

RESEARCH ON TEACHING MODE PRACTICE IN THE COURSE OF PROGRAMMING BASED ON CDIO

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ABSTRACT

CDIO practice is introduced into the course of C++ Program Design to solve the traditional problems of attaching too much importance to grammar learning and much less to real problems solving. The course of Program Design is a major course for students majored in electric fields, especially for students in Excellent Engineers Program. Teachers integrate CDIO into the main points teaching of C++. In class, students are divided into groups to conceive and design a project by themselves, then discuss in classroom. After class, students implement and operate the selected project. Course examination is designed not only to check the theoretical knowledge but also to increase project evaluation weight in final scores. The quantitative and qualitative researches show that the introduction of CDIO's idea of teaching can improve students' abilities of programming, self-learning, writing, communication, cooperation and innovation.

KEYWORDS

CDIO; C++ program design class; project driven; Standards: 2, 3, 4, 5, 6, 7, 8, 9, 10, 11

The core of education is the people, so education should first pay attention to the cultivation of people's comprehensive ability. The aim of higher engineering education is to equip graduates with good engineering ability after years of education in university. With more demand of international talents, it is necessary to meet international requirements of engineers in our education. CDIO is a kind of innovation mode of higher engineering education abroad(Tao & Shang,2006). From 2000, multinational study team of four universities including MIT(Massachusetts Institute of Technology) and KTH(the Swedish Royal Institute of Technology) obtained huge funding of nearly ten million dollars. After four years' exploration, they founded CDIO engineering education concept(Sun,F.Q. et al,2010). The new concept pays more attention to general basic theory of engineering and professional knowledge. The aim of CDIO is training international engineers with both excellent professional skills and good professional ethics through the whole process of teamwork and innovation practice. CDIO represents Conceive, Design, Implement and Operate, it expresses the idea of "learning by doing" and "education and learning based on projects" very well. In China, a number of universities or colleges such as Shantou University(Gu,P.H. et al 2008), Tsinghua University(Gu,X.Y.2009), Dalian Neusoft Institute of Information(Wang,S.W,2009), and Chengdu University of Information Technology(Wang,T.B., et al, 2010) etc, have applied CDIO to their study and practice of professional training mode. Integration is one of the most important concepts in CDIO engineering education pattern. It means integration both in the teaching process of teachers and learning process of students. However, as for computer programming course, boring grammar details consume most of

our time, so it is a little bit difficult for students to apply the theory what they've learned to create a real project. What's more, most of the coursework for student is focused on training students to grasp separate knowledge points, there is hardly any general project to connect all the various parts of the knowledge to a whole one. So integration is a meaningful topic to explore, some universities have achieved worthy effect when they apply CDIO concept to specific curriculum reform(Cao,Y.Y. et al, 2011, Hu,W.L,2014) .

As mentioned above, we try to use CDIO in your computer programming course for the students in their first year in Yanshan University. After a few years' practice, good results have been achieved.

THEORY FOUNDATION OF LEARNING MODE BASED ON THE CONCEPT OF CDIO

CDIO means Conceive, Design, Implement and Operate; it gives access to the whole product's life cycle from product research and development to product operation. Students learn what is engineering actively and practically through rational integration of all the specialized courses. According to CDIO syllabus, the ability of engineering graduates can be divided into four levels including professional engineering knowledge, personal ability, interpersonal ability in a team, and engineering system ability. Practitioners of CDIO should use comprehensive cultivating methods which could facilitate the students to achieve the intended targets in these four levels. CDIO not only inherits and develops the engineering education reform experiences in Europe and the United States in the past 20 years, but also systematically put forward the operative 12 criteria for ability training, full implementation and test evaluation.

Computer programming course is divided into two parts: theory and practice. The theoretical teaching can logically express ideas clearly, but the implementation of logic ideas must be achieved through practice. Practice can consolidate and deepen students' understanding of the course content, enhance the students' programming skills, make them understand the development of software standards, improve the comprehensive ability of knowledge applications, the ability of analysis and problem solving, research work, engineering system and the team cooperation. These aims are in accordance with the requirements of the students' ability in the CDIO syllabus, so CDIO provides a significant guidance on how to reform teaching process in the computer programming education.

ANALYSIS OF PRESENT SITUATION OF PROGRAMMING COURSE TEACHING

With the popularization of computer, the computer programming design not only belongs to computer major students, non-majors also need to learn how to program. The main purpose of our course is teaching a programming language to non-majors freshmen to solve problems in their own area, to grasp the programming design ideas, to understand the classical algorithms of solving common problems, and to improve the ability to solve real problems. Now one of the problems in programing teaching is to pay more attention to theory than to practice, so it is meaningful to discuss how to apply CDIO concept properly to this course. At present, the total teaching hours of C++ programming course in our university is 40 class hours (one class hour =50 minutes), the theory part is 34 class ours, accounting for 85%. So how to make good use of theory part to improve the effect of teaching is a subject deserves our continuous research.

Usually theoretical teaching focuses on grammar; teachers spend too much time on grammar details so when it finally goes to practice there is only a little bit time left. Although students can understand quite well in classroom but they can't program after class. Specifically in the following aspects:

- (1)Focus more on grammar explanation than on practical problem solving.

(2)When it comes to after-school practice, verification of experiment is more than design and comprehensive experiment, which could help students to understand the class better, but can't complete the independent programming task.

(3)The way of examination often focuses on the theory, and the guidance of students also emphasizes the theory.

(4)Only focusing on students' knowledge and cultivation of the ability are far from enough. Taking the knowledge points as the main objective is not adequate too. What students receive is scattered grammatical knowledge; it is difficult to utilize these knowledge points to solve the practical problem.

THE IMPLEMENTATION OF CDIO IN PROGRAM DESIGN COURSE

Aiming at solving the existing problems mentioned above, according to training mode of CDIO, we study and design all aspects of teaching of this course and achieve good results.

Design teaching goal and content based on CDIO

C Conceive	D Design	I Implement	O Operate
Project requirements analysis	Project overall design Project detailed design	Project coding Project testing	Project operation Project evaluation analysis
Teacher : inside class Student : outside class	Teacher : inside class Student : inside class + outside class	Teacher : inside class Student : inside class + outside class	Teacher : inside class Student : inside class + outside class
Basic knowledge of engineering Interpersonal ability of teamwork	Personal ability Systems engineering capability	The group as a unit to complete a project	Group evaluation and group communication
The capability of problem analysis	Communication skills Communication ability The ability of cooperation	Coding ability Code debugging ability	The written expression ability Oral expression ability PPT production capacity

Figure 1. CDIO ability training mode

CDIO theoretical teaching in classroom

In the theoretical teaching of C++ programming course in classroom , we use project-oriented mode, carry out CDIO concept , and design the teaching content from four parts, and these are: project conceive, project design, project implementation, project operation. Students have clear learning objectives which lead the learners into meaningful tasks complete process. According to the software development process, firstly we propose the

sketch of the project, then discuss with the students about goals of the project, and at last determine the functions of the project. The whole process can make the students learn with clear objectives. After that we decompose the projects, and the decomposition reflects the idea of divide-and-conquer method. Then we explain the grammar knowledge needed to students according to their project process, so it is easier for students to understand how to use programming language to solve problems. For example, in order to reduce the difficulty of engineering problem, we use a Student Grade Management System as a project.

The project name: student score management system.

Program design requirements:

- (1) Use an interactive way to manage students' scores.
- (2) The software role: the roles of teachers and students.
- (3) The software function: teachers can add, delete, modify the students' scores; students can only query their own score according to student's ID or name.
- (4) After sorting the students' scores, they will be stored in the data file.
- (5) The query results can be printed.

We help students to understand C++ programming and to achieve success step by step by the following methods. First, we tell them about data types in C++ when they think about the information about the objects they will handle---the students: student IDs, student names, student classes, the score of every course, etc. The combination of information of the object leads to structure of C++. Then, students begin to consider the amount of the objects. Obviously there are a large number of students, so we propose the concept of the array at the right time. Next, they need to perform some operations on these data, so it is the time to introduce the concept of function. Further, they need to capsule data and operations in Class. At last, students start program main function to test these function in the class. And we introduce sequence, branch and loop structure of programming. If the amount of the data is so large that file has to be used to store these data. In this way, students finally complete the C++ knowledge learning through the process of building a project. As a good result, students not only can grasp the grammar but also know how to use them in a project.

CDIO practice teaching in classroom

Take one of our classes for example, the total number of the students is 30. We divide the class into 10 groups, each group has 3 people. In each group, they choose a leader, make a group name and choose a design project. The teacher provides 20 projects for students to choose. Each group can choose from one of them which they are interested in. Each group has their own project and we ensure that they don't have the same topic. The members of each group should talk together a lot what project they intend to choose and make the final decision. The project name of each group as shown in table 1:

Another purpose of the project is to cultivate the students' ability of teamwork and communication skills. After the teacher explain the projects, he (she) leaves some time for the students to discuss what projects they are interested in. Thus guide the students to complete the project conceive and design in classroom. By doing so the students avoid obeying what the teacher say, make students learn actively. Each group of students can choice a topic which the teacher is provided in advance. If some of the students are not selected all the topic which the teacher provided, they can also provide a topic that discussed by themselves. Then the teacher need to review it in order to determine whether the subject can exercise the students. Because the projects are chosen by students themselves, they are interested in them. They have the desire to solve problems, thus stimulate their learning motivation, and thus make them more active in the learning process. By imitating what the teacher does, the students will gradually learn the method of problem analysis and solving.

Table 1: Project name of each group

Name of Group	Project Name
TCL	Hotel MIS design
Learns	Books MIS design
Outstanding	The hairdresser MIS design
Try to be first	Company staff MIS design
East Wind	Student MIS design
Blue Castle	Student attendance MIS design
Voyage	Utilities MIS design
Wings of Dream	The item choice standardized test system design
Night	Hotel order MIS design
Neumann	Simulation of ATM MIS design

CDIO practice teaching after class

Students finish Implement and Operate process after class. Due to the limited classroom time, students could not finish the project implementation in the classroom; they have to use their spare time to search the online information and to inquire project background knowledge. They try to find other solutions of the projects, code based on the discussion in classroom. Because each group's selection is not the same, so their solution is not the same even they do after class. Students can be improved in group communication; the teacher will give personalized guidance.

In the process of completion of the project, the project needs analysis, overall design, detailed design, coding, testing and so the whole process needs team members continue to communicate and discuss, solve the problem constantly, be strictly in accordance with the implementation of a software engineering process, write each part of the document, submit the final project report. In this process, every step can exercise their communication skills, team cooperation ability, problem solving ability and engineering practice ability.

CDIO project evaluation

One of the standards in CDIO teaching mode is how to evaluate student. The C++ programming course adopts the mode of formative assessment, focuses more on the process of learning. First students "demo" their program to the teacher and through the "defence" way to answer the teacher's question, then introduce division of work in each group, the algorithms and the problems they have encountered, and finally submit a summary report of the project; The teacher should not only test the programs, but also check the project document. This way of evaluation can improve learners' writing ability and oral expression ability. The second part is on the basic knowledge which can let the students master t basic knowledge quite well.

ANALYSIS OF THE APPLICATION EFFECT BASED ON CDIO TEACHING MODE

In order to have a comprehensive understanding of to what extent CDIO change the effects of the C++ programming course and in order to learn from the successful experience and to avoid the failure in other courses, we quantitatively analyse of the score changes of the experimental group and the control group through the score comparison. We also qualitatively analyse of the students' feeling and suggestions on the CDIO teaching mode through a questionnaire survey.

Quantitative analysis of the application effect

The author has been teaching C++ programming course to automation major for four years from 2010 to 2013. Traditional teaching mode were adopted in 2010 and 2011, teacher introduced knowledge according to textbook chapters in the classroom, and we deployment a project for practice after class. We use CDIO mode in 2013, evaluation way is nearly the same, 50% theory + 50% project, final result comparison¹ as shown in Table 2.

Table 2 : Students' Score for four years

Year	Score
2010	65
2011	67
2012	71
2013	83

As can be seen from table 2, adopting CDIO teaching mode, the 2013 students' scores increased by a large margin than 2010-2012. After serious analysis, the authors believe that original teaching mode is good at introduce knowledge points in class, but there is hardly any time left for teachers to explain how to apply these knowledge to practical problems solving , so students are still very confused about it. However in CDIO based teaching mode, teaching and discussion in class, practice after-school are all tightly connected with a specific project, all the knowledge points are involved in this project. Students not only can learn the grammar, but also learn how to use them to solve the actual problem what is more important.

Qualitative analysis of the application effect

This course is for freshmen in Automation major in Yanshan University. It is very difficult for them to learn how to do programming only in 40 hours. After adopting CDIO concept to design this module, students generally think that their abilities have been improved in many aspects:

(1) Train the students to have the elementary engineering ability. In classroom teachers organize theory content according to projects, integrate knowledge points into projects; students take projects as their goal to practice after class. Conceive, design, implement and operate all simulate real software engineering scenario. Enable the students to understand the general implementation process of software engineering with the ability of preliminary engineering.

(2) Improve the students ability of self-study. Engineering project is the core of CDIO. In the completion of the project, under the guidance of teachers, students need to consult the relevant learning materials. It can stimulate students' interest in learning. Students tend to ask questions than before in class and after class. Learning efficiency has been improved, and it is a good way to cultivate students' self-study ability.

(3) Improve the comprehensive ability of students. At the completion of the project, the students' communication, cooperation ability has been improved through teamwork. And they need to write a summary report of the project and report it to the teacher about the group work which gives them a good chance to enhance their oral expression ability, language organization ability and document writing ability.

CONCLUSION

CDIO concept pays attention not only to theoretical basis of knowledge but also team cooperation ability, the application ability of students and the ability to control engineering system. In this paper, We aim at solving the existing problems in C++ programming module, according to the demand of CDIO advanced engineering education idea, propose project teaching mode, arouse the students' interests in learning, train students' CDIO ability and obtain good teaching effect. In a word, in accordance with the requirements of the four levels of the CDIO concept, we cultivate students' abilities to understand the basic knowledge and programming, and to improve their cooperation ability and engineering system analysis capability.

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