

Research on Teaching of Computational Thinking Oriented Algorithm Design Course

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Abstract—Algorithm design course is a compulsory course for students of computer majors and is an important part in cultivating students' innovative and logical thinking. Based on the current situation of algorithm design course teaching, this paper expounds the basic ideas of the teaching reform of computational thinking oriented algorithm design course, and the teaching practice.

Keywords—computational thinking; teaching reform; algorithm design course

I. INTRODUCTION

Algorithm design is a compulsory course for undergraduates majoring in computer science and technology, focusing on the basic strategies and skills of various classical algorithms. It is of vital importance to cultivate students' systematic programming ideas and exercise students' logical thinking ability. In recent years, with the rapid increase in the demand for artificial intelligence talents in China, colleges and universities have successively added corresponding artificial intelligence and machine learning courses into the curriculum of computer major. Because those courses require for taking algorithm design course as the leading course, how to further improve the teaching quality of algorithm design course has become a problem to be urgently solved.

Through investigation, it is not difficult to find that the current teaching effect of algorithm design course is not that ideal. On the one hand, the teaching content is relatively old; the starting point of teaching is low; only traditional algorithm design method is explained, and it is difficult to guide and expound the algorithms in the fields of artificial intelligence and deep learning from a high standard. On the other hand, the teaching ideas are relatively backward, and still stay in the teaching mode oriented to imparting knowledge. Some teachers may copy and follow the textbooks, and lack interaction with and guidance to the students in the teaching process so that it is not only difficult for students to find the beauty of the thinking contained in algorithm course, but also difficult for students to have a strong interest in the content of the course. In the long run, the algorithm course is difficult to meet the needs of universities and society for the ability of computer talents.

Therefore, it is inevitable to reform the teaching of algorithm course.

Computational thinking [1] [2] is a new teaching philosophy that is most concerned and always recognized by the computer education circles. Computational thinking is not the mechanical computer thinking, but a divergent way of thinking. It advocates abstraction and decomposition, attention and separation, heuristic reasoning, parallel processing and other thinking concepts. It is a universal way of thinking.

Algorithm design course has a high degree of abstraction and is flexible in application; meanwhile, it has a good inspiration and guidance for learning of the remained professional courses. From this perspective, the teaching content and purpose of this course are in good line with the computational thinking. Therefore, computational thinking is introduced into the teaching process of algorithm design course, and the traditional point-based teaching mode is expanded, so as to improve students' thinking ability, stimulate students' enthusiasm for learning, active the teaching atmosphere in classroom and improving the teaching effect of the course.

II. COMPUTATIONAL THINKING ORIENTED ALGORITHM DESIGN COURSE

A. Computational Thinking

In 2006, Professor Zhou Yizhen proposed the concept of computational thinking on the Communications of the ACM. Professor Zhou believed that computational thinking is a series of thinking activities that use the basic concepts of computer science to solve problems, design systems and understand human's behaviors and do other things involved in computer science [1]. Just as everyone should have the ability of reading, writing, and calculating (3R in short), computational thinking is also the thinking ability that humans must possess. In order to facilitate understanding, Professor Zhou made a more detailed explanation on the definition of computational thinking. The main points are as follows:

- Computational thinking is a way of thinking about how to solve a complex problem in methods such as reduction, embedding, transformation and simulation.
- Computational thinking is a kind of parallel recursive thinking.
- Computational thinking is a method based on the separation of concerns, and takes abstraction and decomposition as the main methods for controlling complex tasks or for designing complex systems.
- Computational thinking is a way of thinking that uses heuristic reasoning to seek for solutions, namely the way of thinking about planning, learning and scheduling in uncertain case.
- Computational thinking is a way of thinking that uses massive data to speed up calculations, and compromises between time and space, and between processing ability and storage capacity.

Computational thinking is not a mechanical solution to a specific problem, but a way of thinking with good universality, and provides a methodology.

The essence of computational thinking is abstraction and automation. Abstraction is reflected in a mapping from the real world to the computer world. The objects, metrics, and solutions in the real world are mapped to the object expressions (such as identifiers, variables, classes, and so on) in the computer world. Automation is embodied in the autonomy of action execution in the computer world. This autonomy is the autonomy under the control of computer programs, but it is also a specific manifestation of computational thinking in the computer world. Computational thinking has the following three characteristics:

- Computational thinking is an abstract way of thinking, not a specific skill or program.
- Computational thinking is a way for humans to solve problems. Although it uses computer to solve problems, it does not mean that human thinking should be fixed in the mechanical mode of computer thinking.
- Computational thinking draws on mathematical thinking in the realization of formal expression, and draws on engineering thinking when solving real problems. Therefore, computational thinking is a multi-level and divergent comprehensive thinking.

B. Application of Computational Thinking in the Teaching of Algorithm Design Course

Algorithm design course is an important teaching tool for training computer majored students' algorithmic thinking ability [3]. The traditional teaching model is centered on teacher, wherein teacher asks questions, analyzes questions, and then asks students to solve the problems. In this way, it is difficult to give full play to the subjective initiative of students, and it is impossible to improve students' thinking ability to actively discover problems. However, those

problems can be well solved by carrying out heuristic teaching oriented to computational thinking. In actual teaching process, after finishing the teaching of basic theories and methods, teacher should encourage students to think and discover problems in practical application. The results prove that this teaching mode can not only effectively stimulate students' innovative and divergent thinking, but also help improving students' abstract thinking ability.

As defined by D.E.Knuth, a winner of Turing Award, an algorithm is a collection of finite rules, while the rule specifies a sequence of operations to solve a particular type of problem. The teaching purpose of algorithm design course is to guide students to master the basic processes and ideas of using computer to analyze, design and solve a problem, and cultivate their computational thinking ability by seeking for a solution to a problem [4]. This indicates that students actually are experiencing the problem solution thinking training while learning the algorithm design course.

The operation timing of algorithm requires that the problem solving process must be carried out in sequence, and there is a certain logical relationship between different steps. Therefore in the process of teaching, teachers should guide students to perceive the process flow and logical relationship of algorithms and experience computational thinking. This process helps to cultivate students' logical thinking ability and rational thinking ability. In the process of teaching, teachers can assume an actual situation of a problem, and encourage students to do brainstorming discussion in groups to discover problems, ask questions and solve problems creatively. In this process, students not only need to reconstruct their knowledge, but also need to reconstruct the meaning of the relationship between knowledge and practical problems, thus cultivating the ability of computational thinking. After subjecting to sufficient training, students can not only establish a consciousness of computational thinking, but also effectively build up abstract thinking and logical reasoning ability.

1) Encouraging innovative thinking and divergent thinking: The teaching purpose of algorithm design course is not like filling up a bucket with water, but like igniting a fire. If following routine of traditional knowledge transfer model, the quality of teaching may never be effectively improved. As we all know, the purpose of learning knowledge is not to memorize the knowledge, but to learn how to use them to discover and solve problems, and create new and optimum solutions. In the early stages of algorithm learning, students mainly imitate. At this stage, they should get to know and learn some classical methods and modes of thinking. After having a certain foundation, teacher should encourage students to flexibly transform and combine classical algorithms without being constrained to a specific mode. In addition, with respect to the algorithm problem having large scale and difficulty, teacher may organize students into groups to make relevant discussion. The process of discussion is actually a process of thinking collision, which not only helps to cultivate students' critical thinking to find

the crux of the problem, but also helps to expand students' ideas and stimulate their creative thinking.

2) *Learning to make appropriate adaptations and putting into practice what one has learned*: Those who have mastered the classic algorithm may not have had the ability to solve practical problems because there is a certain gap between knowledge and actual problems. Therefore, in the teaching process of algorithm design, it is not only needed to guide students to understand the basic theories and methods of classical algorithms, but also needed to guide students to deeply explore the thinking modes behind those algorithms, abstract the most valuable thinking methods, and then compare, analyze and find the difference between the method and actual problems, and then makes targeted solutions.

3) *Practicing while learning to test the learning effect in practice*: Laue, a famous physicist, once said that what is important is not to acquire knowledge, but to acquire the thinking ability. Rome was not built in one day. Computational thinking can be effectively built up if only students adopt correct methods and put into practice relevant training for enough period of time. In actual teaching process, teacher should abstract and summarize the algorithm knowledge, and transform the knowledge points into various exercises, guide students to make analysis, abstraction and comparison in computational thinking and use the learnt knowledge to analyze and solve the problem.

Algorithm design course attaches importance to practice. Simply teaching theory can't achieve good results. Hence, it is necessary to guide students to keep on receive effective practical training for long term. Therefore, the practice in algorithm design course usually adopt a project-driven approach, so that students can understand and apply computational thinking in the process of project development, fully understand and master the advantages of this thinking, and learn based on problems and oriented to project. In actual teaching process, the author adopted the following methods:

First, special tools are used for training algorithmic thinking. Inspired by the algorithmic teaching mode adopted in Berkeley branch of University of California, students are guided to use Scratch software for programming. Because this software adopts building block instructions to build programs, students can easily jump out of the grammar rules, focus on the design of the program logic flow, and improve their computational thinking ability more efficiently.

Second, doing practice in form of competition. Since the first year of university, students have begun doing a lot of exercises to train for taking the ACM / ICPC competition. This training mode helps students to make analysis, modeling, optimization and realization on a problem so that students' logical thinking ability has been greatly improved. In the second year of university, taking advantage of the competitions such as "Challenge Cup", "Internet +" and "Software Cup", students are guided to receive special trainings oriented to the competitions, thus helping students

to improve their software engineering ideas while improving their computational thinking ability.

Third, developing OJ platform and guiding students to receive classified training. By virtue of the national college student innovation and entrepreneurship training program, students are led to independently research and develop the OJ platform for algorithm training. This platform provides algorithmic test banks of different difficulty levels, and guides students to receive special training through regular training during the semester, and collective training in winter and summer vacations.

III. CONCLUSION

Acquiring algorithm design skill is a necessary jetton for computer majored undergraduates to face the future professional challenges; computational thinking is an important tool for cultivating students' innovative abilities. The teaching method for computational thinking oriented algorithm design course as proposed in this paper breaks the barrier of the traditional teaching mode of knowledge imparting, helps students to break the mindset and cultivate an innovative thinking ability. In addition, this method can help students broadening the limits and depth of logical thinking while helping students consolidating their professional foundations. This is helpful to students' vocational development in the future. According to the feedback of teaching in recent years, this teaching mode has obtained strong response among students and achieved remarkable teaching results.

ACKNOWLEDGMENT

I would like to thank Wuhan University of Science and Technology's teaching and research project "Exploration of the Teaching Model of Programming Thinking Based on Computational Thinking" for providing fund support for this paper.

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