On CDIO Teaching Mode Based on Computational Thinking

----A Case Study of Basic Curriculum Reform of Computer Science in CTGU*

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Abstract - In light of the survey of basic computer courses' characteristics and the modern educational philosophy, this paper proposes an improved teaching mode with the combination of CDIO Teaching mode and computational thinking, which emphasizes the equality of interactive teaching subjects, the importance of cultivating students' initiatives through reform of teaching materials, teaching content and the theoretical and practical teaching mode so as to improve their computational thinking ability.

Index Terms - Computational thinking, CDIO, teaching mode, basic course of computer science, education

1. Introduction

The 21st century is witnessing the thriving of basic computer science education in colleges and the turning of all citizens into computer users in society, which has posed a severe challenge for basic computer education in colleges and triggered an all-around reform of curriculum design, teaching methods, teaching materials selection, experimental environment, faculty fostering in institutions engaging in basic education of computer science. Educators concerned in Chinese universities also recognize the importance of improvements in information technology skills and fluency, and a number of studies have been developed on how to do this. But due to the rapid development and spreading of information technology, many textbooks are inevitable fell behind when they are published. So teaching institutions with non-computing students as teaching objects often question the computational competence of students whose majors are not computer science, and doubt the necessity of offering basic courses of computer science in colleges. Those researchers opposing the basic computer education actually cannot see that computer science can be used as analytical tools which go beyond simple IT fluency [1]. To basic computer educators, it implies that efforts should be made to strengthen students' ability to find, describe, define and solve problems, to wit, to foster students' computing ability in the basic courses of computer science.

2. Computational Thinking and CDIO Teaching Mode

Since Jeannette M.Wing professor from Carnegie Mellon University proposed and explained computational thinking as one of the three scientific thinking modes of human beings, more and more researches at home and abroad have been engaged in this field in recent years. It is regarded that computational thinking is based on "solving problems, designing systems, and understanding human behavior, by drawing on the concepts basic computer science"[2], and the essence of computational thinking is automation and abstraction. The advantage of computational thinking is that when simulating a large complex system or the massive data processing, researches can not only rely on traditional disciplines of general mathematical way of thinking, but also the combination of real-world design with implementation of complex systems engineering way of thinking [2]; in other words computational thinking is the combination of mathematical thinking with engineering thinking. The tips for the majority of computer courses educators are that when spreading relevant knowledge we should pay attention to the formal foundation of computer science mathematical theory on one hand, pay attention to cultivating students' engineering thinking on another hand because computer science is ultimately to build practical systems interacting with the real world. In other words, when teaching basic course of computer science, teachers must pay attention to the combination of theory and practice, the integration of mathematical thinking and engineering thinking.

During past decades, lots of teaching methods have been explored in the basic computational courses. But how to cultivate students' computational thinking, how to improve students' ability to solve problems with computers are still the areas which are inadequately studied and carry a great significance. Our group members have been engaged in teaching basic computer courses in China Three Georges University for years, and have accumulated a wealth of experiences and lessons. Based on a lot of research and experience, we proposed in this paper a new CDIO teaching model based on computational for university basic computer courses.

The CDIO (abbreviation of Conceive-Design-Implement-Operate) educational model is undoubted an internationally recognized engineering educational philosophy; the kernel of the model is project-based learning and teaching", which has been widely certificated in educational circles[3-5] .

3. The Reformation of CDIO Teaching Model Based on Computational Thinking

The members of our research group fulfill the CDIO

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educational model idea in full awareness of their educational and innovative features. But if the teaching team was too adaptive to students, theoretical teachings will be weakened and the ultimate goals will be lost in vocational skills training. If the teacher put too much emphasis on the realization and operation of the project, they might embark on empiricism or dogmatism teaching mode. In order to avoid above mentioned consequences of the above, we have given a full play to computational thinking at the same time, and the combination of traditional CDIO mode with the positive aspects of computational thinking. Thus summaries about our reformation and practice have been formulated as the followings.

A. The Textbook Reformation of CDIO teaching mode based on computational Thinking

Accompanied by the higher education transition from the traditional elite education to mass one, especially under the background that our teaching group implement thoroughly the CDIO teaching mode based on computational thinking, the traditional textbooks are no longer suited to our mode of teaching objects and teaching. Our group has studied these similar course materials adopted by colleges at home and abroad, and has conducted series of reforms about basic courses of computer science according to the new changes of national certification exam and the real needs of teaching objects in CTGU. This series of textbooks have the following characteristics:

1) Refusal of the outdated and adoption of the new according to the teaching syllabus. When compiling new textbooks, we have carried out some successions and innovations. To succeed here means to keep the relatively stable and nucleus teaching content as the cornerstone and introduce computational concepts while expounding key knowledge and highlighting problem-solving ideas and methods with the help of computers. To innovate means to make students acquainted with new technologies and new trends so as not to be divorce from realities.

2) Focus on theory, highlighting the practical. Theory and practice are inseparable, relying on each other's. When expound nucleus issues, we highlight the practical ones. At the initial part of every chapter, we usually address one or more questions from real realities to introduce some related knowledge and problem-solving methods. This helps students truly understand the contributions and challenges of computer science posed upon the development of human beings, and know better this informationized society in a rational way.

B. The Reformation of CDIO teaching model based on computational thinking

The traditional CDIO teaching model is an approach to engineering education that integrates a comprehensive set of personal and interpersonal skills, and process, product, and system building skills with disciplinary knowledge [2]. The goal of this teaching model is an organic combination of theory and practice in teaching. But a number of students with less learning initiative are often led blindly by the teacher and don't think the reasons of why, so their ability of discovering and solving problems is inefficiently fostered. Furthermore, some students, who despise the importance of theory teaching, and treasure practical training in basic computer courses, follow the instructions and finish certain small projects at end. So the CDIO teaching mode in practice is forced to connect with traditional vocational skills training and some students' creativity and practical problem-solving ability of the comprehensive hit a big discount. For the better development and implementation of the CDIO model, we should seek to improve our teaching models.

As we all know, learning and thinking is closely linked with each other, if teachers combine the CDIO teaching process with the computational thinking methods, the teaching and learning can be better improved. But our teaching content is still based on basic issues of computer science, the classical algorithms, typical cases, so teachers must help students to enhance their problem-solving ability with the use of the "reduction, embedded, conversion, and emulation, and so on" during the teaching process. In short, we must transform the knowledge-based teaching into thinking-based teaching.

1) The equality of interactive teaching subjects. Our Group has adopted the equal interaction teaching mode in teaching, emphasized the equality interaction between teachers and students. By reasonable thoughts collisions, discussions about how to do the project, the passive students' study conditions can be enhanced obviously. For example, when we explain the basic computer course in hardware sections, we do not use the traditional "click to talk" teaching methods, rather than a collective standing in hardware design, analyzing how to build a microcomputer compliance with Von Neumann laws. Then the educators may motivate young people to engage with discussion about how to design the computer's five components, how to communicate among the five components, and how to integrate the components. The audience will be encouraged to ask questions and contribute ideas about the topic. By designing and discussing, the audience will not only be able to better understand the hardware concept, but also successfully broaden their participation in computer science. The feedback of the audience demonstrates that the students can quickly comprehend the motherboard as a computer system platform position for the five components, the system bus's effort etc. At the same time, the educators successfully cultivate student's systematic thinking**.**

2) The careful organization of teaching content. Before the sessions, the teaching-group should carefully investigate the organization of educational content. In general, the group members induce knowledge spots through the program of instruction at first, and then select typical cases that are closely related to the knowledge spots. After appropriate cases are studied, the educators should design the right questions abstraction, analyze and solve a variety of solutions. For example when we explain the course "computer language c", the research group illustrates a typical case of students' achievement management system. Firstly, the educators

introduce student entity digital thinking and cultivate the audience further abstract thoughts. Secondly, the educators elicit the storage problem of the entity's different properties, and ask students to think about the traditional classification of data types, such as integers, characters, floats, arrays, structures, and so on. Thirdly, the educators draw forth the problem about students' large quantities of the input data. Obviously, if all data are inputted by individual "scanf" sentences, the program is inefficient. Through interactive discussions between teachers and students, the audience can understand the loop structure; at the same time they can comprehend how efficiently computers process large quantities of data. At last, the educators proposed the students' grade sorting question. By inductive method, students can understand not only the traditional bubble sorting algorithms, but also the deductive thoughts.

3) Experimental teaching reform. In order to foster students' computer application ability, we conduct a series of experimental teaching reform. First of all, the students are divided into subgroups with six to eight members who have the same professional background, and the most responsible and capable one in each team is elected as a group leader. Before the experimental course, the team members propose experimental contents, which are practical application related to knowledge issues, and then the instructor helps students to conduct a feasibility analysis, selection and optimization. When the group's experimental contents are determined, group members begin to design, divide and implement the experimental contents as a project. If the group members encounter difficulties that they cannot overcome, the educator should either do appropriate guidance, tips such as the right direction of the deductive reasoning problems, or call other members supply ideas. After the experiments are completed, each group carries on the summary and demonstrates their project.

4. The Comparison and Analysis of Traditional Teaching Mode and the Reformed Teaching Mode

In order to verify whether CDIO teaching mode based on Computational thinking is better or worse than that of the traditional mode, our research group has used the parallel class synchronization experiment method in the education reform in recent years. In the course of reform, the educators use such methods as observation, classroom testing, and sample survey to record the students' performance in classroom, the students' study effects and feeling, the students' acceptance of basic computer courses. At last, we use the contrast research technique to analyze the different effects between two teaching mode. The results of experiments are summarized as table I:

TABLE I the experiment data

	Acceptance of computer course	The average of final grade	The classroom activity
Traditional mode	33.1%	53.2	37.8%
The CDIO based CT	74.5%	71.3	76.7%

As we can see in the table TABLE I, if we use the reformed teaching mode, audiences will have higher classroom activity and acceptance of the basic computer courses' necessity, and higher final exam grades. Meanwhile, the follow-up investigation also demonstrates that students under the reformed mode have better computer literacy in their subsequent curriculum design and professional study.

5. Conclusion and Future Work

In this paper, we have addressed basic computer courses' characteristics and the ineffective of universities' basic computer curriculum, and proposed an improved teaching mode with the combination of computational thinking and CDIO teaching mode. Preliminary experiments have shown that the improved teaching mode can enhance the audience's initiatives and computational thinking ability.

In future work, we will continue working towards improving the audience's computational thinking ability.

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