

# Exploration on Computational Thinking Oriented Heuristic Experimental Teaching

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## ABSTRACT

In view of the shortcomings in the experimental teaching of computer courses in universities, this paper puts forward some heuristic experimental teaching methods which are oriented by the cultivation of computational thinking ability, such as the combination of knowledge points and practice, the expansion of software functions, and the turning of experimental designs into works. The teaching effect analysis shows that the heuristic experimental teaching can improve students' learning initiative, cultivate their computational thinking ability and guide them to apply it to practice, which has achieved good results.

**Keywords:** computational thinking, heuristic experiments, experimental teaching

## I. INTRODUCTION

Since Professor Jeannette M. Wing of Carnegie Mellon University put forward the concept of computational thinking [1] in 2006, many scholars in China have made many active discussions on the connotation and extension of computational thinking in basic computer education. Joint Statement on the Development Strategy of Computer Basic Teaching Launched by the Coalition of Nine Universities (C9) put forward that the core task of computer basic teaching is the cultivation of computational thinking ability [2]; Academician Chen Guoliang constructed the minimum set of basic computer course teaching in universities based on "computational thinking" [3]; some scholars offer solutions from the aspect of course content system [4] [5] [6]; the College Computer Course Teaching Steering Committee of Institutions of Higher Learning of the Ministry of Education distilled 42 main core concepts of computer subjects involved in basic computer teaching in universities through summary and condensation, and proposed a computer

thinking expression system based on 8 categories, namely, calculation, abstraction, automation, design, evaluation, communication, coordination and memory [7].

It is necessary to transform the typical cultivation methods of computational thinking into teaching cases and textbooks and establish a number of feasible teaching programs, so as to provide specific teaching carriers and teaching methods for college teachers, and complete the implementation of "practice". Some scholars have proposed schemes from the form, method and system of experimental teaching [8] [9] [10] [11], but the practice of heuristic experimental teaching method is still limited. Heuristic experiment teaching can start from students' actual situation and adopt a variety of ways to mobilize students' learning initiative and enthusiasm, so as to achieve the purpose of training students' computational thinking ability.

Taking the computer course in university as an example, this paper focuses on the cultivation of computational thinking ability through heuristic experimental teaching, and discusses some problems in the experimental teaching of computer course in university.

## II. STATUS ANALYSIS

There are three types of computer course experiments in college: basic type, comprehensive type and exploratory type. In the experimental teaching, the modular form is adopted to construct different experimental projects from the basic practice of computation, computer hardware practice, computer software practice, computer network, and algorithm and

\*Fund: Higher Education Teaching Research and Reform Project of Universities in Guangdong Province in 2017: "Research on the Teaching Reform of Computer Courses in Independent Colleges and Universities Based on Computational Thinking" (Letter from the Ministry of Education of Guangdong Province [2018] 1); Research and reform project of higher education teaching in City College of Dongguan University of Technology in 2016: "Research on the Teaching Reform of Computer Courses in Independent Colleges and Universities Based on Computational Thinking" (Project No.: 2017yjg028); Industrial and academic cooperation and collaborative education project jointly launched by the Department of Education of Guangdong Province and Cisco Systems, Inc. in 2017: The Reform of University Computer Public Foundation Curriculum with Information Literacy and Computational Thinking as the Core (Letter from the Ministry of Education of Guangdong Province [2017] 153).

program design. The experimental procedure is clear and results are explicit. Students only need to verify step by step, and seldom need to actively design and construct, and conduct in-depth thinking, which is exactly where heuristic experimental teaching needs to cultivate and train computational thinking.

*A. Knowledge point verification is mainly exercises, which lacks thinking*

Taking number system and coding experiment as an example, the experimental contents generally include understanding positional number system, conversion between binary, octonary, decimal and hexadecimal systems and inquiring Chinese and English character encoding, etc. Most of them are in the form of exercises, and students are required to carry out the corresponding conversion calculation, and the use of Windows platform "calculator", ASCII code table or GB Code table for verification.

This kind of experimental form carries on the knowledge points splitting well and can be used easily to verify whether the result is right or wrong. It has the strong pertinence to the student final examination, or the computer rank examination, so students can easy to obtain good scores, and thus achieve the corresponding low study expectation.

However, from the perspective of the cultivation of computational thinking ability, this kind of experiment only enables students to master certain computational ability, but does not help them to understand the profound meaning of number system and coding. Students cannot gain intuitive experience from experiments of why do computers use number systems and codes, what is the nature of number systems and coding and the relationship between 0/1 and the real world and other deep contents. This is not conducive to students' exploration of the origin of the problem, or their in-depth investigation and thinking on the knowledge points. In the future work and study, once they encounter similar problems, they will often have a sense of *deja vu* but feel helpless This experimental form of knowledge point verification does not really inspire students to think and improve their ability to solve problems using the basic concepts of computer science, but it is a common phenomenon.

*B. The teaching of software functions is mainly simple applications, which lacks systematicness*

For a long time, the experimental content of college computer courses focused on the applied properties of computers and the operation of software tools. From the early Wubi typing practice to the current use of Office software, all reflect the experimental system based on the simple application of software functions.

This form of experiment, to some extent, meets students' needs of computer skills training and solving simple tasks. In the early stage of computer popularization development, it has quite positive significance. However, with the popularization of information courses in primary and secondary schools and the popularization of computers in families and work, students have a certain foundation for the simple application of software functions. A questionnaire survey was conducted among 89 students from class 3 and class 4 of Business English (undergraduate) of 2019 in City College of Dongguan University of Technology. It shows that the proportion of students with personal computers in the freshman year was 78% and more than half of the students had certain computer skills and basic knowledge, and had handled simple Office documents.

If the experimental content of university computer courses continues to focus on the simple application of Office software, most students will gradually lose their interest and enthusiasm for computers, and will have a wrong understanding that the College Computer course is equivalent to Office and one can pass the exam without studying hard and it is not important. This has been demonstrated in the head-raising rate in the teaching of simple Office application, even by some teachers and leaders. This is a common misunderstanding of the importance and foundation of university computer courses, and a very real problem for university computer courses. Therefore, it is necessary to reconstruct the experimental teaching content, expand the software function, and combine software application with study and work better.

*C. The experimental design is fragmented and lacks creativity*

Many colleges and universities make use of online learning cloud platform or related MOOCs website resources to closely relate the experimental content to the knowledge points. By the knowledge point test, teachers can ensure whether students have mastered the operation skills of the knowledge points which are closely related to the exam focus. The platform and website can easily make statistics of students' learning status, so that teachers can flip the classroom with emphasis, and explain a certain knowledge point, which can also achieve good teaching effect.

However, the experimental system itself is based on knowledge points and the experimental design is fragmented. Since the score and incentive mechanism is based on the duration and accuracy of exercises doing, students can easily fall into the misunderstanding of the exercises doing and seldom take the initiative to learn more than the test points. So it cannot train students' ability to apply the knowledge points comprehensively, which is a representation of the idea of examination-

oriented education in experimental teaching. This is not conducive to the comprehensive improvement of students' ability to deal with problems, and it is not enough to tap students' creativity and potential.

### III. EXPLORATION OF EXPERIMENTAL TEACHING

#### A. Combination knowledge with practice, emphasizing inspiration

The essence of the number system and coding in the computer is to use 0 and 1 to represent the things and data in the real world, which reflects the ideas of abstraction and design in computational thinking. Therefore, the concept of semantic symbolization is introduced. Based on the idea of semantic symbolization, real world information such as numbers, characters, pictures, sounds and videos can be sampled, quantified and encoded by the combination of binary symbols 0 and 1.

The experimental content of number system and coding can be redesigned. Taking the seven sections of LED digital tube common in life as an example, it is widely used in the field of electrical appliances, especially in the field of home appliances such as display screen, air conditioning, refrigerator, water heater and other screens, can show the number, time, date, temperature, humidity and other information. How is it encoded?

Generally, the seven-segment LED digital tube contains seven light-emitting diodes (three horizontal and four vertical), which can display decimal numbers from 0 to 9 plus the decimal point, as well as English letters, including hexadecimal English letters A to F (b and d are lowercase and others are uppercase), as can be seen in "Fig. 1".

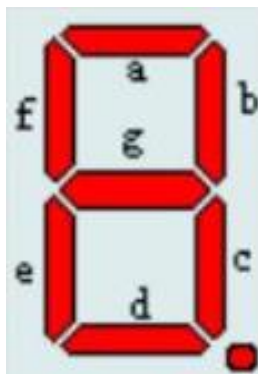


Fig. 1. Schematic diagram of seven-segment LED digital tube.

Similar to ASCII, the seven-segment LED digital tube can be encoded in a byte; the g, f, e, d, c, b bit of the diode correspond to the b6-b0 bit of the byte; b7 diode is set as 0. This is shown in "Table I".

TABLE I. THE CORRESPONDING CODING POSITION OF THE DIGITAL TUBE

b <sub>7</sub>	b <sub>6</sub>	b <sub>5</sub>	b <sub>4</sub>	b <sub>3</sub>	b <sub>2</sub>	b <sub>1</sub>	b <sub>0</sub>
0	g	f	e	d	c	b	a

According to the above coding rules, the binary code of the seven-segment LED digital tube with total cathode representing the number "1" is 00000110B, and its hexadecimal code is 06H. Inspiring students to think makes it easier for them to figure out the codes of other numbers. Students will be further think, why is b7 set as 0 all the time and can it be encoded?

This experiment is a good realization of the connection between the coding knowledge and the real life, and has certain inspiration, stimulating students' interest, and training their abstract ability and thinking ability. The following experiments of coding and implementation adopts Multisim for virtual simulation, and designs the full adder with switch circuit and gate circuit respectively, which inspires students to further understand the 0 and 1 and implementation in computer.

#### B. Expansion of software function, emphasizing comprehensive application

In the process of experimental teaching, software functions should be expanded. This is not just the realization of simple application, but the emphasis on comprehensive application ability. Attention should be paid to the continuous excavation and integration of the application demand in each professional learning and the life, so as to highlight the practicability of software technology, enable students to be able to flexibly use software technology, and improve their information literacy and comprehensive ability.

In the experiment integrating Text and Graphics in Word, the knowledge points involved are Text Box, Art Word, AutoShapes, SmartArt graphics and operation of pictures, etc. Their operations are basically similar, yet traditional experiments require one operation for each, which is repetitive and boring. It is difficult for students to experience the charm of the integration of Text and Graphics in this simple application of the experiment.

Here, a case of making wedding card can be designed [12]. The similar knowledge points such as Text Box, Art Word, AutoShapes, SmartArt graphics, picture insertion operations and so on can be integrated to form a complete piece of work. This not only solves the common needs in life, but also reflects the comprehensive application of knowledge points. The effect picture is shown in "Fig. 2".



Fig. 2. The effect picture of a wedding card.

Similar experiments can also include the making of business cards, scenic spot poster design, personal resumes and graduation thesis layout, etc. Compared with the operation experiments of scattered knowledge points, this kind of experiment greatly expands the application space of software, inspires students' comprehensive application ability, and reflects the training requirements of their computer application ability and information literacy.

C. Turning the experimental designs into works, emphasizing creativity

In order to avoid the mistake of doing exercises massively and fall into the trap of exam-oriented education, the experimental content should not only focus on the knowledge of the exam syllabus.

Instead, a larger range, such as learning requirements, market requirements, competition requirements, etc. can be considered. This will be conducive to the cultivation of students' keen demand for olfactory, creative thinking exercise and enable them to truly regard the experimental designs as their works, and integrate the computer technology into their professions and life. The content of the experiment is

not only limited to the technology itself, but also emphasizes the innovation, design and cultural heritage of the works.

In the experiment of PowerPoint design, the teacher can release the notification requirements of the campus PPT design competition to students, encourage students to actively participate in teams, let them design the experimental contents into a complete work, so as to stimulate students' initiative in learning, and allow them to experience the whole process of design from the experiment, and cultivate their creativity.

Similarly, in multimedia design experiment, in combination with the requirements of competitions such as the computer design competition for college students in Guangdong province or the design requirements of enterprises, the teacher can require students to turn the scattered experimental assignments into works, so as to inspire students to think actively, stimulate their interest in learning, and further improve their design ability and innovation ability. The award-winning works of some students of the university in the 2019 Computer Design Competition of Guangdong University Students are shown in "Fig. 3".

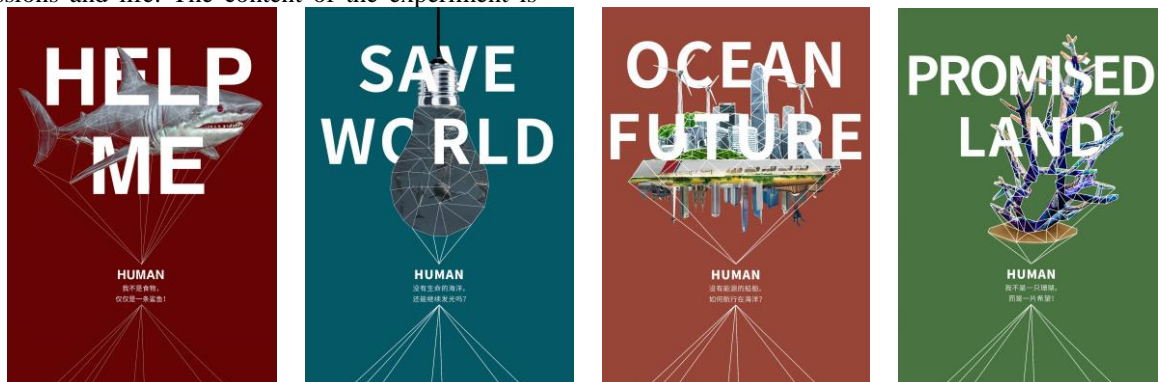


Fig. 3. The award-winning work "Aphotic zone" of a student in the 2019 Computer Design Competition of Guangdong University Students.

**IV. TEACHING EFFECT ANALYSIS**

The heuristic experimental teaching of university computer courses has not only deepened students' understanding of knowledge, but also improved their comprehensive application ability and the innovation design ability. More importantly, it has managed to cultivate students' thinking ability, equip them with the complex and overlapping knowledge structures in the future of the rapid development of information technology and let them have core competitiveness.

In the seventh and eighth National Computer Application Ability and Information Literacy Competition of College Students in 2017 and 2018, many students in City College of Dongguan University of Technology won the national first, second and third prizes, including the first prizes of the Office business

application ability competition undergraduate group and the undergraduate group of computer foundation competition. Besides, students were guided to participate in the Campus PPT Design Competition and the Guangdong Computer Design Competition of University Students and other competitions and also won many prizes. This further explains that heuristic experimental teaching is beneficial to improve students' learning initiative and exercise their computational thinking ability and information literacy ability.

Taking the computer application test organized by Guangdong Provincial Examination Center as an example, the numbers of students in City College of Dongguan University of Technology taking the test in each semester and the passing rate for the past 5 years are shown in "Table II".

TABLE II. THE PASSING RATE OF STUDENTS IN CITY COLLEGE OF DONGGUAN UNIVERSITY OF TECHNOLOGY IN THE COMPUTER APPLICATION EXAMINATION IN IN RECENT 5 YEARS

	The autumn of 2019	The autumn of 2018	The autumn of 2017	The autumn of 2016	The autumn of 2015
<i>The number of participants</i>	2037	2208	1958	2288	3185
<i>Passing rate (%)</i>	86.5	93.8	88.9	90.7	83.67

It can be seen from the above table that since the adoption of heuristic experimental teaching in the autumn of 2016, although the experiment content has been greatly changed from the traditional experiment, the passing rate of the exam have been higher than that of the autumn of 2015, and the passing rate reaches a peak in the autumn of 2018. It shows that the heuristic experimental teaching is conducive to stimulating students' interest, and to their mastery of knowledge points.

**V. CONCLUSION**

The heuristic experimental teaching based on computational thinking focuses on cultivating students' comprehensive application ability and innovative design ability, which is supported and affirmed by teachers and most students. However, a small number of students with poor computer foundation think the experiment is difficult.

It is what needs to be further explored in the teaching of computer experiments in universities how to further reflect the thought of computational thinking through heuristic experiments and improve students' learning initiative and how to teach students according to their aptitude, conduct layered experimental teaching, so that each student can get the training of computational thinking and lay a solid foundation for future work and life in the future.

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