Advances in Educational Technology and Psychology (2020) 4: 94-100
Clausius Scientific Press, Canada
DOI: 10.23977/aetp.2020.41014
ISSN 2371-9400

Exploration and Practice of PLC Virtual Simulation Experiment Teaching Based on CDIO Mode

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Keywords: CDIO mode, PLC, Virtual simulation experiment, Teaching reform

Abstract: This paper introduces the PLC virtual simulation laboratory system, comprehensively analyzes its advantages over traditional laboratories, shortens the experimental cycle, reduces the experimental cost and expands the scope of the experimental content. The introduction of the CDIO model and the analysis of the advantages and adaptability of the CDIO concept in engineering curriculum education. The CDIO concept is combined with the PLC virtual simulation laboratory to design a teaching plan suitable for the PLC experiment course. Through teaching practice and teaching results, it is proved that students' practical ability, innovative ability and the ability of engineering products, process and system construction are improved.

1. Introduction

Under the condition of informatization, the way of knowledge acquisition and imparting, and the relationship between teaching and learning need to be changed. In order to deepen the deep integration of information technology and education and teaching, the Ministry of Education has carried out the construction of the national virtual simulation experiment teaching project [1]. Our college responded positively and carried out a series of teaching reforms. PLC course as one of the core courses of our college, the college attaches great importance to the quality of students' learning, and established a PLC virtual simulation laboratory. Adhere to the principle of "student-centered, output-oriented and continuous improvement", and let the new teaching model become an endogenous force to promote the development of experimental teaching. Based on the analysis of many educational concepts, the concept of CDIO is suitable for almost all engineering colleges and universities [2-4].

CDIO stands for conceiving, designing, implementing and operating,. It takes the life cycle from product development to product operation as the carrier, and allows students to learn engineering in an active, practical, and organic way[5]. CDIO model pays more attention to the essence of engineering practice, the integration of practice and theory, and the cultivation of solid scientific foundation, humanistic literacy and personality development. There are some problems in the courses of most undergraduate mechanical majors in our country, such as "neglecting practice, emphasizing theory, neglecting the teaching of humanities and social sciences, and neglecting the

individualized training of students" and so on[6]. This paper will introduce the PLC virtual simulation laboratory constructed by the combination of PLC and virtual simulation, combined with CDIO teaching mode to improve the problems existing in undergraduate PLC teaching.

2. PLC Virtual Simulation Experiment System

Virtual simulation experiment teaching is an important measure to integrate modern information technology into experimental teaching, expand the breadth and depth of experimental teaching content, extend experimental teaching time and space, and improve the quality and output of experimental teaching. Since the 1960s, the programmable logic controller (PLC) has developed rapidly, its update speed is fast, and it involves a wide range of contents. PLC is based on microprocessor and integrates many theories, such as computer technology, control technology, communication technology and so on. In recent years, it has developed rapidly and applied widely. It has the advantages of flexible use and strong control function, and has become one of the three pillars of industrial production automation.

The development of PLC virtual simulation experiment system is the trend of the times. PLC virtual simulation experiment system includes programming, simulation, communication, configuration monitoring and so on. The controlled object is transformed from real hardware to virtual simulation. Compared with the traditional PLC laboratory, PLC virtual simulation experiment has the advantages of short development cycle, many kinds of experiments, low experimental cost, free from the limitation of time and space and so on. The virtual PLC experiment introduced in this paper is composed of GXSimulator, GXDeveloper and industrial configuration software. The configuration software uses Kingview 6.55, which is widely used at present, and connects them through virtual serial port VSPD to realize real-time working status control and monitoring. King view is used as the upper computer to realize the functions of simulating controlled objects and monitoring. Write the ladder diagram program in GX Developer and download it to GX Simulator for simulation operation, and finally connect the configuration software to realize a complete experimental system.

Comprehensive analysis of PLC virtual simulation experiment to solve the following problems of traditional PLC experiment:

- It solves the problem that there is no controlled object or the controlled object is not easy to realize, and increases the type and feasibility of the experiment.
- Traditional experimental results are not as intuitive as virtual simulation experiments, and cannot vividly reflect the working status, which affects the quality of teaching to a certain extent.
- Science and technology are developing rapidly in the 21st century. Limited by funds, it is difficult for experimental projects to keep up with the pace of development and indirectly affect the quality of teaching. The virtual simulation experiment is better than the traditional experiment from the experimental cost to the experimental cycle.

3. The Application of CDIO Teaching Model

The scale of engineering education in China has been among the best, but the output of the quality of talents in engineering education is very worrying, and there are great deficiencies in students' ability and practical training. In response to this social phenomenon, I put forward the teaching concept of combining the CDIO teaching model of the teaching reform proposed by new century international with the PLC courses closely related to the relevant majors of our college. The original intention is to start with teaching methods and essentially improve the quality of teaching. Compared with the traditional teaching mode, CDIO teaching mode makes the students more active

and the courses more interesting [7]. The students' ability of theoretical transformation and practice is enhanced, and it is more in line with the purpose of engineering colleges and universities to train students' engineering projects.

3.1. Traditional Teaching Mode

In the traditional teaching mode, all courses are designed by teachers and are taught and assessed according to class hours. Students only passively listen to the lecture and imitate the experimental process, the whole process rarely add their own thinking. In the traditional experiments, most of them are confirmatory experiments, which pay more attention to students' external behavior and ignore the internal law of learning. In the process of teaching, students carry out wiring, programming, using instruments and so on according to the experimental tasks assigned by the teacher. The whole process is step by step, and the teaching output is stereotyped and there is no innovation [8].

The shortcomings of the traditional teaching model are very obvious. Many scholars study teaching methods, hoping to find ways to solve the shortcomings of the current traditional teaching model. Based on this background, the teaching reform of the CDIO concept can be implemented and constructed in the PLC curriculum.

3.2. Teaching Construction and Implementation of CDIO Model

The concept of CDIO is different from traditional teaching ideas. The education method is student-centered, and teachers guide and encourage. In this teaching mode, students have more initiative, which not only improves the enthusiasm of students, but also allows students to give full play to their creativity. The connotation of CDIO model education is that the future engineers trained should not only have solid basic engineering knowledge, but also have strong individual ability, teamwork and product, process and system construction ability. The CDIO syllabus has strong versatility and is applicable to all engineering majors in principle [9]. The teaching construction of the CDIO model is based on the CDIO syllabus, which refines the teaching plan which is suitable for the PLC course and is discussed by the teaching and research group.

First of all, basic knowledge is the most important. All designs and experiments are based on basic knowledge, so the basic knowledge is mainly studied in the early stage of the course. This teaching model focuses on cultivating students' self-study ability. Before the course starts, students need to acquire relevant knowledge through the library, the Internet and other channels. Of course, according to the uneven learning ability of students, the first few lessons are left for students to discuss, individual students’ problems are solved internally, and common problems will be explained by the teacher in later courses. This process is not only a review and consolidation process for students with strong learning ability, but also indirectly exercise personal communication ability, and the learning efficiency is also greatly improved. It is easier to get innovative ideas through communication among students [10].

Theoretical knowledge is the premise of the experiment, and the experiment is the practice and verification of the theoretical knowledge. They complement each other and need to be taken into account in the PLC course. According to the educational concept, the design of teaching experiment is mainly divided into three types (confirmatory experiment, comprehensive application experiment and innovative application experiment). The scheme is shown in Figure 1.

In the basic verification experiment course, students learn GX Simulator, GX Developer and Kingview 6.55. The confirmatory experimental project before the teaching reform can also be directly applied. T This process is for students to have a systematic understanding of basic experimental software such as PLC programming and debugging, PLC simulation, configuration

software, etc. At the beginning of the experimental course, the teacher demonstrates the operation on the administrator's machine, and then the students practice on their own. Teachers mainly guide, encourage and help in the experimental courses. Combined with the virtual simulation laboratory, every student has the opportunity to operate on the computer, which greatly improves the quality and efficiency of teaching.

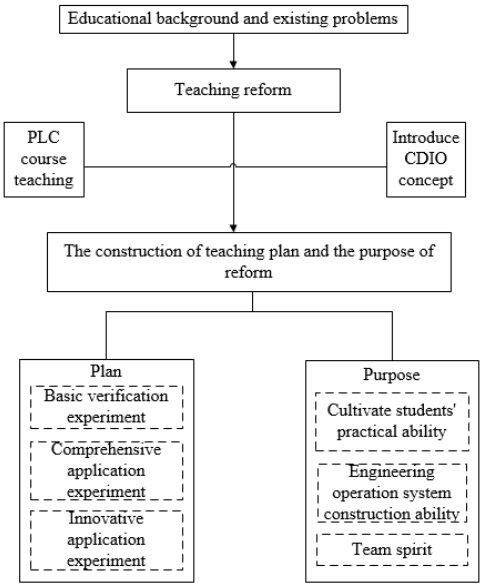

Figure 1: Teaching plan construction flow chart

Comprehensive application-oriented experiments are designed to exercise students' analysis and problem-solving abilities, increase students' understanding of basic knowledge, and achieve flexible applications. Comprehensive experiments are relatively more difficult than basic experiments. Not only are there no standard answers to the experimental results, but the aspects of the experiment are also quite extensive. After the teacher put forward the requirements of the control effect of the experimental project, the programming, configuration interface and serial communication are all designed by students according to their own ideas, which cultivate students' creative ability and innovative thinking. Most of the problems of students in the process of programming can be solved through communication between students, and then complete operation can be realized with the help of instructors. This process is carried out completely in accordance with the CDIO concept, and it has been proved through practice that the average level of students' project completion has been greatly improved.

Innovative application experiment is an open experiment. The teacher will give some open questions based on the background of the engineering project and the knowledge learned in the previous experimental project. Then the students in a class are divided into groups of four (according to the topic, interested students are free to combine and choose the topic). The time of the experiment is set after the theory course, and the PLC virtual simulation laboratory is open to students all day. The students in the group discuss the division of labor, clarify the task to the individual, and work together to complete the task within the specified time. Problems encountered in the experiment (such as program errors, communication failures, etc.) are discussed and resolved within the group. From a series of processes such as scheme design, programming, simulation, configuration screen design and error correction, students not only improve their personal ability, but also cultivate their teamwork ability and system construction ability.

This method is practiced in teaching, and basic scientific knowledge is the cornerstone. When applied to experiments, the teaching output is better than before. Students not only have a deeper understanding of the entire PLC course, but also have a better understanding of the life cycle of engineering projects, which is of great help for students to enter the workplace. The quality of students' experimental results has been greatly improved compared with ordinary teaching models.

4. Practice Results Display

Through the teaching reform of the CDIO model, combined with the virtual simulation experiment, the teaching quality of PLC courses in our college has been substantially improved. This teaching model has changed the previous rigid teaching process and the same experimental results. Students' creative ability can be brought into full play, and their practical ability has been comprehensively improved. This article selects one of the outstanding student experimental results for display.

The development of industrial robots is the general trend, and it plays an irreplaceable role in all fields of industry. Based on this industrial background, the students independently designed an industrial handling robot based on PLC and Kingview. The first is to design the overall structure according to the experimental conditions. Then according to the requirements of the experimental project, design the program, assign I/O ports, serial communication, and Kingview interface design. The design mainly includes three modes: manual mode, automatic mode, and single-cycle mode. Assign I/O according to the needs of the experiment. The allocated I/O is shown in Table 1.

Table 1: I/O allocation table.

Input (I)			Output (O)	
Stop button	SB0	X0	Rising solenoid valve YV1	Y1
Auto mode start button	SB1	X1	Drop solenoid valve YV2	Y2
Single cycle mode start button	SB2	X2	Shift left solenoid valve YV3	Y3
Manual mode start button	SB3	X3	Shift right solenoid valve YV4	Y4
Upper limit switch	SQ1	X4	Grab and release solenoid valve YV5	Y5
Lower limit switch	SQ2	X5		
Left limit switch	SQ3	X6		
Right limit switch	SQ4	X7		
Up switch	SQ5	X8		
Down switch	SQ6	X9		
Move left switch	SQ7	X10		
Move right switch	SQ8	X11		
Grab and release switch	SQ9	X12		

The automatic mode program flowchart is shown in Figure 2. The single-cycle mode flowchart is shown in Figure 3.

The students independently designed the Kingview interface, including work screens, alarm reports, and data curves. The simulation by Kingview verifies the accuracy of the tandem manipulator for handling materials. The configuration software can monitor and detect the position

and working status of the robot in real time, and adjust the working process of the robot through manual and automatic modes.

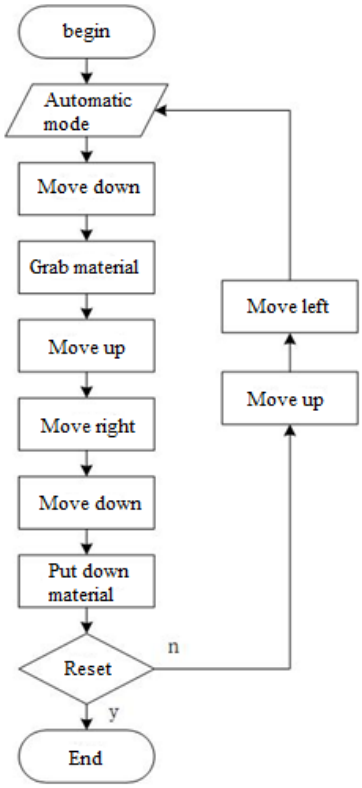

Figure 2: Auto mode flowchart.

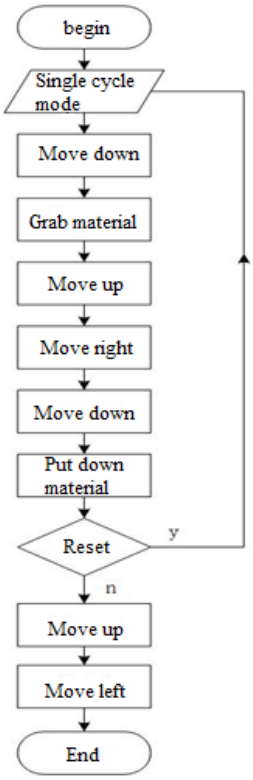

Figure 3: Single-cycle mode flowchart.

5. Conclusions

This paper introduces the experimental teaching scheme based on CDIO mode and PLC virtual simulation laboratory. Teaching practice proved that students' personal ability, innovation ability, teamwork and product, process and system construction ability have been improved. Establish a virtual simulation laboratory to improve teaching infrastructure. The CDIO concept is integrated into the teaching model to improve teaching efficiency. After the teaching reform, students learn more actively, and the overall teaching effect has been substantially improved compared with the traditional teaching model. The CDIO model can be integrated into other engineering courses for teaching reform. This teaching model is of great significance in teaching.

Acknowledgements

This work was supported by Henan University Science and Technology Innovation Team Support Program (19IRTSTHN011), Special Support Plan for High-level Talents of Henan Province-"ZHONGYUAN Thousand Talent Program", Zhengzhou Measurement and Control Technology and Instrument Key Laboratory (121PYFZX181), Employment and entrepreneurship Project in Colleges and Universities of Henan Province(2020-317-8) and Innovation, Excellent Grassroots Teaching Organization of Henan Universities(2019-728-62) and Entrepreneurship and Employment Project of NCWU(2020-52-9).

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