Construction and Practice of Stereoscopic Practical Teaching System for Electrical Major in Application-oriented Undergraduate Universities

Weiwu Zhong*

College of Engineering, Shandong Yingcai University, Jinan, Shandong Province 250104, China

*Corresponding author's e-mail address:137858640@qq.com

Abstract. The decline in the quality of students in application-oriented universities brought about by the popularization of higher education in China has become an undeniable fact. How to develop a scientific, reasonable, and feasible talent cultivation path for existing students has become an urgent problem that higher education workers need to solve. This article is based on the requirements of new engineering disciplines and the CDIO engineering education concept to construct a stereoscopic practical teaching system for electrical major in applied universities and carry out teaching practice. The aim is to explore ways to improve the cultivating quality of applied talents for engineering major in application-oriented universities, and to stimulate students' interest in professional learning, enhance their knowledge application ability, practical hands-on ability, and engineering thinking ability. Teaching practice has shown that the proposed practical teaching system conforms to the laws of engineering education and has a significant promoting effect on the comprehensive improvement of students' professional abilities.

Keywords: New Engineering; CDIO Engineering Education; Practical teaching

1 Introduction

Since the expansion of enrollment in universities in China in 1999, after 20 years of development, the gross enrollment rate of higher education institutions reached 59.6% in 2022, and China has entered the stage of popularizing higher education. The rapid development of higher education has greatly met the demand for professional talents in various industries required for the rapid development of China's economy. At the same time, the decline in student quality caused by the expansion of enrollment in universities has become a common problem faced by many undergraduate and vocational colleges, and this situation has brought serious challenges to talent cultivation in universities [1,2]. For undergraduate level, the problem of student source in private undergraduate colleges is particularly prominent. How to develop effective talent cultivation plans and strategies based on the current situation of student sources, and then implement them

D. Rad et al. (eds.), *Proceedings of the 2024 5th International Conference on Mental Health, Education and Human Development (MHEHD 2024)*, Advances in Social Science, Education and Humanities Research 857,
https://doi.org/10.2991/978-2-38476-271-2_23

in the teaching process of each course, has become a practical problem that all application-oriented universities urgently need to solve. This article explores the construction and practice of a stereoscopic practical teaching system based on the learning status of applied undergraduate students, aiming to enhance learning interest, stimulate learning motivation, and explore reasonable and feasible paths for cultivating application-oriented talents.

The mathematical and physical foundation of students in application-oriented university is relatively weak, and some students have insufficient learning methods and enthusiasm, which have not developed good learning habits. This leads to many difficulties for these students in professional learning after enrollment. As the learning process continues, they gradually lose their sense of learning gain and satisfaction, and then give up professional learning. For application-oriented undergraduate universities, the current issue that cannot be ignored is that the cultural quality of students is generally low, and their learning ability and self-restraint ability are weak. The performance during the four years of university is often like this: from freshman to senior year, the learning enthusiasm continues to decline. The enthusiasm for learning is generally high in freshmen and sophomores, but starting from junior year, the enthusiasm for learning begins to decline. This is manifested by not paying attention in class, not actively consolidating and reviewing after class, and poor learning outcomes. The fundamental reason lies in the lack of solid learning of basic courses in freshmen and sophomores, poor mastery of knowledge, and loss of professional confidence and interest.

2 Strategies for Improving the Quality of Training Engineering Students in Application-oriented Universities

"New engineering education" is an inevitable requirement for engineering education in the context of the transformation of new and old kinetic energy in China. It is also an important measure to explore the formation of leading global engineering education and cultivate new engineering and technical talents with innovative thinking consciousness and broad professional perspectives[3][4]. The CDIO engineering education concept has attracted much attention in the field of engineering education since its proposal in 2000. This concept provides important theoretical and methodological support for breaking down the barriers between theory and practice and curriculum in traditional talent cultivation systems. This article fully considers the requirements of China's "new engineering" education, based on the CDIO engineering education concept, and draws on the professional and curriculum reform experience of famous engineering colleges in China (including universities in Taiwan), to conduct research and practice on the establishment of a practical teaching system for the electrical profession. The aim is to provide basic support for cultivating applied talents who can adapt to the upgrading and transformation needs of the manufacturing industry, and also greatly stimulate students' interest and initiative in learning[5].

In order to enhance students' interest in learning, enhance their practical and practical abilities, and enhance their knowledge application abilities, the new engineering education ideas and CDIO engineering education concepts are integrated into the practical teaching of electrical engineering, and a scientific, reasonable, operable stereoscopic practical teaching system is constructed with project driven teaching and student proactive teaching as prominent features.

3 Construction of Stereoscopic Practical Teaching System for Electrical Major

3.1 Construction Ideas for Stereoscopic Practical Teaching System

A notable feature of the electrical major is that most courses are highly theoretical, and students have a dull and tedious learning process, which makes learning difficult and leads to many students gradually losing confidence in learning their major well. At the same time, this major also has the common characteristics of strong practicality in engineering majors, requiring students to have strong engineering practical abilities and the ability to analyze and solve problems. However, the quantity and quality of traditional practical teaching projects are not sufficient to provide sufficient support for the acquisition of these abilities[6]. In order to solve the above problems, with the aim of cultivating high-quality application-oriented engineering and technical talents, a stereoscopic practical teaching system combining in class and off class has been constructed by changing the traditional experimental teaching system that mainly focuses on verification experiments. By drawing on the CDIO engineering education philosophy, students can experience the entire process of multiple engineering projects from conception, design, implementation to operation during their school years, and receive complete engineering training.

3.2 Construction of Stereoscopic Practical Teaching System

(1) The composition of stereoscopic practical teaching system

The construction of the practical teaching system follows the method of reverse design. Firstly, develop a talent cultivation plan based on the talent cultivation goals and professional abilities, and then develop a teaching outline for professional basic courses and professional courses according to the talent cultivation plan. The teaching outline clearly defines the core knowledge points, general knowledge points, and ability points of each course, and constructs a stereoscopic practical teaching system based on this. In order to motivate students, a significant and effective teaching reform approach is to increase project practice. This approach fully draws on the CDIO engineering education concept and also meets the requirements of new engineering teaching. Therefore, we have established a stereoscopic practical teaching system[7]. The stereoscopic practical teaching system combines in class teaching with out of class teaching, theoretical teaching with practical teaching, overall student requirements with personalized training for some students, modular knowledge with systematic knowledge, and constructs a practical teaching system aimed at shaping students' professional abilities and qualities. Before the reform of the practical teaching system for electrical engineering, there were four forms: course experiments, course design, professional internships, and graduation design. After the reform, two contents were added: extracurricular practice projects and comprehensive practice project. In addition, the original course experiments have been changed to basic experiments and project practices, which are supplements to traditional course experimental projects. All projects are designed based on the CDIO engineering education concept. The comparison before and after the reform of the practical teaching system for the electrical profession is shown in Figure 1.

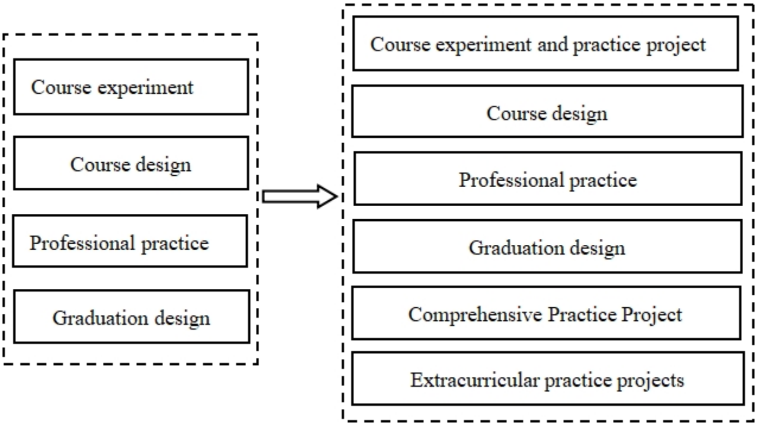

Fig. 1. Contrast of practical teaching system before and after the reform

(2) Incorporating extracurricular scientific and technological practices into stereoscopic practical teaching system

Students can greatly improve their professional comprehensive quality by engaging in extracurricular free practice and participating in technology competitions. However, in practice, it can be found that students often feel at a loss and blind in extracurricular scientific and technological activities without the guidance of teachers, which results in a serious imbalance between their efforts and gains, and undermines their confidence in innovation and progress. This situation is particularly prominent among students in private universities who have relatively weak learning abilities and mastery of professional basic theories. The above situations are not conducive to the cultivation of students' professional confidence and the improvement of their professional abilities. Based on the above reasons, this article incorporates such practical activities into the practical teaching system, with the aim of increasing the leading role of teachers, and transforming their role from "teaching" to "guiding". In such practical activities, it is possible to simulate the development process of real projects in the enterprise. This type of practical teaching is accomplished in the spare time of both teachers and students. In order to ensure the leading role of teachers in students' extracurricular scientific and technological practice, schools and secondary colleges should develop policies and normative documents that encourage teachers to participate in guiding students' extracurricular scientific and technological practice activities. At present, there is no precedent in domestic universities to incorporate extracurricular free practice and technology competitions for college students into the practical teaching system. Another reason for doing so in this project is that extracurricular free practice and technology competitions involve some students who are interested in a certain professional direction, which helps to achieve differentiated and personalized training for students.

(3) Practical projects grading

In order to scientifically design practical projects, drawing on the methods of Shandong University and Yanshan University, all practical projects are divided into three levels: first level, second level, and third level. The first level project focuses on the comprehensive application and innovation of professional knowledge, including graduation design projects and comprehensive practical course projects. The construction of secondary projects aims to organically integrate knowledge from multiple courses, fully reflecting the entire process of conceptualization design implementation operation, including projects that meet the above requirements in course design projects and professional course practice projects. The third level project refers to the practical projects of professional basic courses and the projects that mainly focus on the application of single course basic knowledge in professional course practical projects.

(4) Classification of practical projects

Students have unique project practice content in different learning stages and courses. Different practical projects inevitably have different natures, and a clear understanding of the designed project is necessary before designing practical projects. The project classification based on project characteristics has important guiding significance for the design of practical projects. We classify projects from three perspectives: the comprehensive level of professional knowledge, the integration characteristics of hardware systems, and the software and hardware characteristics.

Project Classification Method 1- Comprehensive level of professional knowledge: In order to scientifically design practical projects, drawing on the methods of Shandong University and Yanshan University, all practical projects are divided into four levels, namely level one, level two, level three, and level four. Level one project focuses on the comprehensive application and innovation of professional knowledge, including graduation design projects, comprehensive practical course projects, and extracurricular practical projects. The construction of level two projects aims to organically integrate knowledge from multiple courses, fully reflecting the entire process of conceptualization design implementation operation, including projects that meet the above requirements in course design projects and professional course practice projects. Level three project refers to the practical projects of professional basic courses and the projects that mainly focus on the application of single course basic knowledge in professional course practical projects. Level 4 project is mainly focused on the validation or application of one or several knowledge points in a single course. This type of project is represented by A, with A1, A2, A3, and A4 representing first level, second level, third level, and fourth level projects, respectively.

Project Classification Method 2- Integration Characteristics of Hardware Systems: According to the integration characteristics of hardware systems, projects are classified from high to low as follows: system integration projects, functional module projects, integrated component projects, and discrete component projects. Among the four types of projects, the hardware used in high-level projects may include hardware from other low-level projects. This type of project is represented by B, with B1, B2, B3, and B4 representing system, functional module, integrated component, and discrete component projects, respectively.

Project classification method 3 - Software and hardware characteristics: According to the software and hardware characteristics of the project, it can be classified into: software and hardware projects, software projects, and hardware projects. Software and hardware projects refer to projects that contain both hardware and software content. Software projects refer to programming and software usage projects that do not include hardware design content. Hardware projects refer to pure hardware practical projects. This type of project is represented by C, with C1, C2, and C3 representing software and hardware projects, respectively.

4 Implementation Strategies for Three-dimensional Practical Teaching

4.1 Course Experiment and Project Practice

The course experiments in the old practical teaching system have been changed to basic experiments and project practices. Basic experiments and project practices belong to the content of in-class teaching, and the total number of their class hours is the experimental class hours of the course. The basic experiments of the course are mainly confirmatory experiments, with the main purpose of deepening the understanding of the theoretical knowledge learned and mastering the application of knowledge through experiments. Based on the characteristics of specific courses, basic experiments can be completed in the classroom or laboratory, especially in the classroom. Specifically, there are two types of classrooms: one is regular classroom without experimental conditions, and the other is laboratory with integrated teaching conditions of theory and practice. Completing basic experiments in regular classroom without experimental conditions requires students to bring their computers and necessary hardware for the experiments. The advantage of completing basic experiments in the classroom is that students can immediately verify their theoretical knowledge through experiments, resulting in a significant improvement in learning effects. Project practice is a kind of design-based, comprehensive, and innovative experiment, which is a higher-order form of experiment. Its purpose is to enable students to master the application of the knowledge they have learned and have the initial ability to use the knowledge to carry out engineering practice. In order to let students have early experience to engineering training, consideration should be given to the changing patterns of the learning content of the electrical major on the timeline. Design multi-level practical projects based on their comprehensiveness and innovation, and differentiate projects with different attributes. Multi level projects are closely related, extending from in class to outside class, from simple to difficult, from discrete to integrated, and from module to system. In the implementation process of practical teaching, students' initiative and creativity are fully stimulated.

4.2 Extracurricular Technology Practice

Extracurricular technology practice does not take up class hours. This activity is aimed at some students who have a strong interest in technology production and belongs to personalized training. Due to the creativity score demand of the school where the author works, the participation rate of students in their four years of university can reach 100%. The sense of reward from extracurricular technology practice activities further stimulates students' enthusiasm for professional learning and improves their innovation awareness and ability. The specific implementation methods include the following three types:

① Participate in various discipline competitions at all levels, such as electronic design competition, intelligent control competition, Internet plus competition, etc. On the basis of voluntary registration, select students with potential to participate. The school is equipped with guiding teachers to provide professional guidance to students;

② Open experiments. Professional teachers, based on their own strengths and laboratory conditions, apply for open laboratory courses and submit detailed open laboratory plans at the beginning of the semester, with a general duration of 16-32 hours. The experimental projects are mainly selected by teachers, and students can also propose teacher approval. The outcome of open experiments include open experiment reports and physical works.

③ Student Autonomous Science and Technology Association. According to different professional directions, associations can be established for electrical majors, such as PLC Application Association, Embedded System Innovation Application Association, Robot Association, etc. Students of this type of association voluntarily register, and in principle, 100% of the registered students will join the association. The school provides all-weather activity places, and students spend their spare time to conduct design works. Carry out activities at a fixed time every week, including training, reporting, seminars, presentations, etc. Considering the characteristics of students in application-oriented schools, each association is equipped with 1-3 guidance teachers to provide necessary professional guidance. Students' excellent works can participate in corresponding level competitions based on their level.

4.3 Comprehensive Practice Course Project

The comprehensive practical course is a compulsory course for the major, with a duration of 1-2 weeks. The project is classified as a first level project. Taking the Electrical Engineering and Automation major as an example, courses such as computer measurement and control comprehensive practice and motor motion control comprehensive practice can be offered. The characteristic of this type of course is to comprehensively utilize the knowledge of multiple courses to carry out practical activities such as design proposal formulation, detailed design, hardware platform construction, control program writing, system debugging and operation, instruction manual writing, project summary report, etc. Like other courses, this type of course should have a detailed teaching outline and project practice guide, with clear provisions for the significance, goals, requirements, implementation, and assessment of project practice. Through the training of comprehensive practical course projects, students' comprehensive knowledge application ability, practical ability, and professional competence have all been synchronously improved.

4.4 Comparison of Practical Teaching Systems Before and After Reform

The statistical results of practice projects for electrical engineering and automation major are: a total of 98 projects after the reform, and 84 projects before the reform. The comparison of the number of various types of projects before and after the reform is shown in Table 1. Figure 2 shows the distribution of various types of projects before and after the reform.

Table 1. Contrast of practical projects quantity before and after the reform

Project type	A1	A2	A3	A4	B1	B2	B3	B4	C1	C2	C3
Quantity before the reform	3	7	3	73	5	22	35	9	24	14	9
Quantity after the reform	8	8	7	77	5	28	38	13	35	16	10

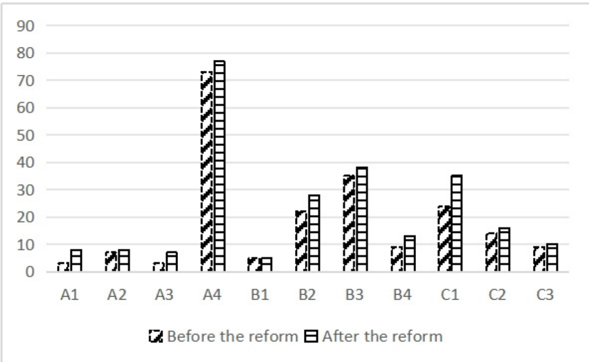

Fig. 2. Distribution of various types of projects before and after the reform

By comparing the practical teaching system before and after the reform, it was found that: the number of practical projects has increased from 84 to 98, an increase of 16.7%. From Figure 2, it can be seen that the projects with the highest increase are A1, A3, and C1 categories. Explanation: (1) Compared to before the reform, there has been a significant increase in comprehensive practical projects, such as increasing the number of A1 level projects from 3 to 8; (2) The number of software and hardware projects has increased significantly, from 24 to 35. This change can improve students' ability to solve complex engineering problems, while also in line with the technological development trend of intelligent manufacturing equipment.

In addition, with the continuous promotion of project-based practical teaching, it is entirely reasonable to add comprehensive practical projects to other basic or professional courses. For example, there are currently 6 experiments in the course of detection and sensing technology, all of which are basic experiments, focusing on performance testing of various sensors. If several comprehensive practical projects are added, following the path of C-D-I-O, to complete the concept of signal acquisition system (C) - design of signal acquisition software and hardware (D) - establishment of hardware system and program writing (I) - system debugging and operation (O) - use of digital technology for post-processing of acquired signals, students' learning interest and ability to handle complex engineering problems can be promoted effectively.

5 Operational Effect of Stereoscopic Practical Teaching System

The practical teaching of the Electrical Engineering and Automation major has shown that the establishment of application-oriented practical teaching system based on the CDIO engineering education concept is in line with the law of cultivating applied engineering and technical talents. The operational effect of this system is mainly reflected in the following aspects:

(1) The learning enthusiasm of students has been greatly improved. In the stereoscopic project-based practical teaching process, students can apply their learned knowledge more to real projects and experience the sense of achievement brought by the application of knowledge. By improving comprehensive abilities during project practice, it can stimulate the interest in learning theoretical knowledge and significantly improve the effectiveness of classroom theoretical teaching.

(2) The practical and problem-solving abilities of students have significantly improved. Traditional practical teaching lacks high-quality and sufficient practical projects as support, which is not enough to fully enhance students' engineering practical abilities. However, the implementation of stereoscopic practical teaching proposed in this paper can effectively compensate for this deficiency.

(3) The extracurricular learning life of students has become more fulfilling. Some students in application-oriented university have low learning enthusiasm and poor self-discipline, resulting in a state of idleness outside of class. The stereoscopic practical teaching system requires students to carry out project practice in their spare time, and this kind of practical activity is where students are interested. Therefore, students can actively and enthusiastically use their spare time to carry out scientific and technological practical activities.

6 Conclusion

On the background of higher education popularization in China, this article constructs a stereoscopic practical teaching system for the electrical major based on the requirements of new engineering education and the CDIO engineering education concept, taking into account the characteristics of students in application-oriented undergraduate universities and based on the traditional engineering practical teaching system.

Teaching practice has shown that this practical teaching system fully takes into account the learning characteristics of students in application-oriented universities in China, and meets the requirements of modern engineering education. The implementation of this system can greatly stimulate students' learning interest and engineering practical ability, and significantly improve their engineering professional literacy. It has certain reference significance for practical teaching in application-oriented undergraduate universities in engineering majors.

Acknowledgement

The author thanks for the support of 2020 Shandong Province Undergraduate Teaching Reform Research Project (No.M2020259).

References

1. Liu Baocun, Gou Minghan. Realistic Background and Feasible Path of High-quality Higher Education System Construction in the Universal Phase [J]. Modern Education Management, 2023 (01): 1-11. (in Chinese)
2. Wu Daguang. Achievements and Early Warnings:Reflections on the Process of Universalization of Higher Education in China [J]. China Higher Education Research, 2023 (04): 8-18 .(in Chinese)
3. Xu Hexiu, Wang Yanzhao, Yang Yafei, et al. Reform in Experiment Teaching of Microwave Technology and Antenna Based on “EIE-CDIO”Mode [J]. Research in Higher Education of Engineering, 2022 (06): 70-74.(in Chinese)
4. Wang Wudong, Li Xiaowen, Xia Jianguo. Reflections on Engineering Education Reform and Emerging Engineering Education Construction[J]. Research in Higher Education of Engineering, 2020 (01): 52-55+99.(in Chinese)
5. Huang Meigen, Wang Tao, Ming Mengjun, et al. On CDIO Practice Training Mode of Engineering Ability Based on Constructivism [J]. Research in Higher Education of Engineering, 2023 (04): 58-64.(in Chinese)
6. Yu Ling, Peng Biyou.Innovative Practice of Teaching-guided Project Designed and Evaluation Methods in Local Engineering Colleges[J]. Research in Higher Education of Engineering, 2024 (02): 91-96.(in Chinese)
7. Guo Xing, Zou Zhuo, Tapio Salakoski et al. Multi-dimensional Logic Based Curriculum Design for Emerging Engineering Education-A Case Study of the Sino-finnish Joint Programme in Fudan University[J]. Research in Higher Education of Engineering, 2020 (03): 43-48.(in Chinese)