

# Teaching Reform and Exploration of Practical Courses Based on Programmable Control

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**Abstract:** As the country continues to promote the development of intelligent manufacturing, all industries are carrying out enterprise automation upgrading, the Pearl River Delta Intelligent Manufacturing Conference held in March 2024 provides a direction guide for each enterprise on how to integrate the intelligent manufacturing technology into each link and provide direction guidance for enterprises to create new models and new business formats. College teachers, in focusing on the teaching process, should closely match the enterprise and social needs and cultivate excellent students. As the core controller of automation control, the application of programmable controllers in teaching is particularly important. In practical classes, by setting progressive difficulty, project guidance, team collaboration, and other links, students can master the automation equipment design of programmable control in repeated practice.

**Keywords:** Programmable controller; Practical course; Project guidelines; Teamwork

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## 1. Introduction

As mentioned at the Pearl River Delta Intelligent Manufacturing Conference held in March 2024, China's manufacturing development has entered a critical period of transition, the application scenarios of intelligent manufacturing technology in traditional manufacturing industries are constantly enriching and the scope of penetration is gradually expanding. As relevant enterprises, they have given direction guidance on how to make good use of intelligent manufacturing and how to create their own ecological environment with intelligent manufacturing as the center <sup>[1]</sup>. In cultivating talents, colleges and universities must not only cultivate moral character but also keep close to society and serve enterprises. In professional courses related to intelligent manufacturing, the teaching model is constantly improved, a variety of teaching methods are adopted, and experimental equipment is updated. Among them, the programmable logic controller (PLC), as the core controller, is particularly important in teaching applications. Therefore, practical courses with PLC as the core of control should constantly update the content and improve teaching methods to adapt to the rapid development of today's society. This paper focuses on the teaching reform and exploration of 2021 students majoring in mechanical design, manufacturing, and automation at Zhuhai Institute of Science and Technology, School of

## 2. PLC as the core of the practical courses

Among the mechatronics courses of the mechanical design, manufacturing, and automation major, there are many courses related to programmable control, and the contents of the practical courses are similar. Taking the mechatronics course of the mechanical design, manufacturing, and automation major as an example, the theoretical courses are explained from the basic structure, working principle, command system, and application examples. Most of the practical courses focus on controlling the effect changes of the lights to complete the practical courses. According to this teaching model, the practical operation is simple and the effect is average. Although it can let students quickly master the basic operations of PLC, become familiar with the operation methods of PLC programming software, and understand the control methods of PLC. However, they have no way to start with the design of more complex control systems.

## 3. Practical teaching content reform

Based on the existing automation equipment, which includes the PLC control design test bench; water tank temperature control design test bench; steel roll forming machine test bench; optical mechatronics integrated control test bench; and Yalong Bay production line test bench. The difficulty levels of the practical course are classified, the first category is the basic experimental design, with the PLC control design test bench as an experimental platform, by changing the application scenarios of the lamp and designing with different effects, students can quickly transition from theoretical learning to practical operation, from abstract program understanding to programming debugging. The effect design on the test bench deepens students' understanding of PLC. Through multiple experiments, from easy to difficult, students can master the basic design of PLC programming. The second type is advanced experimental design, with a water tank temperature control design test bench and steel rolled into a machine test bench as the experimental platform, students will be able to master the wiring methods of each hardware and become familiar with the signals of each hardware by adding input and output hardware, such as various sensors, actuators, etc.; and then adding special function modules to PLC, such as analog input and output modules, allows students to master the wiring methods of each special function module, become familiar with the use of special function modules, and be able to use special instructions to complete the design content. This way, on the basis of the original PLC learning, students not only mastered PLC programming proficiently and learned more about input and output devices but also understood the important position of PLC in intelligent manufacturing. The third category is the integrated design category, with the optical mechatronics integrated control test bed and Yalong Bay production line test bed as an experimental platform, more hardware components and more complex control designs allow students to understand that a production line mainly goes through several stages from raw materials to final finished products, what hardware is used in each stage, and how to program, making students master the programmable controller well; and also adding other controllers, such as frequency converters and servo controllers, to master their control methods, as well as adding touch screen control design, to be able to skillfully use touch screen programming software and combine touch screens with PLC communicates, allowing students to get started faster in subsequent automation equipment installation, debugging, research and development, and other projects after operating on the entire comprehensive experimental platform.

In view of the specific requirements put forward by the reform of the above practical course content, its practical teaching content is in **Table 1**.

**Table 1.** Practical teaching content

Experiment category	Experimental equipment	Experiment content	Experimental hours
Basic design of experiments	PLC control design test bench	1. Fountain effect design	2 credit hours
		2. Digital tube school number display design	2 credit hours
		3. Traffic light design	2 credit hours
Advanced design of experiments	Water tank temperature control design test bench	4. Water tank temperature control design	6 credit hours
	Steel coiling machine test bench	5. Steel coiling machine design	6 credit hours
Comprehensive design	Optical mechatronics integrated control test bed	6. Sorting system control design	12 credit hours
	Yalong Bay production line test bench	7. Assembly system control design	16 credit hours

Through the above reform of practical course content, students can learn and apply PLC more easily, and can achieve greater improvement both in theoretical teaching and practical operation. At the same time, students can perform with ease in relevant competition designs and achieve better results.

#### 4. Project-led teaching methods

Although students can better understand and apply PLC through the reform of practical teaching content, there is still a long way to go in terms of how to develop automated equipment and realize intelligent manufacturing. Therefore, project-guided teaching can enable students to better understand and apply PLC. Students are familiar with the operating procedures of project design and the specific content and operating steps of equipment research and development, which can make it easier for students to get started when they engage in related professional content after graduation. Therefore, practical projects for students cannot be fake, empty, or large, and must be able to be implemented. In general, projects currently being researched by full-time teachers or completed projects will be selected as practical teaching course designs, so that students can truly participate in the projects. During research and development, students can also practice from beginning to end to get results, and gain a sense of accomplishment in learning, which will make students more confident in the use of PLC. The specific steps are as follows:

- (1) Determining the content of the project: When students get the project, they should read the content carefully and filter out the specific control requirements; the team manager should allocate groups according to the situation of each member, and at the same time divide tasks according to the configuration of team members and allocate each requirement in detail.
- (2) Determining the composition of the hardware: According to the project requirements, a simple structural design is first carried out to meet the basic functions required by the project, and then modeled using NX; then each hardware in the project requirements is classified according to the I/O list.
- (3) Determining the design scheme: The whole team discusses the specific control scheme together, selects the most suitable one, and starts drawing control flow charts, electrical schematics, etc.
- (4) Building a prototype platform: According to the program content determined above, the existing hardware is assembled.
- (5) Program debugging: According to the drawn control flow chart, the team writes the program and debugs the prototype. The debugging process needs to be verified repeatedly until it can run stably for

a long time.

- (6) Summary: According to the design of this project, how each member completed the project, what problems and difficulties were encountered during the period, whether they were overcome, etc., what problems occurred during the team collaboration, and how to solve them, etc. are summarized.

Through the project-led teaching method <sup>[2]</sup>, students can better understand PLC control design and have a certain understanding of the specific operation process of the project. Moreover, through the project-based design and implementation of the course, as well as all-round and multi-dimensional assessment and evaluation, students' abilities and qualities are improved in all aspects <sup>[3]</sup>. Judging from the practical content feedback and survey results, the project-based task-based curriculum reform has significantly improved students' learning interest and initiative, effectively cultivated students' practical skills and communication and collaboration abilities, and improved students' mastery of the course, providing a solid foundation for future development in related professional fields.

## 5. Teamwork

Teamwork is something that must be experienced in future study and work. It is also one of our essential skills. Even as a team manager, we have higher requirements for the entire team's task division, team member communication, problem-solving, etc. Setting up a team is conducive to cultivating students' overall professional quality <sup>[4]</sup>. As a country of craftsmen, our country is an external manifestation of spirit, quality, and ability, demonstrating the professional qualities of our people. Therefore, during the project guidance process, the students were divided into 10 teams, each with 10–12 people, with one person serving as the manager, and the rest were divided into four groups, with a team leader assigned to each group. Members of the team must understand each other and clarify their own task goals. In this way, each member can complement each other according to their own abilities and complete the project tasks better. The smooth implementation of the project requires a high degree of coordination and cooperation between the various groups to achieve success. Mutual trust and cooperation between the project teams and the team members are related to work efficiency, completion quality, and the stability of the final overall debugging <sup>[5]</sup>. Thus, teamwork is also what a college student must learn.

The team needs to establish effective member communication skills and enhance everyone's cohesion, so that they can better solve problems, enhance the sense of identity among members, and improve everyone's professional and technical capabilities <sup>[6]</sup>. Especially as a team manager, he must understand all team members, use the strengths of each member, and reasonably allocate tasks in order to better complete the project design.

## 6. Conclusion

This paper takes programmable controllers as the control core. During the operation of each practical course, by changing the experimental platform and adopting a laddering mode, the difficulty of the practical links is gradually increased so that students can better understand the control design method. In comprehensive design and project design, project goals and tasks are jointly completed through team collaboration, and students' practical and innovative abilities are comprehensively improved from individuals to teams.

As a teaching reform of practical courses, the purpose is to improve students' hands-on practical skills, and to deepen their understanding of theoretical learning through practical links, transforming from abstract concepts and program writing to actual hardware connection and equipment debugging, so that students can better learn related courses. We need to strengthen the knowledge, platforms, disciplines, and management

support related to the practical teaching of courses, promote the organic connection between the education chain, talent chain, industry chain, and innovation chain, and finally provide strong support for cultivating intelligent manufacturing professionals.

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