning Platform involves the use of information technology to gather, analyze, and process learning big data that is generated by teachers and students in three categories of teaching activities - pre-class, in-class, and post-class to support students' learning goals and overall capability development.

4.3.1 Pre-class stage

This is mainly the stage of doing pre-class preparation. Students preview the Learning Platform courseware three days prior to class and take the Learning Platform quiz a day prior to class.

4.3.2 In-class stage

The teaching is provided with the help of the classroom teaching, Chaoxing Learning Platform, lab work, and simulation software. Students respond to questions set by the teacher or give feedback on the problems and learning requirements as realized during pre-class preparation. The teacher evaluates the level of understanding of the students in terms of their answers. Simulation software is used on-site to show the teacher programming steps that are practical and task programs are written on-site in the laboratory by students.

4.3.3 Post-class stage

Post-class, students do the assessment of the session using the Chaoxing Learning Platform. To support ongoing improvement, the teacher relies on the post-class summary feature of the platform to learn about and assess the success of the session - which students did well, which students did poorly, and whether the instructional design requires further development.

4.4 Constructing a New Model of Extracurricular Technological Innovation Practice

Through the CIMC "Siemens Cup" China Intelligent Manufacturing Challenge, which is one of the competitions of the university students, the classroom teaching will be supplemented with extracurricular technological innovation training, raising awareness of innovation and programming skills.

Discipline competitions are also incorporated into day-to-day teaching activities and gradually discipline competitions have become a pillar. The CIMC "Siemens Cup" China Intelligent Manufacturing Challenge is an engineering contest, created with the purpose of developing and identifying technical and innovative talents required in the development of intelligent manufacturing, to encourage the students to be interested in studying PLC and improving their practical problem-solving capabilities. To encourage students to actively participate in extracurricular competitions, broaden their knowledge, and cultivate an innovative spirit, the program has so far participated in one provincial-level competition, winning a total of three awards.

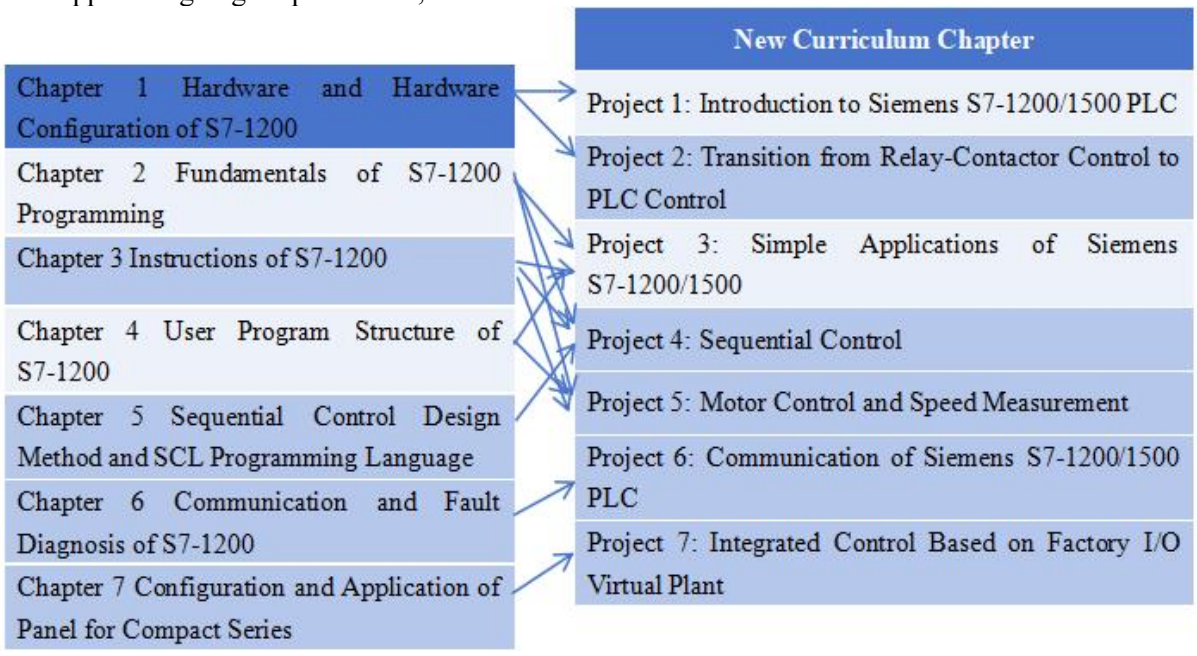

Figure 1. Example of Restructured Knowledge Line

Typical Knowledge System Content for Reconstruction	Thought-Provoking Integration Points
Understanding the Siemens PLC Family	Analyze the meticulous debugging process in PLC programming, and how to enhance the stability and efficiency of industrial control systems by continuously optimizing the program code, demonstrating the embodiment of the craftsman spirit in technical work.
Forward and Reverse Control of Three-Phase Induction Motors	In 2023, Huibo Intelligent Research analyzed the PLC industry and pointed out that the demand for domestic PLCs was increasing. Domestic manufacturers seized the market by leveraging their advantages such as high cost-effectiveness and short delivery times. For instance, Baishen Software independently developed a large-scale PLC, achieving a domestic breakthrough and striving to enter the top ranks of domestic large-scale PLC control system manufacturers within a few years.
Control of Two-Liquid Mixing	In 2023, Huibo Intelligent Research analyzed the PLC industry and pointed out that there was a growth in the demand for domestic PLCs. Domestic manufacturers, leveraging their advantages such as high cost-effectiveness and short delivery times, implemented a sequential control system based on Siemens S7-1200 PLC in a leading domestic manufacturing enterprise in 2022. Through precise sequential control, they optimized the production process, significantly enhancing manufacturing efficiency and product quality, demonstrating the application of technological innovation in intelligent manufacturing.
Stepper Motor Control	In 2023, Huibo Intelligent Research analyzed the PLC industry and pointed out that there was a growth in the demand for domestic PLCs. Domestic manufacturers benefited from their competitive pricing and short delivery times. In 2023, a certain motor manufacturing enterprise in China achieved energy efficiency optimization in motor operation by adopting advanced motor control technology. This not only enhanced the performance of the motors but also significantly reduced energy consumption, demonstrating the combination of efficiency awareness and technological innovation.
Conveyor Belt Control System	In June 2023 and 2024, a domestic automation enterprise introduced Factory I/O virtual factory software to simulate and optimize the production process. By integrating the PROFINET bus standard, it achieved efficient management of equipment communication and data exchange, significantly enhancing the automation level and production efficiency of the production line.

Figure 2. Example of Restructured Ideology Line

4.5 Innovating the Course Teaching Evaluation Method

An interactive, holistic multi-dimensional assessment approach has been built [10]. The monolithic evaluation system has been replaced in everyday teaching. Individual differences of students are respected, creating a multi-dimensional evaluation system that involves teacher assessment, peer assessment and self-assessment with dynamic and all-round evaluation. Various methods and approaches are embraced in the assessment process with the objective to enhance students' initiative, sense of participation, and competitive awareness, while reducing mental load and psychological pressure. The evaluation is performed based on the reformed evaluation system presented in Table 1 that, on the one hand, increases the amount and percentage of digital process-assessment elements to improve the learning involvement, and on the other hand, raises the percentage of practical process assessment to reinforce the learning objectives and intrinsic learning motivation.

Table 1. Assessment and Evaluation System

Assessment Component	Specific Content	Weight	Evaluation Description
Process-based Assessment	Class Attendance	4%	Record attendance in theory and lab sessions to ensure learning participation.
	Online Learning	10%	Based on Chaoxing Learning Platform data, quantitatively evaluates courseware study, quiz completion, and interactive communication.
	Classroom Performance	4%	Evaluate the proactiveness and effectiveness of class discussions, group discussions, and problem inquiry.
	Homework	10%	Combine basic assignments and project reports to evaluate knowledge mastery and engineering expression ability.
	Lab Practice	12%	Comprehensive scoring based on program writing, wiring operation, on-site demonstration, and fault troubleshooting performance.
	Competition / Innovation Project	10%	Extra points are awarded to students participating in the "Siemens Cup" or other innovation projects to encourage innovative practice.
Summative Assessment	Final Written Exam	50%	Closed-book exam, focusing on core theoretical knowledge and comprehensive application ability.

5. Features and Innovations of the Course Teaching Reform

5.1 Innovating the Teaching Philosophy Centered on "Student-Centered" Learning with "Students as the Main Body and Teachers as the Guide", Targeting "Knowledge Inquiry" and "Competence Cultivation"

The traditional lecture-based model has been transformed into a new teaching model oriented toward competence development, guided by project-based cases and learner-centered principles. Group inquiry and case studies are some of the methods used and this enables students to carry out tasks in practice. The focus has shifted from lecturing supplemented by discussion and practical work to practical work supplemented by lecturing, and developing the collaboration, communication and innovation skills of students.

5.2 Innovating a Three-Dimensional, Multi-Level National Quality Online Open Course System with Teaching Content Restructured Along the Knowledge Line, Project Line, and Ideology Line, Supplemented by the Latest Research Outcomes

Through project cases, students learn PLC; through project cases, they grasp principles, linking projects, PLC, and life together to inspire the establishment of correct values and enhance the effectiveness of curriculum-based ideological and political education.

5.3 Innovating the Course's "Three-Step Teaching Method"

The three-step teaching approach based on the Chaoxing Learning Platform is easy to implement, as it only requires the existing multimedia instruction tools and simulators already available at the school. This low-barrier design ensures that the approach can be readily adopted without significant additional investment in hardware or software, making it highly feasible for widespread application across different courses and departments.

Smartphones play a pivotal role in this teaching model, enabling both teachers and students to collect, analyze, and provide feedback on teaching data at each stage of the instructional process—namely, before, during, and after class. Through the platform's integrated features, teachers can promptly identify students' learning difficulties and adjust their teaching strategies accordingly, while students can track their own progress and reflect on their performance in real time. This timely and interactive feedback mechanism fully mobilizes the learning initiative of students, transforming them from passive recipients of knowledge into active participants in the learning process.

Furthermore, the real-time monitoring capability allows teachers to keep a close watch on the

learning progress of each student, enabling early intervention when necessary and ensuring that no student falls behind. The platform also records detailed learning analytics, which provide valuable data for continuous course improvement and personalized instruction. Overall, this approach not only enhances teaching efficiency but also fosters a more engaging and responsive learning environment, ultimately contributing to better learning outcomes and student satisfaction.

6. Achievements and Promotion Value

6.1Main Achievements

6.1.1 Good Teaching Results, Excellent Student Academic Performance, Effective Enhancement of Higher-Order Abilities

After the teaching innovation, the learning initiative and proactivity of the students have significantly improved and the percentage of students with excellent grades has also increased significantly. The outcome of competition has been excellent, one second place prize and two third place prizes in the CIMC “Siemens Cup” China Intelligent Manufacturing Challenge.

6.1.2 Significant Improvement in Teachers' Teaching Competence, Excellent Results in Teaching Competitions, Fruitful Outcomes in Course Construction and Teaching Team Building

The team received one teaching reform project at the university level, and one curriculum-based ideological-political education project, and published one teaching reform paper.

6.2 Promotion and Application Value

A blended teaching approach has been embraced and adopted online-offline with task-driven learning as its vehicle and the emphasis on the central role of the students. Abstract programming is visual and intuitive using simulation software and experimental equipment that are collectively used to debug and write programs. Students record their learning process and upload their learning outcomes to the platform, sharing learning experiences with other students, which gives them a strong sense of academic achievement. This instructional model can enrich students' knowledge base, enhance their practical capacity, and contribute to their learning achievement, professional competence, and competitiveness in employment.

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References

[1] Tan Rongrong, Huang Zhenyu, Zhong Jilei. Teaching Reform and Practice under the Background of “First-Class Course Construction”: Taking the Programmable Controller Application Technology Course as an Example. Electronics Quality, 2026, (4): 124-129.

[2] Li Guangwei. Research and practice of teaching and learning reform in "new engineering" course construction — a case study of the Programmable Logic Controller Principles and Applications course. Theoretical Observation, 2019, (01): 150-152.

[3] Zhang Hongbo. Teaching reform and practical exploration of the “Electrical Appliances and Programmable Logic Controller” course. Technology Wind, 2019, (25): 37.

[4] Wang Yanping, Li Yongmei. Discussion on teaching reform of the Programmable Logic Controller Technology course under the “Internet+” background. New Curriculum Research, 2021, (6): 54-56.

[5] Yang Yang, Teng Haipeng, Pei Mengchen, et al. Informatization Teaching Reform with the SPOC for the Programmable Logic Controller. China Modern Educational Equipment, 2021, (11): 6-8.

[6] Xue Rui, Cui Yanfeng, Wang Liang. Exploration of Programmable Logic Controller Principles course reform under the OBE engineering education model. Education Modernization, 2019, 6(97): 80-82+87.

[7] Zheng Haichun. Exploration and Practice of Teaching Reform of Programmable Controller Course. The Guide of Science & Education, 2022, (21): 107-109.

[8] Luo Xiaojia. Research on the Teaching Reform of the Programmable Logic Controller Course from the Perspective of Curriculum Ideological and Political

Education. Journal of SuZhou University of Technology, 2022, 36(5): 120-124.
[9] Cui Shaochen. Exploration of teaching reform in the Programmable Logic Controller course based on blended teaching methods. Science and Technology Innovation, 2019, (23): 51-52.
[10] Li Chonghua. The Construction and Exploration of the Course System of Programmable Controller Principle and Application. China Modern Educational Equipment, 2018, (7): 20-22.