Research on the Systematic Ability Cultivation of Computer Professional Talents under the Background of Information Technology Innovation

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***Abstract*—The innovation of information technology application is to enhance the ability of independent innovation, and is the key to accelerate the realization of high-level self-reliance and self-improvement. Under the situation of information innovation, the core of talent training is to improve the computer system ability of computer students. Therefore, the cultivation of computer system ability has become one of the most influential hot issues in education and teaching reform of computer specialty. This paper analyzes the characteristics of the cultivation of computer system ability under the background of information innovation, introduces the main connotation and training requirements of computer system ability, expounds the overall idea of system ability cultivation and curriculum system setting, combines AI, big data and computer system ability cultivation to innovate teaching and learning methods, optimizes the training mode of information innovation talents by integrating production and education, and builds a student-centered "double transformation" information innovation teaching system to improve the training quality of information innovation talents.**

***Keywords*—information technology innovation, system capability, teaching system, computer major**

I. Introduction

The goal of information technology application innovation is to develop an independent and controllable IT industry chain, especially in the core hardware and software level of chips, operating systems, terminals, and application software to get rid of the dependence on foreign products. The information technology application innovation industry is a diversified and rapidly developing field. The information and innovation industry has promoted the rise of new forms of business such as cross-border e-commerce, online education, and telemedicine in the world, providing new opportunities and challenges for global economic cooperation and promoting international exchanges and cooperation [1].

Manuscript received February 2, 2024; revised April 1, 2024; accepted June 13, 2024; published October 18, 2024.

According to the data of the Ministry of Industry and Information Technology, the scale of China's information and innovation industry will reach 1668.94 billion yuan in 2022, with a talent gap of one million. It is expected that by 2027, the scale of China's information and innovation industry will reach 370113 billion yuan, with a talent gap of ten million. With the large-scale landing of information and innovation projects, the demand for information and innovation talents related to the management and service guarantee of information and innovation projects is becoming more and more urgent. In order to meet the needs of society, universities are also actively carrying out the training of information and innovation talents. The development trend of modern computer engineering is comprehensive, intelligent, software-defined, and networked, which makes the overall scale of system software increase sharply, from the originally relatively closed and isolated to open, thus posing challenges to talents, including the development of research and conception from the high degree of multi-dimensional system, the comprehensive use of a variety of knowledge for engineering implementation, and the iterative process in the operation process to seek system balance. These challenges require our students to have system ability. Computer system ability is the ability for students to understand the integrity, relevance, hierarchy, dynamics, and openness of computer systems, master the mechanism of computer software and hardware collaborative work and interaction, and comprehensively use a variety of knowledge and technology to complete the whole system development.

II. Research Background

The cultivation of computer system ability has become one of the most influential hot issues in education and teaching reform of computer majors. The cultivation of computer system ability in foreign countries started at the beginning of the 21st century, and the subsequent attention and implementation of computer education. ACM/IEEE computing curriculum system specification is a computer professional curriculum system specification

doi: 10.18178/ijlt.10.5.620-625

jointly formulated by the Association for Computing Machinery (ACM) and the Institute of Electrical and Electronics Engineers Computer Society (IEEE-CS) [2, 3]. It has high authority and has formed a certain influence in the global scope. The ACM/IEEE CC2020 report contains 8 curriculum system specifications, and establishes the concept of "competency-based learning". The talent training objective under the competency model is to train students from three dimensions of knowledge, skills, and dispositions, and create three-dimensional talents with sustainable competency, so that students are competent for future and computing-related work, and adapt to the needs of economic, scientific, and social development. CC2020 puts the focus of knowledge structure adjustment on further strengthening the cultivation of system knowledge and system ability [4]. Internationally, Carnegie Mellon University, Stanford, UC Berkley, and other first-class computer departments in the United States have strengthened the theory and practice of system ability training, set up new system-level comprehensive courses, re-planned the core curriculum content of computer systems, and made the content of the courses more closely related, and has achieved good results.

At present, computer education based on system ability training has been practiced in hundreds of universities in China, and has achieved remarkable results in talent training. The curriculum reform of Nanjing University of Aeronautics and Astronautics, the principle of computer composition curriculum requires students to be able to implement the single cycle/pipeline CPU design and operate the verification from 9 instructions to 36 instructions. By introducing engineering methods, the curriculum is more in line with the characteristics of complex engineering problems [5]. Southeast University joined the "100 Core Plan" base, aiming to let college students further participate in the completion of the whole process design of processor chips and master the core technology. University of Chinese Academy of Sciences launched the "Lifetime One Core" plan, aiming to let undergraduates design processor chips and complete the flow film, guide students' learning habits and training means from the course experimental teaching mode to the real project practice mode, and cultivate processor chip design talents with solid theoretical and practical experience.

The core of the system ability of computer students requires students to master more of the association relationship and logical hierarchy of the software/hardware parts within the computing system, and understand the external characteristics of the computing system and the interaction mode with people and the physical world. The education of the system view reflects the characteristics of engineering education. Compared with the computer foundation and application ability of students in other majors, computer majors pay more attention to the cultivation of students' computer system ability. Therefore, the knowledge system of computer majors not only needs to be updated and expanded, but also their system design innovation ability must be strengthened and improved.

III. Training Ideas

In the context of emphasizing programming ability, the problems existing in the training of the system ability of computer majors are shown in Table I. In the intelligent era, the training of computer professional talents has turned to the more important systemic thinking and systemic design ability.

TABLE I. Problems Existing in the Training of System Ability of Computer Students

Problem Description	Content
The problems in cultivating students' systematic abilities in schools	Insufficient consideration of the connection and correlation between courses
	The teaching content is relatively outdated
	Lack of overall consideration for system design and application ability cultivation in the curriculum system
The problems that students have in terms of systematic abilities	Some students are unable to establish a complete concept of computer systems and lack a systematic perspective
	Students lack sufficient mastery of the core content of computer systems and are unable to handle complex tasks involving software/hardware collaborative design
	Poor comprehensive analysis, design, and application abilities

A. Update the Training Concept

The training idea of information and creative talents should highlight the concept of system view education. The teaching content should reflect the principle of new computing system, and show the computing system platform technology in the practice link. We should deeply understand the impact of systematic professional education on the higher education of computer major. The method of systematic education and system ability training should adopt the method of systematic science. It not only consolidates the theoretical basis of the system, so that students can build a model that accurately describes the real system, and can predict the system behavior with the model; but also strengthens the system practice, and cultivates students' ability to effectively construct the correct system. Starting from the system view, the teaching of computer majors should pay attention to teaching students how to think from the system level (such as the interaction of design process, tools, users, and physical environment), should teach the principles (basic principles, architecture, protocol, compilation, and simulation, etc.), and strengthen the process and content of systematic practical teaching.

- Cultivate information and creative knowledge talents who understand the ecology of information and creative industry and are familiar with relevant policies as a brand new industry, information technology covers a complete industrial chain from the bottom IT infrastructure to the upper application and information security, involving a large number of industries and

ecology. Information technology has higher requirements for related employees, and needs to be very familiar with the relevant industry [6]. Train knowledgeable personnel who are familiar with the information technology industry and industry policies and can be used to guide the work.

- Cultivate information technology talents with development and manufacturing related technical knowledge Cultivate skilled Shell / Python / PHP / Java / Go and other programming languages, master the use, operation, and maintenance and research and development of domestic operating systems, master the operation and development knowledge of Linux system, and be competent for the adaptation, development, testing and other work in the information technology industry.
- Cultivate information technology engineering construction talents with implementation and delivery ability Cultivate talents who master the construction standards of information technology projects in different industries and different processes, are familiar with the application of domestic software and hardware, and the innovation of business models, can carry out the whole cycle management of the construction of information technology projects, and have the ability to control the progress of the project, project quality, personnel flow, project delivery and other abilities [7].
- Cultivate service and support personnel with the ability to perform information technology posts Training for the technical route of the information and communication industry products consulting, design, supervision, testing, maintenance, after-sales, sales, etc., with "information and communication post + service characteristics" integrated service ability (system integration, supervision, information security services, consulting planning, etc.), "information and communication post + product characteristics" general product ability (such as OS adaptation, database optimization, data migration, etc.), "information and communication post + brand characteristics" manufacturer product ability (server maintenance, network construction, network equipment installation and maintenance, information security products, application systems, etc.) of service guarantee talents.

B. Innovative Teaching Methods

Combine AI, big data, and computer system ability training, through the precise determination of teaching content, rapid construction of teaching environment, quantitative analysis of teaching process, scientific evaluation of teaching effect and development of personalized learning mode, innovative teaching and learning methods, so as to improve teaching efficiency and effect [8, 9].

- Make full use of high-quality teaching resources online learning platform. For core and backbone courses, select famous teachers and famous teaching materials, deepen the construction of MOOC and SPOC courses, expand and improve the content and capacity of online professional learning and experimental platform, and realize the sharing of high-quality professional teaching resources.
- Use intelligent learning tools. In order to solve the problems of principle verification and efficient understanding of basic learning of computer system, experimental verification and optimization design of professional learning, etc., the corresponding intelligent learning and verification tools and networked software development tools are scientifically used to improve students' learning efficiency and teachers' educational and teaching innovation ability.
- Teaching analysis and optimization based on big data and AI. Based on the perception of students' professional learning process based on Internet of Things technology, the learning effect is analyzed by using learning big data and AI analysis method, curriculum content is optimized, and personalized learning mode is supported.

C. Optimize Training Mode

In order to effectively realize the optimization of computer professional system knowledge and ability to adapt to the information and innovation era, the following training mode of industry-education integration is constructed.

- Jointly plan professional development. Deepen the integration of industry and education, jointly build the steering committee of professional construction with information and innovation enterprises, focus on the construction of new technology such as computers, Internet of Things, artificial intelligence, big data, and information security, jointly formulate professional construction plan, talent training plan, and determine the professional core ability and training standards.
- Jointly build the training platform for industry-education integration. Bring together the resources of universities, research institutes, and enterprises, actively build the training platform for industry-education integration, jointly build the laboratory and practical teaching base that connect the frontier of industrial technology, provide a teaching environment close to the actual engineering, and provide strong support for the development of information and creative industry and the training of information and creative talents.
- Jointly develop project-based courses. Through deep integration with enterprises, the core courses such as "Principles of Computer Composition",

"Programming", "Computer Network", "Operating System" and "Database" are transformed into information and innovation, the advanced technical knowledge, real cases, and projects of enterprises are organically integrated into the curriculum system, and the practical training courses are jointly compiled to improve the awareness and practical ability of students of related majors to apply information and innovation products, and have the ability to solve complex engineering problems in the information and creative industry.

- Jointly set up teaching and scientific research teams. Select teachers to enter enterprises for training, jointly carry out key technology research and development and technical transformation with enterprises, accumulate practical experience in the production process, improve teachers' professional level and practical ability, and cultivate professional leaders and backbone teachers. Enterprises select technical backbones with rich engineering practice to participate in professional course teaching, guidance practice, and graduation design, and set up school-enterprise joint teaching team. To consolidate the development of the strong teacher plan, to create a high-quality professional and innovative information and innovation teacher team.
- Jointly create a technological innovation platform. In view of the shortcomings and adaption of domestic information and innovation products in use, through research, analysis, program design and verification, and other links, jointly carry out scientific and technological projects with enterprises, solve the technical problems encountered in the process of project research and development, and build a technological research and development platform. To take the integration of industry and education as the specific starting point, strengthen the important role of enterprises, carry out the cooperation of industry and education, actively promote the integration of industry and education and the transformation of achievements. A well-presented results section coupled with a convincing discussion will definitely prove the novelty and importance of your study. It should provide a concise and precise description of the experimental results, their interpretation, as well as the experimental conclusions that can be drawn.

IV. Training System

A. Capability System

From the perspective of adapting to the needs of science and technology and industrial development in the information and innovation era, computer professionals should have the following abilities.

- Computational thinking ability. Computational thinking is the behavior of using the basic concepts of computer science to solve problems and design systems, which is the foundation of computer talents.
- System thinking ability is the overall thinking. Computer professionals must have solid system thinking to complete the specific system implementation in the design, construction, and application of various computing systems, and achieve efficient goals.
- New computing system innovation ability. Computing systems in the intelligent era are diverse. Computer professionals should have the optimization design ability of application scenario analysis, intelligent algorithm optimization, and hardware platform realization, as well as the optimization design ability of strengthening the organic collaboration of new hardware and intelligent software, and the close combination of cloud-edge-end in system design.
- Comprehensive application system research and development ability. The knowledge division in the intelligent era tends to converge, and more disciplines intersect. New computing application systems for different fields also form distinct characteristics of multidisciplinary cross, information, and physical fusion. For example, the research and development of autonomous unmanned systems such as intelligent industrial robots and intelligent agricultural robots involves mechatronics, perception technology, automatic control, hardware platform, algorithm optimization, etc. Therefore, computer professionals need to have interdisciplinary cross-thinking and knowledge fusion ability, as well as comprehensive system integrated design and development ability.
- Post ability is the key factor whether a person can be competent for a certain position. Only with the ability required by the post can a person be competent for the job and complete the task. The quality of post ability directly affects the quality and efficiency of work. If a person does not have enough post ability, it is difficult to achieve good results in the work, and it is also difficult to develop in the workplace. The information and communication technology enterprises set up positions such as operation and maintenance engineer, database administrator, cloud computing engineer, system engineer, pre-sales engineer, etc. According to the job responsibilities and requirements, the information and communication technology post system provides college students with a clear learning path to meet the needs of the enterprise.

B. Teaching System

The construction of student-centered "double transformation" information and innovation teaching system is shown in Fig. 1.

The system takes cultivating students' core abilities such as thinking ability, system ability, innovation ability, application ability, post ability, and practical ability as the center, and establishes a school-enterprise mixed teachers' team to complete the formulation of talent training direction and curriculum system. Through the theoretical teaching channel, students can improve their comprehensive strength by solid learning, solid training, solid foundation, and solid ability. Through the practical training channel, students can improve their special skills and the ability to solve complex engineering problems in the information and innovation industry. The construction of the information and innovation teaching system with the cooperation of theoretical teaching channel and practical training channel can cultivate excellent information and innovation talents that meet the actual needs of the industry and improve students' employment quality. After the implementation of the talent training program, the students have achieved two major changes:

- Students have achieved the transformation from relying on guidance to active exploration. The biggest difference from the previous experiment is that students do not have a teacher's step-by-step detailed guidance, but have to find their own methods, independently design and implement the system, and then verify or even reverse it.
- Students have achieved the transformation from users to creators. College students majoring in computer should learn how to make computers instead of using computers. Students through real participation in the project, only to find that the knowledge and skills learned in the university are useful.

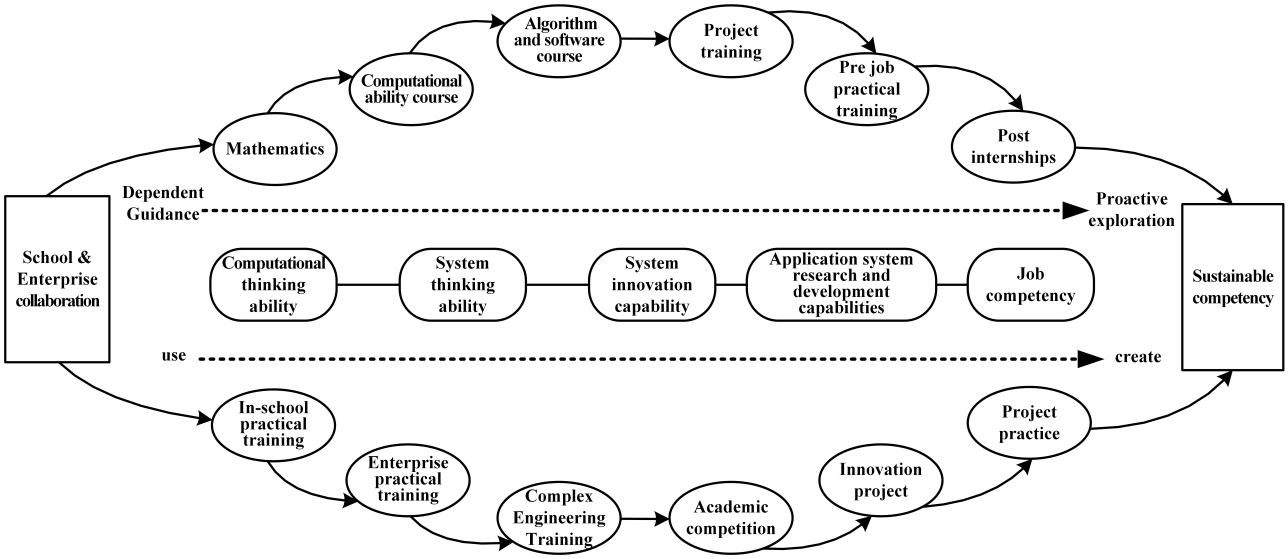

Fig. 1. A student-centered "dual transformation" information and creative teaching system.

V. Conclusion

Computer system ability has become the key ability of computer talents. But the university of computer professional teaching on the system ability is not enough, there are some problems. Therefore, it is necessary to update the concept, optimize the idea, innovate teaching methods, build a new teaching system and other methods, step by step to cultivate students' system engineering ability, cultivate a group of talents with independent innovation ability, master the key core technology, they will not only use the computer, but also make the computer.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Ge Jiao was responsible for conducting experimental research, reviewing literature, collecting data, analyzing data, writing papers, etc.; Yun Wu provided suggestions for the paper and modifiable the paper; both authors had approved the final version.

Funding

This work is supported by the Research Project of University Teaching Reform in Hunan Province (Xiangjiaotong (2023) 352, HNJG-20230884), the Hunan Province Basic Education Teaching Reform Research Project (Xiangjiaotong (2023) 316, Z2023154), the Science and Technology Plan Project of Hunan Province (2016TP1020), "the 14th Five-Year Plan" Key Disciplines and Application-oriented Special Disciplines of Hunan Province (Xiangjiaotong (2022) 351), the construction project of university-enterprise cooperative innovation and entrepreneurship education base in Hunan province (Xiangjiaotong (2018) 380, No. 53), the Hunan provincial university innovation and entrepreneurship education center construction project (Xiangjiaotong (2019) 333, No. 58).

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