PROJECT-BASED LEARNING WITH STEP-UP METHOD —TAKE CDIO ABILITIES CULTIVATION IN COMPUTER SPECIALTY FOR EXAMPLE

Dazhi Jiang

Department of Computer Science, Shantou University, Shantou 515063, China

Jiali Lin

Business School, Shantou University, Shantou 515063, China

ABSTRACT

CDIO (Conceive-Design-Implement-Operate) is a kind of learning based on the whole process of an engineering project as well as a revolution against the lecture-oriented teaching model. The objective of CDIO is to teach the basic concepts and disciplines of engineering in the context of hands-on exercises where students have the opportunity to manipulate concrete objects and ground abstract thought in experience. CDIO, however, does not make explicit mention of operation and design method for students' projects in project-based learning (an important part of CDIO). There is little guidance or consideration around operation and design method, and enablers of manipulability, adaptability and diversity for CDIO projects. Therefore, this paper analyzes the problems of project-based learning with CDIO in computer specialty of Shantou University. Then, for training and exercising students' engineering practice ability adequately and effectively, a new method named as project-based learning with step-up method is presented in this paper. Project-based learning with step-up method divided the traditional project-based learning into four phases projects, which are level 1 projects, level 2 projects, Sci-tech Innovation projects and Social projects. The results of questionnaires supported our hypothesis. Firstly, Project-based learning with step-up method could make significance impacts on technical study and students' subjective initiative; secondly, the new method is better able to cultivate the CDIO abilities of students compared with traditional projects setting. After reform practice, we believed that Sci-tech Innovation projects and Social projects is a valuable supplement to initial projects in terms of technical study, subjective initiative and abilities cultivation in computer specialty of Shantou University. The method presented in this paper may be useful for educators who desire to promote the CDIO projects for students of computer specialty or other engineering specialties.

KEYWORDS

CDIO, Project-based Learning, Step-up, Abilities Cultivation

OVERVIEW OF CDIO ENGINEERING EDUCATION MODEL

As to the quality of engineering education, it is a common thought in industry that graduates are generally lack of understanding of modern engineering processes and innovative spirit,

delayed adaptation to new jobs, limited teamwork experience and practical capability, poor communication skills, weak conception of professional ethics and other humanistic quality. These make it hard for graduates to adapt to the needs of industries [1]. After four years of exploration and study, the education reform and research team of engineering education which composed of four Universities, including Massachusetts Institute of Technology of United States and three Swedish universities, Chalmers University of Technology, Linköping University and the Royal Institute of Technology, created the CDIO idea of the engineering education with the goal of ability-building [2]. CDIO is the newest research result of international engineering education reform in recent years and foremost, an innovative educational framework for producing the next generation of employable engineers. CDIO, which denotes Conceive, Design, Implement and Operate, is a strategic approach to engineering education modelled on the lifecycle of a product, which has been growing in popularity and has been adopted in a number of Universities worldwide [3-4].

CDIO is one of the patterns under the strategy of "project-based learning". CDIO is a kind of education model which combines abstract education and practical education, and its syllabus competence goals and innovative and applied talents quality fit highly.

This paper presented a novel CDIO project operation and design method based on project-based learning: project-based learning with step-up method. With the multistep and assurgent procedure, step-up method establishes a global and step by step CDIO abilities training system. We expected that this study may afford a referable reference to CDIO project operation and design.

PROJECT-BASED LEARNING WITH STEP-UP METHOD IN COMPUTER SPECIALTY

Project problems in our computer specialty

The computer specialty in china was developed by following the general pattern of tertiary education in many respects. Tertiary education was mainly focused on academic and elite education, and did not reflect the characteristics of engineering education. CDIO is a strategic approach to engineering education which has been adopted by most colleges and universities in the computer specialty, such as Shantou University. For project-based learning is an important tache in CDIO approach [5], in computer specialty of Shantou University, initially, three kinds of projects were designed for students, which were level 1 project, level 2 projects and level 3 projects. Level 1 project was a comprehensive project which will last more or less two years. Level 2 projects were series of small projects which were designed according to a given curriculum group and last two or four weeks. And level 3 projects were generally designed for a certain course. However, through almost five years of practice (from 2006 to 2010), these three kinds of projects come cross problems which can be summarized as follows.

1. Project objectives had less pertinence. Although all the projects were designed according to the related courses, and developed based on product lifecycle (conceive, design, implement and operate), these projects were mainly knowledge based project. For abilities in CDIO, these projects covered certain abilities, but different projects used similar syllabus and abilities objectives, it was difficult to form its own characteristics. Students touched each subject shallowly, but not deeply.
2. Similar projects were used in a long time. Projects were not only can't keep in phase with world's new technology, but also can't meet employment requirements. For example, mobile programming is a new embranchment of computer technology which has been widely concerned and attracted. But in the first five years of CDIO engineering education reform, there was no mobile programming project for students in the project practice in

computer specialty of Shantou University. We regretted to say that our existing projects were not kept pace with the world engineering.

3. The students' subjective initiative was limited by the initial level 1 and level 2 projects. The initial project idea was designed, guided and supervised by teachers, and students have to passively accept and implement it. Although we had established a complete set of mechanisms to track the project during its execution, this mechanism was too rigid. On the one hand, it was difficult to stimulate and guide the student to carry out the projects; on the other hand, it was hard to meet the individual needs of students.

Based on the basic ability requirements in CDIO ability outline, combined with the outcome of interview with professors in department of Computer in Shantou University, in this paper, we made a questionnaire with 48 questions, collected the first-hand data by send questionnaire to 80 grade 2 and grade 3 students in our department. And finally, we received 75 feedbacks and 70 met the requirements, representing a response rate of 93.33%.

The statistical result of the survey showed that, 41% students felt the level 1 and level 2 projects, with similar project objectives, is weak in pertinence and diversity. 43% students believe that the level 1 and level 2 projects are too old, did not represent modern advanced technology. 44% students believe that the existing level 1 and level 2 projects can not stimulate students' subjective initiative and meet students' interests and needs, where students are subject to many restrictions. And because the level 3 projects are curriculum designs, the questionnaire did not do such projects statistics.

Project-based learning with step-up method

In view of this situation, computer specialty of Shantou University re-studies on the planning and designing of CDIO projects. Generally speaking, project-based learning is an effective but long-term and periodic process. In this process, project assigning and accomplishing is not the goal of project-based learning. On the contrary, grasp an effectual learning method is its real goal. Therefore, it is necessary to construct a project setting with strong manipulability, adaptability, which not only meets students' diversity needs, but also gradually leads students to master the essence of project-based learning. Thus, according to the basic concept of project-based learning and step-up idea, four phases projects, which divide the whole learning process into four different but interlinked and step-up parts, have been designed since 2010. Follow the four phases projects, students' abilities are cultivated contrapuntally within different phases (Figure 1). Four phases projects are described as follows.
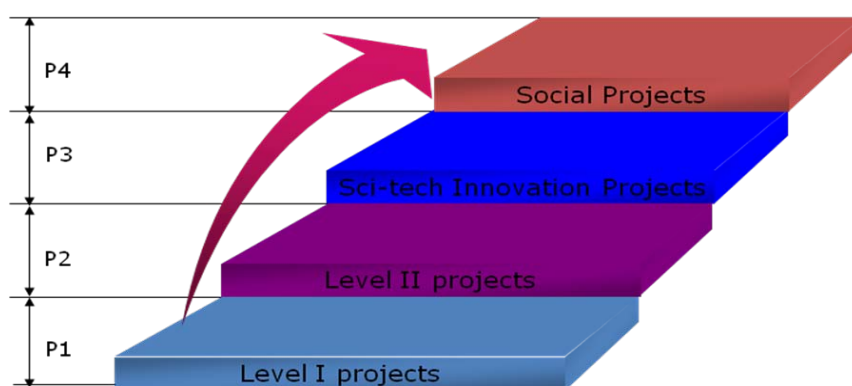

Figure 1. Step-up projects

Phase1 (P1): Level 1 projects. In this phase, three projects are designed which cover the whole computer specialized core curriculum. Level I projects give the students an

approximate recognition of specialized training goal. Sophomores choose one of the projects as their level 1 project.

Phase2 (P2): Level 2 projects. Divide all the computer specialized courses into four curriculum groups. Then, four projects, which cover the whole specialized training goal, are designed according to each curriculum group. Students choose all of the level 2 projects from the second year to third year.

Phase3 (P3): Sci-tech Innovation projects. Science and technology innovation projects are school-level or college-level projects which are developed for all students in the university. Since 2010, our university made more efforts to support these projects. The main purpose of such projects is to develop students' knowledge of comprehensive application ability, self-learning ability, innovation and organizational coordination.

Phase4 (P4): Social projects. Social projects are undertaken from companies outside the university by student's self-organized association. The students who have interests could join freely. Social projects cultivate CDIO abilities from the real business world. Modern Top (MT) club is our student's self-organized association which is organized in 2011. MT club is operated and managed with an enterprise way.

THE CHARACTERRISTICS OF FOUR PHASES PROJECT DESIGN

Project-based learning with Step-up Method could make significance impacts on technical study, students' subjective initiative and CDIO abilities cultivation.

1. Some computer-related advanced technologies are involved in the four phases projects, especially in Sci-tech Innovation projects and Social projects. It could make up for the deficiencies of the original projects setting. For example, our original level 1 project asked students to design a Card System. Card System is a comprehensive project which is not only related to software design, but also involves the knowledge of some hardware. However, the card system which relate to traditional information technology was not so much attractive for students. Whereas, Sci-tech Innovation projects and Social projects which provide opportunities for students to approach some advanced technology, such as mobile programming and so on, can effectively compensate for the deficiencies of the initial project. According to the statistical result of the survey questionnaire, 80.1% students think that they obtain modern advanced technology from these two projects.

2. The new projects setting could gradually highlight the students' subjective initiative. Four phases projects convert the project participation of students from passive acceptance to the initiative. In the four phases projects teachers guide students to do projects which not only enable students to understand the project lifecycle but also allow students to understand the methodology and core essence of "learning by doing" in level 1 and level 2 projects. Then students will select, conceive, design, implement and operate system in an active way with the strategy of gradually liberalized in the Sci-tech innovation projects where teachers only play an auxiliary function of guiding. Sci-tech Innovation projects is the prelude of Social projects. Through the cultivation of Sci-tech Innovation projects, the students' self-confidence, creativity and potential will be inspired. Furthermore, the experience of creating social and commercial projects can be accumulated in the process. Under the training of these Social projects, the full but elementary ability to build enterprise-level projects will be formed primarily. Moreover, these kinds of projects are very helpful to cultivate students' abilities of launching their own business. According to the statistical result, 75% students think that these kinds of projects could highlight the students' subjective initiative effectively.

3. The new projects setting could train CDIO abilities comprehensively. For CDIO abilities cultivation, different project focuses on different capabilities in the four phases projects.

Level 1 project focuses on the professional global awareness, the basic method to develop project and basic professional skills. Level 2 projects depended on synthesis and application of knowledge in a particular curriculum group. It will consolidate professional skills deeply. Sci-tech Innovation projects are projects which rely on the students' spirit of self dependence, such as self-conceive, self-topic selection, self-team building, self-management and self-realization. Social projects are projects which are undertaken from companies outside the university by student's self-organized association. All the projects in this association will be conceived, designed, implemented and operated from the view of social and commercial.

CDIO ABILITES CULTICATION IN PROJECT-BASED LEARNING WITH STEP-UP METHOD

In the questionnaire, we investigated eight kinds of abilities [6], namely:
A1: Engineering reasoning and problem solving
A2: Experimentation and knowledge discovery
A3: System thinking
A4: Personal skills and attributes
A5: Professional skills and attributes
A6: Teamwork
A7: Communications
A8: Conceiving, designing, implementing, and operating system in the enterprise and social context.

In the questionnaire, all the abilities are evaluated by five degrees, which are "very high", "high", "normal", "low" and "very low". We asked respondents to select the most appropriate option in each phase. For statistics, we measured the degrees on a scale of 1 to 5. According to this, "very high" equals to 5 points, "high" equals to 4, "normal" equals to 3, "low" equals to 2 and "very low" equals to 1.

Furthermore, for the requirements in specialty cultivation programme, P1 and P2 are the compulsory projects which students must participate in. While in the P3 and P4, students can choose these projects according to their own objective and willingness. Respondents from the 70 valid questionnaires, 30 of them were involved in a P3 project, 18 were involved in the P4 project. The following table shows the average score of each ability within the different phases.

Table 1
The Average Score For Each Ability Within The Different Phases

Ability/Phase	P1	P2	P3	P4
A1	2.63	3.02	3.50	3.83
A2	2.79	3.02	3.70	3.83
A3	2.79	3.10	3.43	3.50
A4	2.83	3.22	3.73	3.89
A5	2.83	3.02	3.40	3.72
A6	3.00	3.31	3.33	3.89
A7	3.01	3.03	3.40	3.78
A8	2.60	2.78	3.30	3.72

Table 1 shows that, along with the advance of the phase, the scores of all abilities are increased obviously. In P1 projects, the average score is 2.81(the lowest score is A8), which means that students' abilities, which are evaluated by them, are all under the normal level.

And the average score of P2 projects is 3.06, which means the abilities are basically above the normal lever except A8. Compared with the P1, the average score of the abilities in P2 increases 8.9%. In P3 projects, the average score is 3.47. Compared with the P1 and P2, the average score in P3 increases 23.5% and 13.4% respectively. In P4 projects, the average score is 3.77, where the abilities mostly close to the "high" level obviously. Compared with the P1、P2 and P3, the average ability in P4 increases 34.2%、23.2% and 8.6% respectively. Compared P4 with P1, it is easy to find out that the abilities of the A1 and A8 increase most in P4, which scores up from 2.63 to 3.83 and 2.6 to 3.72 respectively. Compared P3 with P1, the abilities of A2 and A4 increase most, which up to 0.91 and 0.9. Compared P4 with P3, the most improved abilities are A6 and A8, with increments of 0.56 and 0.42 respectively.

Through the above comparison, we can conclude that the project-based learning with step-up method will cultivate students' abilities in a rotated and assurgent way like a helix model (Figure 2).
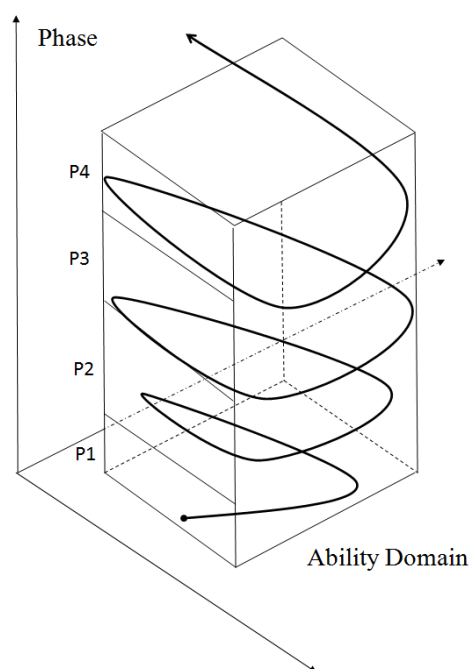

Figure 2. Ability helix model

CONCLUSIONS

CDIO engineering education model has an important inspired significance in the current higher engineering educational reform and exploration in our university. The CDIO education model aims to provide our students with a more balanced and comprehensive educational integration. However, CDIO does not make explicit mention of operation and design method for students' projects in project-based learning. There is little guidance or consideration around operation and design method, and enablers of manipulability, adaptability and diversity for CDIO projects. This paper present a new project design method—project-based learning with step-up method to change this situation. The primary reason for using a project-based learning with step-up method in engineering education is that the students shall be exposed to work methods used in industry. Furthermore, this new model could improve the students' subjective initiative and cultivate the CDIO abilities effectively.

However, in the eight abilities in CDIO, we found that A3 is improved at least compared with the other abilities. In P2, P3 and P4, the percentages of improvement in A3 are 11%, 10% and 2% respectively, which are far below the average improvement 34.2%, 23.2% and 8.6%. It is worth our further attention and improvement.

Furthermore, quality control is the key to run colleges and universities and it should always be kept in mind. For project-based learning with step-up method, our further work will focus on designing and implementing quality monitoring programs and quality control system for teaching quality monitoring.

ACKOWNLEDGEMENTS

REFERENCES

[1]   Haiyi Jin, Dejun Tang, "A CDIO-based Teaching Quality Monitoring System for Computer Science and Technology Specialty at Private Universities", 2010 International Conference on E-Health Networking, Digital Ecosystems and Technologies, IEEE, 2010.

[2]   Worldwide CDIO Initiative, CDIO Knowledge Library. http://www.cdio.org

[3]   Edward F. Crawley, Johan Malmqvist, Soren Ostlund, and Doris Brodeur, Rethinking Engineering Education: the CDIO Approach, Springer, 2007.

[4]   Crawley, E. F. The CDIO Approach to Engineering Education: Introduction, 2010.

[5]   Peihua Gu, Minfen Shen, Shengping Li, Zhemin Zhuang, Xiaohua Lu, et al, "From CDIO to EIP-CDIO: A Probe into the Mode of Talent Cultivation in Shantou University", Higher Engineering Education Research, Jan. 2008.

[6]   Crawley, E. F. The CDIO Syllabus: A Statement of Goals for Undergraduate Engineering Education, 2001.

Biographical Information

Dazhi Jiang is an associate professor for the Department of Computer Science at Shantou University, Shantou, Guangdong. His current interests are in evolutionary computation, data mining and engineering education reform.

Jiali Lin is an associate professor for the Business School at Shantou University, Shantou, Guangdong. Her current research focuses on business statistical, technological economics and management, and social investigation method.

Corresponding author
Dr. Dazhi Jiang
Shantou University
243 Daxue Road
Shantou, Guangdong, CHINA 515063
86-754-82902448
dzjiang@stu.edu.cn