On Improvement of Teaching Quality for Courses of Electronics and Information Engineering Based on CDIO Mode

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Abstract. Since the CDIO engineering education model was introduced to China in 2005, it has had a profound impact on Chinese engineering education in recent years. The concept of CDIO has inspired the teaching reform in Electronics and Information Engineering major. This article starts with analysis of the status of Electronics and Information Engineering major and divides its teaching system into three levels based on CDIO. Afterwards, this article describes the systematic architecture of course projects based on CDIO. Finally, suggestions for the teaching reform of Electronics and Information Engineering education based on CDIO mode is proposed.

Keywords: Teaching reform, Electronics and Information Engineering, CDIO mode.

INTRODUCTION

Since the CDIO engineering education model was introduced to China in 2005, it has had a profound impact on Chinese engineering education in just a few years. CDIO stands for Conceive, Design, Implement, and Operate, which is the ability that engineering graduates should have. It takes the life cycle of product development and product operation as the carrier, allowing students to learn the theory, technology and experience of engineering in an active and practical, and organic manner (Thomas, 2015).

The CDIO engineering teaching method is the latest achievement of the international engineering education reform in recent years. It inherits and develops the engineering education reform concept of Europe and the United States for more than 20 years. Any attempt to improve engineering education must consider the following two central questions: First, when engineering students graduate, what knowledge, abilities and qualities should they have learned and formed? What level should

be mastered? The second question is how to better ensure that students learn these knowledge and abilities? It is the question of "what to do" and "how to do" that any educator must face (Gu *et al.*, 2012). CDIO answers the fundamental questions of engineering education. The teaching method of CDIO advocates comprehensive training of four aspects: theoretical knowledge, personal quality, teamwork ability and engineering system ability (Shu *et al.*, 2005). The concept of CDIO is to provide students with a comprehensive design projects that are close to the actual project as possible and available to be designed for implementation, so that professional knowledge could be combined with practical projects organically (Huang and Li, 2012).

Electronics and Information Engineering major integrates modern electronic technology, information technology, and communications technology, which requires graduates in this major to master a lot of basic knowledge and reasoning ability of electronic technology

and information systems (Zheng and Huang, 2014). The vision of this major is to train advanced engineering and technical personnel who engages in the research, design, manufacturing, application and development of electronic equipment and information systems (Sun and Wang, 2016). In recent years, based on CDIO, some Universities have carried out useful explorations on the training mode reform of application talents in Electronics and Information Engineering major, and have achieved certain achievements. However, due to the limitations of teachers and projects, there are still many problems in the teaching model. How to train high-quality graduates in Electronics and Information Engineering major is still a problem that Universities, teachers and students need to consider.

This article first analyzes the current situation of the training model of electronics and information engineering major, and divides its teaching system into three levels based on CDIO. Then this article introduces how to use CDIO mode in the systematic design of the course project in Electronics and Information Engineering major. Finally, this article puts forward specific suggestions for the education reform of electronics and information engineering education based on CDIO mode.

MAJOR STATUS ANALYSIS

Electronics and Information Engineering is a discipline that uses modern technologies such as computers for electronic information control and processing, which integrates modern electronic technology, information technology, and communications technology (Wang, 2020). With the rapid development of the electronics and information industry, electronics and information engineering major become more and more popular in recent years. The purpose of the major is to train advanced electronic information engineers, who master rich technical theory, have a strong social consciousness, and engage in the design of electronic equipment and information systems with practical experience and innovation capacity (Guo and Wang, 2014). The society's demand for Electronics and Information Engineering application-oriented talents is also increasing. Nowadays, university also pay more and more attention to the cultivation of electronics and information engineering application-oriented talents and have make some achievements. However, there are still lots of problems in the teaching method in this major.

The current problems in the teaching of electronics and information engineering major in our country are mainly manifested in (Zhang, 2018).
Many courses but few class hours. Electronics and Information Engineering is a wide-caliber major. Students need to learn a lot of professional knowledge, so the class hours allocated to each course are very few. A large amount of teaching content is compressed and transmitted to students in a short period of time, which results in the lack of deep understanding of knowledge and lead to the reduction of students' interest and enthusiasm for study.

Theory and practice are out of touch. The current teaching process is mainly based on the textbook knowledge taught by the teacher, and students rarely have access to actual projects. The lack of a combination of professional knowledge and practical projects is the most fundamental reason for students who have worked hard for four years but feel that they have not gained anything. Students only learn theoretical knowledge, but lack practical experience, and do not know how to use those theories they learned.

Outdated knowledge. The content of professional courses cannot keep pace with the times. The textbook focuses on traditional technical theories, and the introduction of new technologies is not enough, which make it difficult for universities and students to accurately understand the latest developments of the enterprise.

Lack of innovation. At present, the proportion of verification experiments in the experiment teaching process of this major is much larger than that of innovative design experiments. Universities don't pay enough attention to the cultivation of students' practical ability and professional development ability, which is not conducive to cultivating students' ability to analyze and solve problems.

All in all, the most fundamental problem is the lack of practice in the current teaching process. In order to solve the above-mentioned problems in the teaching process of Electronics and Information Engineering, it is urgent to reform the teaching method of Electronics and Information Engineering based on the concept of CDIO. The CDIO Education Model advocates providing students with a wealth of opportunities to get actual projects which is available to be designed for implementation, so that students can learn the relevant theoretical knowledge combined with real environments in an active, practical, and organic way. Schools should increase practical projects, and the practical project system of Electronic Information Engineering can be preliminarily divided into three levels based on the CDIO project standards (Wang, 2014; Wang, 2020).

Level 3 is mainly the experimental projects based on the basic theoretical curriculum. Teacher sets up some foundational experiments or simple design projects according to the teaching content of the course. The Level 3 project focuses on deepening students' understanding of theoretical courses, and students also can practice basic practical skills.

Level 2 is to further the train of students' professional capabilities and teamwork awareness, mainly including curriculum design projects, professional comprehensive practice, capstone project, innovative entrepreneurship plans, and professional competitions. Level 2 project is an important extension to the foundational projects, which emphasizes teamwork and professional skills. It is an important module that highlights the cultivation of students' ability to combine theory with practice, think innovatively, team work and learn independently, which is conductive to the ability of students to analyze and solve problems.

Level 1 focuses on the concept of CDIO, which runs through the entire undergraduate teaching stage. Level 1
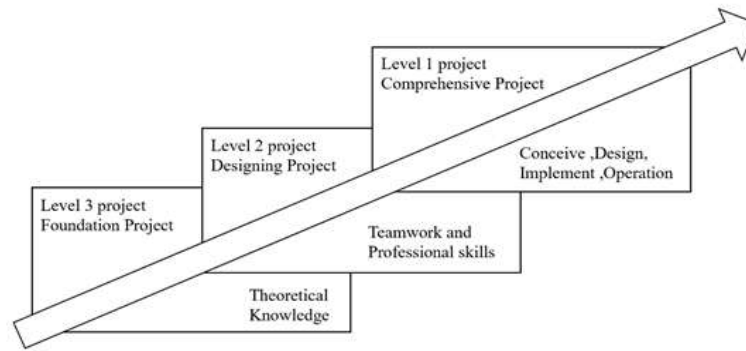
Figure 1. CDIO-based project system

project mainly includes professional introduction courses, cognitive internships, comprehensive engineering training on campus, and graduation internships. Level 1 projects further help students to combine the theories and practical skills and receive the overall training of Conceive – Design - Implement - Operation, which not only cultivate students' engineering practice ability, but also help students establish a clear concept of the major and their future career.

Figure 1 shows the three-level practical project system based on the CDIO project standards. Through the above three levels projects, the practical teaching system of Electronics and Information Engineering major constitutes an organic whole with the Level 1 project as the main line, the Level 2 project as the support, and the Level 3 project as the basis, which realizes the organic combination of theory and practice and help students learn how to use the professional knowledge they have learned in actual projects (Zhan *et al.*, 2016). The practical teaching system based CDIO is conductive to cultivate and improve students' project design ability, teamwork spirit, innovation awareness and other engineering skills. At the same time, it also enable students to understand the needs of the enterprises better, clarify their future career direction, stimulate their interest in learning, and also help them become high-quality engineering and technical personnel's in the fields of Electronics and Information Engineering.

SYSTEMATIC DESIGN OF COURSE PROJECT BASED ON CDIO MODE

Based CDIO mode, Teacher should pay more attention to the integration of the practical process and the teaching process, so that students can master relevant theoretical knowledge in practical engineering more intuitively. Teaching reform based on CDIO is very necessary, the following describes how to apply CDIO mode in the system architecture of course experiment project in Electronics and Information Engineering major (Hu *et al.*, 2009; Cao

and Guan, 2013; Tan *et al.*, 2015).The process of the project based on CDIO is shown in Figure 2.

Cultivation of Conceive Ability

Teacher can assign practical projects which are related to the latest research of the enterprise to students. After students form teams according to the selected practical projects, each team collects relevant literatures and data about the project. Then team members get together to conceive and analyze the requirement of the project according to the information they have acquired to put forward their idea of the project. When someone puts forward an idea, others can be inspired by it, and also put forward more ideas. Idea inspire more ideas, students inspire each other, and complement each other. In this process, teacher can give appropriate suggestions to ensure that the conceive proceeds in the right direction. Finally, students choose the best idea from their ideas as implement plan of the practical project. By this, students' communication ability, decision-making ability and analyze problems ability are cultivated.

Cultivation of Design Ability

After determining the project's implement plan, it is necessary to design the project in detail and form a clear design idea. Each team should be a clear division of labor, which can fully mobilize the enthusiasm and participation of team members. In this stage, the teams can communicate and learn from each other to determine the details and implementation of the plan. For most course experiments of Electronics and Information Engineering major, simulation software is often used for simulation and verification at this stage. In the simulation software, students could design the structure layout of the project and try to select suitable instruments and equipment used in the experiment, and set or adjust their parameters until the design simulation runs successfully and achieves good
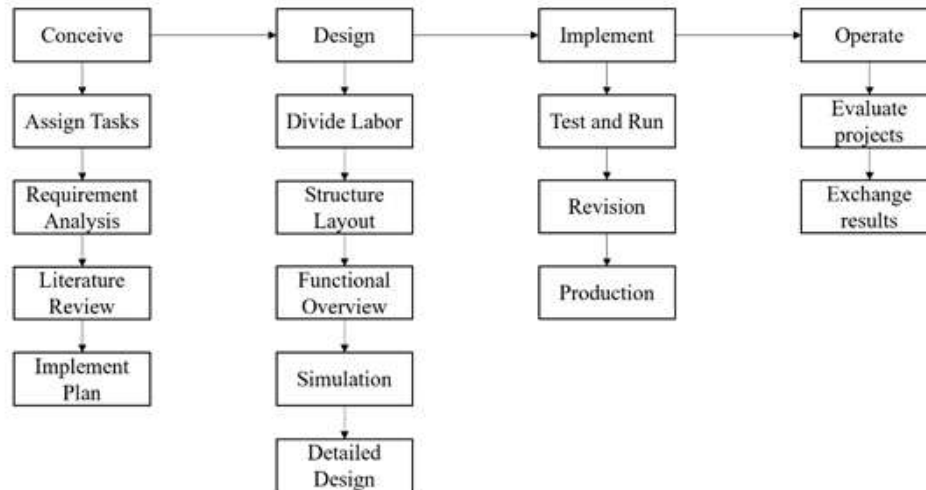
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┌──────────┐      ┌──────────┐      ┌──────────┐      ┌──────────┐
│ Conceive │ ───▶ │  Design  │ ───▶ │Implement │ ───▶ │ Operate  │
└────┬─────┘      └────┬─────┘      └────┬─────┘      └────┬─────┘
     │                 │                 │                 │
┌────┴─────┐      ┌────┴─────┐      ┌────┴─────┐      ┌──────────┐
│  Assign  │      │  Divide  │      │ Test and │      │ Evaluate │
│  Tasks   │      │  Labor   │      │   Run    │      │ projects │
└────┬─────┘      └────┬─────┘      └────┬─────┘      └────┬─────┘
     │                 │                 │                 │
┌────┴─────┐      ┌────┴─────┐      ┌────┴─────┐      ┌────┴─────┐
│Requirement│     │Structure │      │ Revision │      │ Exchange │
│ Analysis │      │  Layout  │      │          │      │ results  │
└────┬─────┘      └────┬─────┘      └────┬─────┘      └──────────┘
     │                 │                 │
┌────┴─────┐      ┌────┴─────┐      ┌────┴─────┐
│Literature│      │Functional│      │Production│
│  Review  │      │ Overview │      │          │
└────┬─────┘      └────┬─────┘      └──────────┘
     │                 │
┌────┴─────┐      ┌────┴─────┐
│ Implement│      │Simulation│
│   Plan   │      │          │
└──────────┘      └────┬─────┘
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                  ┌────┴─────┐
                  │ Detailed │
                  │  Design  │
                  └──────────┘
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Figure 2. The process of the project based on CDIO

results. In this process, the functional overview can be formed and the design plan is continuously adjusted to make the simulation finally successful, which can help students better understand the working principle and familiarize the equipment used. While improving students' practical ability, it also improves the ability of teamwork and the ability to analyze and solve problems.

Cultivation of Implement Ability

After the design plan is run and passed in the simulation software, the implementation stage is next. This process transforms theory into practice, which make students become more familiar with the hardware environment and improve their software programming skills. At the same time, students should still constantly try to adjust the design plan and parameters according to the actual equipment to make the final plan feasible in the implementation process. The process can further improve students' practical ability, innovative ability and analyze ability, which not only enable students to acquire the knowledge and skills to complete projects but also gain a sense of accomplishment.

Cultivation of Operate Ability

After the project is completed, it is necessary to make preparations for the display of the project. Each project team displays their projects and reports the results. The content to report can include the project's design ideas, key technologies, working principles, working processes, existing problems, solutions and so on. Then the students from other groups could comment on it ,which is conducive to further optimize the design plan and solve problems that the team was unable to solve before. This process can not only consolidate students' understanding and application

of professional knowledge, but also improve students' language expression ability, self-confidence, and innovation ability. Finally, teachers need to correct the errors of students' project plan, suppose optimization suggestions in this project, and make a summary, which also enhances the interaction between teachers and students.

This CDIO-based system architecture transforms the traditional teaching mode which regard textbooks and teachers as subject into a CDIO teaching mode with practice and students as subject. According to the CDIO educational concept, the teaching content of each practice process is arranged in a targeted manner to achieve a gradual process. Based on the CDIO educational concept, students can gain a deeper understanding of professional knowledge and practical methods through the curriculum practice project, which improves students' comprehensive ability to discover, analyze, and solve practical problems. At the same time, students' teamwork ability and innovation ability have also been improved.

SUGGESTIONS OF TEACHING REFORM BASED ON CDIO MODE

The traditional teaching model cannot fully train students' practical skills, engineering ability and innovation ability. In order to realize the cultivation of applied talents in electronics and information engineering, current teaching method must be reformed (Qiu, 2015; Zheng, 2020; Wang, 2020).

Optimize Teaching Content

Because Electronics and Information Engineering majors need to learn a lot of professional knowledge, courses need to have a good time arrangement, and the courses to

be studied should be appropriately adjusted to reduce, so that the time length of key professional courses can be increased. The Electronics and Information Engineering major can be divided into many directions. In fact, it is not necessary for students to specialize in each direction. Universities can adopt the personalized training program. In addition to the compulsory courses of some basic professional knowledge, students could choose other professional courses according to their own interests. The time saved can give students more energy to better specialize in the professional areas they are interested in.

Increase practical experiments and projects

While optimizing the arrangement of class hours, teachers should also pay more attention to the improvement of course content. Teachers should change the subject of course from textbook to practice. Teachers can't just teach textbook knowledge mechanically, they should arrange experiments or some simple projects appropriately, which integrate professional knowledge into practice, and teach students how to use the professional knowledge they learn in class in practice. By compressing the theoretical hours and increasing the practical hours, it realizes the teaching mode of active learning and research learning of "learning in practice, practice in learning". In addition, the projects assigned by the teacher to the students should be as relevant as possible to the needs of the current enterprise, so as to avoid blindly learning the knowledge of the textbook, which enables students to better understand this field and clarify their future direction.

Keep up with the times

With the rapid development of Electronics and Information industry, it is necessary to discard the eliminated content in time in the practical teaching process. At the same time, it's also a must to pay more attention to infiltrating the latest theories and technologies of Electronics and Information Engineering into teaching content. What's more, universities and teachers should also select appropriate teaching content in accordance with the future employment of Electronics and Information Engineering students' corporate needs for technical abilities, so as to achieve the purpose of cultivating applied talents. In addition, most of the current teaching models are confirmatory experiments. Independent innovation projects should be added to encourage students to participate in extracurricular professional competitions, which can improve students' independent learning ability, and enhance students' sense of innovation

Improve the Evaluation System

Under the guidance of the CDIO concept, the traditional evaluation method based on written test scores has to be

changed, and the evaluation method should be adjusted to process evaluation. Universities and teachers should adopt diversified learning evaluation methods and choose appropriate evaluation methods according to the curriculum requirements and practical content, such as final practice evaluation, study records, group design and production, course essays, course defense, project reports, self-evaluation and mutual evaluation, innovative credit recognition and so on. Through different evaluation methods, not only the "high scores but low energy" situation is reduced, but also the learning autonomy of students is fully mobilized. While promoting the improvement of students' knowledge and skills, it also improves students' comprehensive abilities such as expression ability, cooperation ability and innovation ability, so as to achieve the goal of cultivating high-quality applied talents..

Adopt a Diverse Teaching Model

In the past, the teaching mode was mostly based on lectures by teachers, and in this way, students acquire knowledge passively. This boring traditional teaching mode can easily reduce students' interest in learning. Teachers can try to change the classroom teaching mode and increase teacher-student interaction based on CDIO education concept. There are various modes that can be adopted such as group cooperation, group discussion, and situation teaching to realize the change from teacher-centered to student-centered. In these ways, teachers lead students to think, which fully mobilizes the students' learning enthusiasm, attracts the attention of the students, activates the classroom atmosphere and improves the efficiency of teaching. Students are no longer passively accepting knowledge, but actively acquiring knowledge. Teachers are the helpers and promoters of students to actively construct knowledge, instead of the transmitters and indoctrinators of knowledge passively. While completing the teaching goals of knowledge and skills, it also improves students' cooperation and communication skills, stimulates students' thinking skills, and cultivates students' practical abilities.

Construction of Textbook and Resource Library

It is an important part of teaching reform to select or develop appropriate textbooks according to the training model of talents. According to CDIO's project-based teaching model, electronics and information engineering professional courses should choose project-based teaching materials. With the rapid development of the Internet and multimedia, textbooks are no longer the only resources for students to learn, and current student learning is no longer limited to the classroom. In the information age, the network platform should be make full use of to establish a professional resource library which

provides learning resources for students' second learning classroom. This is also conducive to introducing the newest professional theories and technologies into students' daily learning and realizing the professional learning keep up with the development of the enterprise.

It is conductive to apply CDIO's educational concept to the teaching process of electronics and information engineering, which pay enough attention to the cultivation of students' practical ability on the basis of imparting professional knowledge, so that students' comprehensive ability can be improved. The core of CDIO's concept is to stimulate students' interest in practice, highlight students' dominant position, and focus on cultivating students' engineering application ability.

CONCLUSION

This article first analyzes the current status of the training mode of Electronics and Information Engineering major, and divides its teaching system into three levels based on CDIO. Then this article describes how to design the system architecture of course projects based on CDIO teaching reform. Finally, this article puts forward some specific suggestions for the reform of electronics and information engineering education based on the teaching concept of CDIO. This article can also inspire other majors to implement educational reform based CDIO.

The CDIO educational concept is integrated into the teaching process, so that students can gain rich practical experience in the school study, and prepare for future employment in the enterprise. In the teaching process, the theoretical knowledge and practical projects are combined to change the current situation where traditional teaching mode is out of touch with actual production. While learning the knowledge and skills required in comprehensive teaching activities, students also better understand how to use the knowledge they have learned. Practical teaching is an important part of the training of engineering and technical personnel in the field of electronic and information engineering. In order to cultivate high-quality applied technology talents, the CDIO engineering education concept is used in the scientific planning of universities to form an organic whole. It is important to regard the project as the main body, reform the practice teaching mode, and highlight the role of practice teaching in cultivating students' engineering literacy. Next, in order to effectively improve the quality of students and the level of professional teaching, it's necessary to continue to explore and innovate teaching mode, and propose and reform the existing problems in teaching actively.

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