Research on the Application of CPI Teaching Method in Computer Courses in University in the Age of AI

Jing GAO and Le HAN
School of Information, Capital University of Economics and Business, Beijing, China

Keywords: Education Informatization, CPI Teaching Method, Cognitive Theory, Artificial Intelligence

Abstract. Since big data was first put forward in 2008, it has caused dramatic effect in education, which impels a lot of educators to explore effective teaching methods. In the meanwhile, people from all walks of life have been seeking new methods along with Artificial Intelligence (AI) being mentioned again since it was presented in 1956. Faced with such earthshaking changes in the field of education, the “digital tsunami”, MOOCs, has erupted, which puts education informatization into a new climax. This article analyzes the development of computer education at home and abroad and discusses various methods of computer education proposed by educators. On this basis, it points out that education informatization is the means of education, and information education is the product of education, and proposes CPI teaching method of computer courses. CPI teaching method is a teaching method based on cognitive theory and structure system of knowledge. Combining with specific discipline, the teaching method is an integration of cognition, practice and innovation. Practice shows that this theory has been applied to computer courses and has achieved remarkable results. It can help students master more knowledge quickly and firmly in a limited time and achieve a high-level self-cognition.

1. Introduction

Big data has caused a huge storm in the field of education since it was first proposed in 2008. People have not fully understood the application of "cloud computing" in education, and "big data" has come to the fore. “Deep learning” and “artificial intelligence” continues to attract the attention of educators. On this basis, university starts to embraced reformation and innovation.

Artificial intelligence has changed the form of enterprise organization and the generation of data, forcing companies to change the business model. At the same time, it also changed the model of education. Similar to the well-known example of "beer and diapers" in data mining, there is a story widely circulated in the United States as to artificial intelligence. A girl who attended high school received a coupon from the Wal-Mart with information on baby products. Her father was angry and asked why they sent it to his daughter. However, it turned out that his daughter was pregnant. So how did Wal-Mart know everything before the girl's father? The reason was that the girl searched for keywords on the Internet so that her behavioral was revealed to the internet. Therefore, the business knew the daughter's situation earlier than the girl's father. So, in the era of artificial intelligence, is it possible for students to understand the dynamics of disciplines earlier than teachers? The answer is yes.

In 1951, computers began to use tape and punch cards to store data. In 2012, data storage, based on distributed data warehouse, mass data storage technology and real-time data warehouse technology of stream computing, carried out new data storage technology. And data has the advantages of large storage, low processing speed and low cost. At the same time, the methods and techniques of artificial intelligence, such as data mining, machine learning, knowledge discovery and natural language processing; have been integrated into education so that information education has been elevated to a new level. However, education informatization cannot be regarded as the improvement of hardware facilities, nor the transfer from textbooks and blackboards to the screen and the network. Guided by modern educational theory, education modernization should make full use of modern information technology to carry out comprehensive transformation of the current
education system, thereby greatly improving the quality and efficiency of education and teaching. Therefore, the reform of the computer courses has been put on the agenda in the era of artificial intelligence.

2. Development of Education Informatization in Computer at Home and Abroad

2.1 Development of Education Informatization in Computer at Home

Due to the problems in traditional computer education and the importance of computer education, the reform of computer courses is urgently needed.

In 2008, in order to improve the transition of the teaching system and the level of computer education in colleges and universities, the College Computing Teaching Steering Committee of the Ministry of Education organized a series of seminars and lectures on the importance of computer teaching and "computational thinking" from different aspects. In 2010, nine “985” universities jointly organized the “Computer Basic Courses Seminar of Nine colleges (C9)” and released the “The Joint Statement on the Development of Computer Basic Teaching of Nine School (C9)”, on which officially started the reform of computer courses in China. The seminar clarified that the computer basic course is an important course to improve students' comprehensive quality and ability of innovation. It is also an important part of university education. It is imperative to build comprehensive system of computer basic course and teaching content. At the same time, it also clarified the importance of “computational thinking”. The reform project of computer courses, led by the Ministry of Education in 2012, aimed to optimize the content and form of university computer courses and further improve students' ability of "computing thinking". In May 2013, College Computer Course Teaching Steering Committee of Ministry of Education issued the “Decision on the Reform of Teaching on Computational Thinking”. The declaration re-emphasized the importance of “computational thinking”, clarified the important role of university computer courses and the need to use “computational thinking” to reform the curriculum system in the new era. In theory, Zhong et al. (2015) discussed the significance of integrating "computational thinking" into computer education. Ren (2016) studied the way of integrating “computational thinking” into university computer courses. Wang (2014) linked “computational thinking” with specific disciplines and provided guidance for the practice of “computational thinking”.

In April 2015, the Ministry of Education issued the “Opinions of the Ministry of Education on Strengthening the Application and Management of Massive Open Online Courses in Colleges and Universities”. The opinions emphasized the application of online courses and the combination of online courses and classroom, through which students can choose their own learning content with different foundations and learning abilities. In addition, through online courses, students can overcome the limit of time and space and make full use of self-learning. It also makes timely communication between teachers and students possible. According to the “In-depth Research and Forecast in MOOCs in 2017”, the scale of user in MOOCs from 2014 to 2016 is shown in Fig. 1. The number increased by 6 times in just three years, indicating that the "online courses" has received huge welcome.

Furthermore, in order to adapt to the era of big data, colleges and universities innovate constantly. In addition to using massive network education resources for learning, universities can also stratify students through big data. According to the scores of after-class testing and data mining, schools can make personalized scheme for students' follow-up learning.
2.2 Development of Education Informatization in Computer Abroad

In 2006, Professor Zhou of Carnegie Mellon University defined "computational thinking" as a series of activities in computer science which include problem solving, system design, and human behavior understanding. In 2008, the United States took "computational thinking" as the core of the reform of computer education in university and launched the "CPATH" program which aimed to improve both undergraduates and teachers' ability of Computational Thinking. Linda Mannila et al. (2014) studied computer courses in several countries and regions and found that students took classes on data acquisition and analysis through computer aided instruction. Hung (2012) assists students in learning by introducing “computational thinking” to class so as to achieve the purpose of building students' computational thinking.

In 2008, the Massive Open Online Course (MOOC) was proposed by Dave Kommel of Prince Edward Island University in Canada and Bryan Alexander of the National Institute of General Education Technology. The emergence of open resources on the Internet enables people from all over the world to learn at anytime and anywhere through the Internet, which has promoted the development of online learning. In 2012, Harvard University began to use “MOOCs” to promote online learning and established its own learning project—HarvardX. It was hoped that this learning program can improve the traditional teaching methods and expand the students' choices. In 2013, the University of California, Berkeley proposed the SPOC (Small Private Online Course), which can be used in an online learning class in campus. As a supplement to the classroom, this kind of courses has surpassed the “MOOCs” in terms of learning effect and teaching methods. It uses the resources on MOOCs and online communication to change the status of traditional classroom. It is a new learning model that integrate traditional classroom with online courses.

3. The Discussion on Teaching Methods at Home and Abroad

Educators at home and abroad have proposed a number of related teaching methods. For example, American educators have proposed APAs (Animated Pedagogical Agents) that allow agents with human characteristics to help teaching in a computer-designed environment. The “Inquiring Learning” method proposed by Finnish educators enables teachers and students to study knowledge together and ask students to learn knowledge by asking questions. These teaching methods are more focused on the improvement of technology, and have largely played a role in “treating the symptoms” rather than “root cause”.

The problem-based method, project-driven method[6], task-driven method[7], topic-based teaching method, guidance-based teaching method and KM teaching method[8] proposed by domestic educators are all reforms and innovations in teaching methods. The "Slim Knowledge System" teaching method attempts to "slim down" the total amount of knowledge in teaching tasks in order to reduce learning difficulty and lower teaching resources. However, it is a cut corner in knowledge learning. "Topic-based Teaching Method" designs specific research units or special topics according to the teaching content, and enables students to think with specific topic so that students
can acquire knowledge autonomously and develop the ability to analyze and solve problems. The “Guidance-based Teaching Method” emphasizes guidance and discovery. It divides the class into four steps: guidance, discovery, discuss and application which focuses on student-oriented learning process and makes students discover and solve problems so that improving their creative ability. The latter two methods have the advantages of improving students' ability to solve problems and the production of innovative thinking. However, its premise is that students need to have thorough grounding in computer science. Professor Yang of Beijing University of Science and Technology has put forward KM teaching method, which combines the "logic structure of knowledge" with "mind map" and takes the logic structure of knowledge as the core. Through macro-knowledge structure and micro-deduction, the teaching methods and models are formed. However, the specific application of KM teaching method is only focused on computer software courses.

According to the practicality of computer courses, it is necessary to motivate students' enthusiasm from the individual aspect. We rely on the social cognition of Bandura (1997) and Wood and Bandura (1989), which argues that mental function is influenced by the environment, behavior, and other personal factors that include cognition and their correlations continually were taken into consideration. By using cognitive psychology to achieve the unity of students' cognitive and practical ability, the unity of content and form and the unity of teaching and research, the opinion of "Cognize, Practice and Innovation" - "CPI" Teaching Method is proposed. Therefore, the effect of learning is influenced by the correlations between recognition, practice and innovation.

4. CPI Teaching Method

4.1 The Concept of CPI Teaching Method

CPI teaching method is a multi-disciplinary, multi-faceted research from Gagne's information processing theory, cognitive psychology, structuralism methodology, thinking science, modern teaching theory, etc., revealing the cognitive mechanism and its regularity.

CPI is the abbreviation of "Cognize", "Practice" and "Innovation". The core of CPI is to improve the individual's creativity with individual's cognitive ability and practical teaching. The three factors interrelated and interact on each other. The nature of interaction is elaborated by five basic abilities of individual (Bandura, 1986). Self-regulation is one of the basic abilities. Self-regulation refers to the process of regulation when changing environment, which is an activity to guide individuals to achieve a certain goal. Self-efficacy is one of the most important concepts in the process of self-regulation (Bandura and Jourden, 1991). Bandura (1986) holds that self-efficacy refers to the judgment of individual's ability to achieve a specific goal. Self-efficacy theory is widely used in various fields, including human resource management, organizational behavior, pre-employment training and so on (Gist, 1987). Some scholars apply cognition to computer skills learning (Compeau & Higgins, 1995a; Martocchio & Webster, 1992) and even to computer-related research (Bandura, 1986; Compeau & Higgins, 1996; Webster & Martocchio, 1992), but there is little to learning methods combined with practice and innovation. CPI teaching method reveals the cognitive mechanism and closely relates the individual's self-efficacy to its goal, thus increasing the interest of learning.

Cognition refers to individualized learning based on the cognition of students, which promotes students self-cognitive learning and analyzing self-ability so as to improve students' cognition and achieve the premise among this three-dimensional relationship.

Practice refers to the process of theory-practice-theory. It is required from local analysis to general analysis. In theory, we seek for two "elements": first is the internal relation among concepts, theorems, principles and theories (distinguish and understand their essence). Another is a thread running through concepts, theorems, principles, and theories. In practice, we seek for two "basic points": first is “must”, which refers that practice must be embodied in theory and students must practice. The second is “accidental”, which means accidental inspiration can be verified by practice.

Innovation is produced on the basis of the enrichment of the internal parts between knowledge and the development of theory, which can be changed from shallow to deep, from simple to
complex and from concrete to abstract. Thus, students can reach the height of innovation. From the perspective of epistemology, the learning at this time is spiraling upward.

4.2 The Mechanism of CPI Teaching Method

CPI teaching method is a kind of teaching method based on structure of knowledge which considers students' individuality. Through this, self-cognitive learning is fully carried out from individual students so that students can improve the ability of innovation. The whole teaching process can first learn knowledge by means of Marzano's Epistemology on the basis of knowledge system.

According to Marzano, the cognitive system consists of four categories: (1) storage and extraction; (2) information processing; (3) input and output; (4) knowledge application. These psychological processes are the operation in knowledge domain. In other words, the storage and extraction process provides learners with access to knowledge already stored in permanent memory and a way to store new knowledge for future use. The information processing is to operate on the stored knowledge (such as matching, concept representation, information filtering, information generalization, information specification and concept production) so that it can be used in specific tasks. The process of input and output (listening, speaking, reading and writing) is to understand communicate and generate communication by the use of knowledge. The application of knowledge is accomplished by means of decision-making, problem solving, experimental inquiry and investigation.

In Marzano's cognitive system model, the highlight is its analysis of the "the basic input and output of communication process", which is "listening, speaking, reading and writing" from the perspective of information processing. Marzano's conclusions are mainly: "speaking" is similar to "listening" and "writing" is similar to "reading." "Listening" and "speaking" use oral language; "reading" and "writing" use written language. This process involves quite complex learning tasks, including the following activities and related functions: (1) decoding the spoken language through a verbal or written language decoder to make it a discernible word, phrase and sentence; (2) analyzing the information in the working memory through the information processing function; (3) activating existing knowledge of a conversation or a topic by means of extraction functions; (4) activating relevant information by means of extraction Functions Knowledge of listening, speaking, reading and writing. Marzano divides the components of the metacognitive system into four categories: (1) clear objectives, (2) clear processes, (3) process monitoring, and (4) deployment monitoring. The self-system is divided into five basic types: (1) self-attribution, (2) confident and knowledgeable, (3) worldview, (4) efficacy, and (5) outlook on life. This belief system constitutes epistemology, ontology and worldview that people often talk about.

Based on Marzano's cognitive theory, the cognitive process of computer course has five dimensions: dimension 1 is “attitude and interest”, dimension 2 is “acquiring knowledge”, dimension 3 is “expanding knowledge”, dimension 4 is “using knowledge” and "Dimension 5 is "innovation of knowledge". The relationship between the above five dimensions is that all learning activities takes place in the learner's attitudes and interests (dimension 1), which is indispensable for any learning process. The other dimensions are the necessary parts in the learning process. Dimension 4 contains dimension 3, which in turn includes dimension 2, which indicates that while expanding knowledge, learners are also acquiring knowledge; while applying knowledge, they are also expanding their knowledge. This fully demonstrates that the process of thinking and the skills of thinking are not mutually separate, but a process of interaction. Similarly, the five dimensions of learning, on the whole, achieve the interaction between cognition and emotion and jointly determine the effectiveness of student learning.

It can be seen that dimension 1 is related to the self-system, dimension 2 belongs to the knowledge domain, dimension 3 and dimension 4 are cognitive systems and dimension 5 is metacognition. These five dimensions are in line with the CPI teaching method of computer
4.3 The Realization of CPI Teaching Method in Computer Courses

The success of the implementation of the CPI pedagogy in computer courses is inseparable from doing the following work.

(1) The selection of the materials of computer-based courses and teaching content is the key to the success of the CPI teaching method. The teaching materials of computer courses are derived from the knowledge system of the course. Fig. 3 is the logical structure diagram of the general knowledge system of computer courses.[12]

Therefore, the selection of teaching materials and teaching contents must be scientific and reasonable so as to achieve the teaching goal. On the basis of considering the original textbooks, it is necessary to select textbooks that meet the characteristics of the students of the school. The current textbooks are the essence of the knowledge that the educators have summarized over the years. When selecting new textbooks, they should be based on the teaching content of the current textbooks which include basic knowledge.

The progress from easy to difficult makes the selection of textbooks achieve the level of cognition, and arouses the enthusiasm of students to solve problems. For example, combing with the specific study of CPU, we designed an experiment of "Off-line Calculator" and verified it online so that students can better understand how the computer performs the calculation and improve their interest in learning hardware.

(2) We should integrate closely with the market and learn new technology and knowledge constantly. Teachers should select materials from technological innovation and technological development. And it is important to introduce new technologies with innovation into the classroom so as to mobilize students' enthusiasm for solving problems and improve the ability of practice. For example, we selected the experiment on "FPGA" and students could design their own CPU. This not only enabled students to learn the contents of the textbook, but also master a lot of new technologies, which greatly stimulated students' interest in learning. At the same time, it broadens their horizons and provides the foundation for their future employment.

(3) We must constantly combine with technological innovation. College students can apply for innovation projects through the innovation platform provided by the school with the help of teachers so that they can continuously improve their cognitive ability and achieve the highest level of CPI teaching method—innovation. Students are asked to put forward questions by themselves and solve problems with teachers' guidance. While completing the project, students improve the ability of innovation and the habit of self-study. They also learn how to discover, think about and find out solutions to problems so as to cultivate their learning ability, consolidate their theoretical

---

*Figure 2. Learning Process Diagram with Cognitive—Practice—Innovation.*
knowledge and improve their practical ability. In practical learning, students designed the "Change of Traffic Lights" project on innovation platform.

![Logical Structure Diagram of the Computer Courses.](image)

The implementation of the CPI teaching method can be briefly described as the following steps, as shown in Fig. 4.

1. Preliminary Preparation. Teachers seek for relevant materials and prepare teaching content according to the requirements of computer courses.

2. The formulation of the plan. Teachers make corresponding teaching plans and specific teaching methods according to the preparatory knowledge and content.

3. Learning and practicing with basic teaching content and experiment. The teachers teach and guide all the students to complete the basic experiments.

![The Implementation of the CPI Teaching Method.](image)
(4) Self-cognitive learning. After reviewing the knowledge taught by the teachers, each group should discuss and put forward solutions.

(5) Practicing and innovating. The students achieve self-cognitive according to the content taught by the teacher. After the students completing the experiment, they should check and debug. When there is a fault, they should be able to find out and learn to self-examine.

(6) Achievement. After completing the design and solving the problem, each group should display their own experimental process. For those groups which are unsuccessful, they need to look for the reasons and debug again. Teachers perform assessments on each group according to specific rules. At the same time, the group conducts self-assessment and the teams conduct mutual assessment. Finally, the scores of the above three are summarized according to the established proportions.

(7) Report. Each student completes the experiment report individually. The whole process form cognition to practice and innovation will be integrated into the report.

(8) Conclusions. On the one hand, teachers review the problems existing in the design and production of each group; on the other hand, they summarize knowledge involved.

5. Conclusions
Since the 1980s, computer education in China has been developed for more than 30 years. Under the strong support of the state and the practice of many teachers and scholars, the thinking of computer education has been preliminarily formed, and a series of computerized textbooks have been compiled and developed. A number of computer courses have been adapted to meet the needs of different disciplines.

In the modern education environment, more and more online courses have emerged, making the classroom student-centered and teachers become “helpers”. As a new educational model, its potential is unlimited. In addition, as the competition in the society continues to be fierce, it is not enough to teach students to analyze information with software. Most importantly, students should have ability to recognize, analyze and solve problems by using "computational thinking". The innovation of these educational methods and ideas reflects the achievements of China's computer education reform.

The CPI teaching method proposed in this paper analyzes the system structure of knowledge, analyzes existing problems and grasps the internal connection between knowledge which enables students to complete self-cognition practice, thus elevating to the level of innovation and improving their interest in learning. In the continuous researches and practice, CPI teaching method has made great achievements. The interactive teaching and innovative have made students develop the interest from computer software to the interest of hardware. The popularization of CPI teaching methods will have practical application and can be extended to other subjects, majors and interdisciplinary implementation.

Acknowledgement
Project of Education Committee in Beijing (No.SM201810038005, title: Research on the Development of Medical Service System of Elderly in Beijing Based on Deep Belief Network.); Project on Reform of education in Capital University of Economics and Business in 2018 (No. 00791854210160, title: Research and Practice on the Informatization Method of Computer Courses.)

References


