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The computational thinking- oriented inquiry teaching mode for advanced programming language course

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ABSTRACT

As the core idea in the computer course,' computational thinking' is an effective means to provide a unique way of thinking and solve the problems of one's major. This paper aims to explore and practice teaching mode and learning mode based on computational thinking method and ability for computer course so that the teaching model can be found to provide methodological guidance for the application and the cultivation of the ability on computational thinking in computer course teaching. Based on the analysis of current status and existing problems of computer foundation course, and the current research status of computational thinking, this paper proposed a innovative teaching mode by comprehensively considering the computational thinking concepts and inquiry-based teaching, select "C language programming design" as a teaching case, shows the improvement on the non-computer professional students' solving problem ability by utilizing the computational thinking teaching mode in computer courses teaching. The questionnaire survey and analysis shows that the proposed teaching mode make students experience every knowledge point in the learning process and realize the self-construction of each link of the knowledge, as well as cultivated a certain ability of computational thinking in solving everything in daily life.

KEYWORDS

Computational thinking; Inquiry teaching; Non-computer major.

INTRODUCTION

As one of the three major scientific thoughts (computational thinking, theoretical thought and experimental thought), computational thinking is the thinking ability that must be possessed in 21st century. It is one of the most effective ways of teaching university computer foundation course to train the ability of computational thinking based on computational thinking. The basic computer course is an important part of general education for higher education, playing an important role for the improvement of the cultivation of comprehensive quality, innovation, social activities. Academician Chen Guoliang academicians pointed out, "the university general education is an important task of university talent cultivation. University education cannot be limited to the basic knowledge instruction, but also develop students' pursuit of science from the learner's rational thinking, making students have a noble personality. As the core idea in the computer course, computational thinking is an effective means to provide a unique way of thinking and solve the problems of one's major. At the same time, computer foundation course is the carrier to train the ability of computational thinking as university foundation course with the same status with math and English[1].

Computer technology is one of the cores of information techniques and the computer course teaching is the most important science curriculum for cultivating learners' ability of computational thinking. Establishing a set of frame structure based on the theory of computational thinking ability cultivation can be an unprecedented help in the future development of the computer education. The direction committee of computer foundation course of the education ministry of institutions and higher education publishing house organized several university computer organizations such as BBS to discuss the form and connotation of "computational thinking", etc. Universities represented by Harbin Industrial University, Zhejiang University have practiced computational thinking reform of university computer course for several years and accumulated a lot of experience. The thought has been deeply rooted in the hearts of the people to cultivate learners' ability of computational thinking as the fundamental task of computer basis teaching, build a complete computer foundation course teaching system based on this foundation, and realize the "computational thinking " oriented university computer education. But how to cultivate computational thinking, what content for university computer courses is to develop computational thinking, what is non computer majors' demand for computational thinking? To solve these problems, this study aims to explore and practice teaching mode and learning mode based on computed tomography method and computational thinking ability for computer course so that the teaching model can be found to provide methodological guidance for the application of computational thinking method and the cultivation of the ability of computational thinking in computer course teaching. It is expected to improve the efficiency of classroom teaching, promote the learners' cognitive ability of computer, and the ability to solve the problem with the computer, and the processing capacity of information technology, etc.

THE CURRENT SITUATION OF BASIC COMPUTER COURSES AND COMPUTATIONAL THINKING

The current status and existing problems of computer foundation course

At present, insufficient understanding of the role of basic computer courses exists in many universities and the teaching plan also becomes a mere formality. As a result, instructors either teach abstract theoretical model of computer, or just about a simple operation. First of all, for a long time, the computer foundation course is falsely recognized as teaching learners how to use the computer, and the core of the teaching task is the application of the computer as a tool. Second, the content of the course is old, which has a big gap with the international advanced level. Third, instructors use improper method. Basic computer course has the largest teaching content such as the basic theory, abstract program code, the human-computer interaction interface, software design and application, and each module has

numerous and different knowledge points compared with learners previous knowledge. Inappropriate teaching methods, therefore, can make the teaching process more complex, and consequently, instead of learning computer knowledge, learners, especially non-computer majors may shut it out. So, how to reform basic computer courses teaching method, infusing the computational thinking and computational thinking ability into basic computer courses teaching, is the emphasis and difficulty at present.

The current research status of computational thinking

Jeannette M.Wing, dean of computer department of the United States Carnegie. Mellon University pointed out that computational thinking, not just belongs to computer scientists, but is the basic skills of everyone. When training children's analytical ability, we should make every child not only master Reading, writing and arithmetic, but also learn computational thinking. Pervasive computing today is like the computational thinking tomorrow, and as the dream of yesterday, pervasive computing i has become the reality of today, and computational thinking is the reality of tomorrow. Computational thinking is to solve problems, design system and understand human behavior with computer science. It includes a series of thinking activities covering the breadth of computer science[2].

Computational thinking affects education in the UK as well as the United States. At the University of Edinburgh in Britain, people discuss the theme of the calculation in a series of seminars. Each seminar, a lot of experts discuss the impact of computational thinking on their discipline. Subjects in the seminars have been extended to philosophy, physics, biology, medicine, construction, education and other various areas[3]. In addition, British Computer Society (BCS) also organized the European experts and scholars to discuss computational thinking, putting forward an action plan for Europe[4].

Academicians Sun Jia-guang pointed out in "the transformation of the computer science" that the most fundamental and long-term's thought for computer science is computational thinking Professor Li Ke, commissioner of information science department two of the national natural science fund committee emphasized the necessity of promoting the basic concept of the computational thinking. Xu Zhiwei, researcher at the institute of computing technology of Chinese academy of sciences, said that general computational thinking is a kind of essential way of thinking that everyone must has, just like literacy and arithmetic. Before 2050, every citizen on the earth should have the ability of computational thinking.

The Education Committee, The national institutions of higher school have reached consensus about the training of computational thinking ability: The computer professional education should give an example in the computational thinking ability training, put every elements of computational thinking into ability structure of non-computer major students, the cultivation of computational thinking ability should be beginning at primary or secondary school students

Computational thinking penetrates in the life of every one of us. In fact, when a student goes to school in the morning, he puts what he need for the day in the backpack, which is equivalent to preset and cache in computational thinking. When a man loses his gloves, he will find through his path, which is the back of computational thinking. To stop renting skis and buy a pair at the appropriate time, which is the online algorithm of computational thinking. To choose the right team in line when paying in the supermarket is the performance model to calculate the multi-server system in mind. Even if during power failure, our phone can still be used, which is related to the irrelevance of failure and design principle of redundancy.

Computational thinking has its unique performance, and the computer science is not only a computer programming. If we can use a computer scientist's thought, we can not only program for the computer, but can also perform multiple levels of abstract thinking. Computational thinking is fundamental, not rigid. Basic skill is the skill people must master in order to adapt to modern society, and rigid skill is just mechanical repetition. Computational thinking is a way of problem solving, rather than think like computers. Compared with boring computer programming, humans are full of wit and imagination. Humans need to exert their imagination to endow computer energy. When equipped with

the computer according to our demand, we can solve the problem unable to solve before computing era, realizing the state of "what you can't image, nothing we can't do ".

COMPUTATIONAL THINKING- ORIENTED REFORM IDEAS FOR C LANGUAGE PROGRAMMING

Reform of the teaching goal

Since the students do not have the knowledge of solving practical problems and the accumulation of experience, so the important teaching points of advanced language programming design is not on how to solve some practical problems. We must devote ourselves to teach the ideas and methods about how solve the problem instead of just teaching how to solve practical problems, it especially suitable for the teaching design and classroom teaching of advanced language programming design. In the process of teaching design and implementation of specific teaching, we must clear make the cultivation and improvement of Computational Thinking capability as the ultimate goal, and make the specific programming design as the means to realize this goal.

The application of computational thinking- oriented inquiry teaching method for C language programming

Inquiry teaching include three aspects of "Problem Posing", "Problem-Inquiry" and "Problem Solving", it required the students use the learning method of "Independent", "Inquiry" and "cooperation to independently learn and dive deep into the main knowledge points of the current teaching content among some teams' communication and cooperation under the instruction of the teacher, so as to better achieve the cognitive and emotional based teaching mode. This paper researched how to utilize the Computational Thinking method to make the students carry on inquiry-learning, so as to better use the function of computational thinking and inquiry teaching, and build a new teaching mode of teachers-dominated, learners- center as well as capacity-building-purpose.

There are five steps in the whole teaching process, they are "Situation Creation", "Using Computational Thinking Method to Provoke Thinking", "Using Computational Thinking Method to Independence investigation"," Using Computational Thinking Method to Collaborative Learning" and "Summary and Improvement according to the actual situation of teaching". The activities of students include "formation of learning psychological", " thinking about my study plan", "collection and processing of material ", "collaborative discussion", "reflection, self-evaluation, mutual-evaluation, expansion, and knowledge migration"; The activities of teachers include "refining of inquiry problem", "Guiding the students to think", "stimulating learning", "assist to provide learning resources", "Providing necessary assistance for students, summarizing and analyzing learning effectiveness". The Computational Thinking- Oriented Inquiry Teaching Method is shown as Figure 1. Here the rhombus indicates the activities of teacher, the circle indicates the teaching process, and the rectangle indicates the activities of students.

Computational thinking- oriented teaching method for "loop control algorithm"

Since many problem need to be solved by the means of loop control, so in the teaching process of C language programming, the "loop control" is the key point that must be grasped in program design algorithm. If the student can well understand and grasp this pint of knowledge then it will be very helpful for the understanding of recursive thinking. How to help the students to analyze the relationship of every aspect of the problem and clear the context of the loop control is the key issue to let the students to grasp the essentials of loop control, internalization of knowledge skill, and utilize the skill in real life and work.

This paper uses "monkeys stealing peaches" as an example to explain how to based on Computational Thinking and Inquiry Teaching to teach the "loop control algorithm", shown as Figure 2.

If the teacher wants the students have a strong learning psychology to solve certain problem, he/she must put forward problems that can cause the students' attention and interest. Speaking, we should set up some questions of representative, applicability, interestingness and have obvious

computational thinking characteristics, so as to make the students actively learn with interests, accept the new knowledge from the aspect of mind and develop students' recursive thinking consciousness.

In the first step, select a representative, applicability and interestingness question as inquiry question, here we select “monkeys stealing peaches” as an example.

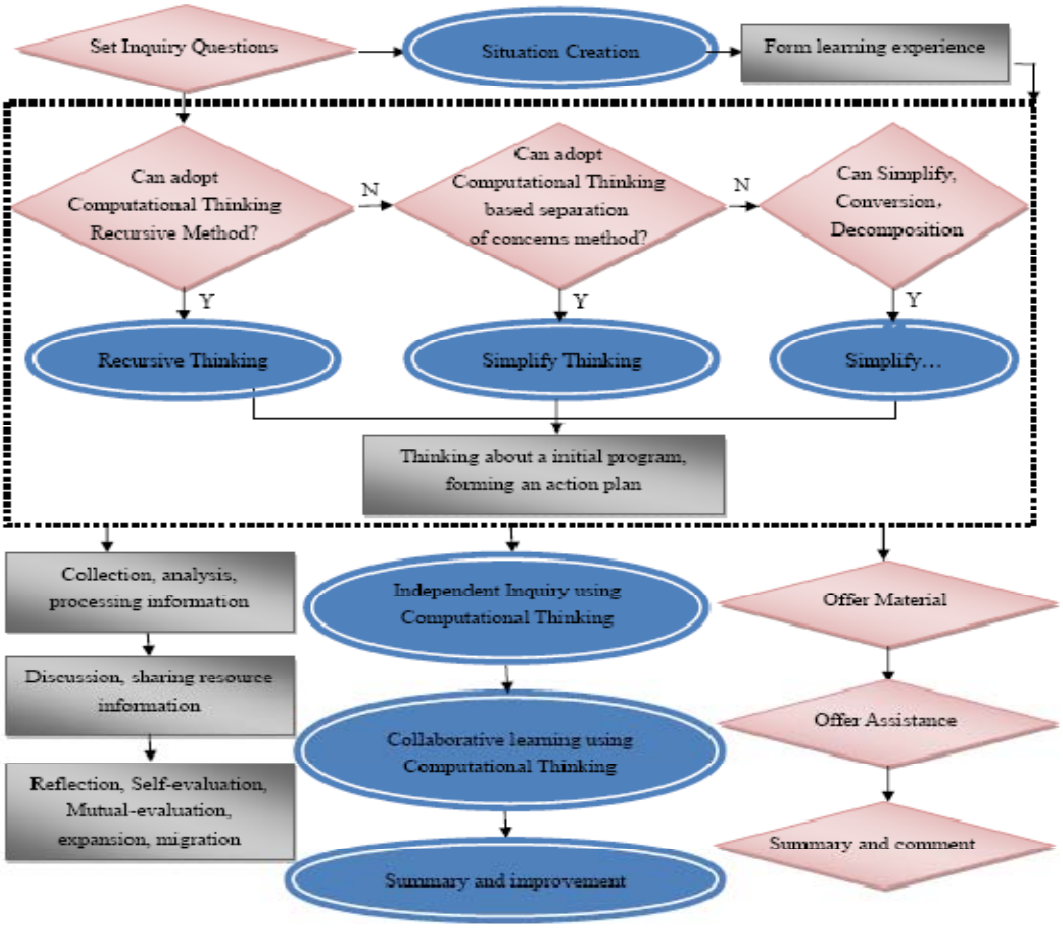

Figure 1 : The Framework of the Computational Thinking- Oriented Inquiry Teaching Method

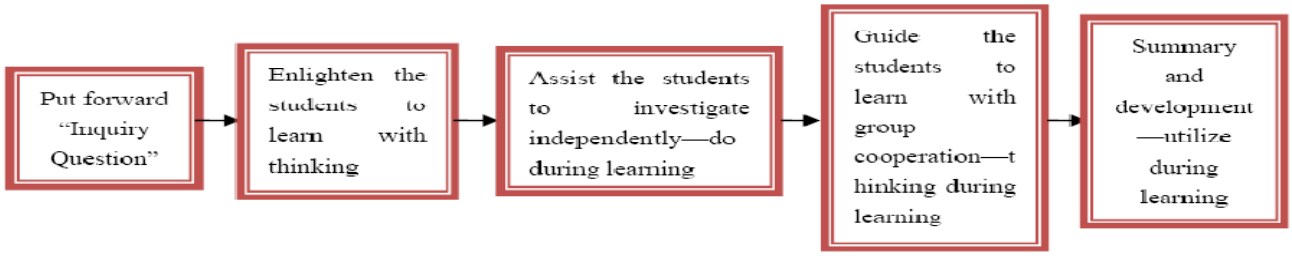

Figure 2 : Computational thinking and inquiry teaching based “loop control algorithm” teaching mode

In the second step, the teacher according to the characteristic of computational thinking to inspire the students whether can use the computational thinking based recursive method to solve the problem. Then the students according to the instruction of teacher, utilize the recursive method of computational thinking to reverse thinking, inference from the backward to the front. The flow diagram is shown as fig 3.

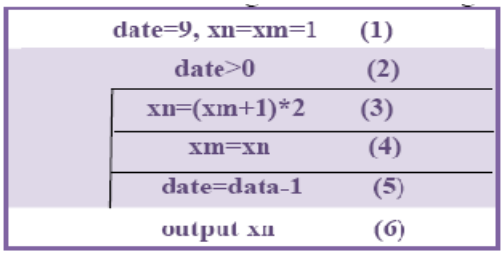

Figure 3 : The Flow Diagram of "Monkeys Stealing Peaches" Problem

(1) Define Variable date, xn, xm, where date indicate the max of the day, xn indicate the number of the peaches of the nth day, xm indicate the number of the peaches of the (n+1)th day.

(2) When date>0, execute the loop.

(3) Utilize the Computational Thinking idea, we can see, the number of the peaches of the nth day is two times of "the number of the peaches of the (n+1)th day add one", that is to say xn=(xm+l)*2.

(4) According to the loop we can see, if assign xn to xm then xm=xn.

(5)Every times go back one day, the date will minus one, that is to say date--

(6) Output the result.

In this case, the step (3) (4) (5) using Computational Thinking method to solve problem. The teacher can fully showed the two stages of recursion and regression in the process of recursive algorithm to the students by the above example. In the recursive phase, change the solution of more complex problems (of size n) to the solution of simpler one (of size smaller than n)---the number of the peaches of the nth day is two times of "the number of the peaches of the (n+1)th day add one", meanwhile in the recurrence stage, there must exist a situation that can terminate the recursion, for example in the 10th day, the number of the peaches is one. In the regression stage, when reach the solution of the most simple case, return step by step, so as to get the solution of the more complex problem.

Through this example the teacher can well guide the student to solve the problem by the recursive algorithm of reverse thinking, so as to experience the idea of recursive algorithm in the learning process. Then the students can learning with thinking, grasp the recursive method, and can using the same method to solve problems when run into the similar problems.

In the third step, the teacher continue to enlighten the minds of the students, let them to carry on the independent inquiry learning, actively and positively learn the new knowledge, and cultivated the ability of self-study and the ability of drawing inferences about other cases from one instance. For the above example, I proposed another problem: not only calculate how many peaches are picked in the first day, but also calculate how many peaches remained every day. I use this expand question to train the ability of the students to learn in the thinking, and the ability of using the new method to solve problems.

In the fourth step, guide the students to solve problem in group collaboration. For example, guide the students to accomplish the finding the solution of the first 50th numbers of "Fibonacci" series. According to the previous thinking training, the students have already learned the migration of knowledge, so under the instruction of the teacher, the students should know the way to solve the above problem is to simplified the complex problem (size of n) to simpler problem (size of smaller than n). For "Fibonacci" series, in order to calculate f(n), must first calculate f(n-1) and f(n), and in order to calculate f(n-1) and f(n-2), must first calculate f(n-3) and f(n-4) and so on, until calculate f1 and f2, then get the result 1 and 1. In the recurrence stage, there must exist a situation that can terminate the recursion, in this example, the terminate condition is n=1 and 2. In the regression stage, when reach the solution of the most simple case, return step by step, so as to get the solution of the more complex problem. In this example, when get the result of f1 and f2, then return and get the result of f1,…, when get the new result of f1 and f2, then return and get result of f2. Up to now, the students have already grasped the solving method of "Fibonacci" series.

Finally, the teacher commented and summarized on the issue, and further proposed a expanding questions and mobility knowledge to let student to use the learned method to discuses, reflection, mutual

evaluation, migration, and expand knowledge. For example, here the teacher can assign homework similar with the learned problem such as" go games" (a game played with black and white pieces on a board of 361 crosses), to let the student to solve the problem with the learned knowledge.

Teaching effect analysis

In order the evaluate the teaching effect of the proposed teaching mode, I carry on an analysis of the investigation on students' problem solving process with 30 mechanical major and food engineering major student who learned C language programming with the proposed method and other 30 mechanical major and food engineering major student who learned C language programming without the proposed method, the comparison is shown in TABLE 1.

TABLE 1 : Teaching effect analysis comparison

With Computational Thinking- Oriented Inquiry Teaching Method		Without Computational Thinking- Oriented Inquiry Teaching Method	
The number of students using structured, hierarchical and sequencing thought to solve problem	The number of students to solve problem without any characteristic	The number of students using structured, hierarchical and sequencing thought to solve problem	The number of students to solve problem without any characteristic
26	4	5	25

According to the above comparison we can see, the students with computational thinking-oriented Inquiry teaching method showed high recursive thinking when solving problem than the students without computational thinking- oriented inquiry teaching method. I also carry on questionnaire survey and analysis on the influence of computational thinking- oriented inquiry teaching method on students' computational thinking ability and learning styles, shown as Figure 4. and Figure 5.

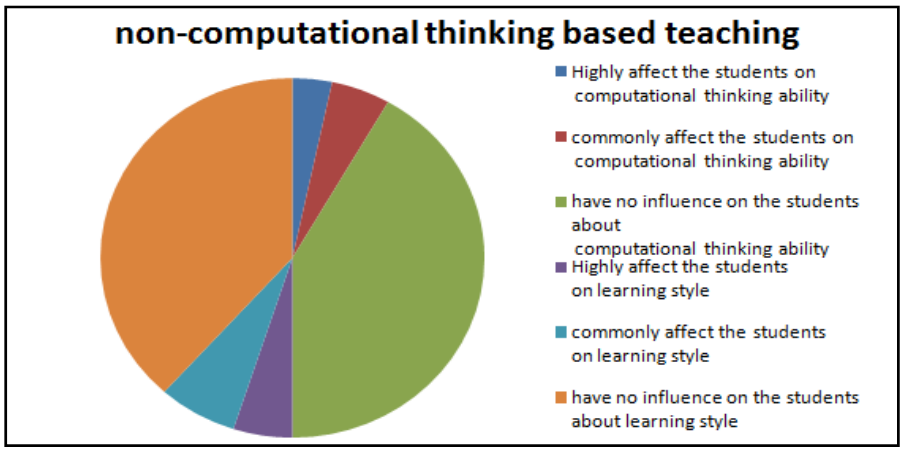

Figure 4 : Influence of computational thinking- oriented inquiry teaching method on students' computational thinking ability

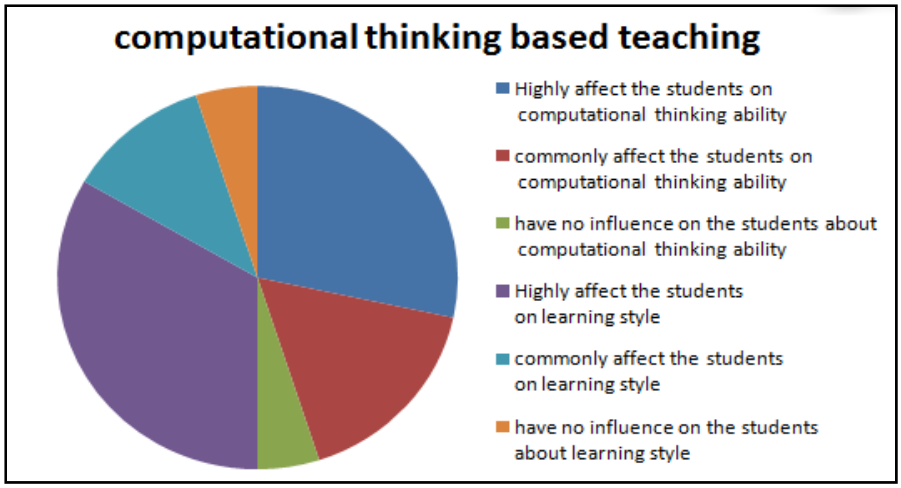

Figure 5 : Influence of computational thinking- oriented inquiry teaching method on students' learning styles

From the above teaching effect comparing analysis, we can see, for the 30 students with computational thinking- oriented inquiry teaching method, although they do not know what kind of ability computational thinking is, but due to the teacher has already conveyed such a method and thought in the teaching process, the students have already had a certain ability of computational thinking, so the knowledge they adopt and the methods they took to solve the problem are belonged to computational thinking method. While if not for a solution of a certain question, but for a large system design, the questionnaire survey and analysis shown that the student just have a certain ability of computational thinking, but nor have a very good computational thinking scientific literacy.

CONCLUSION

Learning and thinking is not independent of each other, but complementary closely linked together, the growth and development of computational thinking have had a great influence on our teaching. This paper proposed a innovative teaching mode by the combination of computational thinking concepts and methods with inquiry-based teaching, select "C language programming design" as a teaching case, shows the advantage of improvement on the non-computer professional students' solving problem ability by utilizing the computational thinking teaching mode in computer courses teaching. The essence of computational thinking is abstraction and automation, this paper shows the whole teaching process by modeling approach, formally shows the improvement of learning effectiveness and the ability of computational thinking. Through the analysis of the model and the verification of the model by the practical case, we can see the computational thinking based inquiry teaching method can well solve the contradiction between teaching and learning, is an education mode of "students as the main body, teacher as the leading", is the fully expansion of the individualized traditional teaching method, provide a reference for thinking teaching and innovation teaching. Learning by means of thinking can not only improve the students' learning efficiency, but also make students experience every knowledge point in the learning process and realize the self-construction of each link of the knowledge. This kind of learning is more conform to the need of cultivating innovative talents state, and provide good information resources and effective learning methods for earning approach for lifelong learning.

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