

# Reform and Practice of the Course “Introduction to Computer Science” in Universities Based on the Cultivation of Computational Thinking and Systematic Abilities

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**Abstract:** Introduction to Computer Science, as one of the fundamental courses in computer-related majors, plays an important role in the cultivation of computer professionals. However, traditional teaching models and content can no longer fully meet the needs of modern information technology development. In response to these issues, this article introduces the concept of computational creative thinking, optimizes course content, adopts exploratory teaching methods, and innovates course assessment methods, aiming to comprehensively enhance students’ computational thinking and innovative abilities. By continuously improving and promoting this teaching model, it will undoubtedly promote computer education in universities to a new level.

**Keywords:** Introduction to Computer Science; Curriculum reform; Computational thinking; Practice

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## 1. Introduction

With the acceleration of global informatization, computer science has penetrated various aspects of social life and become an important force driving social progress and economic development. The computer science and technology major in universities bears the heavy responsibility of cultivating high-quality computer talents for society. As the basic course of this major, “Introduction to Computer Science” is not only an introductory course for students to understand computer science but also an important link in cultivating their computational thinking and systematic abilities <sup>[1]</sup>. At present, there are still many problems in the teaching content and methods of the course “Introduction to Computer Science” in universities, which limit students’ understanding and interest in computer science, making it difficult for them to understand and master the latest computer technology and applications. Therefore, how to reform the course of “Introduction to Computer Science” to meet the needs of information technology development in the new era has become an urgent problem that needs to be solved <sup>[2]</sup>.

## 2. Research status

The concept of computational thinking was first proposed by Professor Yizhen Zhou from Carnegie Mellon University in the United States. Once proposed, this concept has caused significant reactions in the computer industry both domestically and internationally, making how to cultivate students' computational thinking skills an important research topic in current computer education. Currently, domestic and foreign universities have conducted many explorations and practices in the teaching reform of the course "Introduction to Computer Science." Some well-known foreign universities, such as Massachusetts Institute of Technology (MIT) and Stanford University, have taken the lead in introducing the concept of cultivating computational thinking and systems abilities into their courses. They have achieved significant teaching results by updating course content, adopting advanced teaching methods, and adding practical activities. In China, universities are gradually realizing the importance of reforming the course of "Introduction to Computer Science." Tsinghua University, Peking University, and other universities have actively explored curriculum reform, attempting to improve students' computational thinking and systematic abilities through various teaching methods. The course "Introduction to Computer Science" at Tsinghua University has enhanced students' learning interest and practical skills through the introduction of case teaching, flipped classrooms, and other methods.

## 3. The problems of traditional computer introduction course

### 3.1. The course content is outdated

The traditional course content of "Introduction to Computer Science" is often outdated and fails to timely reflect new developments and technologies in the field of computer science<sup>[3]</sup>. This situation makes it difficult for students to understand and master the latest computer technology and applications during the learning process, limiting their knowledge and perspective. For example, some courses still focus on basic principles of computer composition and simple programming languages, neglecting the introduction of cutting-edge technologies such as cloud computing, big data, and artificial intelligence.

### 3.2. Single teaching method

Most undergraduate students nowadays receive an exam-oriented education. The teaching method of the course mainly focuses on lectures, with teachers imparting knowledge in the classroom and students passively receiving it. This one-way information transmission model lacks interactivity and is difficult to stimulate students' interest and enthusiasm in learning<sup>[4]</sup>. In addition, a single teaching method is not conducive to cultivating students' practical skills and innovative thinking, and students often lack experience and confidence in practical operations and problem-solving.

### 3.3. Differences in student levels

There are significant differences in secondary education resources and levels among different regions and schools, and this imbalance in educational resources directly leads to differences in students' computer foundation levels before entering university<sup>[5]</sup>. Due to the fact that teaching content and progress are usually designed uniformly, this difference can lead to some students feeling that the course content is too simple and cannot stimulate their interest in learning. However, other students may feel that the course is too difficult to keep up with, resulting in a sense of frustration and learning pressure. This situation not only affects the teaching effectiveness but also hinders the comprehensive development of students' abilities<sup>[6]</sup>.

### **3.4. Incomplete evaluation system**

Universities across the country generally set this course as an exam course, evaluating students' academic level through a unified exam at the end of the semester. Although most universities have included a certain proportion of regular course and homework grades in their educational reform, their proportion is low <sup>[7]</sup>. This evaluation method focuses on the examination of knowledge points, neglecting the comprehensive evaluation of students' computational thinking and systematic ability, making it difficult to fully reflect their learning effectiveness and ability level, and unable to provide effective feedback and guidance for teaching reform.

## **4. The goals and ideas of teaching reform in the course “Introduction to Computer Science”**

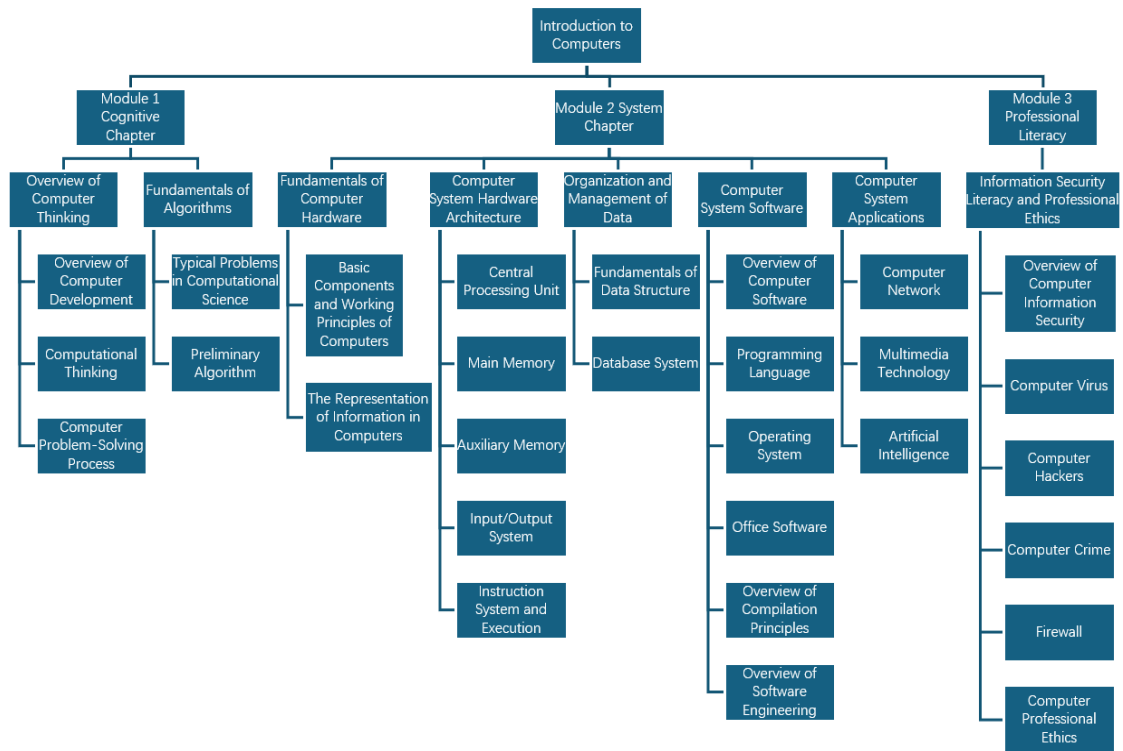
The teaching team of the “Introduction to Computer Science” course at the School of Information Science and Technology of Hainan Normal University has carried out normalized teaching reform and practice in response to the diversified problems in the current “Introduction to Computer Science,” and in response to the courses we undertake in the fields of Information Science, Statistics, and Internet of Things.

- (1) Cultivating creative thinking in computation: Through curriculum reform, we cultivate students' creative thinking in computation, enabling them to have innovative abilities and be able to use computational thinking to solve complex practical problems.
- (2) Enhancing systematic ability: We cultivate students' systematic ability, so that they can understand and handle various parts and their interrelationships in computer systems as a whole, and improve their comprehensive quality.
- (3) Improving practical skills: We increase practical activities, enhance students' hands-on and practical skills, and enable them to apply theoretical knowledge to practical work.
- (4) Adapting to technological development: We update course content, timely introduce the latest technologies and theories in the computer field, enable students to master cutting-edge knowledge, and adapt to the needs of industry development.
- (5) Enhancing learning interest: By reforming teaching methods and content, we enhance students' learning interests and enthusiasm and improve their sense of identification with computer science.

## **5. Teaching reform and practice of the course “Introduction to Computer Science”**

### **5.1. Course content design based on cultivating computational creative thinking ability**

The traditional teaching of “Introduction to Computer Science” usually only focuses on imparting computer knowledge and cultivating application skills, ignoring the reality of constantly emerging new technologies and making it difficult to effectively adapt to rapidly developing social needs. Therefore, while retaining the original teaching content of “Introduction to Computer Science,” we have changed the traditional “simplified and condensed version of professional courses” course content arrangement, combined with the latest theories and technological developments in the computer field, with the cultivation of computational creative thinking ability as the core, integrating computational creative thinking into the course teaching process, and cultivating students' ability to apply computational creative thinking to solve practical problems and innovation ability. The course system of “Introduction to Computer Science” is constructed based on the concept of computational creative thinking, and the course content arrangement is shown in **Figure 1**.



**Figure 1.** Content arrangement of “Introduction to Computer Science” course

The focus of teaching content is on clarifying professional goals, understanding basic professional knowledge, and understanding new technologies for professional development. We have simplified some of the basic content in the course, incorporated it into the scope of self-study, and utilized online course resources such as massive open online courses (MOOCs) to encourage students to engage in self-directed learning. The course requires students to understand the role of computational and creative thinking in problem-solving, as well as the general steps of using computational and creative thinking to solve problems. On the basis of emphasizing students’ understanding and mastery of basic knowledge and skills, this course design promotes the cultivation of their creative thinking ability in computation, enabling them to transform practical problems into problems that can be solved in computer systems through abstraction, induction, innovation, and other methods.

## 5.2. Exploratory teaching based on the cultivation of computational creative thinking ability

In order to cultivate applied innovative talents, we have introduced an inquiry-based teaching model in the course of “Introduction to Computer Science,” with teachers as the guide and students as the main body, aiming to cultivate students to use computational creative thinking to acquire knowledge, cultivate skills, and develop personalities. Through this teaching model, students are motivated, guided, and assisted to actively discover, analyze, and solve problems. At the same time, students are allowed to independently choose to deeply explore various knowledge modules in the teaching content, fully unleashing their learning initiative and creativity.

In the process of classroom teaching, by optimizing the allocation of teaching staff and absorbing teachers from different professional backgrounds engaged in computer research and application, a teaching team is formed. Teachers proficient in different professional fields use diverse teaching methods such as lectures, discussions, and engineering cases to provide targeted teaching on different topics involved in the curriculum

system.

For example, for cutting-edge technologies such as big data, cloud computing, and the Internet of Things, we choose to give lectures in the form of special topics. This not only expands students' knowledge but also stimulates their learning initiative and creative thinking, promoting their enthusiasm for subsequent course learning. Through expert lectures, students can learn about the latest technological developments and practical application cases, enhancing their interest and enthusiasm in the field of computer science. For example, when teaching software development technology content, teachers choose typical examples that are close to students' lives as teaching cases based on knowledge points, gradually inspiring and guiding students. This method emphasizes the application of computational thinking to solve specific problems, allowing students to truly experience the basic methods and thinking patterns of computer problem-solving through practice, rather than just learning the programming language itself. Through practical operations and case analysis, students can better understand abstract theoretical knowledge and apply it to solve practical problems.

This exploratory teaching model not only stimulates students' interest and initiative in learning but also focuses on cultivating their creative thinking and systematic abilities in computation. By optimizing the allocation of teaching staff and diversifying teaching methods, students can grow in a more open and challenging learning environment, gradually possessing the ability to cope with future technological changes and social demands.

### **5.3. Course assessment method based on the cultivation of computational creative thinking ability**

The traditional course assessment method usually consists of four parts: attendance, homework, experiments, and final exams. However, in order to enhance students' interest in learning and cultivate their computational and creative thinking abilities, we have adjusted the assessment method to thematic discussions, experimental demonstrations, classroom presentations, and course assignments. This reform not only innovates in the form of assessment but also optimizes the training objectives.

The new assessment method mainly focuses on cultivating students' creative thinking in calculation and enhancing their self-learning ability. The thematic discussion section aims to expand the depth and breadth of students' knowledge in a certain field and enhance their computational thinking ability and teamwork through in-depth exploration and interaction. The experimental demonstrations stimulate students' enthusiasm and require them to demonstrate their experimental results through hands-on operations, thereby improving their practical problem-solving skills and innovation awareness. Classroom presentations are another crucial aspect, as students can better grasp the knowledge points and combine theory with practical applications through preparation and presentation. The course assignments consolidate the knowledge learned and enhance the ability to ask, analyze, and solve problems by completing diverse assignments.

### **5.4. Analysis of teaching effectiveness**

In order to test the implementation effect of the reform and practice of the "Introduction to Computer Science" course in universities based on computational thinking and systematic ability cultivation, we conducted a follow-up survey and sampling comparison of students majoring in teaching at the end of each academic year. Specifically, we randomly selected 50 students from grades before 2023 who did not adopt the teaching reform model as the control group, and an equal number of students from grades after 2023 who adopted the reform model as the study group. We conducted surveys on their course satisfaction, professional identity, learning interest, and other aspects, collected survey data, and compared course assessment scores to check the effectiveness of teaching reform (**Table 1**).

**Table 1.** Comparison of course satisfaction, professional identity, and learning interest before and after the reform

Index	Control group (before 2023)	Study group (after 2023)
Course satisfaction	70%	85%
Professional identity	65%	80%
Learning interest	60%	78%

Through comparative analysis, we can evaluate the specific effectiveness of the reformed curriculum system in improving students' computational and creative thinking abilities, increasing their learning interest and satisfaction, and providing empirical evidence for further optimizing and promoting teaching reform. Preliminary feedback shows that students who have implemented the reform have significantly improved their course satisfaction, professional identity, and learning interest, indicating that the reform measures have effectively promoted the comprehensive development of students.

## 6. Summary

“Introduction to Computer Science,” as a fundamental course in the field of computer science and technology, undertakes the important task of cultivating students' computational thinking and systematic abilities. However, traditional teaching models and content are no longer able to meet the needs of modern information technology development. This article aims to enhance students' innovative thinking and practical operation skills by introducing the cultivation of computational creative thinking and systematic abilities, enabling them to apply theoretical knowledge to practical problems and cultivate high-quality computer professionals with innovative and systematic thinking abilities. In the future, with the deepening of teaching reform, the country will cultivate more computer professionals who can meet the needs of society, and contribute to technological progress and social development.

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## Disclosure statement

The authors declare no conflict of interest.

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