The Exploration and Practice of CDIO-Based Integration Postgraduate Teaching Mode

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Abstract. Focusing on the problems existing in current engineering postgraduate teaching, a new CDIO-based integration teaching mode is proposed in the paper. This teaching mode creatively combines CDIO, Project-driven and Integration Teaching models together. The course projects are divided into senior and junior projects according to the training objective. Both the senior project and the junior project would be completed in accordance with the steps of "concept, design, implementation, operation". The Integration Teaching is adopted in classroom teaching to combine theoretical study with experimental operation and practical application as a whole. The results of the implementation show CDIO-based integration teaching mode would improve effectively postgraduate students' practice ability, innovation ability and scientific research ability. The proposed teaching mode in this paper is not only suitable for the cultivation of all engineering major postgraduate, but also can be applied to undergraduate teaching to promote the cultivation of Engineering Talents.

1. Introduction

The following problems exist in the teaching of engineering postgraduate course: 1) emphasis on instruction but underestimate guide, ignore the initiative and enthusiasm of students; 2) stress on theory but despise practice, lack of series of practice training, ignore the cultivation of students' practical ability and innovation ability; 3) emphasis on curriculum contents but pay little attention on student’s quality, focus on teaching of knowledge and methods, ignore improvement of the comprehensive quality of scientific research. In view of the above problems, the project-driven integration teaching mode based on CDIO is implemented in postgraduate signal processing courses such as "digital image processing” and "information theory and encoding".

The curriculum projects are divided into senior and junior projects. The senior project can be also called comprehensive engineering project, and the junior project is simple course project. Senior projects drive the study of the whole course. Through achieving project objectives, students’ comprehensive quality of scientific research and innovation ability will be lifted. Junior projects run throughout the classroom teaching. By using computer simulation, the implementation of junior projects convert the pure theory teaching into the integration teaching, transform the traditional spoon-feeding teaching into interactive heuristic learning, and combine theoretical study with experimental operation and practical application as a whole.

2. Basic Idea of CDIO-based Integration Teaching

2.1 CDIO Education Model

CDIO, the full name is Conceive-Design-Implement-Operate, engineering education pattern was founded by four universities such as Massachusetts Institute of Technology and the Royal Swedish Academy of Sciences and etc.[1] It was regarded as a new model of engineering education and its aim was to develop students’ ability of engineering application and to solve their employment problems efficiently. It works as an education concept and methodology system to guide the reform of
engineering education training model. It is consistent with the law of modern engineering and technical personnel training[2].

CDIO concept attempted to change the way of seeking knowledge and shed light on the long-term puzzle about which was more important between knowledge-induction and ability-development in engineering education. It emphasizes the importance of engineering practical teaching, emphasizes to train the students the abilities of active learning, practice, problem-analyzing and problem-solving, and emphasizes to train the vocational skills, professional ethics, as well as teamwork and communication. CDIO culture model reform on mechanical engineering, electronic engineering, chemical engineering, etc., was attempted in many universities[3].

2.2 Project-driven Teaching Model

Project-driven teaching method based on constructivism learning theory plays an active role in improving the quality of teachers’ teaching and the abilities of students’ learning. Therefore, project-driven teaching method provides a new way to teaching mode’s reform. This method is student centered. In the whole process, teachers play the roles of organizer, mentor, helper, and facilitator. Project driven model of teaching can stimulate students' interest and desire for knowledge, and develop abilities of independent learning and analyzing and solving problems[4]. Project-driven teaching method takes specific project tasks as learning purposes and takes optimized learning resources as learning medium and the representation of learning production as evaluation tools[5]. Students complete the project that teacher assigned through researching new knowledge themselves to acquire new knowledge.

2.3 Integration Teaching Model

Integration teaching is a new teaching mode in which theory, experiments and practice are combined in a scientific way[6]. It breaks the bonds of traditional teaching manner where theory and practice are separated from each other. Theory instructions, experiment guidance, and practice teaching are integrated and complementary with each other, and all of these can be accomplished by one teacher. Classroom is moved to the laboratory and computer room in which teachers should teach by demonstrating the practical work, and in which students should learn by doing actual work independently. Through hands-on learning interest of students can be aroused. Through hands-on they can also deepen their understanding of the principles, master skills, and learn to use [7].

3. CDIO-based Integration Teaching

Aiming at the problems existing in the teaching of graduate students, the concept of CDIO engineering education is introduced into project-driven teaching. The comprehensive senior project and the well-designed course junior projects are completed in accordance with the steps of "concept, design, implementation, operation". The traditional teaching mode and the discipline system are broken in classroom teaching. The integration teaching of theory and practice can fully arouse the students' interest and enthusiasm. The students will learn knowledge in the process of completing project and improve the independent learning ability, creative thinking ability, engineering practical ability and the comprehensive quality of scientific research. Taking the "digital image processing" as an example, CDIO-based integration teaching method is introduced in detail.

3.1 Objectives of Project

The senior project which is equivalent to a small research subject covers the entire knowledge system of the course. The goal of senior project is to cultivate students' comprehensive application ability, innovative practice ability and the comprehensive quality of scientific research.

The junior project which is similar to the design experiment corresponds to the class content. The goal of the junior project is to drive students learning and understanding knowledge by stimulating students' learning interest and initiative and to enhance students' ability of practice and applying through the completion of project tasks.
3.2 Project Design

The key point of implementing project teaching mode is choosing the appropriate research project. The senior project should not only arouse students' interest but also be difficult to moderate. The boundaries of the project should be set but innovative space should be left. Through comprehensively considering both the basic content of the course and the practical image processing projects which finished by project group member, "face recognition system", "moving target detection" and other 7 project topics are chosen after extensive discussion and repeated screening. In order to further improve students' ability of discovering problems and solving problems, a free proposition project is added.

Junior projects are designed according to the content which taught in one lesson. First of all, the teaching content is refined and developed into many coherent project training modules, which makes the teaching content modular and the content of module itemized. Then the project is designed for each module. One junior project which covers independent knowledge module is usually one image processing method or a kind of algorithms, such as “the application of image filtering operator”.

Some other junior projects may are related with several interconnected modules, such as “image segmentation”.

3.3 Implementation of Project

For senior project, students are divided into groups. There are generally two or more students in one group. Each group selects and completes only one senior project to achieve the purpose of combining the theory with scientific research practice. Teacher gives project introduction to students in the first lesson of the course. Group and topic list should be submitted to the instructor at the second lesson or a little lately. Students are required to use their spare time to complete the senior project. Senior projects assessment will be carried on after the end of the course. The project cycle is usually 12 to 15 weeks, which can be adjusted according to the actual project progress. In the teaching process, teachers need to track the project progress of each group and encourage students to solve the encountered problems through communicating with each other or following teacher’s guidance. Every student is required to write an English paper in IEEE format according to the results of the project in order to train students' ability to write scientific papers.

Junior projects are completed by using the integration teaching mode. Students are required to bring their own computer to classroom, or the lesson is carried on at computer Lab through "learning by doing". The junior project corresponding to a lesson is introduced at the beginning of the lesson. Students think about how to complete the projects and conceive some problems in their mind. These problems can help students focus on lectures and grasp the main meaning of knowledge. The left time in the lesson is divided into two parts. Firstly the teacher makes an introduction of the module knowledge relative to the project. Then the students try to complete the project. In the process of teaching, instructor adopts heuristic teaching methods to stimulate students' enthusiasm and encourage students to ask questions or discuss problems. In the process of implementing the junior project, the students are also divided into groups to discuss, design and implement the project. The instructor monitors the progress of each group and makes guidance. At the end of the lesson, every group will demonstrate and illustrate the project. The teacher carries on the summary and the comment to help the student digest and absorb the knowledge. With improvement of students' practical application ability, the difficulty of junior projects is gradually increased. At the end of the course, one junior project will involve multiple knowledge modules. The teacher will reduce the frequency of inspiration to fully mobilize the initiative of students and cultivate the ability to solve problems independently or in cooperation.

3.4 Project Reporting and Evaluation

After projects are completed, the project group should display their achievement to the whole class. The evaluation of the senior project includes project demonstration, project presentation and project defense. The project demonstration is mainly to demonstrate the function of the software. The
instructor will give feedback about how to improve the software. In the project presentation, students need to elaborate product planning, analysis, design, encoding and testing process of software development. Students answer the questions raised by the teacher or the other groups in making defense. The instructor grade the project by evaluating students’ innovation, thinking, expression and teamwork ability. Before the final project assessment, the teacher will conduct regular periodic inspection. On the one hand, the periodic inspection can motivate the project team to ensure the progress of the project. On the other hand, it can cultivate students’ critical thinking ability, creative practice ability and language expression ability. The final score takes into account factors such as "stage acceptance score", "group paper score", "group result acceptance score", "group report score" and "member contribution ratio". Every factor is assigned with different weights.

Junior project assessment is relatively simple. After the completion of the project, the project group demonstrates the program and introduces the design process one by one. Instructor gives scoring and makes a record. The score of junior project will be part of the regular grade. The final course grades are made up of the senior project score and the regular grade.

4. Practical Effects of CDIO-based Integration Teaching

In the teaching process of "digital image processing" for graduate students from grade 2012 to grade 2015, CDIO-based integration teaching mode is applied gradually. According to the practice and feedback, the new teaching model is constantly revised and improved. CDIO-based integration teaching mode achieves good results. Junior projects stimulate the students’ interest in learning and the desire for obtaining knowledge, and effectively improve the students’ ability to acquire knowledge and hands-on practice. Under the inspiration of junior projects, the students are more focused and more active. Comprehensive senior projects are effective in training students’ ability to discover problems and solve problems, independent learning, creativity and thesis writing. Compared with other traditional teaching methods, CDIO-based integration teaching mode has obvious advantages, which has been admitted by the students. After the end of the course, many students have a strong interest in image processing and related fields. Proportion of postgraduates who choose graduate project of image processing field is respectively 50% for grade 2013, 33% for grade 2014, 38% for grade 2015, 45% for grade 2016. In the course of "information theory and coding" and "modern signal processing", the integrated teaching method based on CDIO also is adopted and good results have also been achieved.

5. Conclusion

CDIO-based integration teaching was implemented in signal processing postgraduate courses from 2013. After four years of hard work, CDIO-based integrated teaching mode was gradually perfected. Good results had been obtained in application-oriented training, not only improving students’ practical ability, knowledge level and self-study ability, but also to some extent training graduate students’ scientific research ability, innovation ability and employability. The overall teaching quality had been improved significantly and the training effect was getting better. During the teaching reform, the quality of teachers was improved at the aspects of practical teaching and scientific research.

In summary, good effect was achieved by CDIO-based integration teaching mode for signal processing courses. This teaching reform mode was widely welcomed by the students. It effectively enhanced the comprehensive ability of the postgraduate, and effectively implemented the seamless docking of the practical training with theory teaching as well as experimental operation. CDIO-based integration teaching mode in this paper is suitable for the cultivation of all engineering major postgraduates to promote the teaching quality and talent training quality. It can also be applied to undergraduate teaching to promote the cultivation of Engineering Talents.
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