

Innovation and Practice of Project-driven Teaching Method in the Course of Electrical Control and PLC Technology

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Keywords: Project-driven mode, PLC, heuristic teaching.

Abstract: In the teaching of the "Electrical Control and PLC Technology" course, project-driven teaching method promotes the cultivation of professional ability through task-driven and project guidance. This paper presents the specific implementation process of the project-driven teaching method in the course and the good teaching effect achieved by the application of the project-driven teaching method. The specific implementation process includes how to stimulate students' interest in learning, project formulation, project implementation, and project completion. The teaching effects achieved are demonstrated in the form of screen and video recording when students complete the project, and documents submitted by students when completing the project during COVID-19. It fully embodies the active teaching role and good teaching effect achieved of the project-driven teaching method in the course of "Electrical Control and PLC Technology".

1. Introduction

On January 19, 2020, the Ministry of Industry and Information Technology released the "2019 China Electronic Information Manufacturing Comprehensive Development Index Report". The report pointed out that the rapid advancement of 5G, industrial Internet, intelligent upgrading, and new digital infrastructure can bring important development opportunities to the electronic information manufacturing industry. From the perspective of the Industrial Internet, industrial electronics and equipment such as PLCs (programmable logic controllers), industrial control computers, and industrial smart modules will all have emerging fission and iterative upgrades, and will obtain further development opportunities. However, most students cannot really master the software and hardware design, installation and debugging with regard to PLC electrical control after learning the course "Electrical Control and PLC Technology". Some students do not have the overall design ability of the project process. There is a big gap between the abilities of students and the needs of society.

In 'Discussion on teaching reform of "Electrical Control and PLC" course in applied undergraduate colleges', Duan [1] proposed that the course of "Electrical Control and PLC Technology" in applied undergraduate colleges should pay attention to the characteristics of strong practicality to carry out the adjustment of the course teaching content, the reform of the teaching

mode, and the change of the assessment mode. She also pointed out that this course in applied undergraduate colleges should focus on cultivating students' changeable ability that applying theoretical knowledge to practice and certain innovation ability, thus meeting the needs of social and technological development [1]. In the 'Practice research on the teaching reform of electrical control and PLC based on virtual simulation technology' proposed by Lin and Sun [2], the abstract electrical control schematic diagram became 'live' with the help of virtual simulation technology in the practice of teaching reform, which vividly and concretely showed the electrical control process and the response of electrical components. Furthermore, the teaching method that combined PLC-electrical control simulation and traditional training was also explored in order to achieve the purposes of stimulating students' interest in learning and improving learning effects [2]. In 'The teaching reform of the course "Electrical Control and PLC" emphasizing engineering orientation' proposed by Zhang and Zhao [3], with the emphasis on "engineering practice" as the orientation, the content, methods, means, assessment methods, experimental settings and curriculum practice training of the course teaching have been reformed and practiced to achieve the purpose of cultivating students' engineering ability.

There have been many successful cases of project-driven teaching methods in actual teaching. By focusing on the current situation where the training of engineering technical personnel is out of touch with production and innovation practice, Zhang and Liu [4] have proposed an electronic comprehensive practice teaching reform method driven by scientific research results, effectively improving students' ability to deal with engineering problems. Xu [5] wrote a textbook entitled "Packaging Design Project Teaching" based on several years of exploration and practice. Li [6] applied the project-driven teaching method to computer software courses, which improved students' practice ability.

2. Significance of Project-driven Teaching Method in the Course

The goal of project-driven teaching method applied in "Electrical Control and PLC Technology" is to cultivate students' project thinking and engineering ability, so that students have the ability to solve practical application problems, complete program writing and debugging. Teaching achieves the following effects, including (1) the transformation of the mode of combining theory and practice: from the passive completion of experiments arranged by the teacher to the challenging completion of active selection or design projects by students; (2) the change of knowledge mastery: from the partial mastery of knowledge to a comprehensive mastery and application of knowledge, cultivating students' project thinking ability; (3) the cultivation of engineering ability: training students to independently design electrical program, architecture, and scheme, write programs, and conduct development and testing through specific, practical engineering projects, thereby improving students' engineering awareness and engineering application ability; and 4) the cultivation of team spirit. A few students complete a project together, which can further cultivate students' mutual communication skills and team spirit, and cultivate students' ability to innovate and start businesses. Project-driven teaching method in the teaching of the "Electrical Control and PLC Technology" course promotes the cultivation of professional ability through task-driven and project guidance. Starting from the general process of global design of PLC control system, students' project thinking is cultivated by instructing students to complete project tasks independently from simple to complex. Students' capabilities of solving practical application problems are obtained through the combination of theoretical teaching, experimental operation and comprehensive design training. Students' engineering abilities are cultivated by being able to allocate I/O to specific projects, draw wiring diagrams, and complete program writing and debugging. Therefore, students can meet the

company's job requirements for college graduates in the direction of "Electrical Control and PLC Technology", increasing the employment rate of automation students.

3. Specific Implementation of Project-driven Teaching Method in the Course

The "Electrical Control and PLC Technology" course applies the project-driven teaching method. First, by playing the videos recorded by previous students who completed specific projects independently, the students can feel the interest, practicality and learnability of this course vividly and concretely, so as to achieve the purpose of stimulating students' interest in learning and improving learning effects. Subsequently, specific projects are arranged to inspire and guide students to independently complete the project and record videos, thereby exercising students' engineering thinking ability and ability to do brain work, use their brains, and practice abilities, cultivating students' engineering awareness, and improving students' innovative ability, practical ability and comprehensive quality. The implementation process of project-driven teaching method is shown in Figure 1, including four parts: stimulating students' interest in learning, project formulation, project implementation, and project assessment.

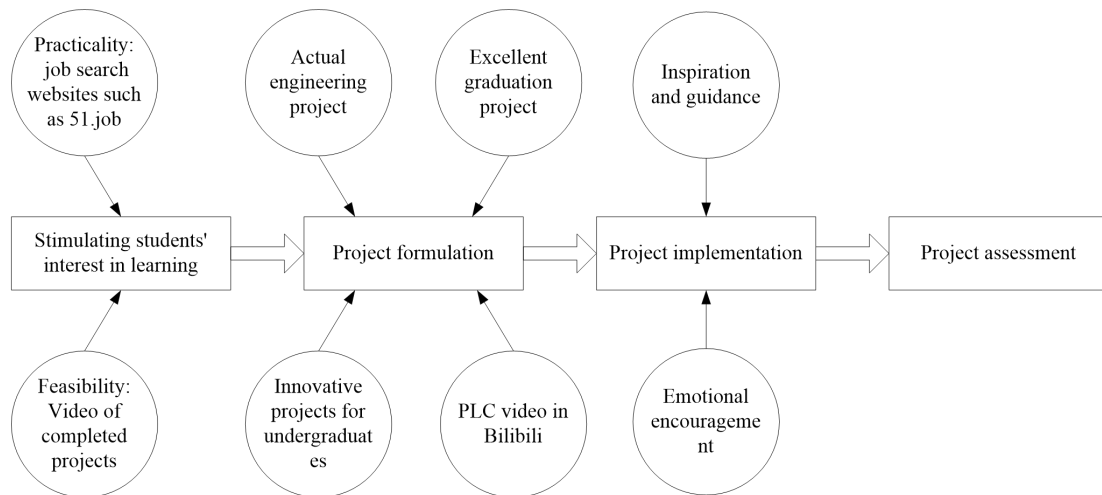


Figure 1: Implementation process of the project-driven teaching method.

3.1. Stimulating Students' Interest in Learning

First, stimulate students' interest in learning. Only with interest in learning can they actively participate, and the expected learning effect can be achieved. How to stimulate students' interest in learning? First of all, it is practicality. Let students understand the society's demand for talents of PLC direction and job requirements through the job search website (Table 1).

Table 1: This caption has one line so it is centered.

| | | | |
|-----------------------------|--|---|--|
| Recruiting companies | Oerlikon Textile Technology Co., Ltd. Beijing Century Honglian Electronics Co., Ltd. SMC (China) Co., Ltd. | Xi'an Medical Group Co., Ltd. Shanghai T-bank Enterprise Management Co., Ltd. Beijing Fubon Zhida Automation Technology Co., Ltd. | Sky Leading Shanghai Co. Ltd. Beijing Integ-Forever Co. Ltd. Anwha (Shanghai) Automation Engineering Co., Ltd. |
| Job requirement | independently design PLC program and improve PLC control system | Electrical program architecture design, program design, development and testing | Electrical research and development, PLC programming, installation and debugging |

Secondly, it is feasibility. First step is to establish students' self-confidence, believing that they can complete a PLC-related project through hard work. Then, by playing the video recorded by previous students who completed the project independently (Figure 2), students can feel that the project set in this course can be completed through their own efforts.

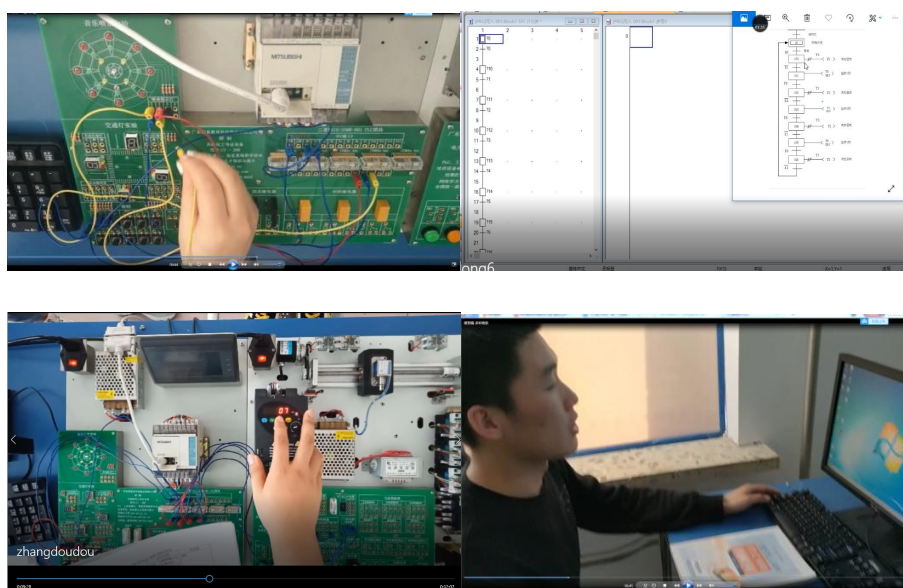


Figure 2: Video screenshots of projects completed by students of automation Grade 2016.

3.2. Project Formulation

The sources of the projects mainly include (1) the inquiry of excellent undergraduate graduation projects related to PLC in the past years on CNKI, (2) excellent provincial and national level projects related to the PLC direction, and PLC competitions, and (3) communications with students who have graduated and are engaged in PLC-related industries.

After projects are selected, the relevant teachers should conduct project first and evaluate them, including the difficulty of the project, the number of projects, how many students complete a project, the effects of the projects after completion, and the exercises by the projects on all aspects of students. These are all worthy of repeated scrutiny when setting up a project.

3.3. Project Implementation

After the specific project is selected, it is the project implementation process. In the implementation process of the project, students' independence must be reflected, and students' ability to solve problems should be trusted. Heuristic guidance and emotional encouragement should be provided to strengthen students' sense of accomplishment and gain so that students have more interest in learning, which forms a virtuous circle.

Small knowledge points such as the basic instructions of PLC, the operation of timers, and the functional instructions of PLC use the mode of 'classroom teaching → software verification → student screen recording' to lay a solid foundation for basic knowledge (Figure 3). Specific projects such as the application of frequency converter and touch screen adopt the mode of 'classroom teaching → experimental teaching → project design → student video' to realize project-driven teaching. Taking the actual project as the teaching carrier, from easy to difficult, from simple to complex, in-depth step by step, teaching is conducted to ensure the effective implementation of the project-driven teaching method.

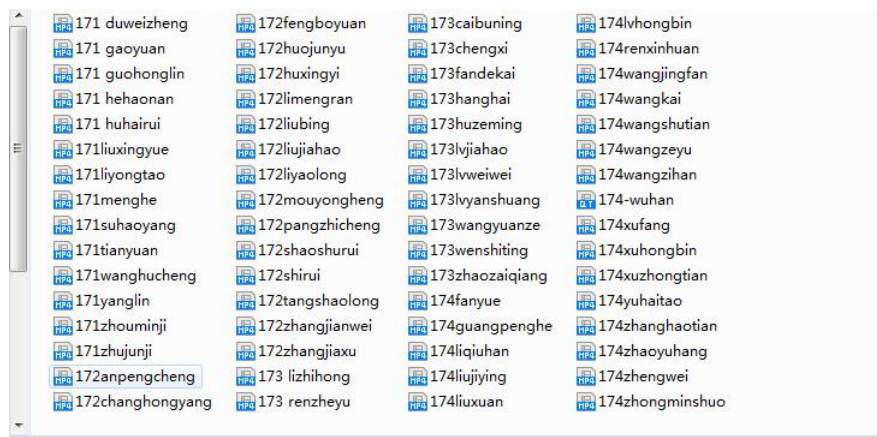


Figure 3: Screen recording files of small knowledge points.

3.4. Project Assessment

Process assessment should be enhanced. During the implementation process of the project, scores are recorded in stages. Even if the project is not completed eventually, the assessment results will be included in the final total score of the course, improving student participation in the project. The course score is calculated according to formula (1).

$$a = b \times 50\% + c \times 50\% \quad (1)$$

where a represents the course score, b represents the usual performance, and c represents the final exam score. The composition of the usual performance b is shown in formula (2).

$$b = d \times 50\% + e \times 50\% \quad (2)$$

where d represents the status of attending class status, and e represents the project participation status. The composition of e is shown in formula (3).

$$e = f \times 30\% + g \times 30\% + h \times 40\% \quad (3)$$

where f represents the degree of difficulty of the project, g represents the situation of team collaboration, and h represents the situation of the project completion. The specific scores are shown in Table 2.

Table 2: Project Score Distribution.

| Degree of difficulty of the project | | Situation of team collaboration | | Situation of the project completion | |
|-------------------------------------|-----|--|-----|-------------------------------------|-----|
| Difficult | 100 | communicate and learn from each other | 100 | 100% completion | 100 |
| Medium | 80 | often communicate with each other | 80 | 80%-100% completion | 80 |
| Easy | 60 | occasionally communicate with each other | 60 | 60%-80% completion | 60 |
| Select the project but not to do | 0 | No communication with each other | 0 | Less than 60% completion | 0 |

4. Practical Effect of Project-driven Teaching Method

Through the application of project-driven teaching methods in actual teaching for two years, a certain expected effect has been achieved. Student participation increased significantly. The total number of students in automation Grade 2016 is 117, and 33 students of them participated in the project. In addition to the three students who took the postgraduate entrance examination, all other students had employment. The total number of students in automation Grade 2017 was 125, and 87 students of them participated in the project. Except for the 9 students who took the postgraduate entrance examination, 58 students currently have employment (as of January 29, 2021). In the past two years, more students have chosen PLC direction for their graduation projects than before. Moreover, the quality of their graduation projects has been significantly improved. The number of students seeking jobs in PLC-related industries has also increased.

The project-driven teaching method also supports online teaching. Affected by the COVID-19, the "Electrical Control and PLC Application Technology" course in the spring semester of 2019-2020 adopted a network teaching mode. Although there was no hardware part in the project, some students used computers to simulate the project and record the screen.

5. Conclusions

This paper presents the specific implementation process of the project-driven teaching method in the teaching of the "Electrical Control and PLC Technology" course. Additionally, it also demonstrates the good teaching effects obtained by the application of the project-driven teaching method in the past two years, including the stimulation of students' interest in learning, the improvement of students' creative ability and capability of solving practical engineering problems, and the cultivation of students' teamwork spirit. The project-driven teaching method not only benefits automation students or undergraduate students who enroll PLC-related courses, but it is also a process of strengthening comprehensive ability for teachers who are interested in this direction.

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