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Exploration of the Integrated Training Model for Information Technology Teachers

Haitao Sang[1]*, Bo Chen[1], Zongliang Ye[2], Jing Cai[2]

[1]School of Electronics and Electrical Engineering, Lingnan Normal University, Zhanjiang 524048, Guangdong Province, China
[2]Huazhou City School of Confucianism, Maoming 525100, Guangdong Province, China

***Corresponding author:** Haitao Sang, sanght@lingnan.edu.cn

Abstract: With the acceleration of the social information process, information awareness and information skills have become the basic qualities of every citizen. The establishment of the training mechanism for scientific and technological innovation talents from the beginning of higher education is insufficient to meet the needs of the development of the times. It is imperative to improve the training of information technology innovation talents and explore a new training model. This paper describes the general situation of the development of education in the field of information technology from a domestic and international perspective. It then analyzes the existing problems, explores new exploration models and implementation suggestions, and puts forward prospects at the end of the paper.

Keywords: Information technology discipline; Personnel training; Model exploration

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1. Introduction

The knowledge in the field of information technology has penetrated every corner of society and has become an indispensable basic knowledge of contemporary society like Chinese and mathematics. Training young people to master the basic knowledge of information technology can lay a good educational foundation for society to train talents in professional fields, and make a key contribution to improving the scientific quality of individuals. According to traditional cognition, the cultivation of scientific and technological innovation talents lies in the category of higher education. However, with the emergence of new technologies and the establishment of new majors, we realize that the establishment of scientific and technological innovation talents training mechanism from the beginning of higher education is insufficient to meet the needs of the development of the times, and it also causes many unknowns to the top of scientific research. In fact, as early as July 2017, the "New Generation of Artificial Intelligence Development Plan" issued by The State Council proposed to attempt to let the emerging disciplines sink from higher education to basic education, establish talent ladder training, and form a talent echelon. In 2021, The State Council set up the latest Outline of the National Science Literacy Action Plan (2021–2035), which also mentioned strengthening the coverage of scientific and technological knowledge to young people in the form of popular science. From a series of national policy guidance, we can see that it is imperative to improve the training of information technology innovation talents and explore new talent training models.

2. Development status of information technology basic disciplines at home and abroad

In the 21st century, the requirements for teenagers' scientific and technological literacy are also iterated with the changes of the times. Different institutions put forward several literacy requirements at different stages:

(1) The United States 21st Century Skills Alliance (P21) proposed the four C competencies. The framework encompasses Creativity, Communication, Collaboration, and Critical Thinking. This is also the prototype of young people's comprehensive literacy. Subsequently, on this basis, European countries, including the United Kingdom, and Asian countries, including China, have built their own comprehensive literacy systems for young people.

(2) The Organization for Economic Cooperation and Development (OECD) has a global assessment of young people's abilities (PISA), and an assessment report is produced every three years. This report also includes the ability assessment of young people around the world in three aspects: mathematics, reading, and science. It will also evaluate the attitude, willingness, mood, method, and happiness of young people in each country. In 2015, PISA mentioned the hope that young people will be able to "think like scientists" in the future.

(3) Around 2018, on the basis of the 4C ability, several countries including China put forward the 5C ability, which for the first time included citizenship into the core quality of young people and proposed that young people should have civic happiness and social responsibility.

(4) In the 2018 PISA report, the definition of information technology literacy in various countries has been upgraded to a higher level, and the concept of "digital literacy" has been put forward to call on young people around the world to develop digital literacy capabilities.

The subject of information technology education in foreign countries has been deeply involved in the primary and secondary education system. In October 2017, in the "2017 Developer Skills Report" released by HuffPost, a world-renowned developer skills assessment platform, it was mentioned that the country with the highest penetration rate of youth information technology education is the United States (44.8%), far exceeding second-ranked Australia (10.3%), and third-ranked United Kingdom (9.3%). A comparison of information technology education in primary and secondary schools in the United States, the United Kingdom, and Australia is shown in **Table 1**.

Currently, China has recognized the importance of information technology education in primary and secondary schools and has continuously issued encouraging policies to support its continuous development, promoting the process of popularizing and deepening information technology education at the national level of basic education. Especially in April 2022, the Ministry of Education promulgated the latest "Information Technology Curriculum Standards for Compulsory Education (2022 Edition)," which finally updated the curriculum standards that have been applied in the field of information technology education in primary and secondary schools for many years, and changed the information technology curriculum from a combined approach with comprehensive practice courses to an independent compulsory course starting from the third grade [1]. This serves as a milestone in Chinese youth information technology education. The standards clearly mention that the core literacy to be cultivated by the information technology curriculum includes four aspects: information awareness, computational thinking, digital learning and innovation, and information social responsibility [2]. In addition, based on the core literacy and learning objectives, and according to students' cognition, six logical main lines have been established: data, algorithms, networks, information processing, information security, and artificial intelligence.

Table 1. Comparison of information technology education in foreign primary and secondary schools

Country	Stage division	Teaching method	Objectives
United Kingdom	The process is divided into four stages: KS1, KS2, KS3, and KS4	As a standalone subject for education	1. To increase access to computer science knowledge for all students. 2. To provide additional intermediate computer science instruction that will allow interested students to delve into all aspects of computer science and prepare them for the workplace or college.
United States	The process is divided into five stages: 1A, 1B, 2A, 3A, and 3B	As a standalone subject for education	1. Ability to understand and apply basic principles and concepts of computer science, including abstraction, logic, algorithms, and data representation. 2. Ability to analyze problems in computational terms and have repeated practical experience in writing computer programs to solve such problems. 3. Ability to analyze, evaluate, and apply information technology, including new or unfamiliar technology, to solve problems
Australia	The process is divided into five stages: F-2, 3-4, 5-6, 7-8, and 9-10	As a standalone subject for education	1. To cultivate digital literacy and computer thinking. 2. To lead students to a broader understanding of the impact of technology on families and communities. 3. To educate students to understand the social and ethical implications of technology and solve more complex problems.

This shows that China's primary and secondary school information technology education is gradually maturing and becoming systematized. However, there is still room for further optimization in linking up primary and secondary school science education teachers, excellent researchers in information technology directions from universities and research institutes, and outstanding engineers from enterprises to form a systematic information technology basic discipline education system.

3. Analysis of existing problems

Although China has issued a series of policies to promote the popularization and deepening process of information technology education, there are still some problems in curriculum design, training methods, inclusiveness, talent ladder, and teacher level.

Curriculum design: Although the new curriculum standard of 2022 has boosted the basic education of information technology, and effectively implemented the information technology course into an independent compulsory course in the stage of compulsory education, there are some areas that require improvement or refinement. For example, there is no specific implementation and detailed plan for curriculum design, teaching and research methods, and teaching content, and no national unified teaching material. From the perspective of information technology practitioners, information technology courses lack some essential content [3].

Training methods: Adolescent behavior and cognition play an important role in the learning process. We often find that children are slow or unable to learn knowledge, sometimes not because of IQ (intelligence quotient), but because of the mismatch between the learning content and the behavior and cognition of the age [4]. For example, when using the mouse as a tool to operate the computer, we neglect the problem that the fine motor development of children may not be keeping pace. Therefore, it is crucial to design teaching and training methods that match the children’s age.

Inclusiveness: Before the release of the 2022 version of the new curriculum standards, the learning of computer and information technology disciplines has been driven by competitions and selections [5]. Therefore, we have been discussing the issue of inclusiveness. It is important to select talented children through competitions and selections. However, in the era of rapid development of science and technology, as a knowledge base subject that no one can avoid in the future, inclusiveness is more important.

Talent ladder: We take the demand for talent in the subdivision of computer science as an example. In the field of artificial intelligence, the data released by the Prospective Industry Research Institute of the Talent Exchange Center of the Ministry of Industry shows that the supply and demand ratio of talents and positions in different technical directions is lower than 0.4, indicating that the supply of talents in the field of technology is seriously insufficient. In the field of chips, according to the White Paper on Talents in China’s Integrated Circuit Industry (2020–2021 edition), it is expected that by 2023, the demand for talents across the industry will reach 766,500 people, while the talent gap is more than 225,000 [6]. We have predicted that the demand for information technology talents in the future will be huge. Therefore, there is still a lot to be done in the reserve of scientific and technological talents, as China lacks a complete talent reserve and ladder training mechanism.

Teacher level: A strong teaching system is highly dependent on teachers’ professional degree, teaching research, teaching methods, and other abilities [7]. This can be seen in the stratified teaching in Australia, teachers making their own teaching plans and programs in the United Kingdom, interdisciplinary and project-based teaching methods (PBL) in Finland, and states and regions in the United States developing their own teaching materials. Therefore, building a large, professional, and innovative team of information technology teachers is the key to improving the digital literacy of Chinese teenagers.

4. Exploration of new models

In order to solve the above problems, we need to build a multi-dimensional and optimal teaching system, seek suitable teaching methods that match the behavior and cognition of teenagers, open the path of basic education and higher education, and establish an ideal teacher training mechanism.

4.1. Interdisciplinary integration

Information technology should be integrated with mathematics, physics, nature, art, engineering, and other disciplines, maximizing the advantages of the PBL teaching method, and improving the integration of information technology and other disciplines. Conversely, many disciplines should also integrate the knowledge of information technology, to enhance students’ interest in independent learning.

4.2. Integration of theory and practice

Theory and practice should be integrated. Traditional information technology courses typically involve reprogramming using programming tools to implement various virtual applications or algorithm research, or emphasis on hardware, with the perception that robot teaching aids encompass the entire information technology curriculum. We should fully integrate theory and practice, ensuring students’ mastery of theoretical and practical knowledge.

4.3. Integration and inclusiveness

In the process of talent training and reserve, integration and inclusiveness complement each other. Inclusiveness involves accumulating a large quantity of talents, while integration involves selecting quality talents, this approach ensures the well-rounded development of talent. We can adopt different teaching communication methods, namely science popularization + science education. Popular science courses, lectures, and activities are highly effective and inclusive teaching methods, allowing easier understanding. The content of science education can be used as the curriculum system of deep learning and precise selection for teaching and research. We can explore dividing the knowledge system into inclusive system and extended system, and then integrate with the teaching methods of popular science and science education, and strive to make the breadth and depth of inclusive development.

4.4. Teaching methods based on cognition

In the process of exploring the progressive and spiraling rise of computer and information technology subjects in course content, audience cognition, and teaching methods, we found that the same course content corresponded to cognition of different ages and distinct teaching methods had varying effects. Therefore, we should not only focus on the penetration of content, but also emphasize on the understanding of audience groups and teaching methods. Taking artificial intelligence programming language as an example, Python, Scratch, and Tangible Tile-based language are respectively applicable to groups of different age levels. Python language reduces the learning and acceptance threshold of learners to the junior and senior high school level; the graphical drag and drop of the language in Scratch lowers the threshold of learning and acceptance to the upper elementary school. However, considering the behavioral development characteristics of preschool and lower grade primary school children, using tools requiring fine motor operation such as mouse is not suitable for them, so the Tangible Tile-based language can be used to lower the learning and acceptance threshold of learners.

4.5. Training mechanism of science and technology teachers

The convergence and integration of basic education and higher education are not only reflected in the content, methods, and behavioral cognition but also reflected in the training of science and technology teachers in the basic education stage. In 2017, major universities set up artificial intelligence colleges, and conditional provinces launched artificial intelligence compulsory courses in high school; In 2021, the Ministry of Education proposed to carry out national security education in primary and secondary schools, and network information security is one of the 16 kinds of national security; At the beginning of 2022, the National Academic Degree Authorization Committee decided to set up the 14th discipline category—“interdisciplinary discipline,” “integrated circuit science and engineering,” and “national security” become the first-level disciplines under this category, and set up a separate undergraduate major. In just five years, several new subjects have been born in the field of information technology, but the number of information technology teachers in the field of basic education is severely insufficient, with unsatisfactory teacher capability. We suggest that non-normal colleges and universities should participate in the training of information technology teachers in primary and secondary schools from the perspective of professional fields, so as to solve the problems of professional ability and the shortage of information technology teachers in primary and secondary schools.

4.6. Establishment of a science and technology teacher database

In order to increase the depth of science and technology teachers, it is suggested that the government, the society, the association, and the teaching research institute rely on the system to build a multi-level and graded science and technology teacher database. The teacher training mechanism and teacher database are established from the three gradients of science and technology teacher counselors, grassroots teaching and research staff, and science and technology teachers. Teachers who are competent and willing are selected to participate in professional knowledge training organized by colleges and universities regularly, and the advanced mechanism between the three gradients is suggested. In addition, the treatment of front-line science and technology teachers and career promotion planning are improved to attract more science and engineering college graduates into primary and secondary schools.

5. Implementation suggestion

5.1. Extension and supplement of compulsory education curriculums

From the perspective of computer and information technology professionals, the new curriculum standard complements a more comprehensive curriculum system for compulsory education or high school education. The core technology fields covered by the information technology science education system include but not limited to computational thinking, chips, cloud computing, mobile communication, artificial intelligence, network security, etc. Specific to each technical field, it should mainly include two aspects of education content: "basic knowledge and scientific principles" and "experiment and practical operation." Basic knowledge and scientific principles are the basis of the two educational contents. Knowledge is systematized and 8–10 key knowledge points are arranged for each course. Through principles explanation, case analysis, teaching aids demonstration, practical exercises, and other methods, a course is arranged in one semester. In addition to in-class teaching, we can also prepare supporting extracurricular teaching aids, each corresponding teaching aids books can expand the 8–10 knowledge points in class to about 30 supplementary knowledge points, so that students can gain more knowledge and have a deeper understanding of more concepts of basic information technology. The theory of information technology is highly practical, particularly in the education of young people, the proportion of students who really engage in the research of information technology theory is smaller. The majority of students use the results of their work in the information technology industry to support their careers. Therefore, it is necessary to pay special attention to experimental practice and ensure that students can truly master the knowledge through programming, production, testing, and other application links. In addition, it can make full use of the dividend of the current advanced development of information technology, with the help of online teaching systems and offline science and technology teaching aids and classrooms. This approach results in more three-dimensional teaching, and more excellent researchers can update the latest scientific research results application cases through the Internet, and enter the primary and secondary school "classroom" in real-time.

5.2. Construction of teacher training mechanism

Full-time teachers in primary and secondary schools are the primary group involved in the information technology basic science education. It is vital to improve the teaching staff of the basic information technology. Specific training mechanism suggestions are as follows: Firstly, the recruitment of teachers should be eclectic, selecting talents from a wide range of sources. The recruitment of teachers can sink into the group of enterprise information technology practitioners and computer teacher training graduates. Enterprise information technology practitioners can prevent the decline of students' learning interest and sense of participation in teaching due to the application of the first-line industry. The graduates of computer education majors are equipped with a relatively solid background of information theoretical knowledge and the education mode of normal majors, so they are suitable for training full-time teachers of information technology in primary and secondary schools. Therefore, the teachers of information technology in primary and secondary schools can be selected from this group of people, focusing on theoretical education and experimental and practical training, which complement each other. Secondly, the forging of teachers should be persevered for a long time. It is necessary to forge a strong team of full-time teachers of information technology from the aspects of talent selection, gradient construction, professional title promotion, treatment guarantee, etc. In addition, to avoid being too hasty, we should follow a step-by-step approach to work on and polish the quality, ability, and toughness of the full-time teachers of information technology in primary and secondary schools with the cumulative effect of time.

5.3. Establishment of pilot school

A team of teachers who are forward-looking, have hardware and software strength, scientific and technological innovation characteristics, vitality, and excellent students are selected to pilot the compulsory education, senior high school education, and higher education integration through the talent training program. Integrating universities and middle schools, it completes a series of tasks such as teacher training, curriculum standard establishment, teaching and research mutual assistance, science and technology output, and talent selection.

In order to promote the high-quality development of basic education in Guangdong Province, taking the field of information technology as an example, the School of Electronic and Electrical Engineering of Lingnan Normal University and Rucheng School of Guangdong Huazhou signed a contract to cooperate in the construction of "Information Technology Innovation Talent Training Base" in June 2022. There is a clip-like difference in the computer courses between the secondary school and the university, so Lingnan Normal University hopes to use the practical experience of the university courses to organize and construct a series of courses suitable for "medium and large" connection, and establish good "medium and large" computer courses connection. The School of Electronic and Electrical Engineering of Lingnan Normal University has embraced an educational concept of using the backbone of scientific research to support the development of basic education, and this cooperation represents a bold innovation and attempt.

6. Conclusion

The world is constantly being transformed by new information technology, the basic knowledge and application scope of information technology has long been separated from the professional field, and has become the basic concept and common sense of life that everyone needs to master. Therefore, it is urgent to encourage educators in primary and secondary schools and researchers in colleges and universities to invest in the training of young talents in basic disciplines of information technology. The education department, the publishing industry, parents, and members of society should form a consensus and linkage mechanism to ensure that the new generation of young people in China can master the basic knowledge of information technology that is systematic, practical, and dynamic in content.

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